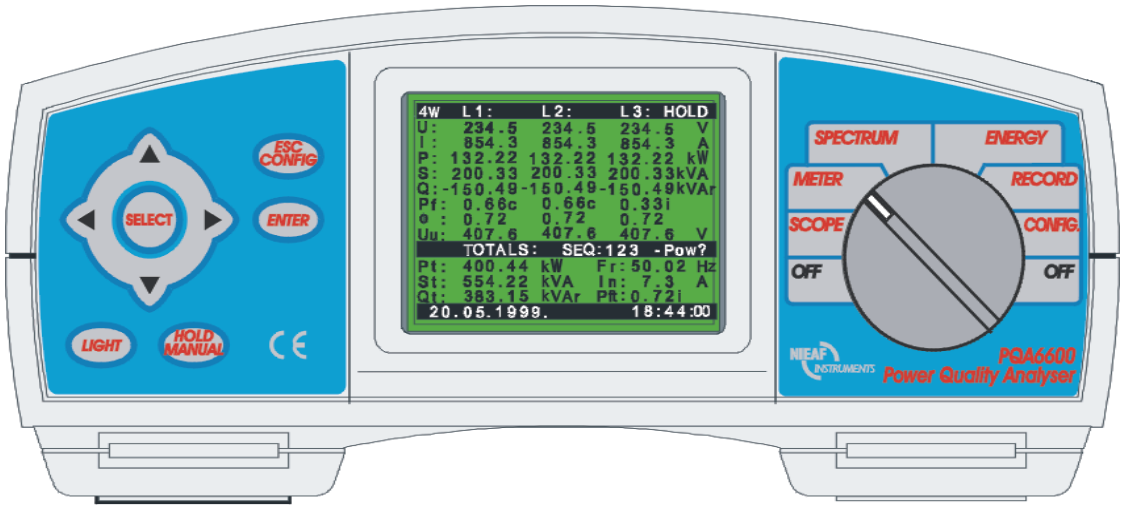
User manual
POWER QUALITY ANALYZER
PQA 6600



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Specifications of the equipment:	Power Quality Analyzer PQA 6600
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Contents

POWER QUALITY ANALYZER

The Power Quality Analyzer is a portable multifunction instrument for measurement and analysis of three-phase power systems.

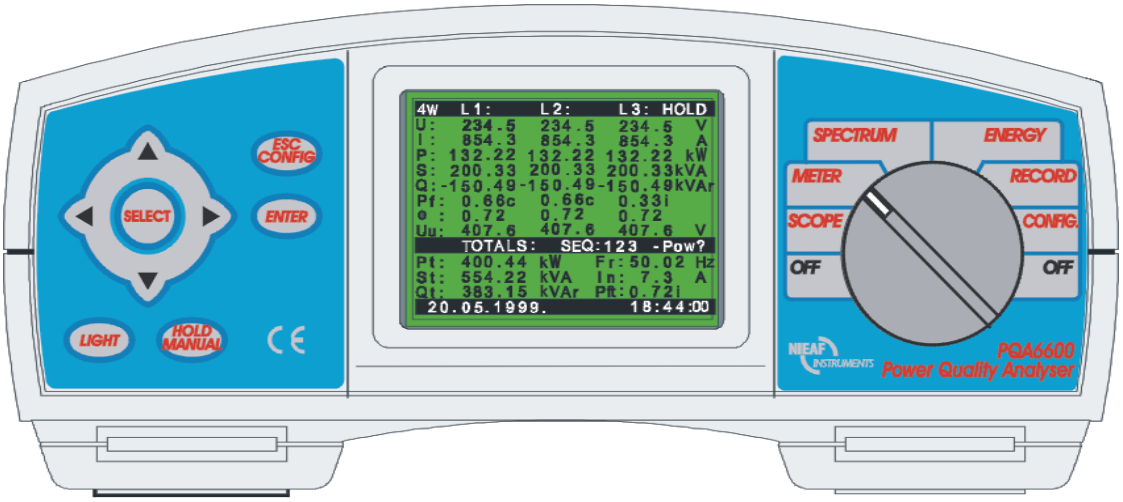


Fig. 1

Main features

- Comprehensive real time monitoring, recording and analysis of 3 phase (3φ) power systems.
- Wide range of functions:
  - True r.m.s. Voltage
  - True r.m.s. Current
  - Power (Watt, VAr and VA)
  - Power Factor
  - Energy
  - Power Scope
  - Harmonic Analysis
  - Statistical Analysis
  - Flickers
  - Anomalies
- In recording mode the measured values are stored in memory for later analysis.
- Special recording modes for waveform capture with various trigger options.
- Special recording modes for monitoring the quality of the observed supply system:
  - Periodics,
  - Waveforms,
  - Transients,
  - Fast logging,
  - EN 50160.
- Minimum, average & maximum value calculations for recorded quantities, with various pre-formatted reports.

- Oscilloscope mode for displaying waveforms, both in real time and for stored waveform analysis.
- Harmonic distortion analysis up to 63rd harmonic, both on line and on recorded data.
- Energy monitoring and analysis.
- Internal rechargeable batteries.
- RS232 communication port for connection to a PC.
- Windows software for data analysis and instrument control.

SAFETY CONSIDERATIONS

GENERAL

To ensure operator safety while using the Power Quality Analyzer, 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. Use in a fashion other than as 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 must only carry out Service or calibration!**

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

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

APPLICABLE STANDARDS

The Power Quality Analyzer is designed in accordance to the following European standards:
Safety:
- EN 61010-1

Electromagnetic compatibility (noise and immunity):
- EN 50081-1
- EN 61000-6-1

Measurements according to European standard:
- EN 50160

SECTION I

GENERAL INFORMATION

1. INTRODUCTION

This manual provides information for the connection, operation, programming, data analysis and maintenance of the Power Quality Analyzer (shown in *Fig. 1*).

The manual is divided into five sections, each covering a particular aspect of the operation of the Power Quality Analyzer.

Section	Topic
I	General information
II	Internal Operation
II	Meter Operation
IV	Connection to Power System
V	PC Software
VI	Theory of operation

2. DESCRIPTION

2.1. FRONT PANEL

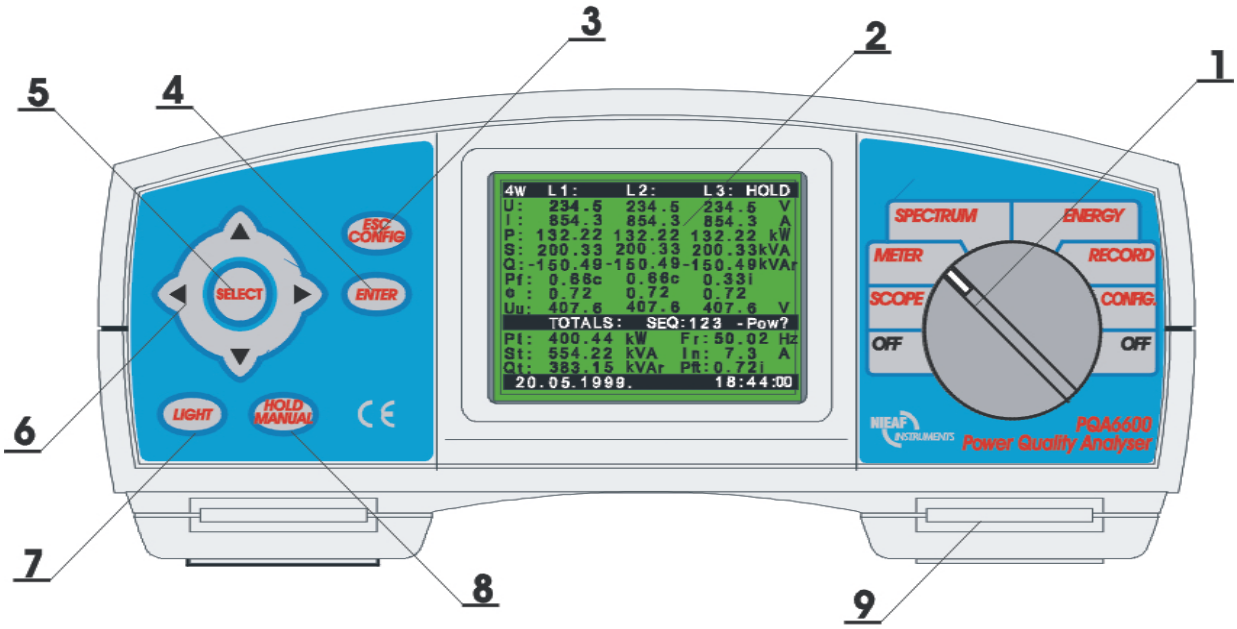


Fig. 2: Front panel

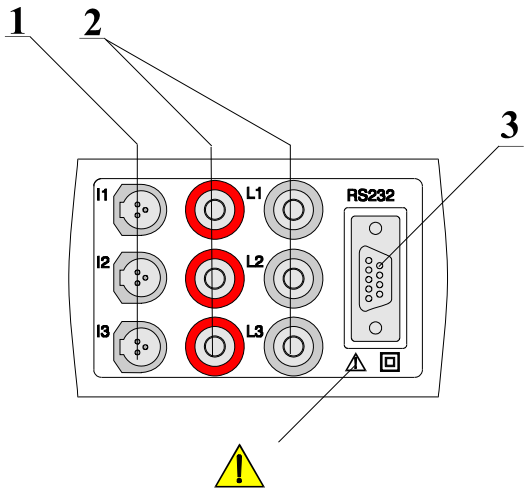
Front Panel Layout:

*1..... **FUNCTION switch**, selects one of seven functional/operating menus:*

- ***OFF*** *Power OFF*
- ***CONFIG*** *Instrument configuration menu*
- ***RECORD*** *Recording menu*
- ***ENERGY*** *Energy measurement*
- ***SPECTRUM*** *Harmonic analysis menu*
- ***METER*** *Basic power, current & voltage measurements*
- ***SCOPE*** *Waveforms display & control*

2..... ***LCD*** *Graphic display with LED backlight, 160x116 pixels.*
3..... ***ESC/CONFIG key*** *To exit any procedure or open configuration menu.*
4..... ***ENTER key*** *To confirm new settings, start recording procedure.*
5..... ***SELECT key*** *Enable selected signals.*
6..... ***ARROW keys*** *Move cursor and select parameters.*
7..... ***LIGHT key*** *LCD backlight ON/OFF (Backlight automatically turns OFF after 30 sec. if no key action occurs)*
LIGHT + ↑ *Increase display contrast*
LIGHT + ↓ *Decrease display contrast*
8..... ***HOLD/MANUAL key*** *Display screen is temporarily frozen and/or manual triggering (SCOPE, METER and SPECTRUM functions only).*
9..... ***BELT slot*** *For attachment of a carry strap*

2.2. CONNECTOR PANEL (on side of Meter)



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

Fig. 3: Connector panel

Connector Panel Layout:

1 ..... Current Clamp-on current transformers/Transformers (I_1, I_2, I_3) input terminals
2 ..... Voltage (L_1, L_2, L_3) input terminals
3 ..... RS 232 connection (for connection of the Power Quality Analyzer to a PC)

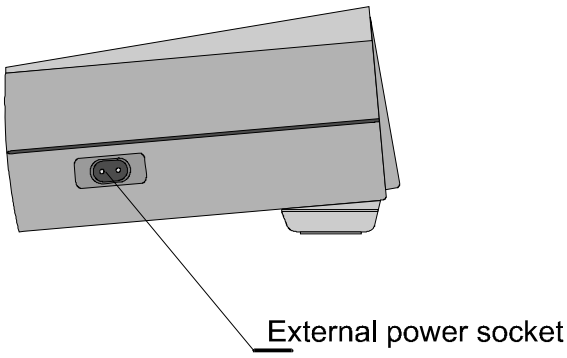


Fig. 4: External power socket

2.3. BOTTOM VIEW

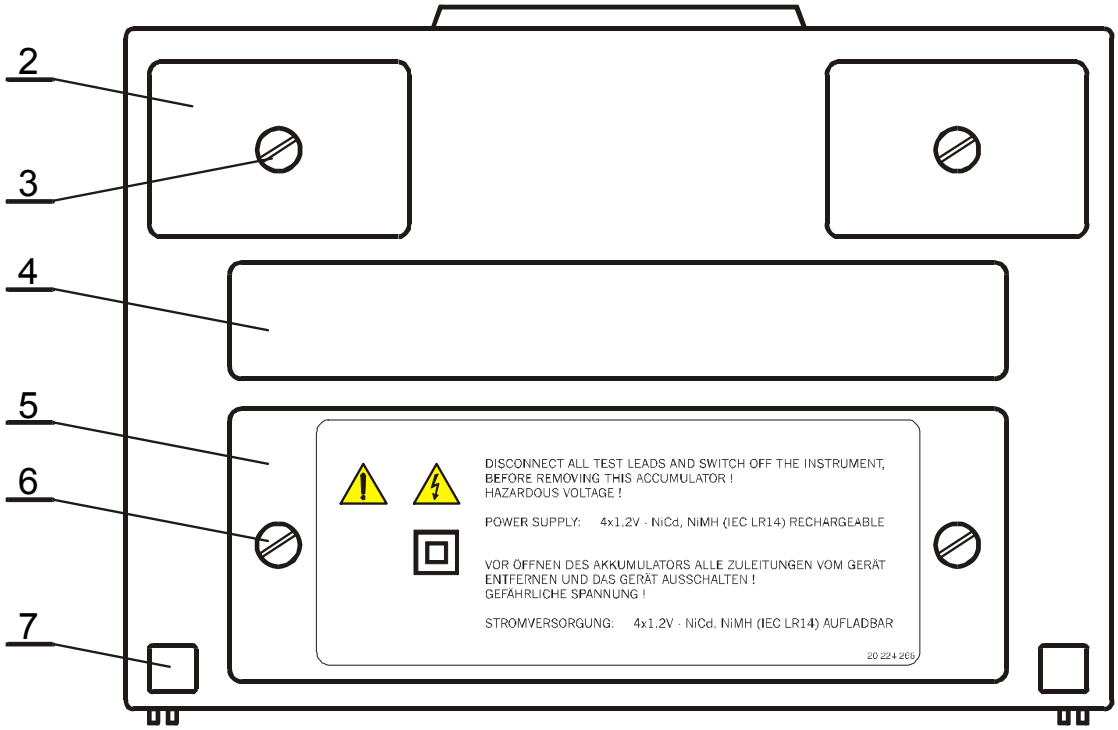


Fig. 5: Bottom view

Bottom View Layout:

2 Plastic cover (fixes nylon strap to the instrument). There is a screw under this cover that needs to be unscrewed when opening the instrument for service or calibration purposes.

⚠ ***The Instrument contains no user serviceable parts. Service or calibration must only be carried out only by an authorized dealer*** ⚠

3 Screw (unscrew to remove carrying strap or to open the instrument).
4 Label with measurement ranges.
5 Battery/fuse compartment cover.
6 Retaining screw (unscrew to replace batteries or blown fuse).
7 Rubber foot.

2.4. Standard accessories

Current probes:

- Current clamp-on Current transformers (CTs) 1000 A / 1V, type A1033, 3 off
- Current transformers (Optional)

Cable accessory:

- Voltage measurement cables, 6 off
- Alligator clips, 4 off
- Probe tips, 3 off
- Mains cable
- RS 232 communication cable
- Soft carrying bag
- Instruction manual
- Handbook 'Modern Power quality Measuring Techniques'
- Product verification data
- Warranty declaration

Windows PC software:

- PC analysis and control software package

2.5. Optional accessories

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

3. TECHNICAL SPECIFICATIONS

The instrument's technical specification below details the performance standard or limit to which the instrument has been designed and tested.

3.1. INPUTS

3.1.1. AC VOLTAGES

The instrument has a three-phase AC voltage input (3 differential inputs, L_1 - N_1, L_2 - N_2, L_3 - N_3). Voltage measurement is direct with internal voltage dividers. There are no internal fuses in the voltage inputs.

- Over voltage category ⚠ **CAT III 600 V**
- Input voltage range: 10 - 550 Vrms (0.02 U_n - U_n)
- Permissible overload voltage: 600 Vrms
- Resolution: 0.1 V
- Accuracy: ± 0.5 % of reading ± 2 digits
- Crest factor max: 1.4
- Frequency range: 43 - 68 Hz fundamental
- Basic r.m.s. integration period: 10 ms (1/2 of signal cycle)

3.1.2. AC CURRENTS

The instrument has three AC current inputs, suitable for Clamp-on current transformers or other **voltage output current sensors**.

- Input current (voltage) range: 0.02 - 1 Volt rms (0.02 I_n - I_n) Equivalent to 20 - 1000 Amp with the standard Clamp-on current transformer (ratio: 1000 A / 1 V).
- Resolution: 0. 3 mV (0.3 Amp with the standard Clamp-on current transformer - ratio: 1000 A / 1 V.)
- Accuracy: ± 0.5 % of reading ± 6 digits plus current transformer accuracy
- Crest factor: 2.5
- Maximum permissible overload: 150 % I_n (sinusoidal current)
- Maximum input voltage: 1 Vrms
- Basic r.m.s. integration period 10ms (1/2 of signal cycle)

⚠ **Use double insulated minimum CAT III 600 V Clamp-on current transformers and/or current transformers**

3.1.3. Phase angle

Consider Phase angle data of used current transformer.

3.1.4. REFERENCE CONDITIONS

AC voltage for power measurements:	0.02 U_n - U_n
AC current:	0.02 I_n - I_n
Power factor:	four quadrants (1.00 cap - 0.00 - 1.00 ind)
Frequency:	45 - 65 Hz
Waveform:	Sinusoidal AC voltage and current
Distortion factor:	< 2 %
Auxiliary power supply:	230 V $\pm$ 10 %
Ambient temperature:	23 °C $\pm$ 3 °C
Humidity:	60 % $\pm$ 15 %

3.1.5. DIGITAL HARDWARE SPECIFICATIONS

A/D conversion: 14 bit with 128 samples per channel per period (43 - 68 Hz).

3.2. OUTPUTS

3.2.1. Communication

Communication type	RS232 serial interface, fully opto isolated
Baud rate:	2400 - 57,600 baud.
Connector:	9 pin D-type.

3.2.2. Display

Display: Graphic Liquid Crystal Display with LED backlight, 160 x 116 dots resolution.

3.2.3. NON - VOLATILE MEMORY

2048 Kbytes SRAM, battery backed.

3.3. POWER SUPPLY

3.3.1. AC power supply

Operating range:	230 V a.c. + 10 % - 20 %, CAT III, 45 - 65 Hz, 8 VA Fuse: F2 T 100 mA (250 V in the battery compartment)
Optional on request:	115 V a.c. + 10 % - 20 %, CAT III, 45 - 65 Hz, 8 VA Fuse: F2 T 200 mA 250 V

3.3.2. DC power supply

Internal 4 x 1.2 V NiCd or NiMh rechargeable IEC LR14 batteries provide full operation for up to 5 hours.
Internal battery charger, charging time approx. 10 hours.
Fuse: F1 T 630 mA (250 V in the battery compartment)

3.4. CALCULATION BASED QUANTITIES

3.4.1. Scope

Display options:	Waveform of pairs (L1: U1 and I1; L2: U2 and I2; L3: U3 and I3); U123, and I123
Ranging:	Auto / manual
Waveform area:	150 (H) x 90 (V) dots

3.4.2. Meter

Displayed	Quantities related to selected measuring connections per phase, i.e.: measured voltage (U), current (I), and calculated active power (P), apparent power (S), reactive power (Q), power factor (Pf) with its characteristic (c, I, none), cosØ between U and I, and calculated Line – Line voltage; Quantities for complete three phase system, i.e.: calculated active power (Pt), apparent power (St), reactive power (Qt), power factor (Pft), neutral current (In); Frequency of selected synchronization channel.
Basic accuracy for P, Q, S:	± 1 % of reading
Resolution for P, Q, S:	0.01 of displayed value

3.4.3. Spectrum

The instrument computes harmonics on signals sampled with an A/D converter.

Harmonics

Recording interval	160ms (8 cycles)
Calculation range	DC – 63rd
Display range	DC – 25th
Displayed items for selected harmonic	Order, relative and absolute value

Range	Limits of error		Resolution
I_r, U_r	THD	HD	on LCD and PC
2 … 100 %	0.2 % x U_r/U (I_r/I)	0.2 % x U_r/U (I_r/I)	0.1 %

Note: THD *Total Harmonic Distortion*
HD *Harmonic Distortion*
U_r U_{range}
I_r I_{range}

Mains Signaling / Interharmonics

Recording interval	160ms (8 cycles)
Display range	DC – 512th
Displayed items	Order, relative and absolute value

Range	Limits of error		Resolution
U_r	THD	HD	on LCD
2 … 100 %	0.2 % x U_r/U	0.2 % x U_r/U	5 Hz

3.4.4. Energy

Displayed: Quantities from integration of calculated power as:
- cumulative values (TOTAL);
- partly cumulative (reset able by user request) (SUBTOTAL);
- values related to last integration period (LAST IP).

Quantities are: active energy (EP), capacitive energy (EQC), inductive energy (EQI).

Basic accuracy: ± 1 % of reading

Resolution: 0.1 of displayed value

3.4.5. Recorder measurements

See paragraph *Section III 3.2 Recorder set-up* for detailed possibilities and ranges of selected recording type.

3.5. GENERAL SPECIFICATIONS

Working temperature range:	- 10 °C … + 45 °C
Storage temperature range:	- 20 … 70 °C
Max. humidity:	85 % RH (0 ÷ 40 °C)
Pollution degree:	2
Protection classification:	double insulation
Over voltage category:	Voltage inputs: CAT III 600 V AC power supply CAT III 300 V
Protection degree:	IP 44
Dimensions:	265 x 110 x 18.5 mm^3
Weight (without accessories):	2 kg

3.6. MAINTENANCE

3.6.1. Batteries

⚠ **Instrument contains rechargeable NiCd or NiMh batteries. Do NOT replace with alkaline cells. These batteries should only be replaced with the same type as defined on the battery cover label or in this manual.**

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

If it is necessary to replace batteries, all four MUST be replaced. Ensure batteries are installed with the correct polarity; incorrect polarity can damage the batteries and/or the Instrument.

There may exist special environmental regulations concerning the disposal of batteries. These must be followed.

⚠ **In case of blown battery fuse (F1), this should be replaced with the same type as defined on the label close to it.**

3.6.2. Cleaning

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

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

3.6.3. Periodic calibration

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

3.6.4. Service

For repairs under warranty, or at any other time, please contact your distributor.

Manufacturer's address:

Nieaf-Smitt B.V.
Vrieslantlaan 6
3526 AA Utrecht
The Netherlands

Tel: +31(0) 30 2881311
Fax: +31(0) 30 2898816
E-mail sales@nieaf-smitt.nl

The Instrument contains no user serviceable parts. Only an authorized dealer must carry out Service or calibration!

SECTION II

INTERNAL OPERATION

1. INTRODUCTION

This section contains technical information on the internal operation of the Power Quality Analyzer, including descriptions of measuring methods and recording principles.

2. MEASUREMENT METHODS

Measurement methods are based on the digital sampling of the input signals. Each input (3 voltages and 3 currents) is sampled 128 times in each input cycle. Duration of this input cycle depends on the frequency at the synchronization input (one of the 3 voltage inputs or a current input). At 50 Hz, the input cycle period is 20 ms.
Basic measured values are calculated at the end of each sampling period and the results are available on the display or are recorded.
Fast Fourier transform (FFT) based results are only calculated on every 8th input cycle (every 160 ms @ 50 Hz).
The following equations are used for computing the given quantities.

Basic calculations

Parameter	Equation for calculation	Unit	Formula N°
Phase voltage	$U_x = \sqrt{\frac{1}{128}\sum_{i=1}^{128} u_{x_i}^2}$	V	[1]
Phase current	$I_x = \sqrt{\frac{1}{128}\sum_{i=1}^{128} i_{x_i}^2}$	A	[2]
Phase active power	$P_x = \frac{1}{128}\sum_{i=1}^{128} u_{x_i} * i_{x_i}$	W	[3]
Phase to phase voltage	$U_{xy} = \sqrt{\frac{1}{128}\sum_{i=1}^{128}\left(u_{x_i} - u_{y_i}\right)^2}$	V	[4]
Neutral conductor current	$I_0 = \sqrt{\frac{1}{128}\sum_{i=1}^{128}(i_{1i} + i_{2i} + i_{3i})^2}$	A	[5]

Additional calculation (using basic values)

Parameter	Equation for calculation	Unit	Formula N°
Phase apparent power	$S_x = U_x * I_x$	VA	[6]
Phase reactive power	$Q_x = \sqrt{S_x^2 - P_x^2}$	VAr	[7]
Phase power factor	$PF_x = \frac{P_x}{S_x}$		[8]
Phase voltage crest factor	$Q_{x_{cr}} = \frac{U_{x_{max}}}{U_x} * 100$		[18]
Phase current crest factor	$I_{x_{cr}} = \frac{I_{x_{max}}}{I_x} * 100$		[19]

Additional calculation (using FFT transformation)

Phase voltage-current angle	$\phi = \phi_i - \phi_u$ ϕ_i, ϕ_u are calculated by FFT VI angle for the fundamental component		[9]
Phase voltage THD	$thd_{U_x} = \frac{\sqrt{\sum_{n=2}^{63} hn_{U_x}^2}}{h1_{U_x}} * 100$	%	[10]
Phase current THD	$thd_{I_x} = \frac{\sqrt{\sum_{n=2}^{63} hn_{I_x}^2}}{h1_{I_x}} * 100$	%	[11]
Phase voltage individual harmonics	$Hn_{U_x} = \frac{hn_{U_x}}{h1_{U_x}} * 100$	%	[12]
Phase current individual harmonics	$Hn_{I_x} = \frac{hn_{I_x}}{h1_{I_x}} * 100$	%	[13]

Total values

Total active power	$P_t = P_1 + P_2 + P_3$	W	[14]
Total reactive power	$Q_t = Q_1 + Q_2 + Q_3$	VAr	[15]
Total apparent power	$S_t = \sqrt{P_t^2 + Q_t^2}$	VA	[16]
Total power factor	$Pf_t = \frac{P_t}{S_t}$		[17]

In a 3φ systems with a normal 3 wire connection, the following values are not available for displaying and recording:

- Neutral conductor current
- Phase voltage-current angle
- Phase power factor

Flicker measurements: according to IEC / 61000-4-15.

SECTION III

OPERATION MANUAL

1. GENERAL

This section describes how to operate and program the Instrument.

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

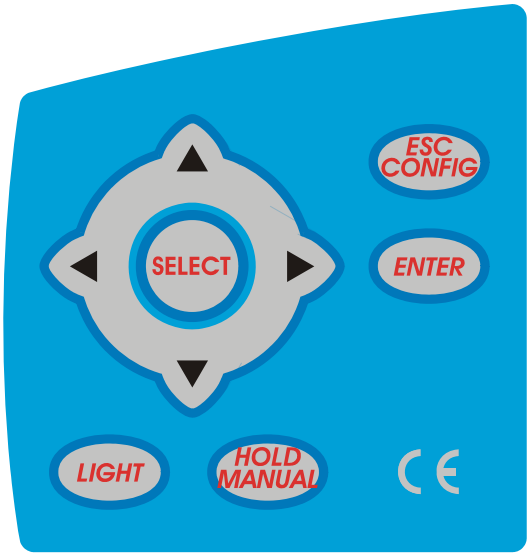


Fig. 6: Keypad

ESC / CONFIG	To enter the configuration menu in all rotary switch positions *and* To exit any procedure
ENTER	To confirm new settings, start recording procedure
SELECT	Enable selected signals
ARROW	Move cursor and select parameters
LIGHT	LCD backlight ON/OFF *Backlight is automatically turned off after 30 seconds of the last key operation.*
LIGHT + UP	Increases display contrast
LIGHT + DOWN	Decreases display contrast
HOLD / MANUAL	Display Freeze, in SCOPE, METER and SPECTRUM functions *and* Manual trigger in recording modes

Note: *Throughout these instructions the '**up arrow**' key is called the '**UP key**', the '**right arrow**' key the '**RIGHT key**', the '**down arrow**' key the '**DOWN key**' and the '**left arrow**' key the '**LEFT key**'.*

One of seven functional/operating menus can be selected with the rotary selector switch:

OFF	Power OFF
CONFIG.	Instrument configuration menu
RECORD	Data Logging (Recording) menus (periodics, waveforms, fast logging, transients, EN 50160)
ENERGY	Energy measurement
SPECTRUM	Harmonic analysis menu
METER	Basic power, current & voltage measurements
SCOPE	Waveforms display & control

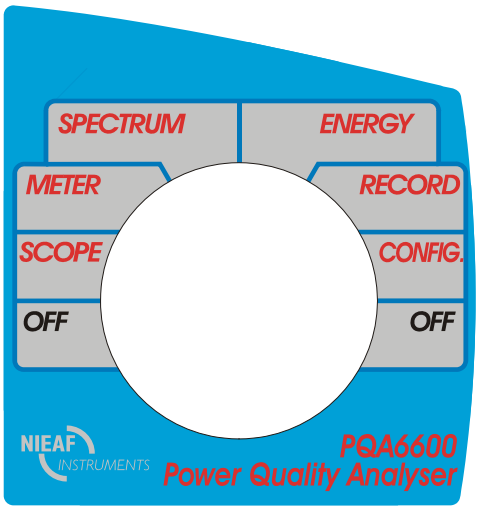


Fig. 7: Rotary switch functions

The instrument's main design function is the logging of various parameters on power distribution systems. Logging functions are selected on the right side of the rotary switch.

Recording mode	**OFF**	All settings are saved. *Warning given if recording is in progress.*
	CONFIG.	General configuration. *Submenus cover specific functions.*
	RECORD	Data logging and monitoring (periodics, waveforms, fast logging, transients, EN 50160).
	ENERGY	Total and subtotal cumulative register (energy counters).

The instrument can also be used for real time measurement, selectable on the left side of the rotary switch. These functions are independent of recording status.

Real-time measurements	**SPECTRUM**	Harmonic Analysis
	METER	Basic measurements on three phase systems
	SCOPE	Oscilloscope displays of measured waveforms
	OFF	All settings are saved. *Warning given if recording is in progress*

Further information on the RECORDING Mode functions is available in Section VI 'THEORY OF OPERATION.

2. OFF

Selecting **OFF** turns the instrument OFF after 2 seconds. All current settings and set parameters are saved during this period in non-volatile memory. If switching OFF occurs while the instrument is set for recording, this is treated as a POWER BREAK and the date & time of Power OFF is saved. This will also occur if the instrument loses its power supply while recording (see section II.3.5 Power Break Recording).

3. CONFIGURATION

Configuration menu can be selected by turning the rotary switch to CONFIG. position or pressing ESC / CONFIG key.
Use this menu to set all parameters for Recording and Real time measurement.
From this main screen, various configuration sub-menus can be accessed, allowing instrument parameters, measurement conditions and settings to be changed.

Instrument details, model number, software version & serial number and battery status, are displayed only when the rotary switch is in the CONFIG position.
The legend "**EXTR**" is shown when the instrument is powered from the mains supply and a "**BATT**" legend with its bar graph indicates that the instrument is powered by battery and the charge state of the battery.

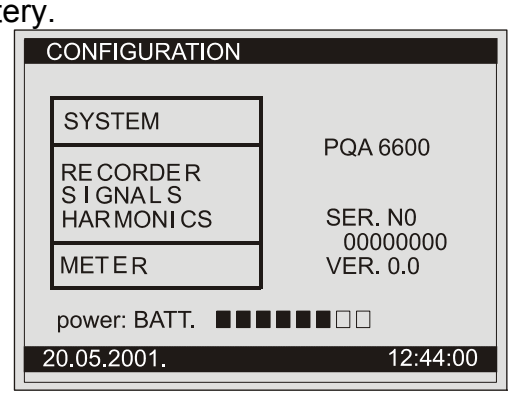


Fig. 8: Main Configuration menu

The main **CONFIG** menu consists of five items. Use the **UP** and **DOWN** keys to highlight the appropriate item, then press the **ENTER** key to select it.
The **HOLD** key is ignored in this menu.

Note: *Warning '**CONFIG.ERROR'** is activated in case of confirmed incorrect parameter selection.*
***ESC** – clears warning and close accessed menu without any changes.*
***Enter** - clears warning and resets accessed menu to the last stored state.*

3.1. SYSTEM sub-menu

This sub-menu allows setting of the password, the serial port baud rate, instrument date & time and language. From this menu the user can reinitialize the instrument to factory settings, or clear the memory.

ENABLE PASSW.
SER. PORT RATE
DATE/TIME
LANGUAGE
SYSTEM REINIT.
CLR.REC.MEM.

If the password is enabled → | CHANGE PASSW. |

Use **UP** or **DOWN** keys to select the required menu item, then press the **ENTER** key.

ENABLE PASSW. To enable password, which protects from unauthorized changes.

CHANGE PASSW. Press **Enter** for a new four key combination and repeat the combination for confirmation.
Press **SELECT** key to disable password.

Note:
The LCD key is not a valid password key

SER. PORT RATE Set the baud rate for serial communication port by using **SELECT** key. (from 2400 to 57,600 baud)

DATE / TIME Use the **LEFT** or **RIGHT** key to select Date and Time fields and the **UP** & **DOWN** keys to adjust date or time.
Only valid date/time values will be accepted.
Press **ENTER** to confirm the settings or **ESC** to cancel any changes.

LANGUAGE To select appropriate language

SYSTEM REINIT Clears all settings and sets defaults values as below.

- Recording mode PERIODICS
- Recorder START / STOP MANUAL
- Statistic ON
- Periodic ON
- Anomalies ON, fixed
- Main IP 1 min
- Power sub IP 1 per(iod)
- Nominal voltage 230 V
- Up/Down limits 10 %
- Buffer mode linear
- Selected channels none
- Selected harmonic none
- Voltage multiplier(K) 1
- Current range 1000 A
- Connection 4w
- Sync. frequency 50 Hz
- Sync. input AUTO
- Serial port rate 57600

CLR.REC.MEM Clear all records in memory.

Other enabled items after system reinit function.

a) Harmonics

Line	L1, L2 L3
thd	thdU
U (order)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 19, 21, 23, 25
I (order)	none

b) (Recorder) Signals

Line L1	U
Line L2	U
Line L3	U
T (three phase system)	Freq, Uu

c) Recorder conditions

Recorder mode	PERIODICS
Start	MANUAL
Stop	MANUAL
Statistics	ON
Periodic	ON
Anomaly window	Fixed
Main integration period	1 min
Power sub integration period	1 per
Nominal voltage	230 V
Upper limit	10 %, 253 V
Lower Limit	10 %, 207 V
Buffer mode	linear

d) Default settings for EN 50160 recording mode

Recorder mode	EN 50160
Start	MANUAL
Stop	MANUAL
Flickers	ON
Periodic	ON
Anomaly window	Fixed
Main integration period	10 min
Power sub integration period	---- (not defined)
Nominal voltage	230 V
Upper limit	10 %, 253 V
Lower Limit	10 %, 207 V
Buffer mode	linear

Selected signals and harmonics are the same as above, see a) and b).

3.1.1. PASSWORDS

All programming functions and recorder settings (including the start and stop of data logging) are password protected. Unless the password is entered, the various settable parameters and functions can only be viewed. In all configuration sub-menus, pressing any edit key (**UP, DOWN, LEFT, RIGHT, SELECT, ENTER**) will activate password input procedure. The instrument then asks for password before accessing selected menu or activity.

PASSWORD: ****	**Default password** ◀, SELECT, ▶, ENTER

The password is automatically cleared 5 minutes after the last key operation.

Note: *The instrument waits to enter password for 5 s then close password dialog with short sound and flashed password error warning.*

3.2. RECORDER (Data Logging) Set-up sub-menu

Use this sub-menu to set Data Logging mode, parameters and START / STOP conditions for logging.

Note: *Actual start or stop of logging can only be controlled from the main **RECORD** menu (when rotary selector switch is in the RECORD position).*

Table 3.1. contains summary of parameters for all recording modes.

Notes: *When recording mode is changed the instrument gives the possibility to reset parameters of selected mode to default value.*
Parameters cannot be changed when logging is running.

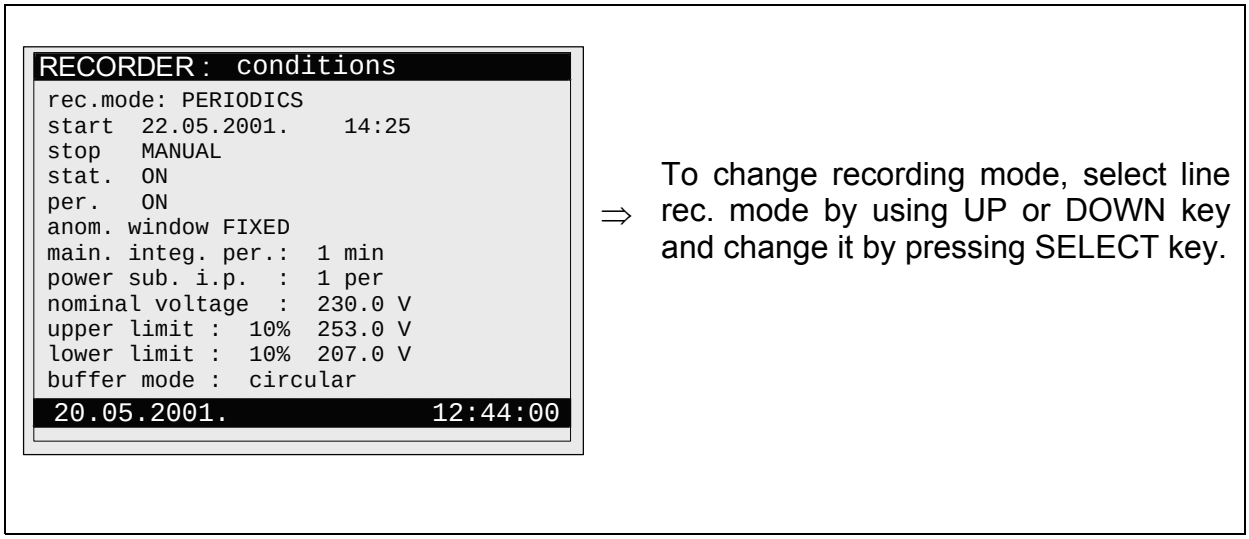


Fig. 9: Recorder set-up example

Press **ENTER** to confirm the new settings or **ESC** to cancel.

Starting or Stopping of Data Logging is effected from the RECORD menu.

Recorder mode	PERIODICS	WAVEFORMS	FAST LOGGING	TRANSIENTS	EN 50160
Trigger		level, manual, timer	level, manual, timer	level, manual	
Start	manual, time				manual, time
Stop	manual, time				manual, time
Signals		U1, U2, U3; I1, I2, I3	U1, U2, U3, I1, I2, I3	U1 U2 U3, I1 I2 I3	
Store buffer		per, sec [3]	sec	per [3]	
Pretriger buffer		per, sec [3]	sec	per [3]	
Level trigger input		U1, U2, U3; I1, I2, I3; Ux, Ix	U1, U2, U3, I1, I2, I3, Ux, Ix	Ux, Ix	
Level trigger level		V, A [2]	V, A [2]	----, V, A [1]	
Level trigger slope		rise, fall	rise, fall		
Trigger dL/scan				----, V, A [1]	
Store mode		Single shot, repeat	Single shot, repeat	Single shot, repeat	
Max record buffer		per, sec [3]	sec [3]	per [3]	
Flicker					on, off
Periodic	on, off				on, off
statistic	on, off				
Anomaly window	fixed, variable, off				fixed, variable, off
Main integration per.	1 sec – 30 min				1 sec – 30 min
Power sub integration period	1 per – 20 per				
Nominal voltage	50 - 450 V				50 - 450V
Upper limit	+1 to + 30 % nominal voltage				+1 to + 30 % nominal voltage
Lower limit	-1 to - 30 % nominal voltage				-1 to - 30 % nominal voltage
Buffer mode	linear, circular				linear, circular

Notes: *1) Peak value for current and / or voltage*
2) R.m.s. value for current and / or voltage
3) per: mains periods (cycles)
sec: seconds

Table 3.1: Summary of recording modes and parameters

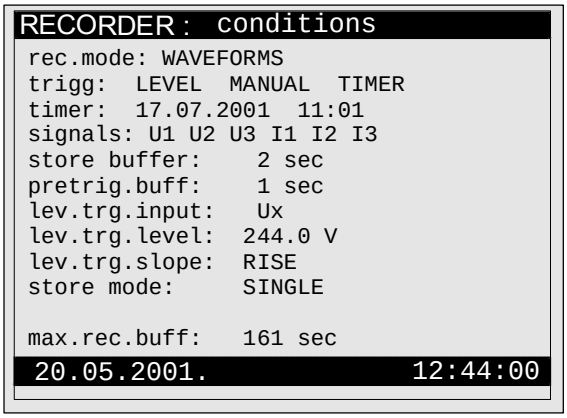
3.2.1. Parameters in PERIODICS

See Fig. 9 for PERIODICS menu.

START		Use **SELECT** key to toggle between **MANUAL** and **Date / time.**
	Manual	Recording starts immediately if period recording is OFF. If Periodic Recording is ON, there is a “null” seconds delay.
	Date / time	START occurs at user preset date and time. Recording can be stopped manually at any time. Use **LEFT** or **RIGHT** keys to select between Date / Time fields and the **UP** & **DOWN** keys to set a new date or time. Only valid date/time values will be accepted.
STOP		Use **SELECT** key to toggle between **MANUAL** and **Date / time.**
	Manual	STOP in manual mode is immediate.
	Date / time	STOP occur at user preset date and time. Recording can be stopped manually at any time. Use **LEFT** or **RIGHT** keys to select between Date / Time fields and the **UP** & **DOWN** keys to set a new date or time. Only valid date/time values will be accepted.
STAT.		*Statistical Analysis* Use the **SELECT** key to enable and/or disable analysis.
	ON	Enabled Analysis
	OFF	Disabled Analysis
PER.		*Periodic Analysis* Use the **SELECT** key to enable and/or disable analysis.
	ON	Enabled Analysis
	OFF	Disabled Analysis
ANOM. WINDOW		*Abnormal window* Use the **SELECT** key to toggle between OFF, FIXED or VARIABLE recording. **Voltage Anomaly recording is available only for the voltages selected for recording (see 3.2.4 SIGNALS) regardless of the status of Periodic Analysis. If no voltage is selected then there would be no logging of Voltage Anomalies.**
	OFF	Disabled abnormal window recording.
	FIXED	The window (and the Upper & Lower Limits) is set around the nominal voltage and remains fixed during recording session.
	VARIABLE	The window (and the Upper & Lower Limits) is set around the average of dynamically calculated voltage. Use the **LEFT** and **RIGHT** keys to adjust the averaging period for calculating new values of average voltage (1 s to 900 s).

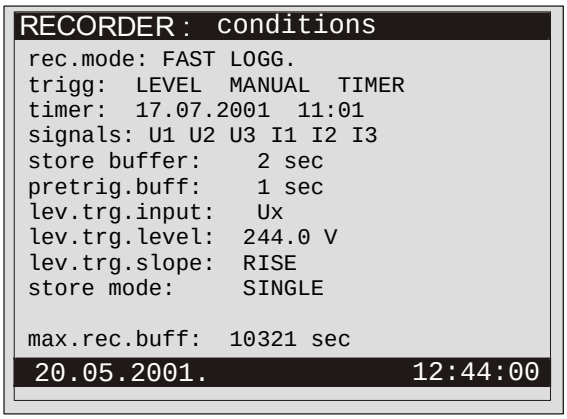
MAIN INTEG. PER.	*Main Integration period* Selected duration for Periodic Analysis. Use the **LEFT** and **RIGHT** keys to set the integration period (between 1 s and 30 min).
POWER SUB. I.P.	*Power sub Integration period* Averaging sub period for power measurement. Used in Periodic Analysis to average readings (see PERIODIC ANALYSIS and the accompanying Figure). Use the **LEFT** and **RIGHT** keys to set the required value (between 1 and 20 mains cycles).
NOMINAL VOLTAGE	The nominal voltage used as a reference in Voltage Anomaly recording. In **FIXED** window mode, this is the actual voltage used. In **VARIABLE** window mode, this is the start value of voltage, later modified to the average value of voltage during the previous Integration Period while recording. This value can be changed in METER Configuration Menu only.
UPPER LIMIT	These are the limits that define the pass window for Voltage Anomaly recording. Any voltage value outside the specified limits is detected and stored as an anomaly. Use the **LEFT** and **RIGHT** keys to set the required limit: - 1 % to 30 % of nominal voltage for upper limit and - -1 % to - 30 % of nominal voltage for lower one.
LOWER LIMIT	
BUFFER MODE	The data storage type for data logging (recorder) function that can be performed in two ways: **Linear** or **Circular**. Neither mode will affect any memory allocated for Statistical Analysis.
Linear	Recording stops when the memory is full.
Circular	Recording is stopped when stop date/time is reached, or manually. Once memory is full, the oldest data is over-written.

3.2.2. Parameters in WAVEFORMS



TRIGG	*Trigger* Use **LEFT** and**/**or **RIGHT** and **SELECT** keys to select any combination of possible triggers: Level, Manual and Timer. Recording can be stopped manually at any time.
Level	Recording starts when any of the selected input signals reach selected level and slope.
Manual	Recording starts immediately after start in Recorder menu.
Timer	START occurs at user preset date and time. **Timer** is first condition when the **Level** is also enabled.
TIMER	Use **LEFT** or **RIGHT** keys to select between Date / Time fields and the **UP** & **DOWN** keys to set a new date or time. Only valid date/time values will be accepted
SIGNALS	Use **LEFT** and**/**or **RIGHT** and **SELECT** keys to select any combination of possible signals (U1, U2, U3, I1, I2, I3) to trigger waveform recording.
STORE BUFFER	Use the **SELECT** key to toggle between its length in periods (per) and/or seconds (sec). Use **LEFT** and**/**or **RIGHT** keys to decrease / increase the length. Range: - sec > 2 s to max.rec.buf. value - per > 10 per to max.rec.buf. value.
PRETRIG.BUFFER	*Pre-trigger buffer* Use the **SELECT** key to toggle between its length in periods (per) and/or seconds (sec). Use **LEFT** and**/**or **RIGHT** keys to decrease / increase the length. Range: - sec > 1 s to store buffer value - 1, - per > 5 per to store buffer length - 1.
LEV. TRG. INPUT	*Input for level triggering* Use the **SELECT** key to toggle between possible inputs for triggering (U1, U2, U3, I1, I2, I3, Ux, Ix).
LEV. TRG. LEVEL	*Input level for level triggering* Use **LEFT** and**/**or **RIGHT** keys to decrease / increase level of selected input(s).
LEV. TRG. SLOPE	*Input slope for level triggering* Use the **SELECT** key to toggle between **Rise** and **Fall** slope of selected input(s).
STORE MODE	The data storage type for data logging (recorder) function that can be performed in two ways: **Single shot** or **Repeat**.
Single shot	Recording stops when the memory is full.
Repeat <n>	Recording is stopped when stop date/time is reached, or manually, or when repeat value is reached. Once memory is full, the oldest data is over-written. Range: 2x to 254x or <max>
MAX.REC.BUF	Maximum buffer length according to selected parameters.

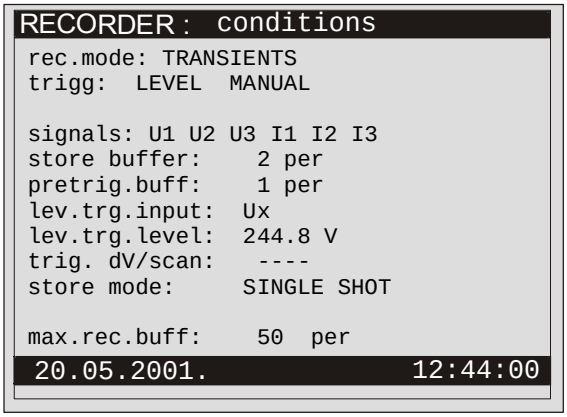
3.2.3. Parameters in FAST LOGGING



TRIGG	*Trigger* Use **LEFT** and/or **RIGHT** and **SELECT** keys to select any combination of possible triggers: Level, Manual and Timer. Recording can be stopped manually at any time.
Level	Recording starts when any of selected input signals reach selected level and slope.
Manual	Recording starts immediately after start in Recorder menu.
Timer	START occurs at user preset date and time. **Timer** is first condition when the **Level** is also enabled.
TIMER	Use **LEFT** or **RIGHT** keys to select between Date / Time fields and the **UP** & **DOWN** keys to set a new date or time. Only valid date/time values will be accepted.
SIGNALS	Use **LEFT** and/or **RIGHT** and **SELECT** keys to select any combination of possible signals (U1, U2, U3, I1, I2, I3) to trigger waveform recording.
STORE BUFFER	Buffer length in seconds (sec). Use **LEFT** and/or **RIGHT** keys to decrease / increase the length in range: 2 s to max.rec.buf. value.
PRETRIG.BUFFER	*Pre-trigger buffer* Buffer length in seconds (sec). Use **LEFT** and/or **RIGHT** keys to decrease / increase the length in range: 1 s to store buffer length - 1.
LEV.TRG.INPUT	*Input for level triggering* Use the **SELECT** key to toggle between possible inputs for triggering (U1, U2, U3, I1, I2, I3, Ux, Ix).
LEV.TRG.LEVEL	*Input level for level triggering* Use **LEFT** and/or **RIGHT** keys to decrease / increase level of selected input(s).
LEV.TRG.SLOPE	*Input slope for level triggering* Use the **SELECT** key to toggle between **Rise** and **Fall** slope of selected input(s).

STORE MODE	The data storage type for data logging (recorder) function that can be performed in two ways: **Single shot** or **Repeat**.
Single shot	Recording stops when the memory is filled.
Repeat <n>	Recording is stopped when stop date/time is reached, or manually, or when repeat value is reached. Once memory is full, the oldest data is over-written. Range: 2x to 254x or <max>
MAX. REC. BUF	Maximum buffer length according to selected signals.

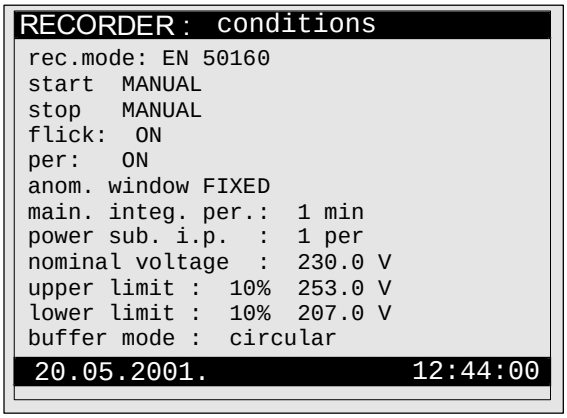
3.2.4. Parameters in TRANSIENTS



TRIGG	*Trigger* Use **LEFT** and/or **RIGHT** and **SELECT** keys to select any combination of possible triggers: Level and Manual. Recording can be stopped manually at any time.
Level	Recording starts when any of selected input signals reach selected level and slope.
Manual	Recording starts immediately after start in Recorder menu.
SIGNALS	Use **LEFT** and/or **RIGHT** and **SELECT** keys to select a combination of possible signals (U1, U2, U3, I1, I2, I3) to trigger recording of transients.
STORE BUFFER	Buffer length in periods (per) in range: 10 per to max.rec.buf value. Use **LEFT** and/or **RIGHT** keys to decrease / increase the length.
PRETRIG.BUFFER	*Pre-trigger buffer* Buffer length in periods (per) in range: 10 per to store buffer length - 1. Use **LEFT** and/or **RIGHT** keys to decrease / increase the length.
LEV.TRG.INPUT	*Input for level triggering* Use the **SELECT** key to toggle between possible inputs for triggering (Ux, Ix).
LEV.TRG.LEVEL	*Input level for level triggering* Use the **SELECT** key to toggle between selected input triggers (Ux: V or Ix: A) and none (----).

	Use **LEFT** and**/**or **RIGHT** keys to decrease / increase level of selected input(s).
TRIG. dV/scan	*Input slope for level triggering* Use the **SELECT** key to toggle between selected input triggers (Ux: V or Ix: A) and none (----).
STORE MODE	The data storage type for data logging (recorder) function that can be performed in two ways: **Single shot** or **Repeat**. Neither mode will affect any memory allocated for Statistical Analysis.
Single shot	Recording stops when the memory is full.
Repeat <n>	Recording is stopped when stop date/time is reached, or manually, or when repeat value is reached. Once memory is filled, the oldest data is over-written. Range: 2x to 254x or <max>
MAX. REC. BUF	Maximum buffer length according to selected parameters.

3.2.5. Parameters in EN 50160



START		Use **SELECT** key to toggle between **MANUAL** and **Date / time.**
	Manual	Recording starts immediately if period recording is OFF. If Periodic Recording is ON, there is a “null” seconds delay.
	Date / time	START occurs at user preset date and time. Recording can be stopped manually at any time. Use **LEFT** or **RIGHT** keys to select between Date / Time fields and the **UP** & **DOWN** keys to set a new date or time. Only valid date/time values will be accepted.
STOP		Use **SELECT** key to toggle between **MANUAL** and **Date / time.**
	Manual	STOP in manual mode is immediate.
	Date / time	STOP occurs at user preset date and time. Recording can be stopped manually at any time. Use **LEFT** or **RIGHT** keys to select between Date / Time fields and the **UP** & **DOWN** keys to set a new date or time. Only valid date/time values will be accepted.

FLICK	*Flicker Analysis* Use the **SELECT** key to enable and/or disable analysis.
ON	Enabled Analysis
OFF	Disabled Analysis
PER.	*Periodic Analysis* Use the **SELECT** key to enable and/or disable analysis.
ON	Enabled Analysis
OFF	Disabled Analysis
ANOM. WINDOW	*Anomaly window* Toggling between OFF, FIXED or VARIABLE recording is possible in **PERIODICS** (see Section III, paragraph 3.2.1) or using a PC software. **Voltage Anomaly recording is available only for the voltages selected for recording (see 3.2.4 SIGNALS) regardless of the status of EN 50160 Analysis. If no voltage is selected, there will be no logging of Voltage Anomalies.**
OFF	Disabled anomaly window recording.
FIXED	The window (and the Upper & Lower Limits) is set around the nominal voltage and remains fixed during recording session.
VARIABLE	The window (and the Upper & Lower Limits) is set around the average of dynamically calculated voltage. Use the **LEFT** and **RIGHT** keys to adjust the averaging period for calculating new values of average voltage (1 s to 900 s).
MAIN INTEG. PER.	*Main Integration period* Selected duration for Periodic Analysis. Use the **LEFT** and **RIGHT** keys to set the integration period (between 1 s and 30 min).
POWER SUB. I.P.	*Power sub Integration period* This function is not active in EN 50160 Recording mode
NOMINAL VOLTAGE	The nominal voltage used as a reference in Voltage Anomaly recording. In **FIXED** window mode, this is the actual voltage used. In **VARIABLE** window mode, this is the start value of voltage, later modified to the average value of voltage during the previous Integration Period while recording. This value can be changed in METER Configuration Menu only.
UPPER LIMIT	These are the limits that define the pass window for Voltage Anomaly recording. Any voltage value outside the specified limits is detected and stored as an anomaly. Use the **LEFT** and **RIGHT** keys to set the required limit: - 1 % to 30 % of nominal voltage for upper limit and - - 1 % to - 30 % of nominal voltage for lower one.
LOWER LIMIT	

BUFFER MODE	The data storage type for data logging (recorder) function that can be performed in two ways: **Linear** or **Circular**. Neither mode will affect any memory allocated for Statistical Analysis.
Linear	Recording stops when the memory is full.
Circular	Recording is stopped when stop date/time is reached, or manually. Once memory is full, the oldest data is over-written.

Note: When EN 50160 recording mode is selected the instrument puts the message: **Enter for default sett**. after pressing any cursor key.

- *If Enter is pressed the instruments prepares default settings and selections as are defined in chapter 3.1. d. This settings are also recommended for EN 50160 recording mode.*
- *If ESC is pressed current settings are accepted.*

3.3. SIGNALS sub-menu

This menu allows selection of signals, and calculated parameters for storage during Data Logging (recording) for PERIODICS and EN 50160. A maximum of 64 signals can be selected; the number of residual free locations is shown in the upper right corner of the display and is common for **Signals** and **Harmonics** menus.
Signals sub-menu enables selection of phase and/or total 3φ values.

Note: *Selecting a voltage signal U will also automatically enable logging of Voltage Anomalies for that phase (if Voltage Anomaly recording mode is selected as **FIXED** or **VARIABLE**).*

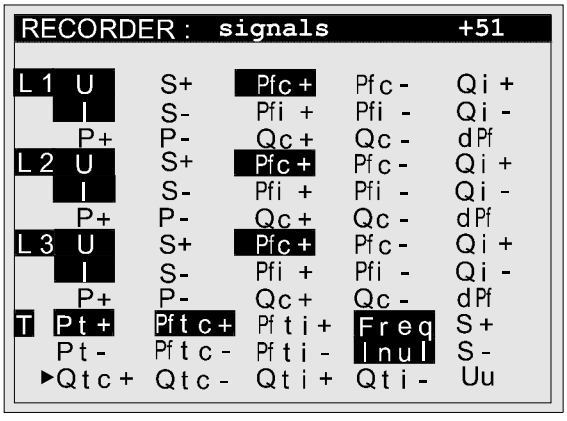


Fig. 10: Signal Sub-menu

Use **LEFT**, **RIGHT**, **UP** and **DOWN** keys to select the required signal. Enable or disable the signal for recording with the **SELECT** key.
Press **ENTER** to confirm the new settings or **ESC** to cancel.

3.4. HARMONICS sub-menus

This menu allows selection of harmonics for storage during Data Logging (recording) for PERIODICS and EN 50160. A maximum of 64 signals can be selected; the number of residual free locations is shown in the upper right corner of the display and is common for **Signals** and **Harmonics** menus.
Selected harmonics are valid for all the selected phases (L_1, L_2, L_3 as shown at the top of the screen).
It is not possible to set different combinations for individual phases.
Selecting one or more harmonics will automatically select total harmonic distortion (THD) measurement.

Use **LEFT**, **RIGHT**, **UP** and **DOWN** keys to select the required signal. Enable or disable the signal for recording with the **SELECT** key.
Press **ENTER** to confirm the new settings or **ESC** to cancel.

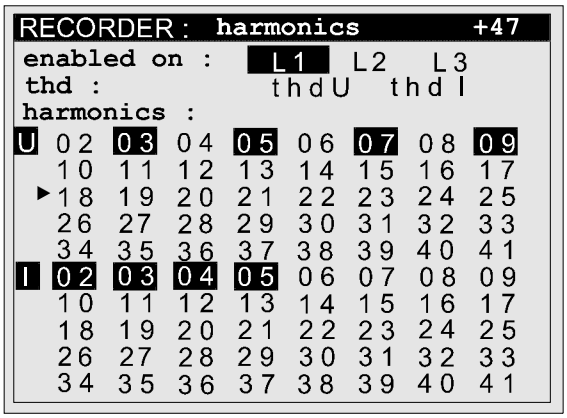


Fig. 11: Harmonics Sub-menu

Note: *In EN 50160 recordings can be selected up to 18 harmonics.*

3.5. METER sub-menu

This menu allows setting of various input parameters. These parameters are used for calculating the true r.m.s. values of all measured and calculated quantities, for scaling input signals and for synchronization.

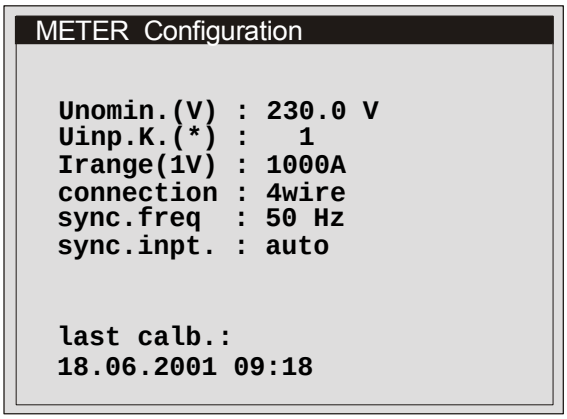


Fig. 12: Meter Configuration Sub-menu

Use the **UP** and **DOWN** keys to select the required parameter.

$U_{NOMIN.}$(v)	Range: 50.0 V to 450.0 V	Nominal measuring range of instrument voltage inputs. It is used for calculation and display of results only. Default value is 230.0 V.
$U_{inp.K.}$(*)	Range: 1 to 800	Scaling factor for voltage inputs. This allows for external voltage transformers or dividers that may be used and ensures that readings are related to the primary. Example: for 11 kV / 110 V, the multiplication factor must be set to 100. Use the **LEFT** and **RIGHT** keys to set $U_{inp.K}$. Standard and default value is 1. Displayed full scale voltage range is $U_{NOMIN.}$ * $U_{INP.K.}$
I_{range} (1V)	Range: 1 A to 30 kA	Scale factor for current inputs. Defines the current equivalent to a 1 V input signal. Use the **LEFT** and **RIGHT** keys to set I_{range}. Standard and default value is 1000 A.
connection		Defines the method of connecting the Instrument to the 3φ systems:
	4 wire	3φ 4-wire system (with a Neutral conductor). All voltage and current inputs are used.
	3wire	3φ 3-wire system (without Neutral conductor) 3 current transformers used.
	AARON	3φ 3-wire system (without Neutral conductor) (also known as the '2 wattmeter method') 2 current transformers used. Press **SELECT** key for connection type selection.
sync. freq.	50 Hz, 60 Hz	Default mains frequency for input cycle period/scanning. It is ignored when the instrument detects valid frequency on the selected sync. input. Press **SELECT** key for selection of system frequency.
sync. inp.	U_1, U_2, U_3, I_1, AUTO	Default synchronisation input. Use fixed input for synchronisation or auto detect mode (automatic scanning for a valid synchronisation input).

	Press **SELECT** key for selection between inputs.
last calb.	Information about last calibration of the instrument.

Notes: *Settings for $U_{inp.K.}$ and I_{range} affect all displayed values (power, energy, harmonic components, etc).*
Maximum value of $U_{INP.K.}$ depends on selected I_{RANGE} according to following approximation:
$U_{INP.K.} * I_{RANGE} < 109000$

Press **ENTER** to confirm new settings or press **ESC** to cancel.

4. RECORDER (DATA LOGGING)

Use this function to display the present data logging (recording) status and the selected main Data Logging parameters. Recording can be started or stopped from this screen.

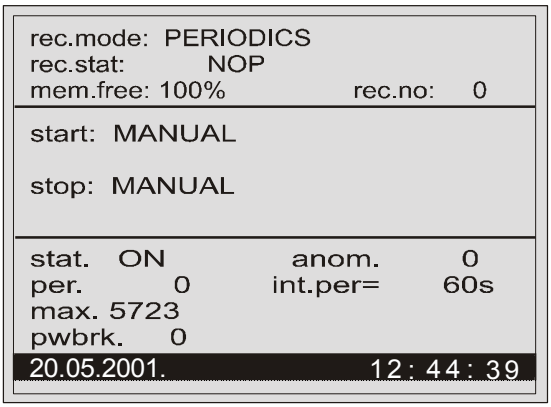
4.1. START or STOP Data Logging

The following procedure describes the START and / or STOP of Data Logging:

a) Press **SELECT** key. The password entry screen is opened
b) Enter the password. After confirming the password, press **ENTER** to start or stop Data Logging (depending on current status).
c) If START is selected, the instrument checks the current set of recording parameters before start of logging data.

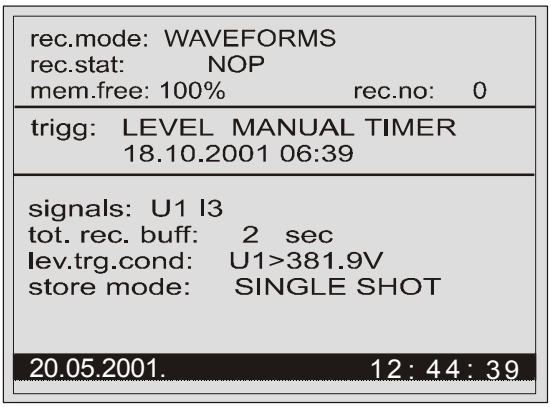
If the instrument is set for recording, this will be indicated on the display irrespective of the position of the rotary Selector Switch:

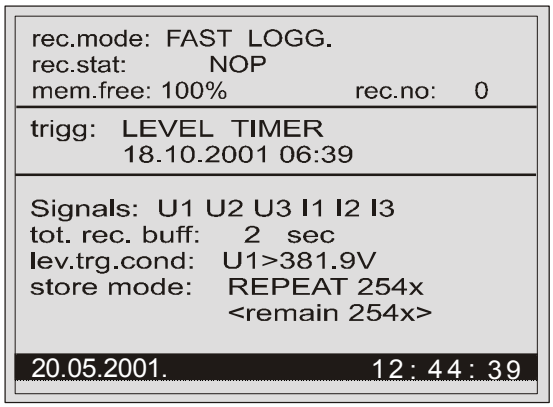
- **Rec.On:** Recording in progress
- **Rec.Wt:** Waiting to start recording
- **SEND:** Instrument is sending data to a PC
- **HOLD:** To temporarily froze display contents;
  In SCOPE, METER and SPECTRUM functions only



⇒ Change recorder mode in: CONFIG \ RECORDER \ rec.mode

⇓





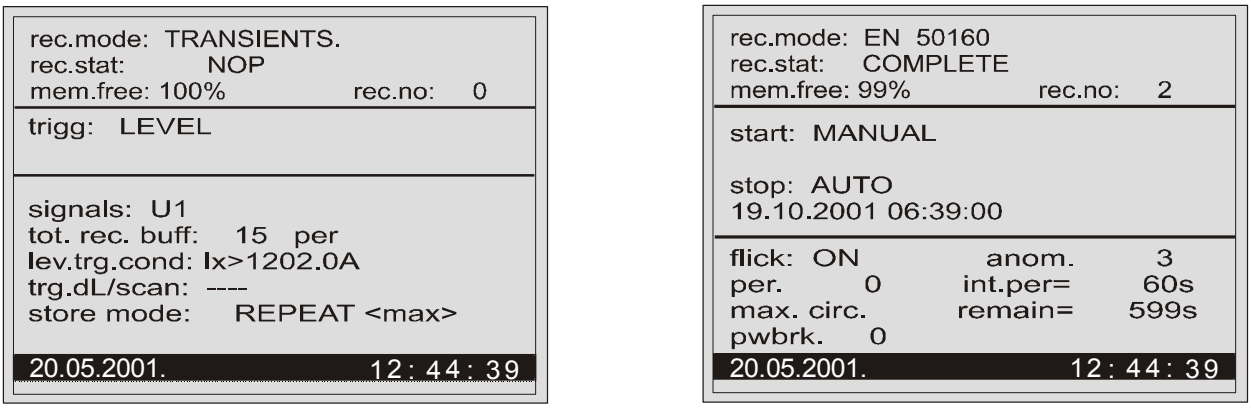


Fig. 13: Example RECORDER screens

4.2. Checking and changing Recording or Configuration parameters

To check the parameters and settings of the instrument press ESC / CONFIG key or turn the rotary switch into CONFIG. See paragraph *3. Configuration*. When data logging is in operation the parameters can only be observed. Data logging must stop to change any parameter or setting.

4.3. Common data logging parameters

In RECORDER function the display is divided into three sections. Upper section is common, middle and bottom sections are specific to the selected recording mode. The common section contains the following parameters:

rec.mode	Actual recording mode selected in CONFIGURATION RECORDER menu	
	PERIODICS	
	WAVEFORMS	
	FAST LOGG.	
	TRANSIENTS	
	EN 50160	
rec.stat.	Present recorder status:	
	NOP	No operation
	WAIT	Recorder (in AUTO mode) is waiting for start date & time
	RUN	Recorder is running
	STOP	Recorder (in AUTO mode) has been stopped manually. Recording aborted.
	COMPLETE	Recording completed
mem.free	Recording memory available	
	100%	Empty memory
	0%	Full memory
rec.no		Number of stored record buffers

4.4. Periodics recorder

start If the instrument is in **Rec.Wait** mode and the memory is empty, the programmed START date & time is displayed.
If instrument is in **Rec.Run** mode, the actual recording start date & time (as opposed to the programmed one) is displayed.

stop: If the instrument is in **Rec.Wait** or **Rec.Run** mode, the programmed STOP date & time is displayed.
If the instrument is in **Rec.Stop** or **Rec.Complete** mode, the actual recording stop date & time (as opposed to the programmed one) is displayed.
Under certain circumstances, the instrument also displays the reason for stopping the recording:

MANUAL BREAK Manual stop in AUTO stop mode
END OF MEM. Memory full (in linear memory mode)

stat Statistical Analysis enabled (ON) or disabled (OFF).

anom The number of detected and saved Voltage Anomalies.
If currently in a Voltage Anomaly, a flashing arrow points to the number.

per Number of recorded periods from start of data logging.

int.per Current integration period (IP) in seconds.

max Approx max. number of periods that can be saved (in Linear Buffer mode only).

pwbrk N° of power ON/OFF events during the current recording period.

4.5. Waveforms recorder

trigg Selected triggers for initiating of the selected logging.
Selected timer trigger also displays logging start time.

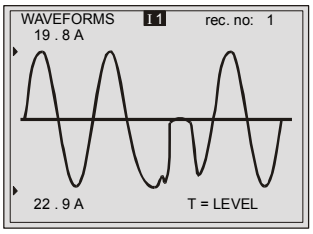
signals Selected signals for logging.

tot. rec. buf Length of store buffer for logging after trigger.

lev. trg. Selected trigger input, level and slope.

cond It is visible only when level triggering is enabled. Symbol '>' shows rising slope and '<' falling slope.

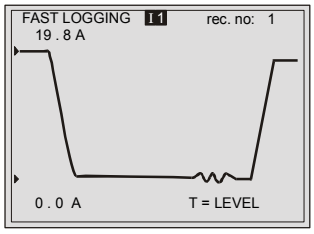
store mode Selected storing mode.
In repeat mode the instrument displays the number of repeat shots still available



Note:
Last detected event is displayed

4.6. Fast logging recorder

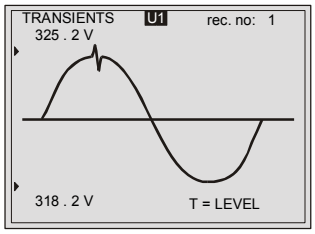
trigg	Selected triggers for initiating of the selected logging. Selected timer trigger also displays the time to start logging
signals	Selected signals for logging.
tot. rec. buf	Length of store buffer for logging after trigger.
lev. trg.	Selected trigger input, level and slope.
cond	It is visible only when level triggering is enabled. Symbol '>' shows rising slope and '<' falling slope.
store mode	Selected storing mode. In repeat mode the instrument displays the number of repeat shots still available



Note:
Last detected event is displayed

4.7. Transients recorder

trigg	Selected triggers for initiating of the selected logging.
signals	Selected signals for logging.
tot. rec. buf	Length of store buffer for logging after trigger.
lev. trg.	Selected trigger input and level.
cond	It is visible only when level triggering is enabled.
trg. dL/scan	Minimum slope to trigger. It is visible only when level triggering is enabled.
store mode	Selected storing mode. In repeat mode the instrument displays the number of repeat shots still available



Note:
Last detected event is displayed

4.8. EN 50160 recorder

start	If the instrument is in **Rec.Wait** mode and the memory is empty, the programmed START date & time is displayed. If instrument is in **Rec.Run** mode, the actual recording start date & time (as opposed to the programmed one) is displayed.
stop	If the instrument is in **Rec.Wait** or **Rec.Run** mode, the programmed STOP date & time is displayed. If the instrument is in **Rec.Stop** or **Rec.Complete** mode, the actual recording stop date & time (as opposed to the programmed one) is displayed. Under certain circumstances, the instrument also displays the reason for stopping the recording: **MANUAL BREAK** Manual stop in AUTO stop mode **END OF MEM.** Memory full (in linear memory mode)
flick	Flicker Analysis enabled (ON) or disabled (OFF).
anom	The number of detected and saved Voltage Anomalies. If currently in a Voltage Anomaly, a flashing arrow points to the number.

per Number of recorded periods from start of data logging.
int.per Current integration period (IP) in seconds
max Approx max. number of periods that can be saved (in Linear Buffer mode only)
pwbrk N° of power ON/OFF events during the current recording period.

5. ENERGY

This function displays the various energy registers.

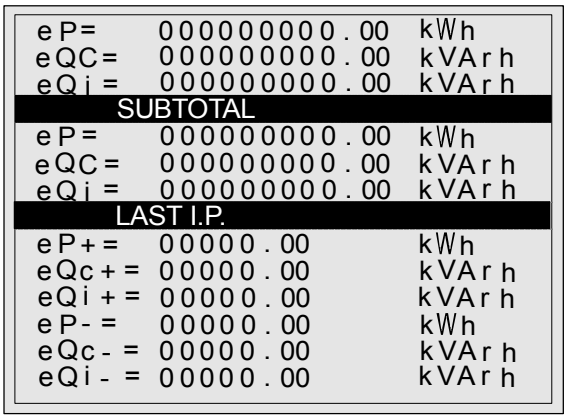


Fig. 14: Energy Registers

- Top three lines: **Total** cumulative registers of
  Active energy **Ep** in kWh
  Reactive capacitive energy **EQC** in kVAr
  Reactive inductive energy **EQi** in kVAr

- SUBTOTAL lines: **Subtotal** cumulative registers of
  Active energy **Ep** in kWh
  Reactive capacitive energy **EQC** in kVAr
  Reactive inductive energy **EQi** in kVAr

To reset the Total and / or Subtotal registers:

a) Press **SELECT** key. The password entry screen is opened.
b) Enter the password.
c) After confirming the password, press **ENTER** to reset the **Subtotals** or **ESC** to quit.
d) After resetting subtotals, press **ENTER** to reset the **Totals** or **ESC** to quit.

- LAST IP lines: Display energy in last integration period (if data logging is active):
  Active positive energy **Ep+** in kWh
  Reactive positive capacitive energy **EQc+** in kVAr
  Reactive positive inductive energy **EQi+** in kVAr
  Active negative energy **Ep+** in kWh
  Reactive negative capacitive energy **EQc+** in kVAr
  Reactive negative inductive energy **EQi+** in kVAr

Note: *At least one signal from Signal Sub-menu (Fig. 10) and Periodics from Configuration Sub-menu (Fig. 9) must be selected.*

6. SPECTRUM

6.1. Harmonic Analysis

This function displays the results of Fast Fourier Transformation (FFT) calculations in numeric and graphic mode.
Graphs are auto scaled in order to ensure maximum resolution.
The top line provides information on the selected input (U_1, I_1, U_2, I_2, U_3, I_3), its absolute value and the synchronization frequency.
The bottom line provides details of the selected harmonic component and its absolute and percentage values. The equivalent bar graph is identified by a flashing cursor.

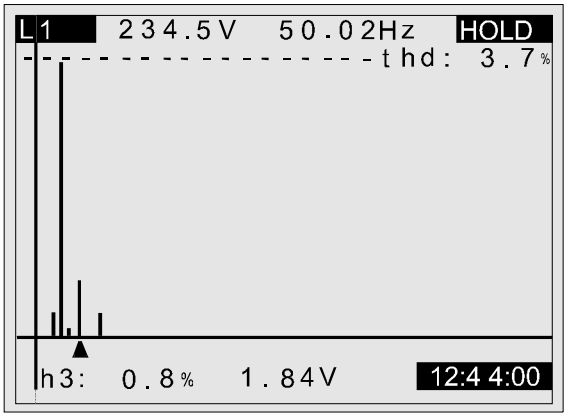


Fig. 15: Harmonic Analysis

Use **LEFT** and **RIGHT** keys to select the required bargraph, and the **SELECT** key to choose the required input signal (U_1, I_1, U_2, I_2, U_3, I_3).

6.2. Mains Signaling and Interharmonic Analysis

If a signal decomposition with Fourier transformation results with presence of a frequency that is not integer multiple of fundamental, this frequency is called interharmonic frequency and component with such frequency is called interharmonic.

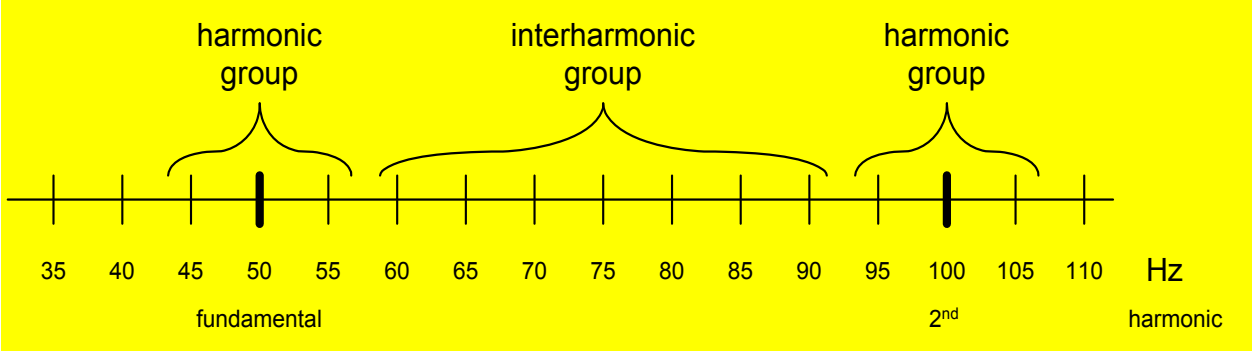


Fig. 15a: Detail of interharmonics spectra

Mains Signaling is classified in four groups:

- ripple control systems (110 Hz to 3000 Hz)
- medium-frequency power-line carrier systems (3kHz – 20kHz)
- radio-frequency power-line carrier systems (20kHz – 148.5kHz)
- mains-mark system

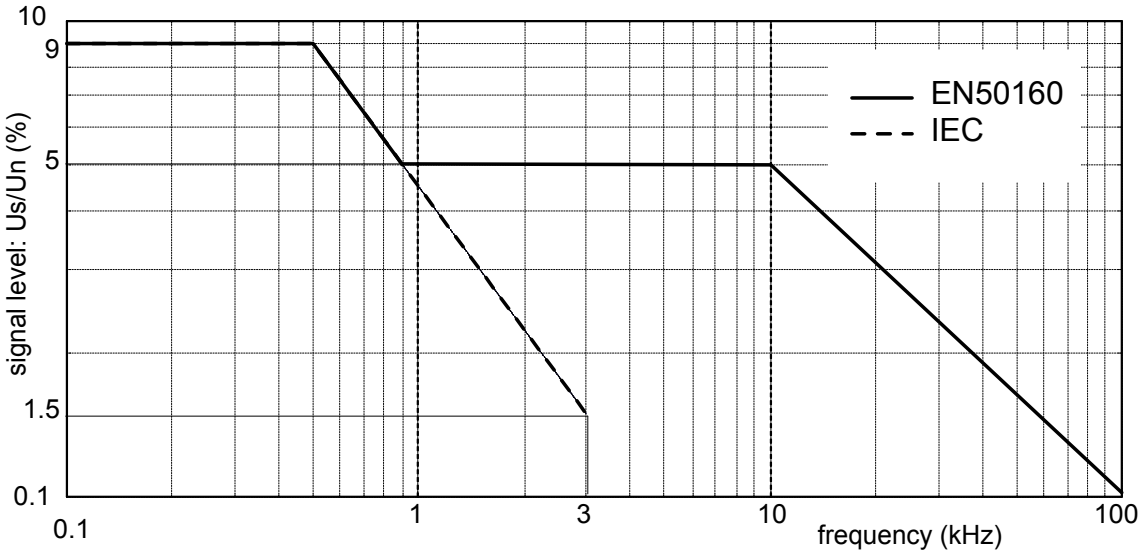


Fig 15b: Mains Signaling voltage level limits according EN50160 and IEC

To enable **'SIGNAL / INTER'** menu press **ENTER** key in **Spectrum** screen. Use **UP** and **DOWN** keys to toggle between 'Harmonics' and 'Signal/Inter' option and press ENTER to select required one (see Fig.15a). Mains Signaling and Interharmonic measurements are part of EN50160 measurement. If EN50160 is not selected, **'Select EN50160'** message is displayed.

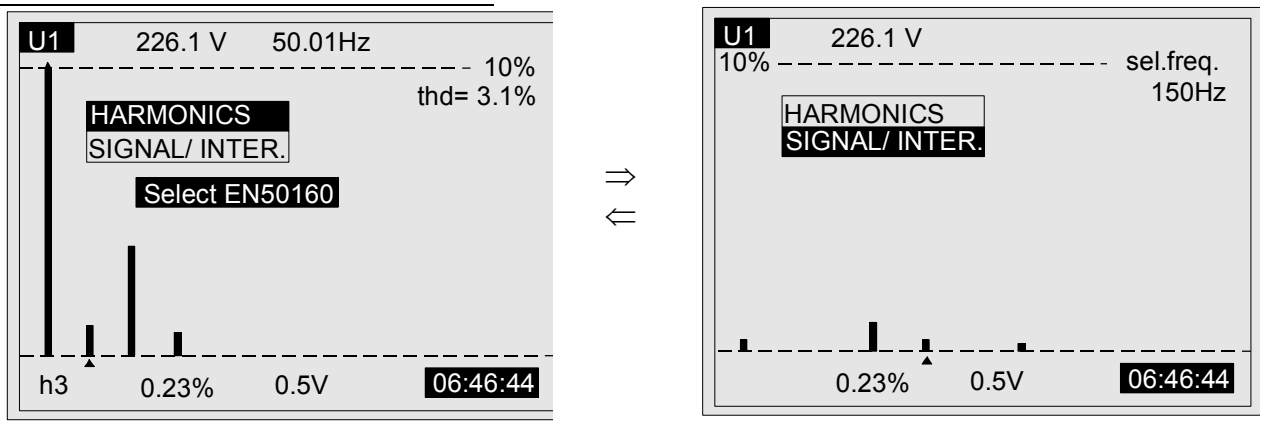


Fig. 15c: Mains Signaling / Interharmonic Analysis

Use **LEFT** and **RIGHT** keys to select the required frequency (from DC to 2560Hz - 5Hz step), and the **SELECT** key to choose the required input signal (U_1, U_2, U_3,).

7. METER

This function displays the basic measured quantities (AC) in the 3φ system. The display format and legends (V, kV, A, kA, W, kW, MW, etc…) are automatically selected appropriate to the measured values. The following quantities are displayed:

Phase r.m.s. voltage (U_1, U_2, U_3).
Phase r.m.s. current (I_1, I_2, I_3).
Per phase signed active, apparent and reactive powers (±P, ±S, ±Q).
Power Factors with indication of direction (capacitive or inductive).
Phase angle between voltage and current.
Phase to phase r.m.s. voltage (V_{1-2}, V_{2-3}, V_{3-1}).
Total 3φ signed active, apparent and reactive powers. ($\pm P_t$, $\pm S_t$, $\pm Q_t$)
Total 3φ Power Factor with indication of direction (capacitive or inductive).
System frequency.
Current in neutral conductor, r.m.s. value.

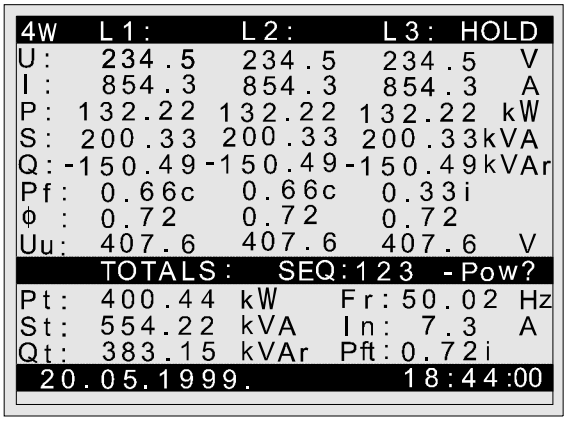


Fig. 16: Meter Display Screen

Notes: *In 3φ systems with a 3wire connection, the Instrument does not display values for the 3rd phase. The central (TOTALS) line may then display two additional messages:*

seq? *When three phase system is not connected in the correct phase sequence (L_1-L_2-L_3).*

pow? *When active power in one or more phase is negative.*

Frequency will be displayed in inverse if the instrument is unable to find a valid sync. input. The default sync. frequency (as defined elsewhere) is used.

8. SCOPE (OSCILLOSCOPE FUNCTION)

This function provides signal waveform displays together with summary details of the signal. The displayed signals are auto-scaled to suit the display, and may vary dependant on the total harmonic distortion.
The top line provides information about the selected input (U_1, I_1, U_2, I_2, U_3, I_3), its value and the synchronization frequency.

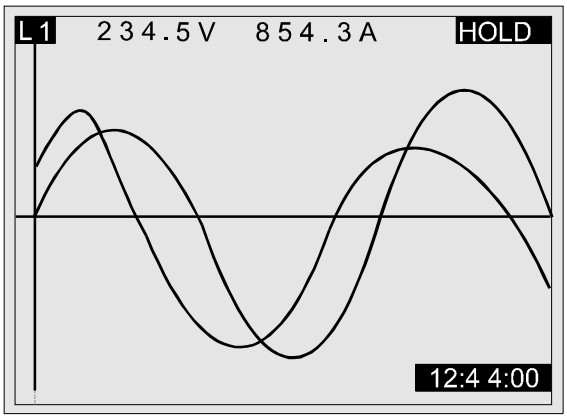


Fig. 17: Scope Display without display of additional information

Use the **SELECT** key to toggle between the signal display options (**L_1, L_2, L_3, 3U, 3I, L_1…).**
Display of additional information is controlled by toggling the **ENTER** key.
To scale voltage waveforms: Use **LEFT** or **RIGHT** keys
To scale current waveforms: Use **UP** or **DOWN** keys

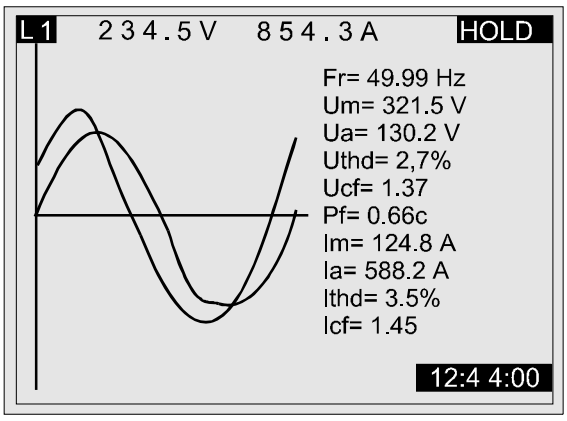


Fig. 18: Scope Display with display of additional information

9. FREQUENCY AND OVERLOAD INFORMATION

For **METER, SCOPE** and **SPECTRUM** screens

The synchronization frequency is measured on the input selected in the meter configuration menu (U_1, U_2, U_3, I_1 or AUTO). If no valid frequency can be detected (after software filtering) the Instrument will, if in AUTO mode, scan the other channels for a signal that could be used for synchronization. If no stable frequency signal can be found, the Instrument will use the default (50-60 Hz) frequency selected in the METER configuration menu and display this frequency value in inverse.
An overload detected on any input is indicated on the instrument display in inverse mode of the particular input value.
Overload conditions are:

a) Voltage inputs: U > 550 V ac r.m.s. and / or U > 770 Vp,
b) Current inputs: U > 2 V ac r.m.s. and / or U > 2.5 Vp

SECTION IV

CONNECTION TO POWER SYSTEMS

WARNING!
This Instrument requires connection to dangerous voltages.
Use suitable safety accessory.

This instrument can be connected to the 3φ system in 3 ways:

- 3φ four wire system L_1, L_2, L_3,N; I_1, I_2, I_3
- 3φ three wires system L_{12}, L_{23}, L_{31}; I_1, I_2, I_3
- Aaron (2 wattmeter) 3φ connection L_{12}, L_{32}, I_1, I_2

The actual connection scheme must be defined in METER Configuration menu (see Fig 19 below).

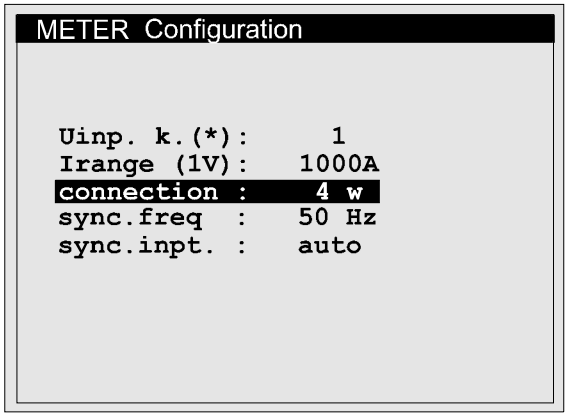


Fig. 19: Meter Configuration Menu

Use **LEFT** and **RIGHT** keys to select the appropriate connections scheme.

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

- **Current Clamp-on current transformers**
- The arrow marked on the Current Clamp-on current transformers must point in the direction of current flow, from supply to load.
- If a 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 **MUST** measure the current in the phase line to which the voltage probe from L_1 is connected.

Wiring connections are shown in *Fig. 20*, *Fig. 21* and *Fig. 22* below.

On systems where the voltage is measured on the secondary side of a voltage transformer (say 11 kV / 110 V), a scaling factor taking account of that voltage transformer ratio must be entered in order to ensure correct measurement (see Section III 3.2.5 METER Configuration).

1. 3φ 4-wire system (with Neutral conductor)

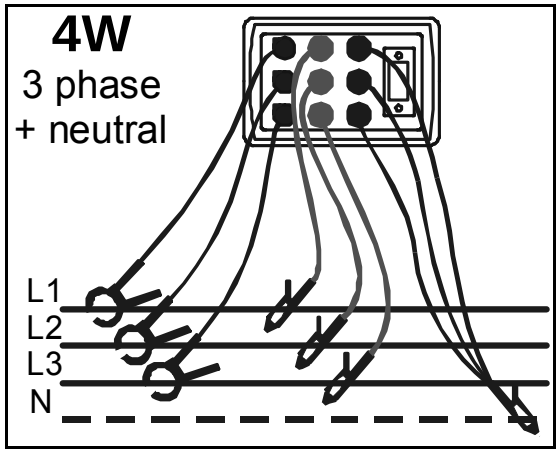


Fig. 20: 3φ 4 wire system

2. 3φ 3-wire system with 3 current transformers (no Neutral conductor)

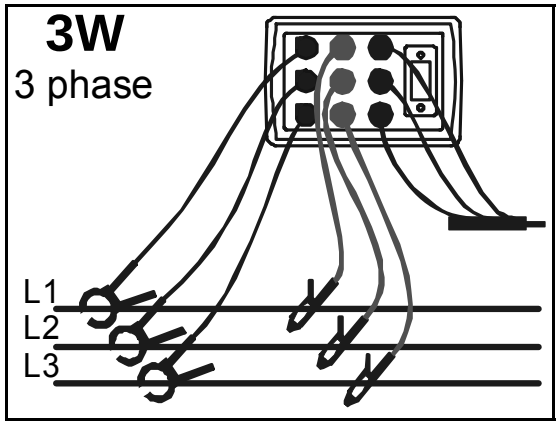


Fig. 21: 3φ 3 wire system with 3 current transformers

3. 3φ 3-wire system with 2 current transformers (2 Wattmeter connection)

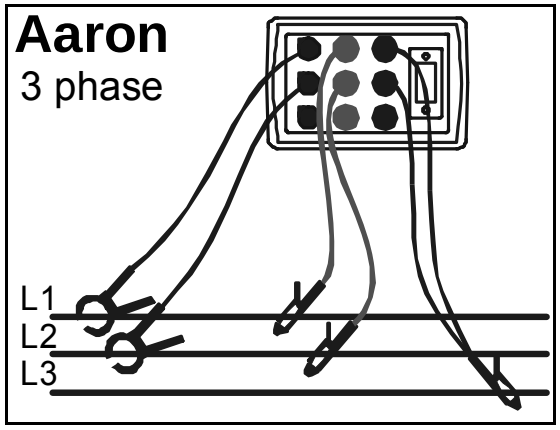


Fig. 22: 3φ 3 wire system with 2 current transformers (2 Wattmeter connection)

WARNING
Connecting to Current Transformers
The secondary of a current transformer must NOT be open circuited when on a live circuit.
An open circuit secondary can result in a dangerously high voltage across the terminals.

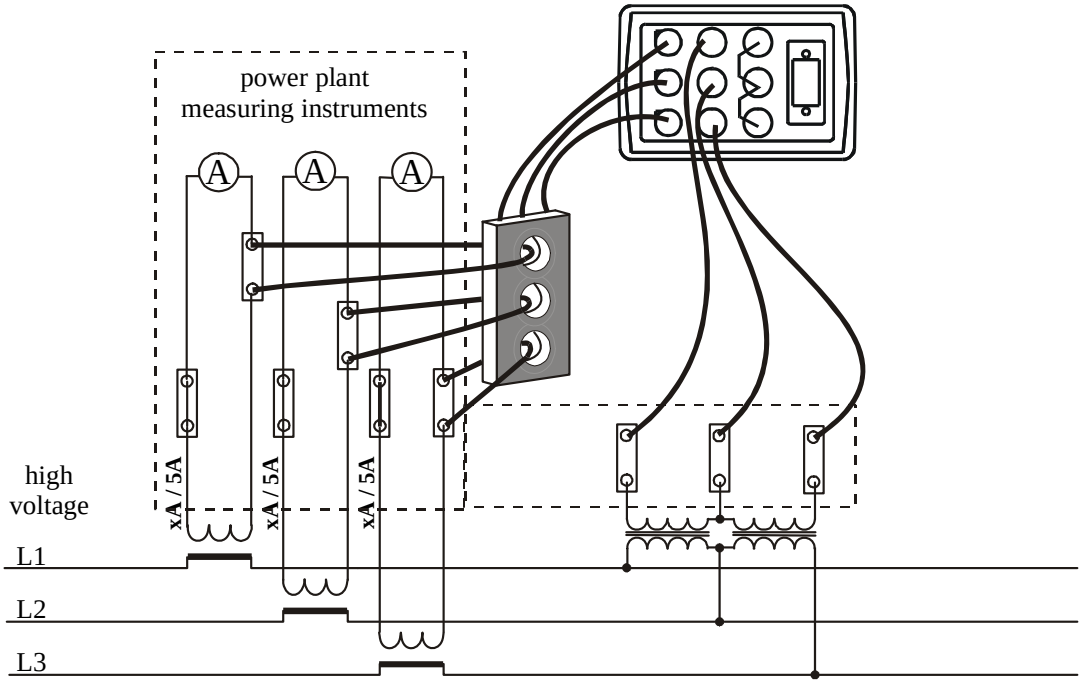


Fig. 23: Connecting to existing current transformers on a high voltage system

SECTION V

PC software

1. INTRODUCTION

The Power Quality Analyzer is supplied complete with a powerful suite of Windows software that can be used for:

- Configuring the Instrument
- Setting measurement parameters
- Download of recorded data
- Off-line analysis of recorded data
- On-line capture and analysis of current voltage and power signals.

The software also provides the necessary tools to allow measured data etc to be included in various reports.
The Minimum requirement for running the software is the ability of the PC to run Windows 95.

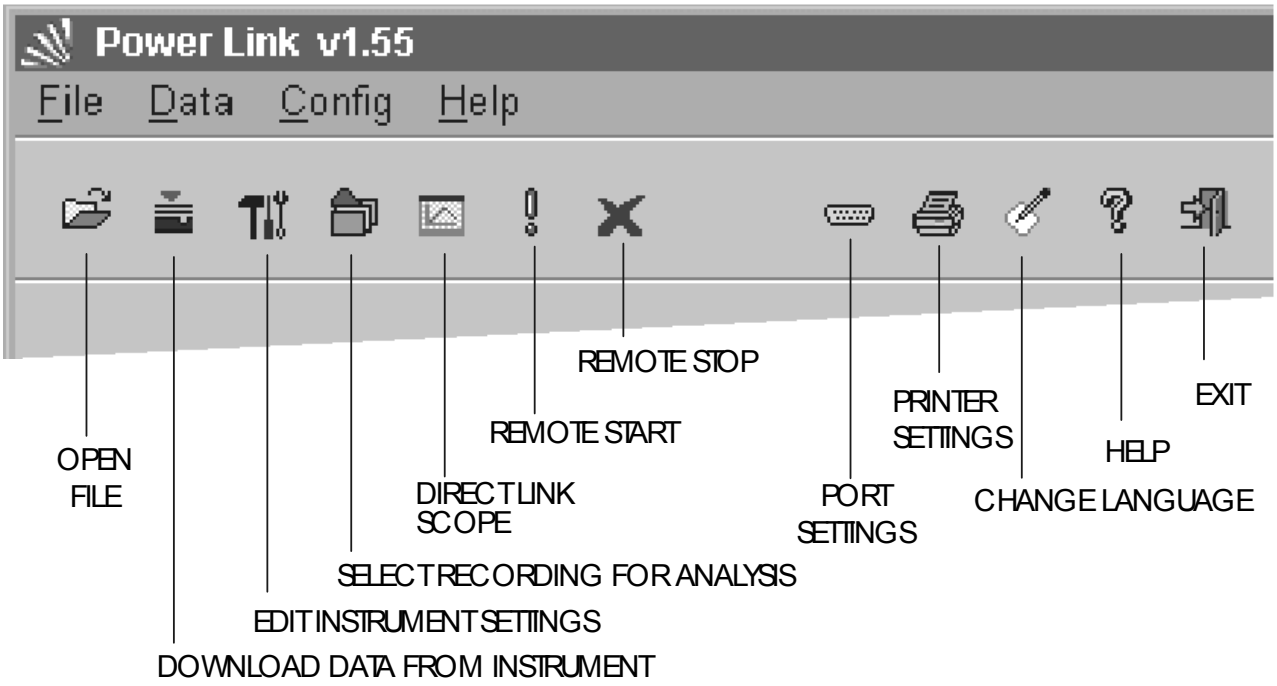


Fig. 24: Basic opening screen

The Basic opening screen is the starting point for all actions. It provides general information about the Instrument and - by clicking on 'toolbar buttons' or selecting pull-down menus - access to all functions. The buttons provide access to:

- Download of data
- Setting Instrument configuration parameters
- Analysis of downloaded or previously saved data
- Direct Link - Operating on-line with the Instrument
- Data Logging START/STOP

2. INSTRUMENT SET-UP

To set the instrument configuration parameters, double click on **Settings**; the program will download current settings from the instrument and display them on the screen.

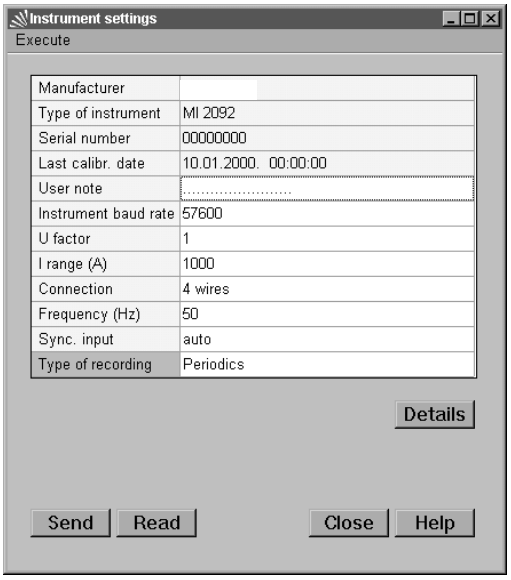


Fig. 25: Instrument settings screen

The Instrument settings screen contains the instrument data and parameters fields and buttons. Buttons are:

Details To edit the parameters of a selected recording type
Send To send Set-up parameters to the instrument
Read To download Set-up parameters from the instrument
Close To close this settings screen
Help To run online help

To change values on parameter fields, double click on the specific field and select between the available options.

User note This field is available for entry of any text Name, Survey Reference, etc.

Instrument Baud Rate Increment / Decrement the value using PgUp / PgDown keys or double click to the following dialog, see Fig. 26.

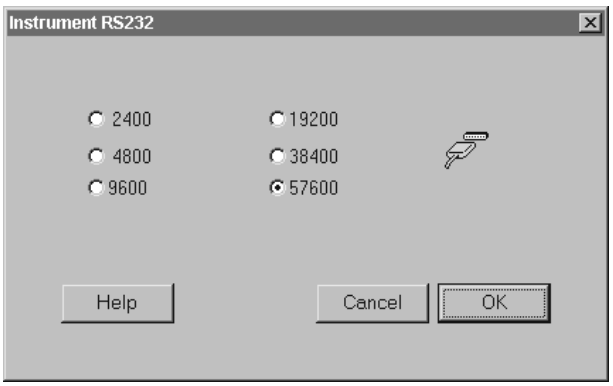


Fig. 26: Baud Rate Set-up screen

U factor **Voltage Transformer Ratio**
Increment / Decrement the value using PgUp / PgDown keys.

I range (A) **Scale Factor for the Current Transformers**
Increment / Decrement the value using PgUp / PgDown keys.

Connection Select the System Connection.

Note:
Aaron is a 3 wire measurement with 2 current transformers

Fig. 27: Connection screen

Frequency (Hz) To toggle between 50 Hz and 60 Hz, double click on the Frequency field.

Sync. Input **Frequency Synchronization Input**
Select the input using PgUp / PgDown keys.

Type of recording Select the type of Data Analysis required.

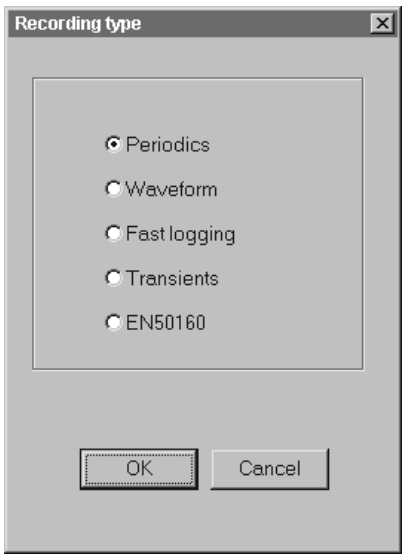


Fig. 28: Recording Set-up screen

To view details on the selected type of recording click on DETAILS button.
To return to the Main Menu, click on the **Close** button.

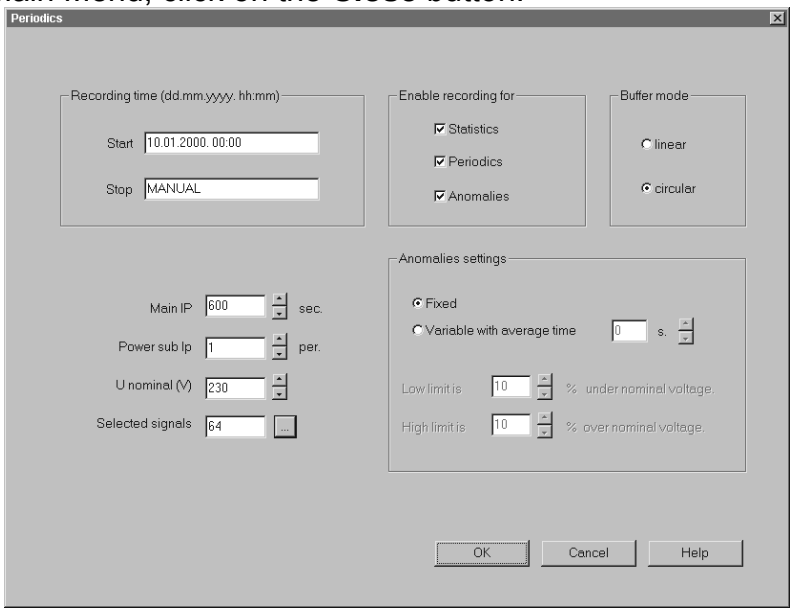


Fig. 29a: Details screen for 'periodic' recording

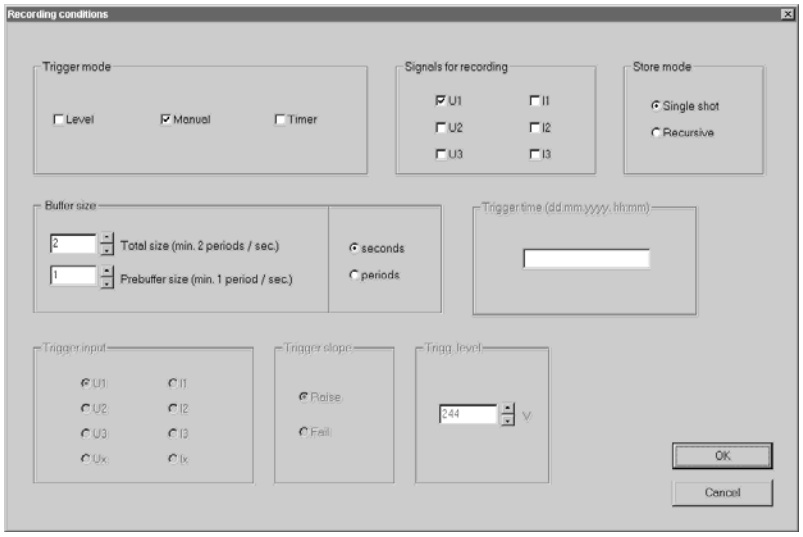


Fig. 29b: Details screen for 'Waveforms' & 'Fast logging' recording

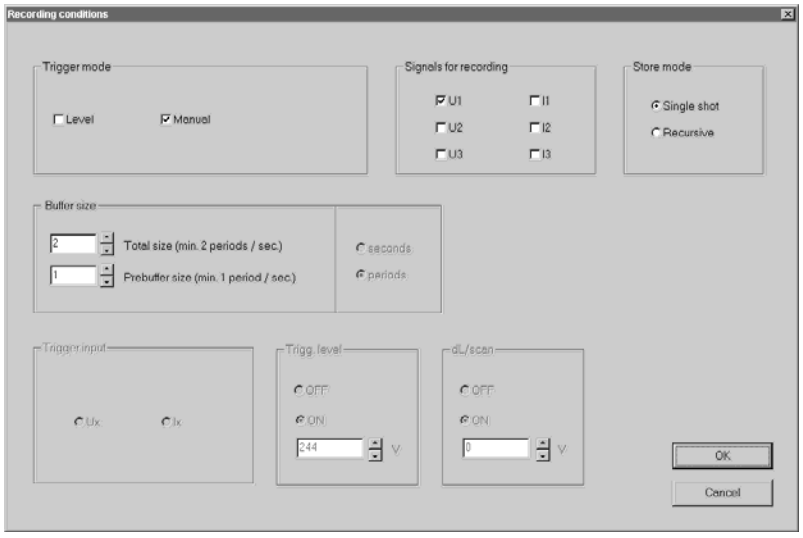


Fig. 29c: Details screen for 'Transients' recording

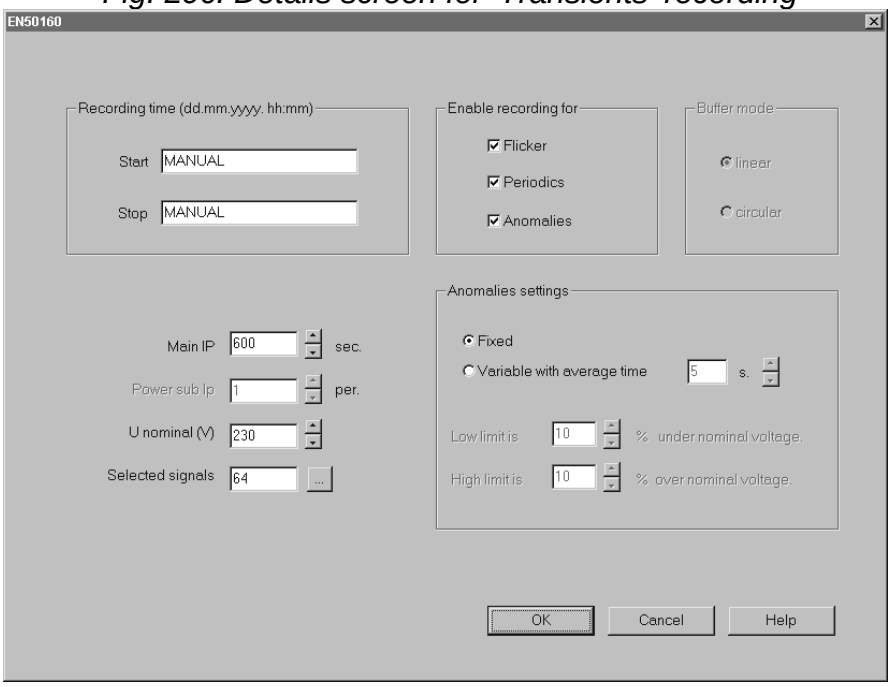


Fig. 29d: Details screen for'EN50160' recording

Selected signals

In PERIODICS and EN 50160
From the list of available signals, select those signals that you require to be logged, recorded and analyzed.
To select a signal, click the left mouse button on the selected parameter.

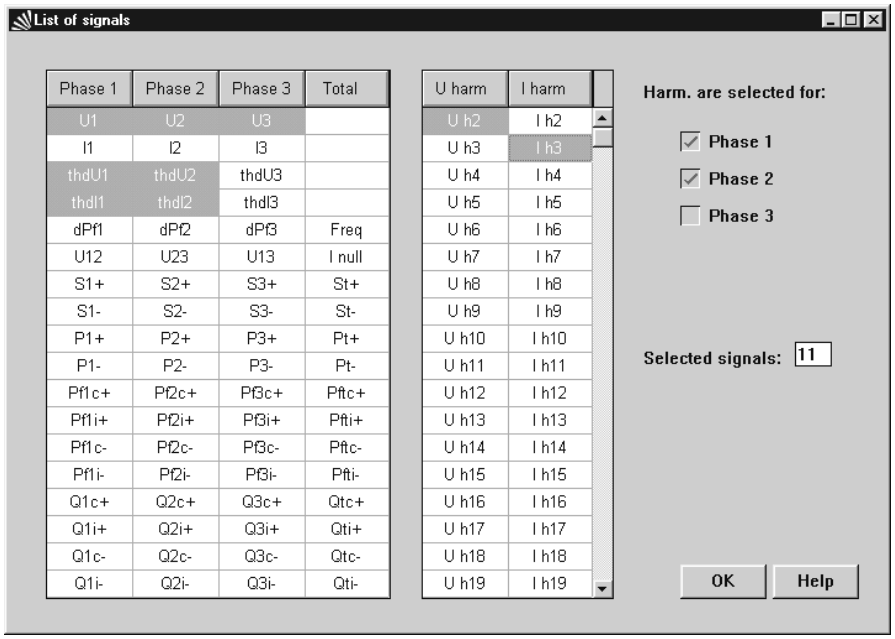
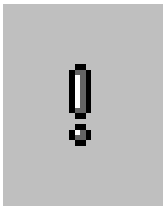
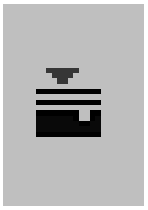
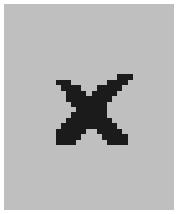


Fig. 30: Data Logging Signal Selection screen

Details for recording modes (waveforms, fast logging, transients, and EN 50160) are given in Section III, chapter 3.2 RECORDER.

3. ANALYSIS OF RECORDED DATA

	**Remote Start** Button to Start Recording.		**Download** button Download data from instrument to the PC.
	**Remote Stop** Button to Stop Recording.		**Analysis** button The File settings and Analyze menu is opened.

The following procedure is required to analyze data:

a) Stop recording and wait for the instrument to complete its recording activity.
b) Press the download button, the List of recordings to be downloaded is presented.
c) Select recordings to download.
d) Start downloading; file-save menu will open to store records on disc.
e) Wait for completion of data transfer.
f) Press Analysis button, file-open menu will open to select and open data file.
g) After confirming the entered filename the List of recordings window will open.
h) Select one of these recordings for analysis.

Types of recordings are periodics, waveforms, fast logging, transients and EN50160.

Note: *In f) any data file can be opened for later analysis*

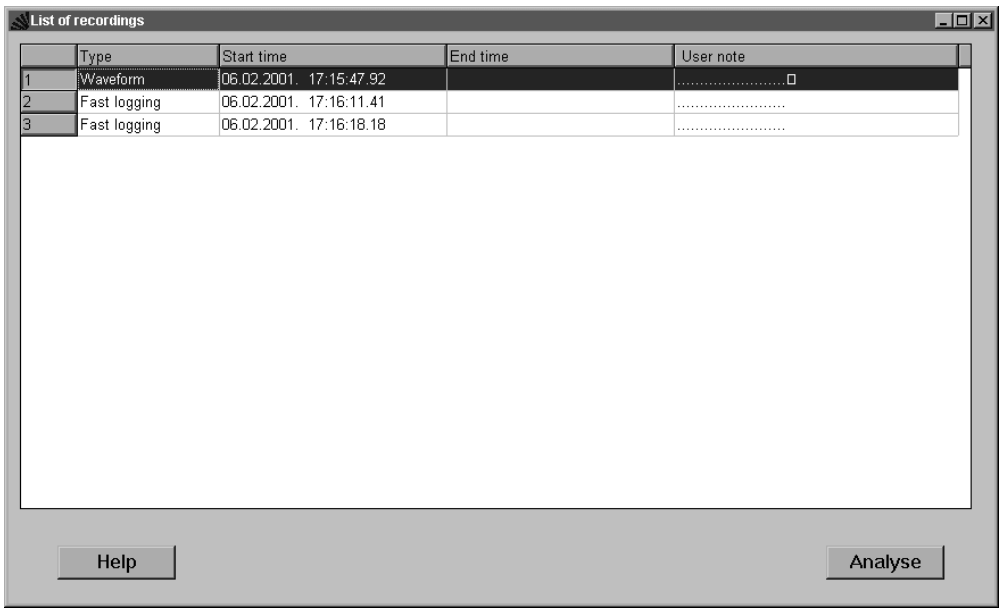


Fig. 31: List of recordings

3.1. SCREENS IN PERIODICS RECORDING MODE

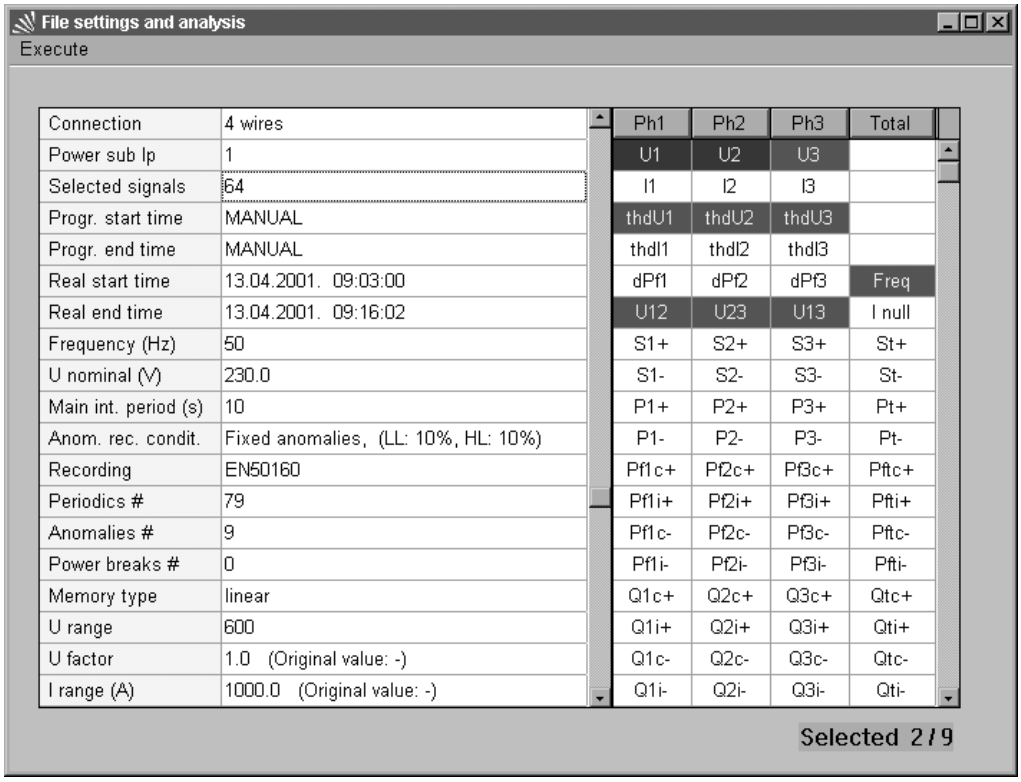


Fig. 32: Data Logging Set-up and Status screen for EN 50160 (also for Periodics)

Recorded signals (available for analysis) are colored blue.
To select a signal for analysis, click on the blue colored field, which changes to red when selected.

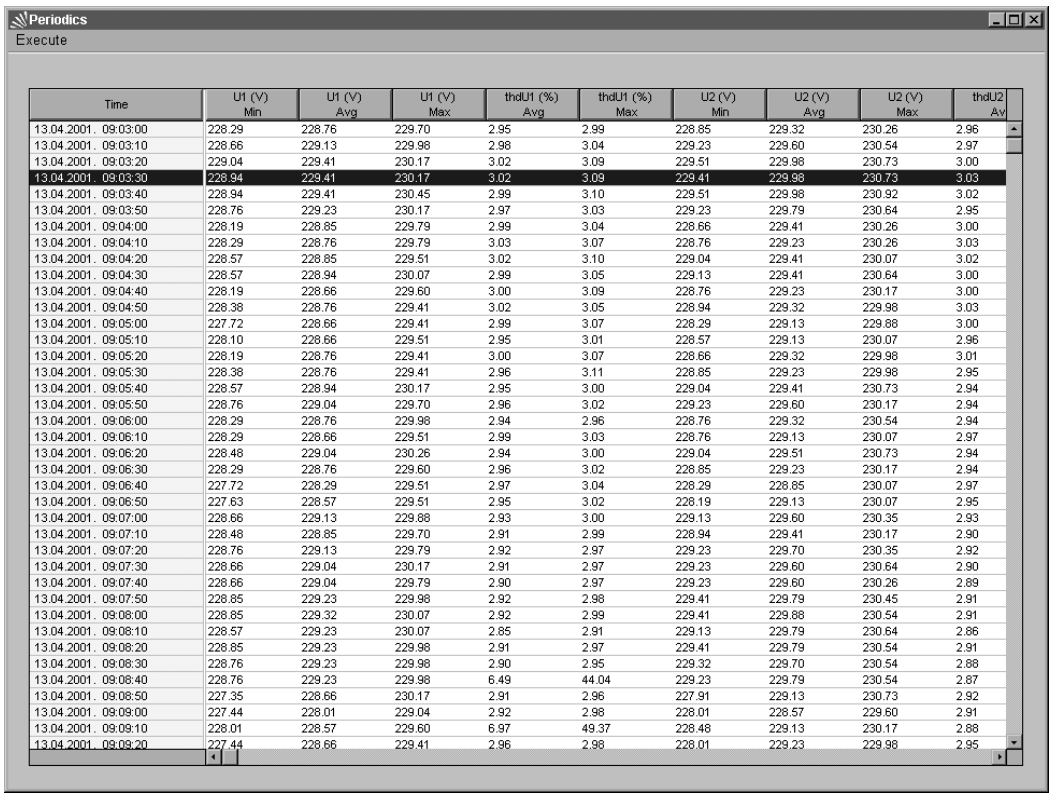
Once parameters have been selected, click '**Execute**' on the Menu Bar and select the type of analysis required:

- Statistical Analysis
- Periodic Analysis
- Voltage Anomalies.

In the following examples, U_1 and U_2 have been selected for analysis; the Integration Period is set to 10 min.

Periodic Analysis

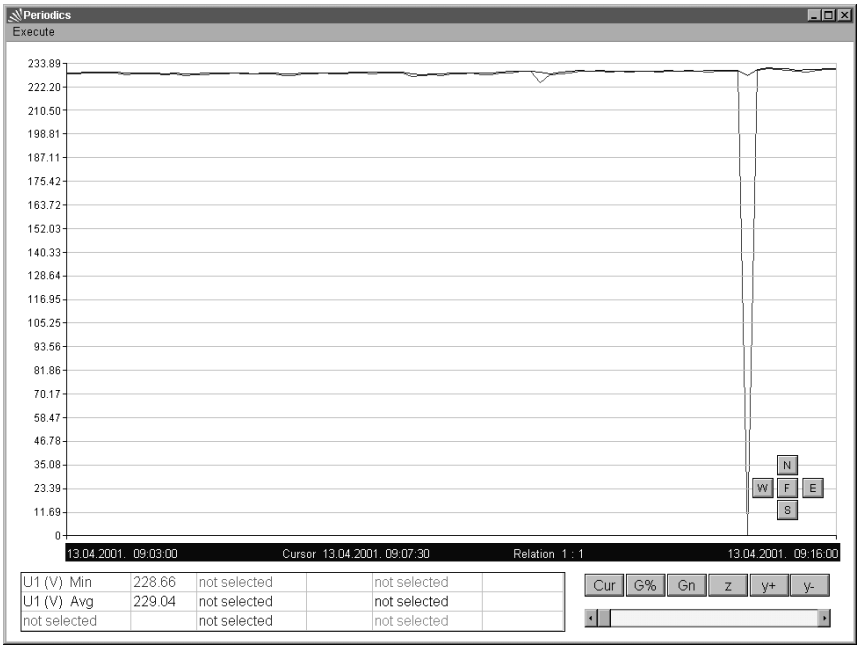
Recorded data can be analyzed in numerical form.



Time	U1 (V) Min	U1 (V) Avg	U1 (V) Max	thdU1 (%) Avg	thdU1 (%) Max	U2 (V) Min	U2 (V) Avg	U2 (V) Max	thdU2 Av
13.04.2001. 09:03:00	228.29	228.76	229.70	2.95	2.99	228.85	229.32	230.26	2.96
13.04.2001. 09:03:10	228.66	229.13	229.98	2.98	3.04	229.23	229.60	230.54	2.97
13.04.2001. 09:03:20	229.04	229.41	230.17	3.02	3.09	229.51	229.98	230.73	3.00
13.04.2001. 09:03:30	228.94	229.41	230.17	3.02	3.09	229.41	229.98	230.73	3.03
13.04.2001. 09:03:40	228.94	229.41	230.45	2.99	3.10	229.51	229.98	230.92	3.02
13.04.2001. 09:03:50	228.76	229.23	230.17	2.97	3.03	229.23	229.79	230.64	2.95
13.04.2001. 09:04:00	228.19	228.85	229.79	2.99	3.04	228.66	229.41	230.26	3.00
13.04.2001. 09:04:10	228.29	228.76	229.79	3.03	3.07	228.76	229.23	230.26	3.03
13.04.2001. 09:04:20	228.57	228.85	229.51	3.02	3.10	229.04	229.41	230.07	3.02
13.04.2001. 09:04:30	228.57	228.94	230.07	2.99	3.05	229.13	229.41	230.64	3.00
13.04.2001. 09:04:40	228.19	228.66	229.60	3.00	3.09	228.76	229.23	230.17	3.00
13.04.2001. 09:04:50	228.38	228.76	229.41	3.02	3.05	228.94	229.32	229.98	3.03
13.04.2001. 09:05:00	227.72	228.66	229.41	2.99	3.07	228.29	229.13	229.88	3.00
13.04.2001. 09:05:10	228.10	228.66	229.51	2.95	3.01	228.57	229.13	230.07	2.96
13.04.2001. 09:05:20	228.19	228.76	229.41	3.00	3.07	228.66	229.32	229.98	3.01
13.04.2001. 09:05:30	228.38	228.76	229.41	2.96	3.11	228.85	229.23	229.98	2.95
13.04.2001. 09:05:40	228.57	228.94	230.17	2.95	3.00	229.04	229.41	230.73	2.94
13.04.2001. 09:05:50	228.76	229.04	229.70	2.96	3.02	229.23	229.60	230.17	2.94
13.04.2001. 09:06:00	228.29	228.76	229.98	2.94	2.96	228.76	229.32	230.54	2.94
13.04.2001. 09:06:10	228.29	228.66	229.51	2.99	3.03	228.76	229.13	230.07	2.97
13.04.2001. 09:06:20	228.48	229.04	230.26	2.94	3.00	229.04	229.51	230.73	2.94
13.04.2001. 09:06:30	228.29	228.76	229.60	2.96	3.02	228.85	229.23	230.17	2.94
13.04.2001. 09:06:40	227.72	228.29	229.51	2.97	3.04	228.29	228.85	230.07	2.97
13.04.2001. 09:06:50	227.63	228.57	229.51	2.95	3.02	228.19	229.13	230.07	2.95
13.04.2001. 09:07:00	228.66	229.13	229.88	2.93	3.00	229.13	229.60	230.35	2.93
13.04.2001. 09:07:10	228.48	228.85	229.70	2.91	2.99	228.94	229.41	230.17	2.90
13.04.2001. 09:07:20	228.76	229.13	229.79	2.92	2.97	229.23	229.70	230.35	2.92
13.04.2001. 09:07:30	228.66	229.04	230.17	2.91	2.97	229.23	229.60	230.64	2.90
13.04.2001. 09:07:40	228.66	229.04	229.79	2.90	2.97	229.23	229.60	230.26	2.89
13.04.2001. 09:07:50	228.85	229.23	229.98	2.92	2.98	229.41	229.79	230.45	2.91
13.04.2001. 09:08:00	228.85	229.32	230.07	2.92	2.99	229.41	229.88	230.54	2.91
13.04.2001. 09:08:10	228.57	229.23	230.07	2.85	2.91	229.13	229.79	230.64	2.86
13.04.2001. 09:08:20	228.85	229.23	229.98	2.91	2.97	229.41	229.79	230.54	2.91
13.04.2001. 09:08:30	228.76	229.23	229.98	2.90	2.95	229.32	229.70	230.54	2.88
13.04.2001. 09:08:40	228.76	229.23	229.98	6.49	44.04	229.23	229.79	230.54	2.87
13.04.2001. 09:08:50	227.35	228.66	230.17	2.91	2.96	227.91	229.13	230.73	2.92
13.04.2001. 09:09:00	227.44	228.01	229.04	2.92	2.98	228.01	228.57	229.60	2.91
13.04.2001. 09:09:10	228.01	228.57	229.60	6.97	49.37	228.48	229.13	230.17	2.88
13.04.2001. 09:09:20	227.44	228.66	229.41	2.96	2.98	228.01	229.23	229.98	2.95

Fig. 33: Tabular Data Analysis screen

Data can also be graphed, with advanced navigating and search facilities. To create graph select desired columns (max. 9) and then select: Execute \ Draw selected columns.



Buttons:

N,S,W,E	Navigation buttons
F	Restore original screen
Cur	Cursor on / off
G%	Y axis in [%]
Gn	Y axis normal
z	Graph window
y+	Zoom in (Y axis)
y-	Zoom out (Y axis)

Fig.34: Graphic Data Analysis screen

Voltage Anomalies

Recordings of Voltage Anomalies (or Voltage Breaks) can be displayed in both numerical and graphic format.

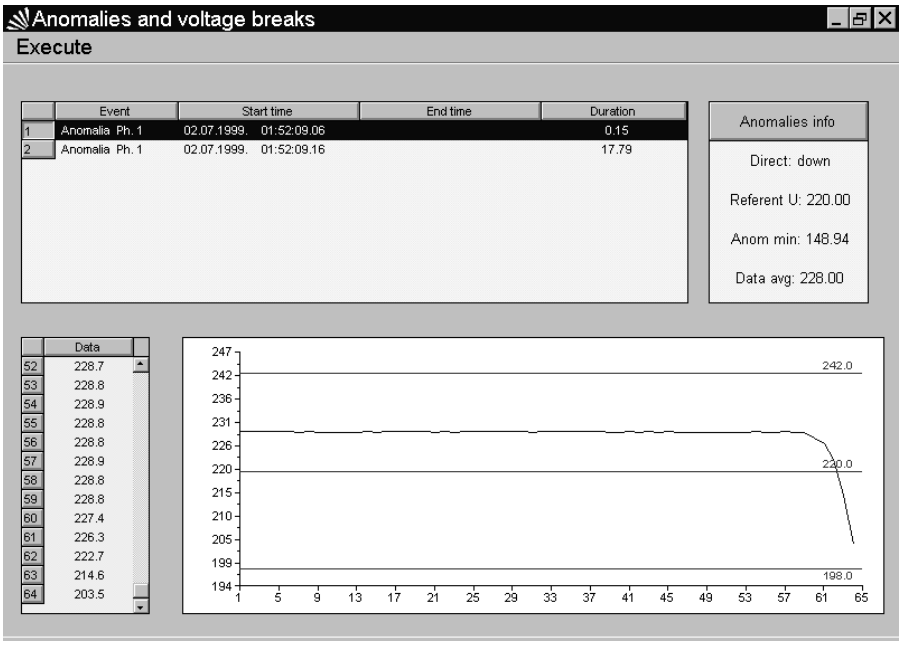


Fig. 35: Voltage Anomalies and Breaks screen

A full listing of all Voltage Anomalies is provided, together with the set-up information, and an analysis of each record can be quickly viewed in both graphic and tabular form.

Statistical Analysis

A Statistical Analysis of recorded data can be displayed in both numerical and graphic format.

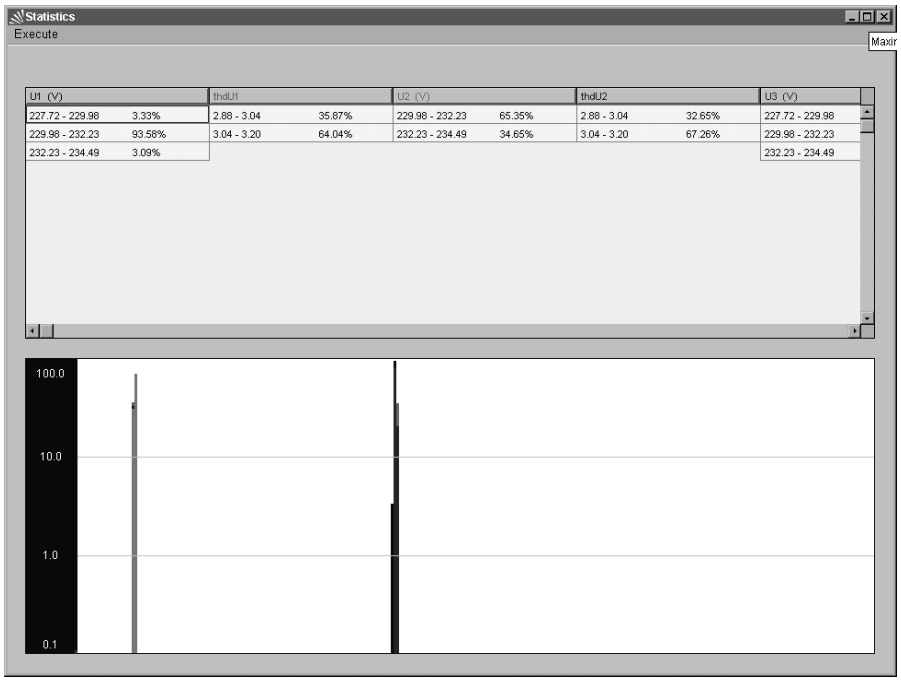


Fig. 36: Statistical Analysis screen

3.2. SCREENS IN WAVEFORMS RECORDING MODE

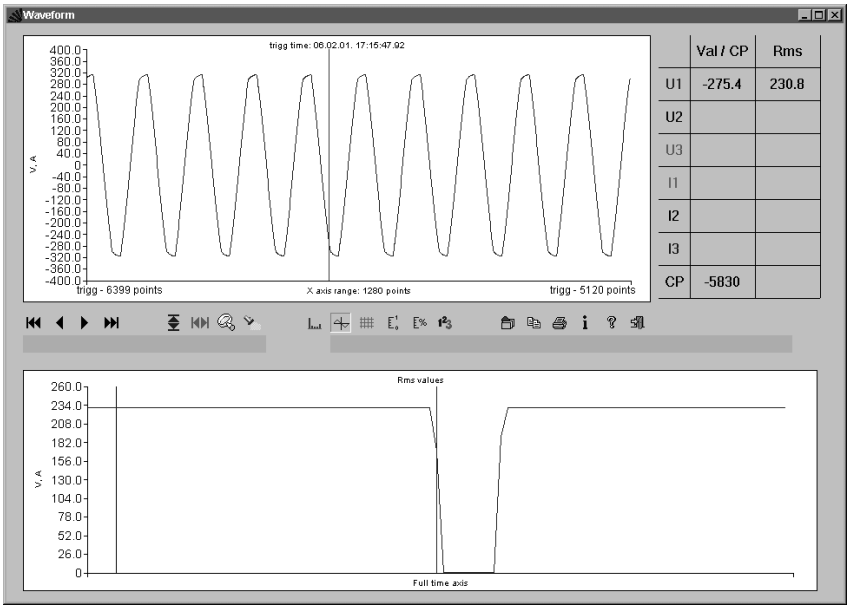


Fig. 37:Waveforms analysis screen

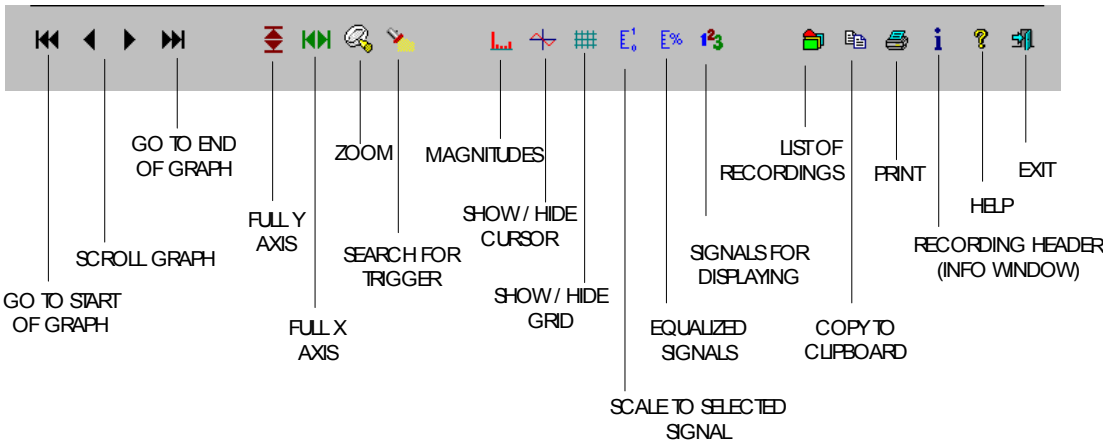


Fig. 38: Fast buttons

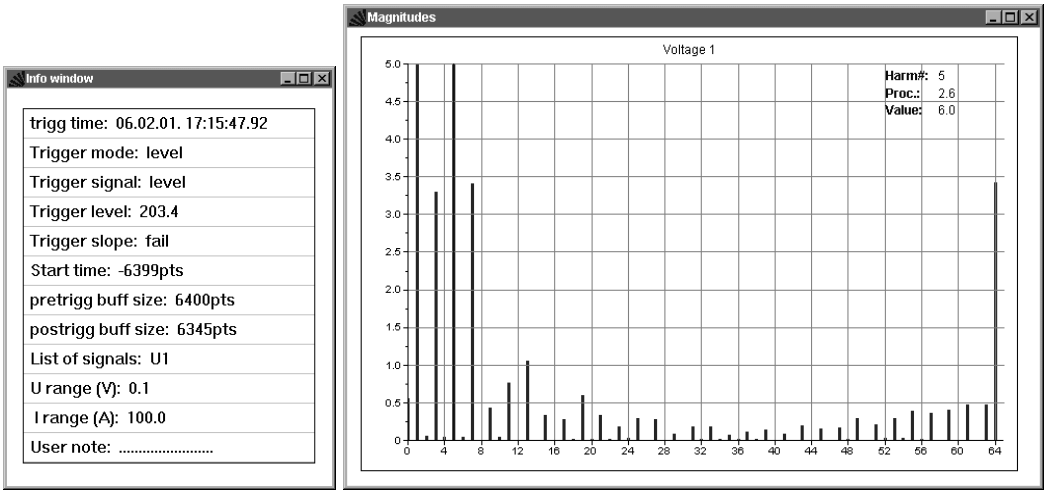


Fig. 39:Waveform info & magnitudes screen

3.3. FAST LOGGING RECORDING MODE

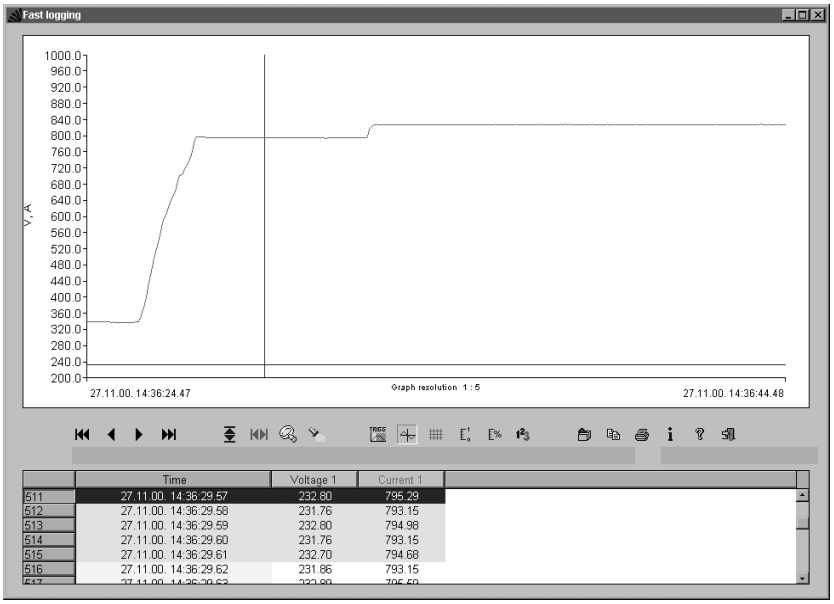


Fig. 40: Fast logging analysis screen

3.4. TRANSIENTS RECORDING MODE

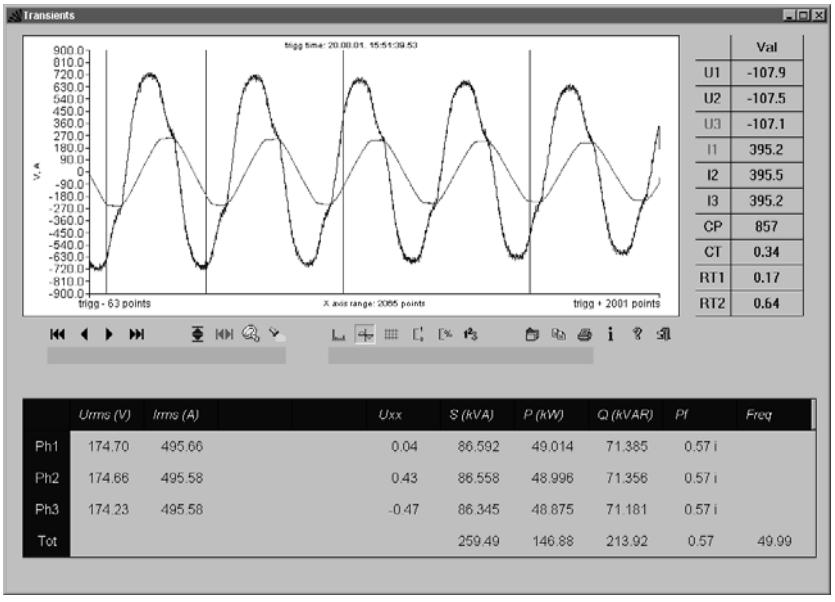


Fig. 41: Transients analysis screen

The table on the right gives information about the measured values in cursor position (when the cursor is shown – show hide cursor button).

CP – Cursor Point
CT – Cursor Time
RT1 – Range Time 1 (range start time)
RT2 – Range Time 2 (range stop time)

All values are related to the trigger point.

The table on the bottom of the screen is calculated from the values between start and stop time (RT1 and RT2). To set start and stop time it is necessary to activate cursor (red vertical line is shown on graph). Select the desired start point on graph and press right mouse bottom to select "**Range start".** This point will be marked on the graph.

Initially RT1. and RT2 are 0 and when the first (start time) RT1 is set it will be taken as stop time because it is greater then RT2 – (values in table are always calculated between RT1 and RT2)

3.5. EN 50160 RECORDING MODE

For EN 50160 type of recording the standard graphical summary will automatically be displayed. From this representation the user can see which measured values exceed the limit value as per EN50160 standard, or what reserves are still available. The Red section of the stacked bar represents the quantity of the measured value under where 95 % of all measured values lie. The Blue section represents the remaining 5 % of measured values.

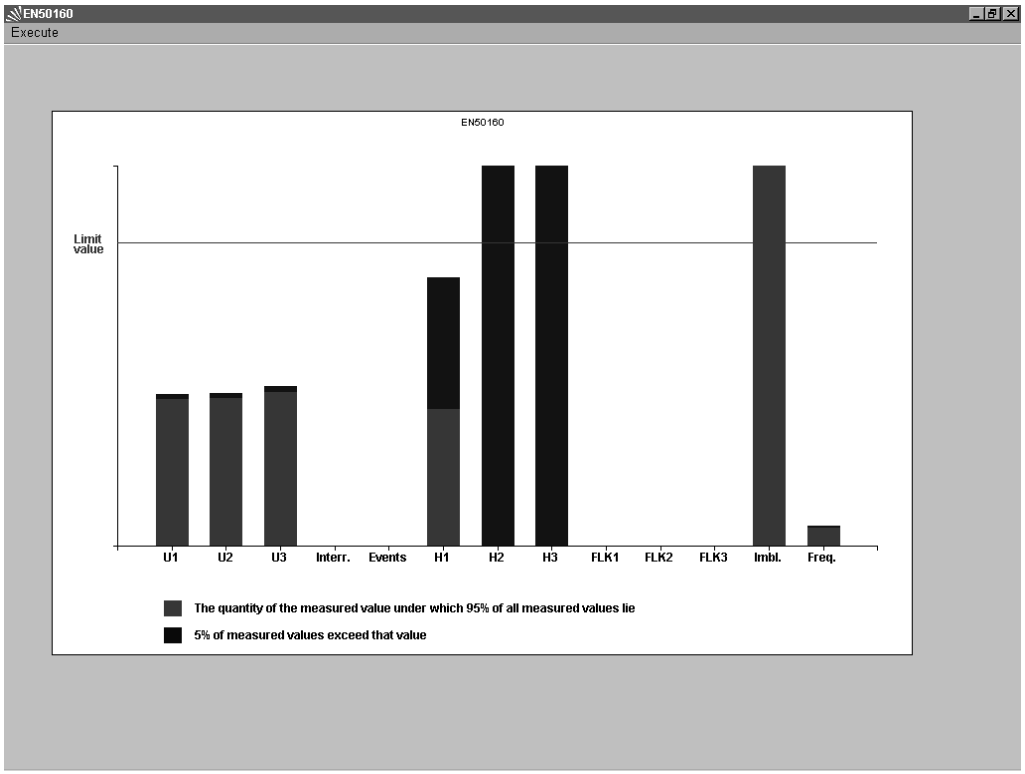
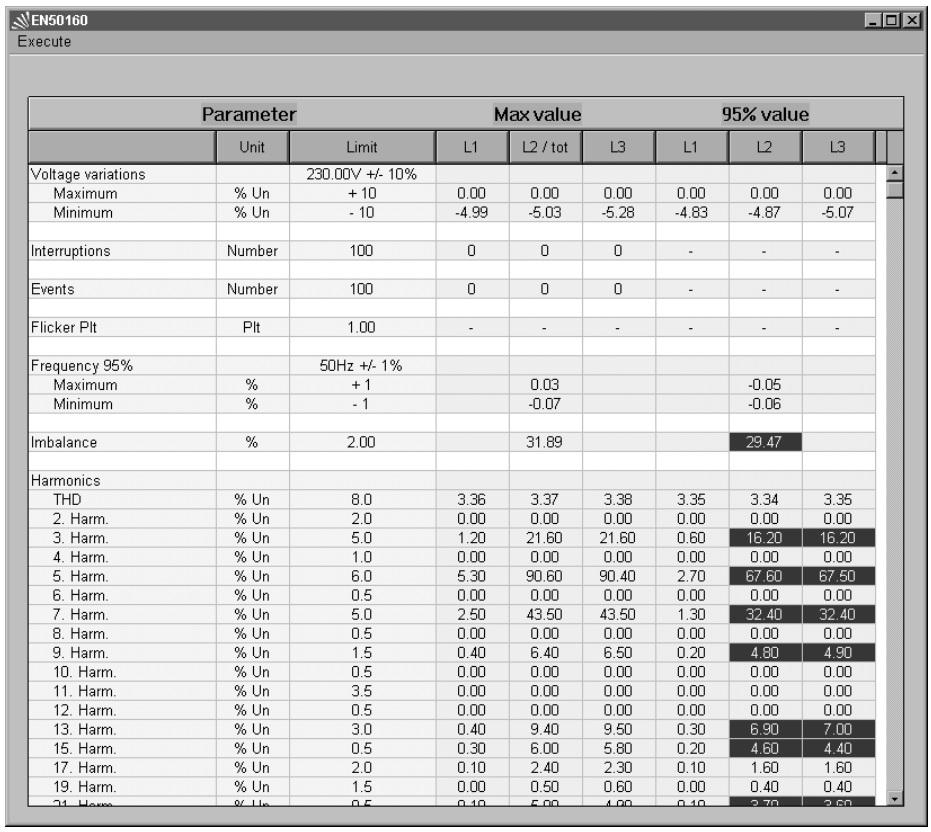


Fig. 42: Graphical summary

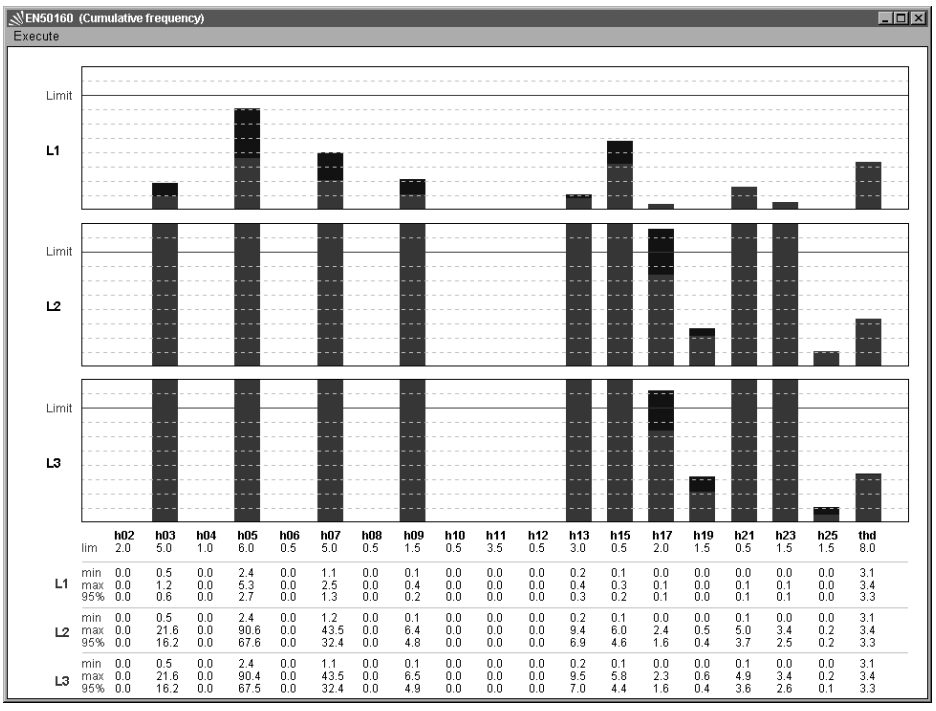
All parameters represented in the graphical summary can be also viewed in tabular format.
In this table limit values are shown, maximal values, and the 95 % values. The column 'Max value' displays the maximum and minimum deviation in percent in relation to the nominal voltage. In the '95 % value' column the upper and lower limit indicate if 95 % of all measurement values are between the positive and negative value.



Parameter			Max value			95% value		
	Unit	Limit	L1	L2 / tot	L3	L1	L2	L3
Voltage variations		230.00V +/- 10%						
Maximum	% Un	+ 10	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	% Un	- 10	-4.99	-5.03	-5.28	-4.83	-4.87	-5.07
Interruptions	Number	100	0	0	0	-	-	-
Events	Number	100	0	0	0	-	-	-
Flicker Plt	Plt	1.00	-	-	-	-	-	-
Frequency 95%		50Hz +/- 1%						
Maximum	%	+ 1		0.03			-0.05	
Minimum	%	- 1		-0.07			-0.06	
Imbalance	%	2.00		31.89			29.47	
Harmonics								
THD	% Un	8.0	3.36	3.37	3.38	3.35	3.34	3.35
2. Harm.	% Un	2.0	0.00	0.00	0.00	0.00	0.00	0.00
3. Harm.	% Un	5.0	1.20	21.60	21.60	0.60	16.20	16.20
4. Harm.	% Un	1.0	0.00	0.00	0.00	0.00	0.00	0.00
5. Harm.	% Un	6.0	5.30	90.60	90.40	2.70	67.60	67.50
6. Harm.	% Un	0.5	0.00	0.00	0.00	0.00	0.00	0.00
7. Harm.	% Un	5.0	2.50	43.50	43.50	1.30	32.40	32.40
8. Harm.	% Un	0.5	0.00	0.00	0.00	0.00	0.00	0.00
9. Harm.	% Un	1.5	0.40	6.40	6.50	0.20	4.80	4.90
10. Harm.	% Un	0.5	0.00	0.00	0.00	0.00	0.00	0.00
11. Harm.	% Un	3.5	0.00	0.00	0.00	0.00	0.00	0.00
12. Harm.	% Un	0.5	0.00	0.00	0.00	0.00	0.00	0.00
13. Harm.	% Un	3.0	0.40	9.40	9.50	0.30	6.90	7.00
15. Harm.	% Un	0.5	0.30	6.00	5.80	0.20	4.60	4.40
17. Harm.	% Un	2.0	0.10	2.40	2.30	0.10	1.60	1.60
19. Harm.	% Un	1.5	0.00	0.50	0.60	0.00	0.40	0.40

Fig. 43: Analysis summary in table form

For statistical analysis of harmonics there is ‘Cumulative frequency’ representation. The stacked bar chart principle is the same as in the ‘Graphical summary’. The user can easily see which harmonics exceed the permissible limit value and what reserves are available.



		h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h15	h17	h19	h21	h23	h25	thd
	lim	2.0	5.0	1.0	6.0	0.5	5.0	0.5	1.5	0.5	3.5	0.5	3.0	0.5	2.0	1.5	0.5	1.5	1.5	8.0
L1	min	0.0	0.5	0.0	2.4	0.0	1.1	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	3.1
	max	0.0	1.2	0.0	5.3	0.0	2.5	0.0	0.4	0.0	0.0	0.0	0.4	0.3	0.1	0.0	0.1	0.1	0.0	3.4
	95%	0.0	0.6	0.0	2.7	0.0	1.3	0.0	0.2	0.0	0.0	0.0	0.3	0.2	0.1	0.0	0.1	0.1	0.0	3.3
L2	min	0.0	0.5	0.0	2.4	0.0	1.2	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.0	0.0	3.1
	max	0.0	21.6	0.0	90.6	0.0	43.5	0.0	6.4	0.0	0.0	0.0	9.4	6.0	2.4	0.5	5.0	3.4	0.2	3.4
	95%	0.0	16.2	0.0	67.6	0.0	32.4	0.0	4.8	0.0	0.0	0.0	6.9	4.6	1.6	0.4	3.7	2.5	0.2	3.3
L3	min	0.0	0.5	0.0	2.4	0.0	1.1	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.0	0.0	3.1
	max	0.0	21.6	0.0	90.4	0.0	43.5	0.0	6.5	0.0	0.0	0.0	9.5	5.8	2.3	0.6	4.9	3.4	0.2	3.4
	95%	0.0	16.2	0.0	67.5	0.0	32.4	0.0	4.9	0.0	0.0	0.0	7.0	4.4	1.6	0.4	3.6	2.6	0.1	3.3

Fig. 44: Cumulative frequency – harmonic analyzing

4. DIRECT LINK - SCOPE

The Direct Link facility allows direct on-line operation, with real-time values from the voltage and current inputs displayed on the screen. Complex calculations can be carried out and the waveforms of selected input signals can be saved, exported to an ASCII file or to the Clipboard for use with third party analysis tools.
To open the connection to the instrument, click on the '**go!'** button.

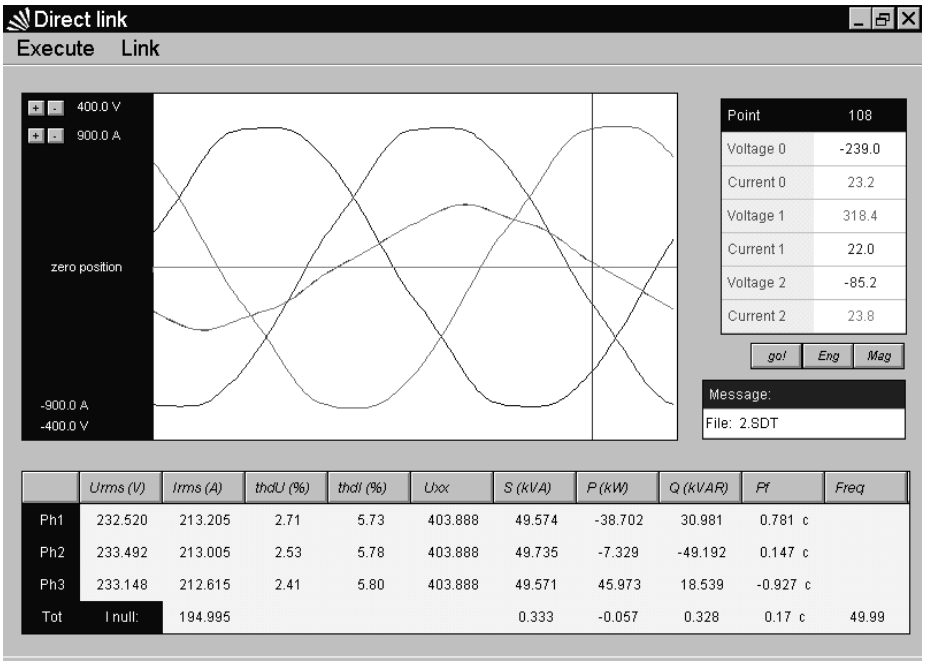


Fig. 45: Direct Link oscilloscope screen

To read **Energies** from the instrument, click on the '**Eng**' button. A small window showing the current values of the energies is displayed.

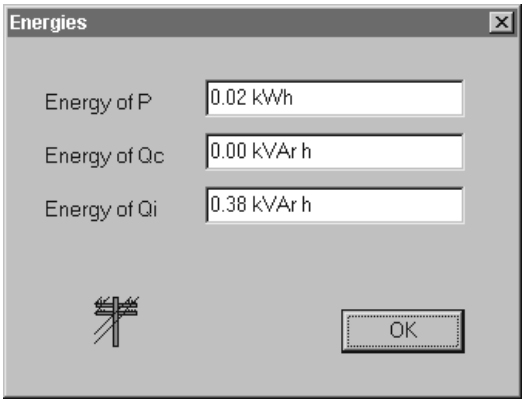


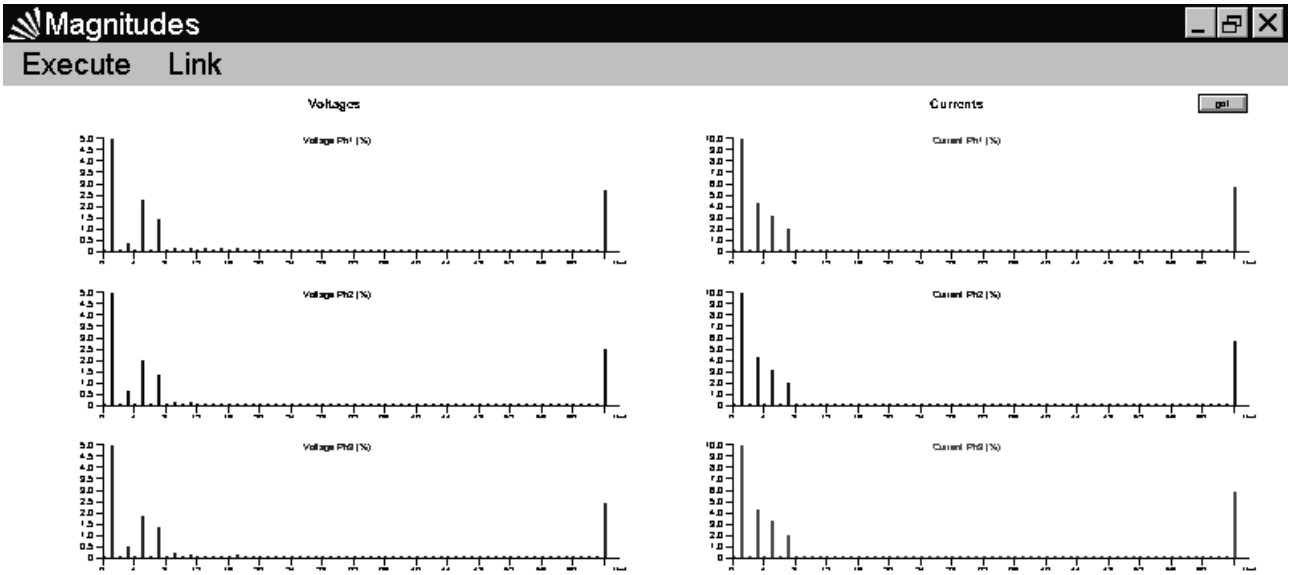
Fig. 46:Energy screen

To look at Harmonics, both Voltage & Current, click on the '**Mag**' button. The harmonic analysis screen is displayed, with six histograms – three voltage and three current – showing harmonics up to the 63rd.
To zoom in on any one histogram, click on that display. To return to a display of all six histograms, click on display.

To alter the scaling of any of the graphs, click on the vertical axis:

- Near the top to increase the range.
- Near the bottom to expand the scale.

To show the harmonics in tabular form, select '**Show Table**' from the '**Execute**' menu. Moving the mouse pointer along any of the graphs will activate a curser, which identifies a single harmonic, with the tabular display scrolling in sympathy with the curser position.
To return to the main **Direct Link** screen, select '**Close**' from the '**Execute**' menu.



Point	U1 (%)	U1 (V)	I1 (%)	I1 (A)	U2 (%)	U2 (V)	I2 (%)	I2 (A)	U3 (%)	U3 (V)	I3 (%)	I3 (A)
0	0.03	0.07	0.14	0.31	0.00	0.00	0.08	0.17	0.07	0.17	0.00	0.00
1	100.00	232.43	100.00	212.86	100.00	233.42	100.00	212.65	100.00	233.08	100.00	212.2
2	0.08	0.18	0.22	0.47	0.10	0.22	0.19	0.40	0.06	0.15	0.22	0.46
3	0.40	0.92	4.28	9.12	0.69	1.60	4.33	9.20	0.54	1.26	4.34	9.22
4	0.06	0.13	0.15	0.31	0.05	0.12	0.19	0.39	0.08	0.18	0.16	0.34
5	2.25	5.24	3.21	6.83	2.00	4.68	3.22	6.84	1.89	4.40	3.24	6.87
6	0.02	0.03	0.01	0.03	0.02	0.04	0.02	0.05	0.01	0.02	0.03	0.07
7	1.41	3.27	2.02	4.29	1.35	3.15	2.03	4.32	1.35	3.15	2.03	4.31
8	0.03	0.07	0.02	0.04	0.01	0.03	0.02	0.03	0.02	0.05	0.04	0.08

Fig. 47: Direct Link Harmonic Analysis Screen with tabular display

Note: *If the display appears to become frozen, there is insufficient time for the display to process all the acquired data. The 'Request Time' (in the 'Execute' menu) should be increased. For a Baud rate of 57600, a Request Time at least 1300 ms is recommended.*

SECTION VI

Theory of operation

1. GENERAL

Data recording is one of the main functions of the instrument. However, while recording data for later analysis, the Instrument can also carry out the following functions:

- **Statistical analysis – Statistical analysis of the measured signals.**
- **Periodic analysis – On line recording and analysis of various measured signals over preset periods.**
- **Voltage anomalies - Detection and recording of voltage anomalies.**
- **Power breaks – Detection and recording of supply interruptions.**
- **Waveforms**
- **Fast logging**
- **Transients**
- **Flickers**
- **EN 50160**

Apart from power break recording, which is always enabled, all the other functions are independent and can be disabled or enabled by the user. The measuring principles are the same in all-recording functions and are described in Section II-2 below. Averaging and statistical techniques are described later in this section.

Data is stored in non-volatile memory and can be downloaded to a PC for further analysis and printing. Downloading can be carried out either on-line while recording and / or after recording has finished. Independent of the recording status, the Instrument can send all samples of an input signal to a PC (for external analysis and viewing) every second.

2. STATISTICAL ANALYSIS

The input range (from 0 to full scale) for each value is divided in 256 divisions (100 for PF and cosφ). Measured values are scaled accordingly. The result is a statistical table, a Gaussian function, which can be analyzed using the PC software (see section V below). Statistical analysis is carried out only on signals selected in the Signals submenu.
Statistical analysis cannot be applied to Harmonic measurements.

3. PERIODIC ANALYSIS

Periodic Analysis is carried out over a programmable integration period (IP). The user can set this (from 1 s to 15 min). During the integration period, the instrument calculates maximum, minimum and average values of selected quantities. At the end of the Period, these values are stored in memory together with the Period Start date/time and synchronization input.

Stored values differ for the various parameters:

- For THD measurement — Only maximum and average values.
- For voltage harmonics and voltage-current angle — Only maximum and minimum values.
- For current harmonics — Only maximum values.
- All other Parameters — Minimum, maximum and average

Active power is divided into two quantities: Import (positive) and Export (negative). Reactive power and power factor are divided into four quantities: positive inductive (+i), positive capacitive (+c), negative inductive (-i) and negative capacitive (-c). Neutral conductor current (I_0) is ignored when measuring in 3-wire connection.
For power, voltage and current measurements, values are stored for each input cycle. Harmonics and THD values are computed on samples of each 8^{th} input cycle.
For calculation of Average Voltage, voltages less then 2 % of full scale (0.02 x U_n) are treated as voltage interruptions and are excluded from any calculations.

The stored maximum and minimum values are based on values calculated during each input cycle, while average values (except for voltage, power & harmonics) are calculated at the end of each IP and are based on the number of input cycles in the period.
Average values for power, voltage and harmonic components ignore input cycles where the voltage is lower then 0.02 x U_n. Further, if a Power Break or a Power Up occurs during an IP or the IP starts during a Power Break, the Instrument will start a new cycle (see also Power Break recording below).
The following Figures and table offer a detailed descriptions of the values used for recording.
The meaning of abbreviations is described below.

SYMBOL DEFINITIONS

General symbols

U	rms voltages
I	rms currents
P	active power
S	apparent power
Q	reactive power
I_0	rms neutral conductor current
PF	power factor
Cosφ	voltage - current phase angle
THD	total harmonic distortion
H	individual harmonics (%)
h	individual harmonic (V or A)
IP	integration period

Additional symbols

x	phase
t	total
i	inductive (with P, Q or PF symbol)
c	capacitive (with P, Q or PF symbol)
+	positive (with P, Q or PF symbol)
-	negative (with P, Q or PF symbol)
n	harmonic number (with H or h symbol)
a	average (with any general symbol)
m	max. or min (with any general symbol)
na	not available
pn	N° of input cycles in integration period (IP)
hpn	N° of input cycles for harmonics in IP (pn/8)
ppn	N° of input cycles for powers
Up n	N° of input cycles for voltages
PC	personal computer
cr	crest factor
pb	power break time inside IP

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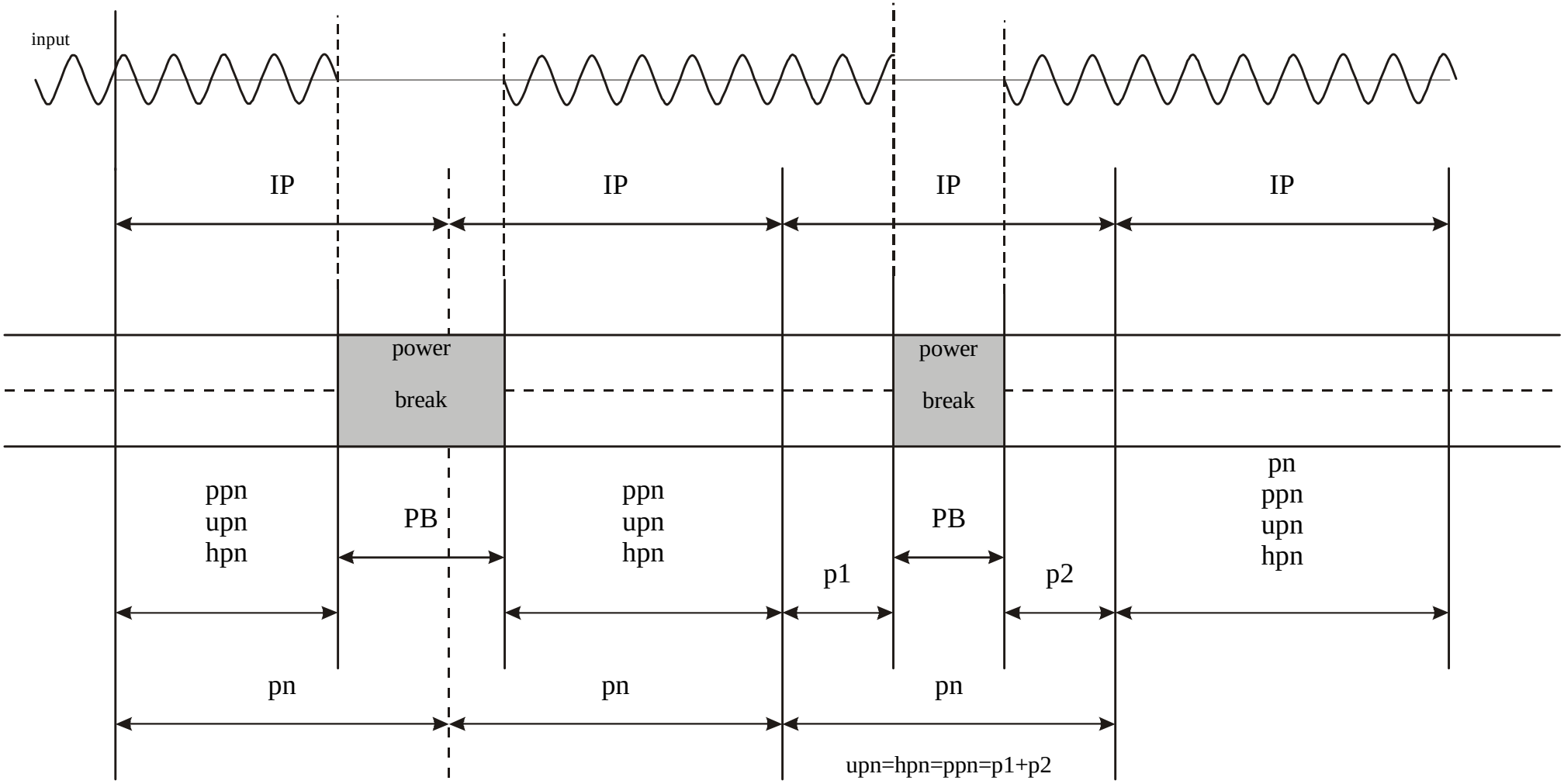

Fig. 48: Input Cycles used for calculation under various Power Break situations

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When measuring Power and Power Factor, values can be calculated for each individual cycle or averaged over a period (the 'Power sub IP') that can be set to any value between 1 and 20 cycles (a 400 ms window at 50 Hz).

If the Instrument is recording a power, it automatically calculates and records the energy of the selected power in an IP.

Values used for the calculation of maximum and minimum Powers and Power Factors are the average values calculated on power sub IP values (see *Fig. 35* below)**.**

Recording of voltage or current THD is automatically enabled if one or more individual voltage or current harmonics are selected.

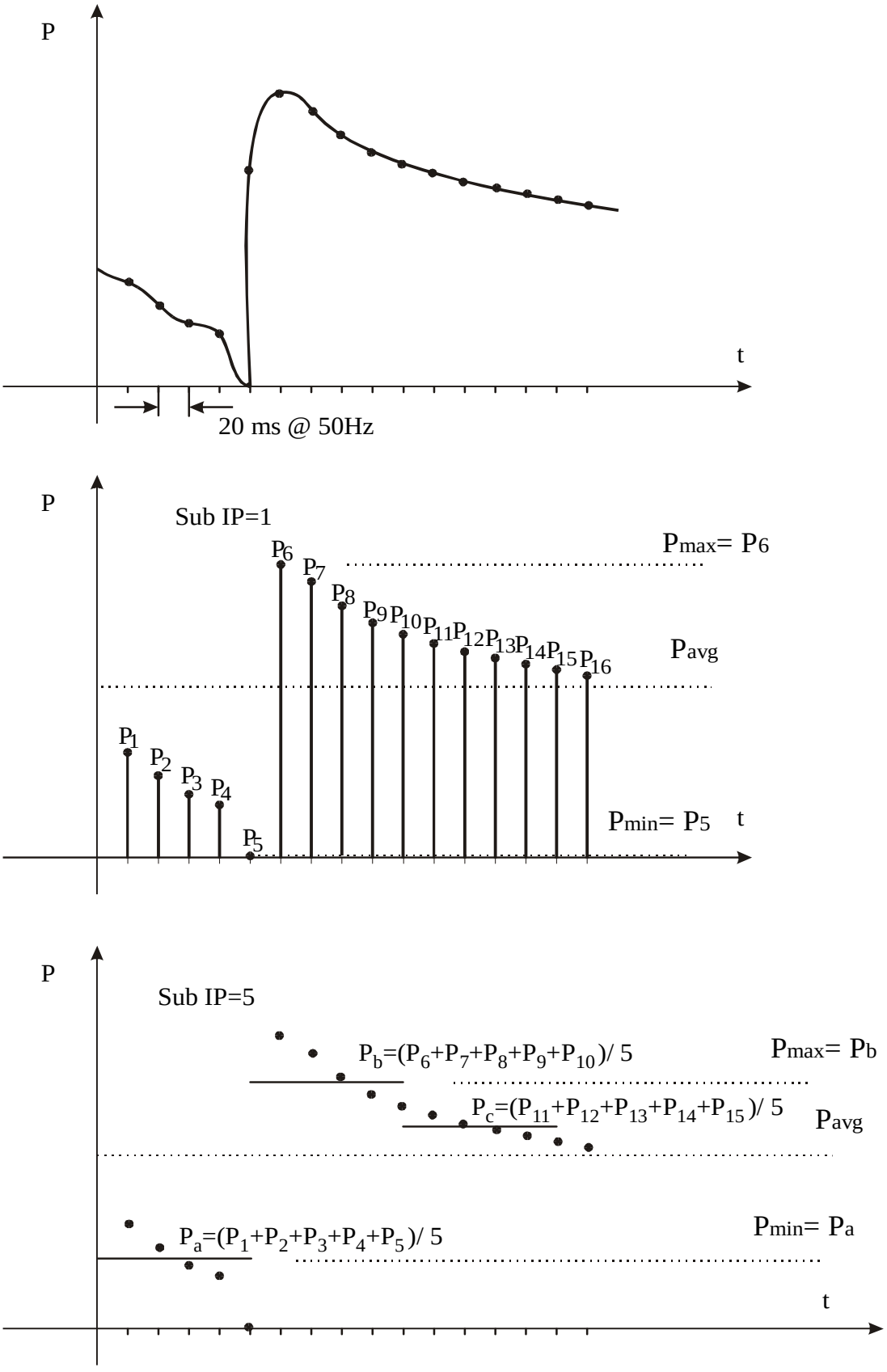


Fig. 49: Examples of calculation of Maximum & Minimum values for various 'Power sub IP' periods

Minimum & Maximum PER PHASE Values

	LOAD TYPE				
VALUE	**CONSUMNIG**		**GENERATING**		**Note**
	inductive	capacitive	inductive	capacitive	[formula]
m Px+	P_X		0		[3]
m Px-	0		P_X		[3]
m Qxi+	Q_X	0	0	0	[7]
m Qxc+	0	0	0	Q_X	[7]
m Qxi-	0	0	Q_X	0	[7]
m Qxc-	0	Q_X	0	0	[7]
m PFxi+	PF_X	1	na	na	[8]
m PFxc+	na	na	1	PF_X	[8]
m PFxi-	na	na	PF_X	1	[8]
m PFxc-	1	PF_X	na	na	[8]
m U_X	U_X				[1]
m I_X	I_X				[2]
m $U_X$thd	$U_X$thd				[10] -max only
m $I_X$thd	$I_X$thd				[11] -max only
m cosφ_X	cosφ_X				[9]
m U_XH_n	U_XH_n				[12]
m I_XH_n	I_XH_n				[13] -max only

Available Maximum & Minimum per phase Values for each Input Cycle

Note: *$U_X$thd, $I_X$thd, cosφ_X, U_XH_n, I_XH_n are calculated every 8th input cycle*

Minimum & Maximum TOTAL (3φ) Values

	LOAD TYPE				
VALUE	**CONSUMNIG**		**GENERATING**		**Note**
	inductive	capacitive	inductive	capacitive	[formula]
m Pt+	P_t		0		[14]
m Pt-	0		P_t		[14]
m St+	S_t		0		[16]
m St-	0		S_t		[16]
m Qti+	Q_t	0	0	0	[15]
m Qtc+	0	0	0	Q_t	[15]
m Qti-	0	0	Q_t	0	[15]
m Qtc-	0	Q_t	0	0	[15]
m PFti+	PF_t	1	na	na	[17]
m PFtc+	na	na	1	PF_t	[17]
m PFti-	na	na	PF_t	1	[17]
m PFtc-	1	PF_t	na	na	[17]
m I_0	I_0				
m Freq	Freq				

Available Maximum & Minimum 3φValues for each Input Cycle

Note: *P_t, S_t and Q_t are average values in power sub integration period that is from 1 to 20 input cycles. PF_t is also a result of those values*

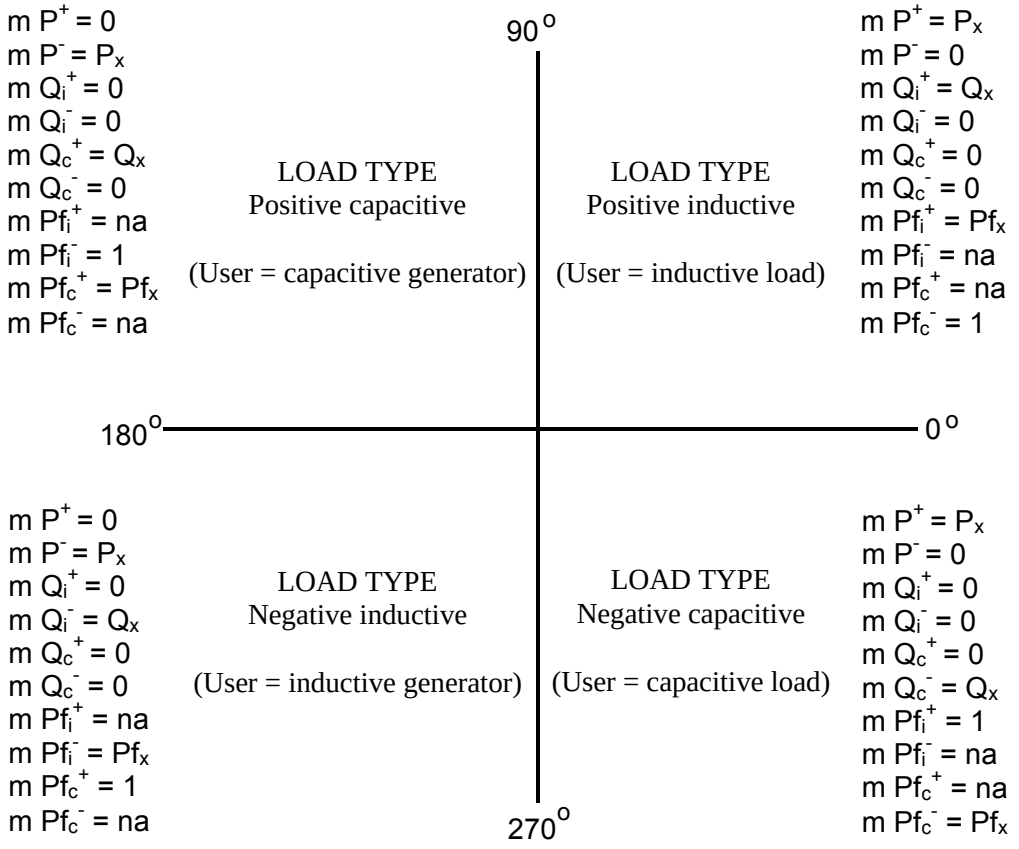


Fig. 50: Import/Export and Inductive/Capacitive Phase/Polarity Diagram

Per Phase Values (averaged at the end of an IP)

Watts	$aP_x^+ = \frac{\sum_{j=1}^{n}\left(P_x^+\right)_j}{pn}$	$aP_x^- = \frac{\sum_{j=1}^{n}\left(P_x^-\right)_j}{pn}$
VAr	$aQ_{xi}^+ = \frac{\sum_{j=1}^{n}\left(Q_{xi}^+\right)_j}{pn}$	$aQ_{xc}^+ = \frac{\sum_{j=1}^{n}\left(Q_{xc}^+\right)_j}{pn}$
VAr	$aQ_{xi}^- = \frac{\sum_{j=1}^{n}\left(Q_{xi}^-\right)_j}{pn}$	$aQ_{xc}^- = \frac{\sum_{j=1}^{n}\left(Q_{xc}^-\right)_j}{pn}$
PF	$aPf_{xi}^+ = \frac{aP_x^+}{\sqrt{\left(aQ_{xi}^+\right)^2 + \left(aP_x^+\right)^2}}$	$aPf_{xc}^+ = \frac{aP_x^+}{\sqrt{\left(aQ_{xc}^+\right)^2 + \left(aP_x^+\right)^2}}$
PF	$aPf_{xi}^- = \frac{aP_x^-}{\sqrt{\left(aQ_{xi}^-\right)^2 + \left(aP_x^-\right)^2}}$	$aPf_{xc}^- = \frac{aP_x^-}{\sqrt{\left(aQ_{xc}^-\right)^2 + \left(aP_x^-\right)^2}}$
Volts & Amps	$aU_x = \frac{\sum_{j=1}^{n}\left(U_x\right)_j}{upn}$	$aI_x = \frac{\sum_{j=1}^{n}\left(I_x\right)_j}{pn}$
Harmonics	$aU_x thd = \frac{\sqrt{H_y U_x}}{H_1 U_x} * 100$; $H_y U_x = \frac{\sum_{z=1}^{n}\left(\sqrt{\sum_{j=2}^{63}\left(Uh_n\right)_j^2}\right)_z}{hpn}$; $H_1 U_x = \frac{\sum_{z=1}^{n} U_x h_1}{hpn}$	
	$aI_x thd = na$	$a\cos\varphi_x = na$
	$aU_x H_n = na$	$aI_x H_n = na$

Note: *If power breaks occur, periods 'pn' (for power calculations) and 'upn' (for voltage calculations) are modified to:*

$$pn = \frac{IP}{ic} - \frac{pb}{ic} \qquad upn = \frac{IP}{ic} - \frac{pb}{ic} - ic_l$$

Where are:

ic input cycle time
pb power break time inside the IP
ic_l number of cycles with $U_X < 0.02\ U_{range}$

Total 3φ Values (averaged at the end of an IP)

Watts	$aP_t^+ = \frac{\sum_{j=1}^{n}\left(P_t^+\right)_j}{pn}$	$aP_t^- = \frac{\sum_{j=1}^{n}\left(P_t^-\right)_j}{pn}$
VAr	$aQ_{ti}^+ = \frac{\sum_{j=1}^{n}\left(Q_{ti}^+\right)_j}{pn}$	$aQ_{tc}^+ = \frac{\sum_{j=1}^{n}\left(Q_{tc}^+\right)_j}{pn}$
VAr	$aQ_{ti}^- = \frac{\sum_{j=1}^{n}\left(Q_{ti}^-\right)_j}{pn}$	$aQ_{tc}^- = \frac{\sum_{j=1}^{n}\left(Q_{tc}^-\right)_j}{pn}$
VA	$aS_t^+ = \sqrt{\left(aP_t^+\right)^2 + \left(aQ_{ti}^+ + aQ_{tc}^+\right)^2}$	$aS_t^- = \sqrt{\left(aP_t^-\right)^2 + \left(aQ_{ti}^- + aQ_{tc}^-\right)^2}$
PF	$aPf_{ti}^+ = \frac{aP_t^+}{\sqrt{\left(aQ_{ti}^+\right)^2 + \left(aP_t^+\right)^2}}$	$aPf_{tc}^+ = \frac{aP_t^+}{\sqrt{\left(aQ_{tc}^+\right)^2 + \left(aP_t^+\right)^2}}$
PF	$aPf_{ti}^- = \frac{aP_t^-}{\sqrt{\left(aQ_{ti}^-\right)^2 + \left(aP_t^-\right)^2}}$	$aPf_{tc}^- = \frac{aP_t^-}{\sqrt{\left(aQ_{tc}^-\right)^2 + \left(aP_t^-\right)^2}}$
Current &Frequency	$aI_0 = \frac{\sum_{j=1}^{n} I_{0j}}{pn}$	$aFreq = \frac{\sum_{j=1}^{n} Freq_j}{pn}$

Note: *If power breaks occur, period 'pn' (for power calculations) is modified to:*

$$pn = \frac{IP}{ic} - \frac{pb}{ic}$$

Where:

ic *input cycle time*
pb *power break time inside the IP*

Voltage unbalance calculation according to IEC 61000-4-30, paragraph 5.7.

4. VOLTAGE ANOMALY RECORDING

Voltage anomalies occur when a voltage exceeds preset boundaries. The rms voltages of each half input cycle are used for comparison. For every Voltage Anomaly detected, the Instrument stores:

- Date & time when the anomaly started.
- The nominal voltage.
- Minimum or maximum voltage during the anomaly.
- The previous 64 rms values, calculated on half input cycles (half periods), before the anomaly occurred.

Voltage Anomaly recording is enabled on selected voltage inputs and can be calculated based either on a fixed tolerance window or on a variable tolerance window.

Fixed Tolerance Mode The nominal voltage is set by the user, and the high and low limits are set as a percentage of the nominal voltage.

Variable Tolerance Mode The nominal voltage is calculated and is the average voltage during the previous anomaly integration period (settable between 1 and 900 s). The new nominal reference voltage can be up to ± 30 % of the programmed nominal voltage. High and low limits are set as a percentage of the nominal voltage and can be between ± 1 % and ± 30 % of the nominal voltage.

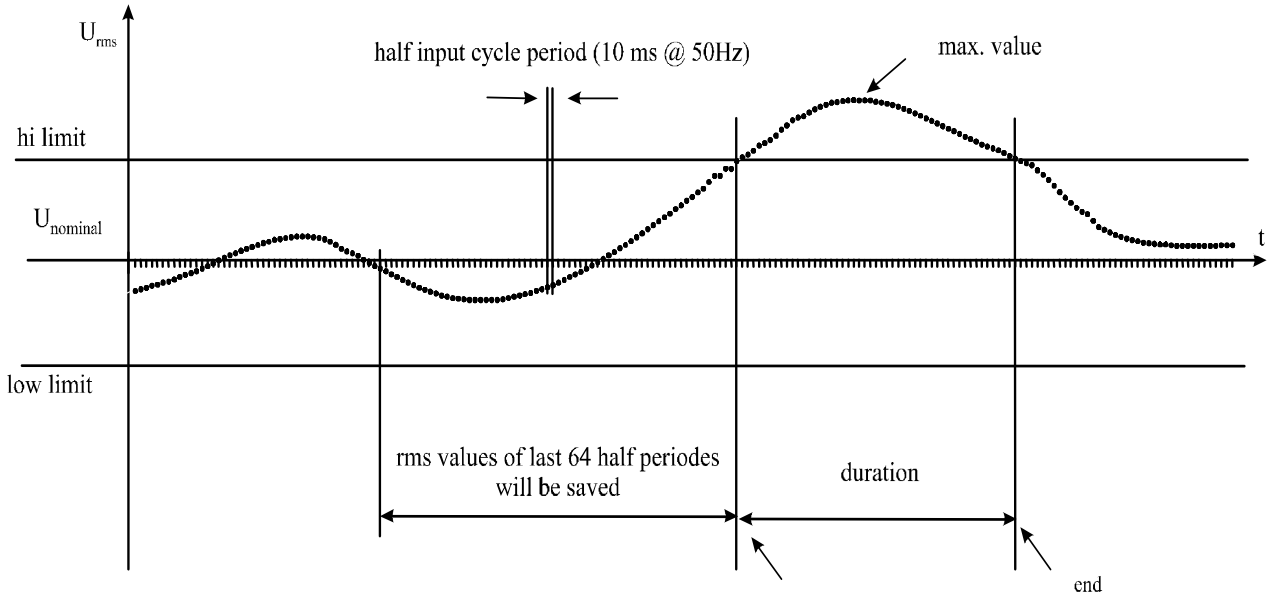


Fig. 51

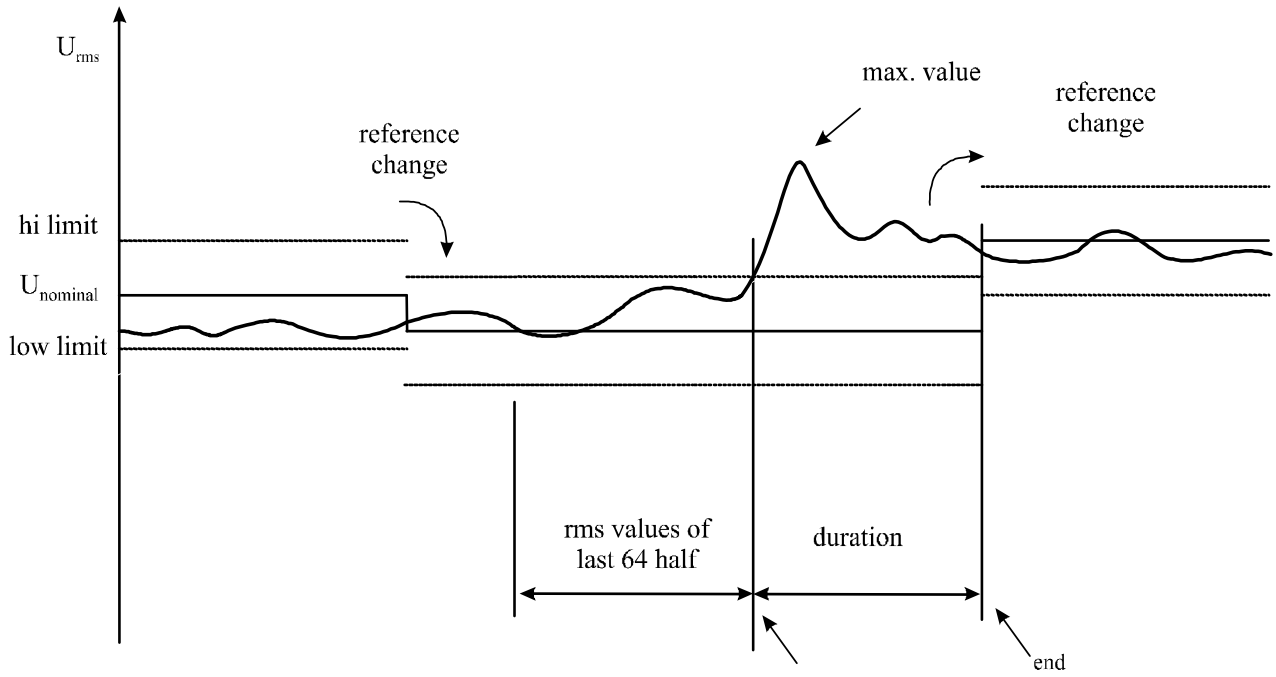


Fig. 52

5. POWER BREAKS RECORDING

If data logging is in progress, the start of every OFF state of the instrument is treated as a Power Break. This OFF state occurs either if the instrument is switched OFF (using the rotary switch) or if it lose its power supply, either battery or mains.
For each Power Break, the instrument logs the date & time of both the beginning and end of the power break, and the cause of the power break (manual or loss of supply).

6. WAVEFORMS

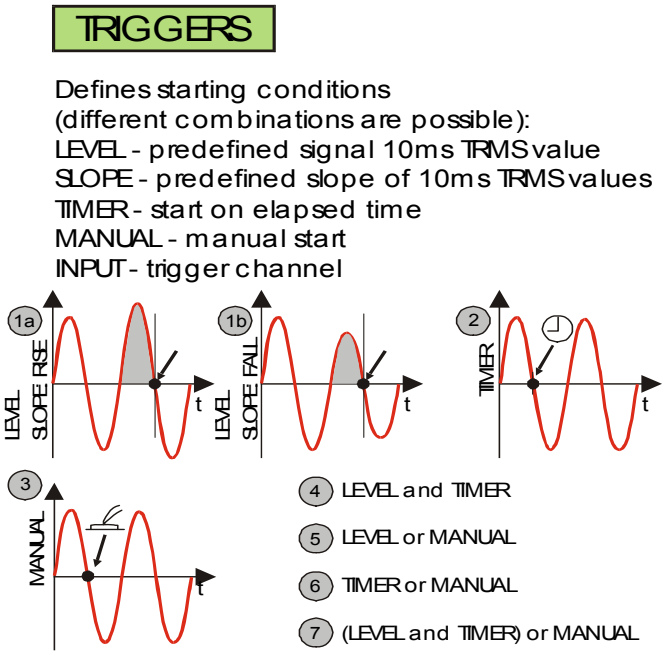


Fig. 53: Triggers in Waveforms recording

Waveform measurement is a powerful tool for troubleshooting and capturing current and voltage response in a switching situation. Waveform method saves waveforms of selected inputs on a trigger occurrence. The trigger can be set manually, by timer or when half-period RMS value of selected trigger input rises/falls above/below a trigger level. Selected pre- and post- trigger periods expressed in periods of power frequency or in seconds are stored in the instrument's memory. Each saved period in a waveform record consists of 128 sampled values.

7. FAST LOGGING

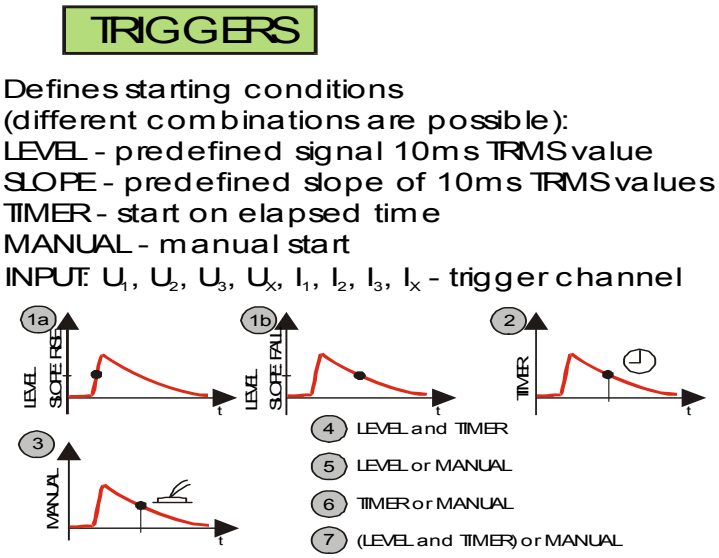


Fig. 54 Triggers for fast logging recording

Fast logging is a measurement similar to a waveform recording but instead of storing 64 points in a wave half-period only the RMS value of the particular half-period is saved. In this case only 1/64 of the memory is spent on record data. Triggering and signal selection are the same as for waveform recording.

8. TRANSIENTS

Transient is a term for **short, highly damped** momentary voltage or current disturbance. There are two types of transient overvoltages:

- impulsive overvoltages
- oscillatory overvoltages

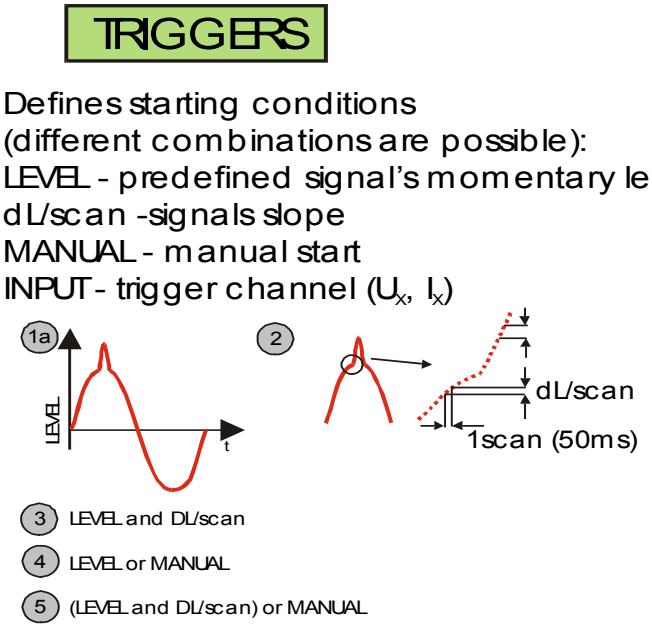


Fig. 55: Transients

Transient recording is the measurement method with the fastest sampling rate that the instrument can provide. Up to 25 kHz signals can be captured in this mode of operation.
The Principle of measurement is similar to waveform recording, but with a higher sampling rate. With single signal enabled for capturing, there are 1000 samples in a 50 Hz signal period. When all six signals are enabled, 400 samples per period per signal are stored in the instrument memory.

Relation between selected signals and sampling time is given in table below.

Table: sampling times

Selected signals	No. of inputs	Sampling time
single voltage input	1	20 μs
single current input	1	20 μs
all voltage inputs (U_1, U_2, U_3)	3	30 μs
all current inputs (I_1, I_2, I_3)	3	30 μs
one voltage and one current input	2	40 μs
U_1, U_2, U_3, I_1, I_2, I_3	6	50 μs

9. FLICKERS

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 56.

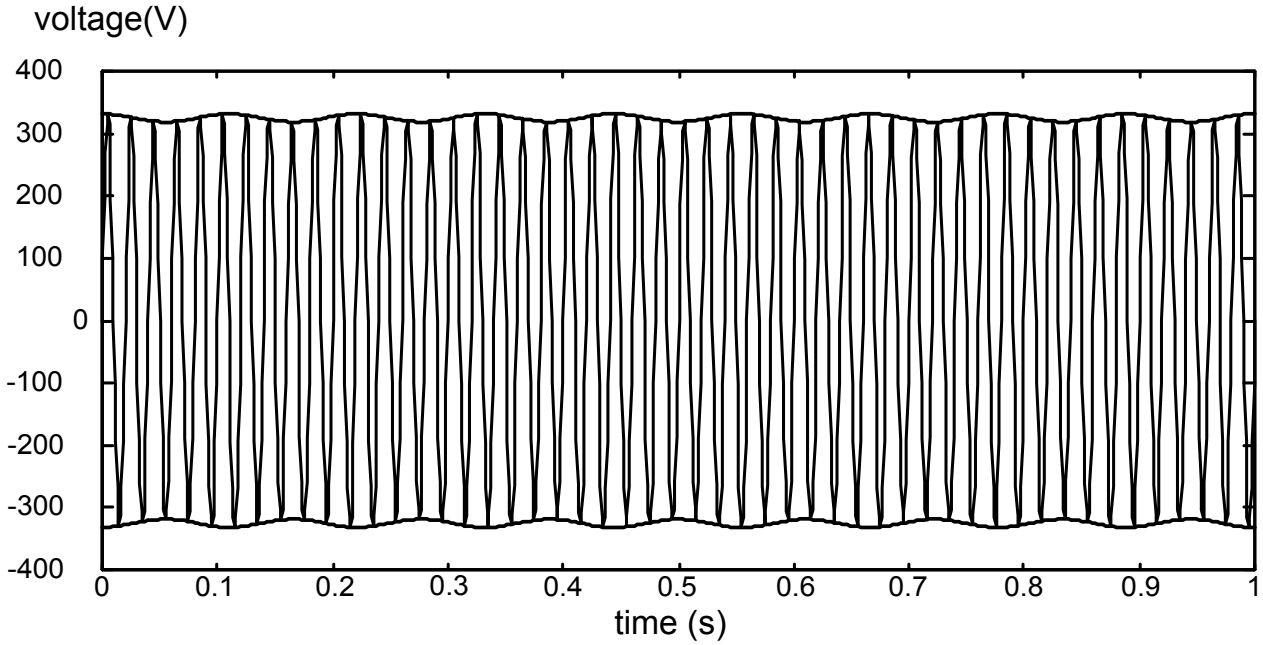


Fig. 56: Voltage fluctuation

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 57.

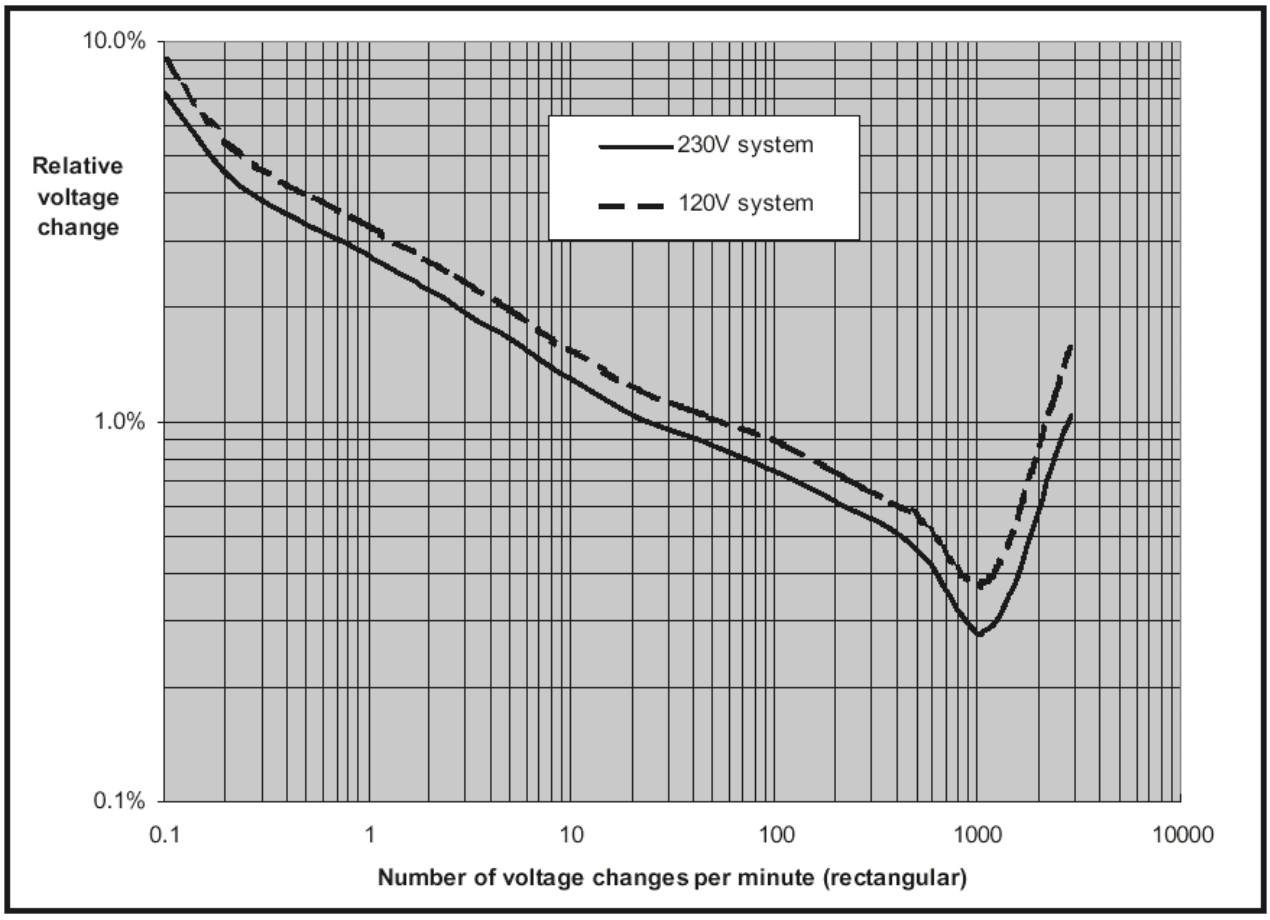


Fig. 57: Curve of equal severity (Pst=1) for rectangular voltage changes on LV power supply systems

10. EN50160

Standard EN50160 "Voltage characteristic of electricity supplied by public distribution systems" is a standard that defines the voltage characteristics of a Low voltage (LV) and Medium voltage (MV) distribution system. It is used as a base for utility-client contracts in the European Union and for small power generation contracts.

The following table presents the limits defined in EN50160. If no voltage level is explicitly stated, then the same limit is valid both for both LV and MV.

The measurement procedure is very simple: one must connect the voltage of all 3 phases to an instrument, choose "EN50160" measurement and measurement can start. All parameters except time of the beginning and end of recording are automatically set. Start and stop time can be set or manual start-stop sequence must be performed over a one week period.

Table 1: EN50160** limits for characteristics of supply voltage

Characteristic	Nominal value	ip	Variation min/max	Meas. period	Note
Power frequency	50 Hz	10 s	- 1 % / + 1 % @ 99.5 % of a year - 6 % / + 4 % @ 100 % of a year	1 week	
	50 Hz	10 s	- 2 % / + 2 % @ 95 % of a week - 15 % / + 15 % @ 100 % of a time	1 week	for isolated systems
Magnitude of supply voltage	LV: 230 V MV: Uc				until 2003: LV Un may be according national HD 472 S1
Supply voltage variation	LV: Un MV: Uc	10 min 10 min	- 10 % / + 10 % @ 95 % of a week - 15 % / + 10 % @ 100 % of a week - 10 % / + 10 % @ 95 % of a week	1 week 1 week	
Rapid voltage changes	LV: Un MV: Uc		generally ± 5 % max. ± 10 % several time a day generally ± 4 % max. ± 6 % several time a day	1 day	indicative
Flicker severity			Plt < 1 @ 95 % of a week	1 week	Pst is not used
Supply voltage dips	LV MV		10 - 1000 / year, < 1 s, depth < 60 % caused by large loads 10 - 1000 / year, < 1 s, depth < 60 % caused by large loads and faults	1 year	indicative depth: % of Un (Uc)

Table 2: Continued

Characteristic	Nominal value	ip	Variation min./max.	Meas. period	Note
Short interruptions			10 to several hundreds, 70 % < 1 s	1 year	indicative; duration < 3 min
Long interruptions			10 - 50	1 year	indicative; prearranged are not counted in
Temporary overvoltages	LV MV		< 1.5 kV rms up to 5 s < 2.0 Uc; failures < 3 Uc; ferro resonance		indicative
Transient overvoltages	LV MV		< 6 kV		indicative
Supply voltage unbalance		10 min	< 2 % @ 95 % of the week, occasionally up to 3 %	1 week	
Harmonics		10 min	table 4 @ 95 % of the week	1 week	
Inter-harmonics		10 min	limits under consideration	1 week	NOT INCLUDED in report
Mains signalling		3 s	less then EN50160 curve on Figure 16 @ 99 % of a day	1 day	NOT INCLUDED In report

11. MEMORY USAGE

The instrument contains non-volatile memory for storing of recorded data. Storing records slightly differs between Periodics and EN 50160 and/or Waveforms, Fast logging and Transients recording modes.

11.1. Memory for Waveforms, Fast logging and Transients

Figure 57 describes the storing modes and buffer organization of one measurement record relative to trigger event. While the instrument waits for the trigger it takes measurements. When the trigger occurs it still continues to measure and prepares the data for storing according to the selected pre-trigger and total buffer length.

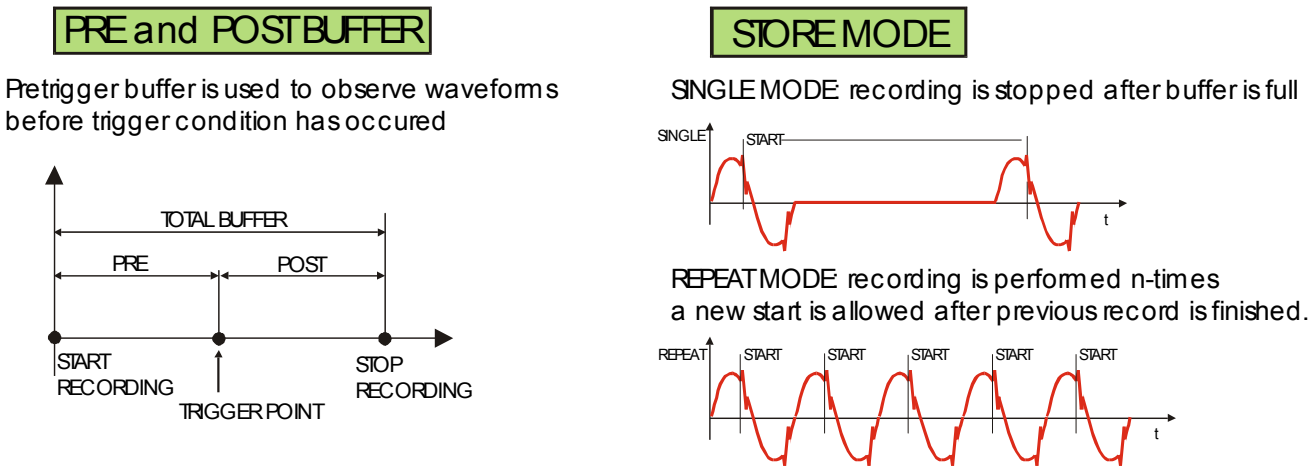


Fig. 57: Explanation of storing philosophy for Waveforms, Fast logging and Transients recordings

11.2. Memory for EN 50160 and Periodics

EN 50160 and Periodics mode have linear and circular storing possibilities, i.e. in linear mode the instrument continues logging until the memory is full while for circular mode it has continuous recording with overwriting of the oldest records. It is good praxis to predict logging period.

11.3. Record length

Following table contains of the summary of record length for each recording option.

Recording function	Record length in bytes
Periodics *Record unit: main IP* Periodics Statistics Anomalies and power breaks	Number of non-power signals * 6 + number of power signals * 12 + Number of harmonic signals * 6 (for selected phases) + 12 (header). 780 Number of signals * 1024 164 (each anomaly)
Waveforms *Record unit: 1s and/or 1 period*	Record length per period: number of selected signals * 256 Number of records per second: value of system frequency (45 to 66)
Fast logging *Record unit: 1s*	For 50Hz: number of selected signals * 200 For 60Hz: number of selected signals * 240
Transients *Record unit: 1 period*	Sampling in transients measurement: Selected signals Scan Rate [Hz] Transient detect ability [□s] 1 50000 20 2 33333 30 3 25000 40 6 20000 50 Record length: Scan Rate * selected signals * 2 / System frequency
EN50160 *Record unit: main IP* Flickers Periodics Anomalies and power breaks	Number of non-power signals * 6 + number of power signals * 12 + Number of harmonic signals * 6 (for selected phases) + 12 (header) 780 780 164 (Each anomaly)

Notes: Power signals: Active power (P), reactive power (Q) and apparent power (S).
Options in Periodics and EN50160 increase record length if enabled.
2Mbyte of memory is available for storing results.

Example for EN 50160 recording mode

Example for evaluation of record lengths and maximum recording times for EN50160 recording function
Common data:

- recording in three phase system with following selection: all phase voltages and currents, system frequency, three power signals and 18 harmonics per phase (54 signals)
- disabled flickers, periodics and anomalies.

Record length calculation:

Item	Item quantity	Bytes/item	Bytes in record	
non-power signals	7	6	42	
power signals	3	12	36	
harmonic signals	54	6	324	
header	-	12	12	
		Record length	414	Bytes

One main integration period (IP) record contains in this example 414 bytes. It is maximum 4830 stored records or for approximately 33.5 days at main IP of 10min.

Continuing this example but with enabled flickers, periodics and anomalies. Enabled periodics adds to each record 780 bytes and increase record length to 1194 bytes, while anomaly and flicker increase length of the record only when they occur.
Record length with flicker: 1194 + 780 = 1974 [bytes],
Record length with anomaly and flicker: 1194 + 780 + 164= 2138 [bytes],
Let us assume 15% flicker (only) probability and 5% probability of anomaly and flicker.
Following is comparison of these data and also for main IP = 10 min.

Item	**Rec. length [bytes]**	**Max. No. records**	**Max. recording time [days]**	**Note**
All disabled	414	4830	33.5	
Periodics	1194	1675	11.6	
Periodics + Flicker	1974	1013	7	100% flicker
Periodics + Flicker + voltage anomaly	2138	935	6.4	100% flicker, voltage anomaly
Periodics + Flicker + voltage anomaly	1194 to 2138	1471	10.2	15% flicker, 5% voltage anomaly

12 MODEM DATA TRANSFER

1. INTRODUCTION

Modem data transfer enables remote handling of the instrument and its data. When the instrument has to be located on distant or hardly accessible place, the modem is the only practical solution for fast access to the instrument. It is only necessary to connect modem to the instrument at the location where measurements are performed and activate modem control. The instrument and modem are connected via RS232 interface.

Minimum requirements for the instrument and modem interface:

Equipment	PC Software ver.	Firmware ver.
Power Harmonics Analyzer PHA 3300	Power Link 4.0	Ver 5.00 + modem option
Power Quality Analyzer Plus PQA 6600	Power Link 4.0	Ver 5.00

Minimum requirements for PC:

- PC Pentium, Windows 98 or higher

2. MODEMS

It is possible to use a range of standard (analog) and GSM modems with a PC and the instrument.The following table shows possible combinations for remote measuring system:

On PC side	On measuring place
Standard (analog) internal modem	GSM terminal modem or Standard (analog) external modem
Standard (analog) external modem	
GSM terminal modem	

All PC external modems and modems for the instrument must have RS232 interface.
GSM modem connected to the instrument needs a PIN card with included DATA number (VOICE number is included by default but it is not needed). Please contact your GSM provider for the DATA number.
Application described in this manual is based on 'Siemens TC35 GSM terminal' modem and 'US Robotics – Faxmodem' standard (analog) modem. For a third party modem device, apply appropriate settings as required by modem vendor.

We recommend preparing a test system for verification and training before performing actual measurements at the remote place.

Required accessories

Standard (analog) modem (external):	GSM modem:
- Modem - RS232 interface cable - Modem power supply - Active standard phone line	- Modem - RS232 interface cable - Modem power supply - Antenna - PIN card with active data (mandatory) and voice (optional) phone numbers

Notes:

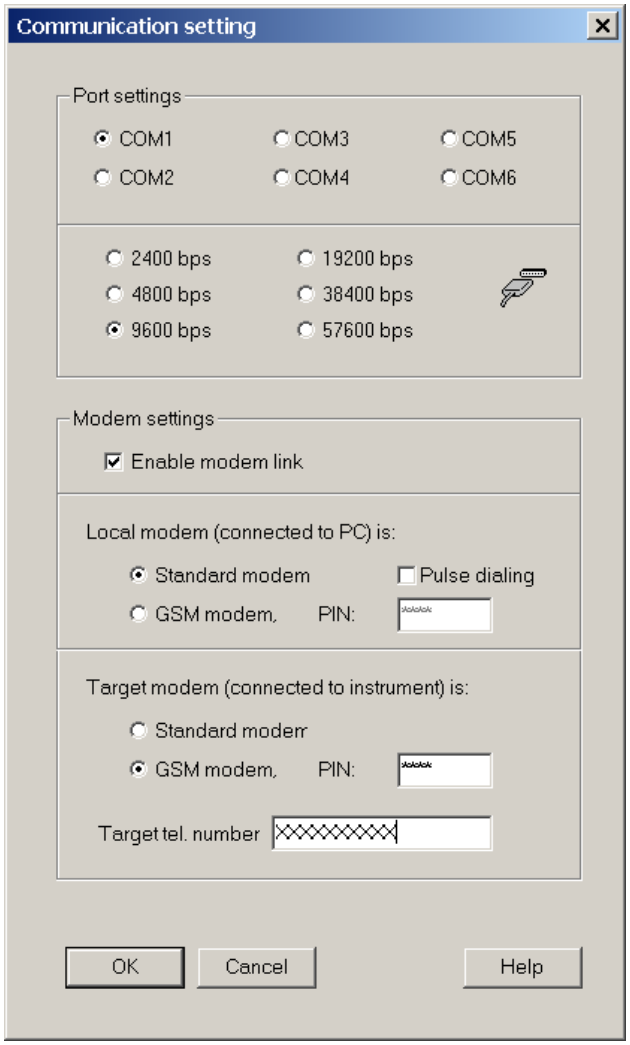
- For GSM system, pay attention to install its antenna at the appropriate place with good signal condition.
- **If modem communication is enabled, it is not possible to transfer data from the instrument to the PC using RS232 connection. To enable direct RS 232 connection between the instrument and PC, you should disable modem communication in Power Link and on the instrument**.

3. MODEM, INSTRUMENT AND POWER LINK CONFIGURATION

3.1. Power Link configuration

Power Link software should be configured before establishing modem communication. The following procedure is required:

- Run Power Link application.
- Select **Communication Settings** menu and enable modem communication (see the following figure).



- Select **GSM** or **Standard modem** for local and standard modem.

- Enter PIN codes for local modem (connected to PC) and target modem (connected to the instrument) if required.
- Enter the phone number of the target modem (connected to the instrument) the program will communicate with.
- Set suitable baud rate.
- Save the settings.

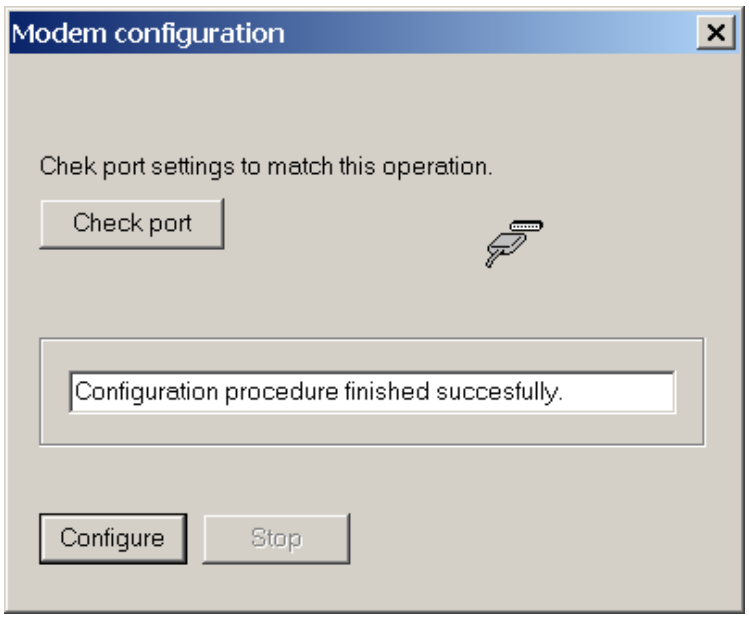
Note:
- Serial port baud rate is automatically set to 9600 Bauds (for GSM modem) and cannot be set to any other rate.
- Take care that all devices (PC, both modems and instrument) are set to the same baud rate.

3.2. Modem configuration at the PC side

The modem connected to the PC should be configured before use. The PC with internal modem does not need any external extension. For external modem do the following:
- Connect the modem to the unused COM port of the PC using RS232 interface cable. The modem and PC should be switched off when connecting them together.
- Switch them on and wait until the PC finishes its initialization sequence.
- Insert PIN card in the case of using GSM modem.
- Connect telephone line to the modem in the case of using standard modem.

3.3. Modem configuration at the instrument side

The modem connected to the instrument should be configured before use. Use the Power Link and do the following configuration procedure:
- Insert PIN card into modem (for GSM modem).
- Connect modem to the PC, run Power Link and click ''**Modem** / **Configure target modem**'' (see the following figure).



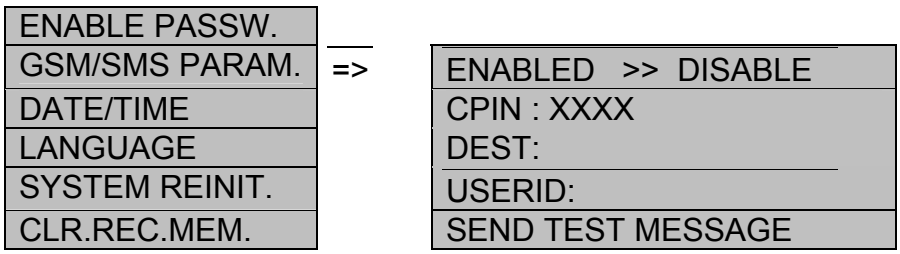
- Disconnect the modem from the PC and connect it to the instrument with special RS232 cable (see chapter 4 for connection diagram) , both must be in the power off state (switched off).

When the modem is being configured with Power Link the following settings are executed:
- disable PIN for GSM modem (AT+CPIN=XXXX and AT+CLCK="SC",1,XXXX,
- enable automatic answering (AT&D0),
- set automatic answering after 2 RINGS (ATS0=2),
- set ECHO answering to OFF (ATE0),
- disable "Wait for dial tone" option (ATX0),
- set PORT baud rate for standard (analog) modem,
- save parameters (AT&W),
- activate saved parameters (ATZ).

When the third party modem requires different settings we recommend using the Hyper Terminal program for modem configuration. It is part of standard Windows setup. You can find it on your PC: Programs / Accessories / Communications / Hyper Terminal.

3.4. Instrument configuration for modem communication

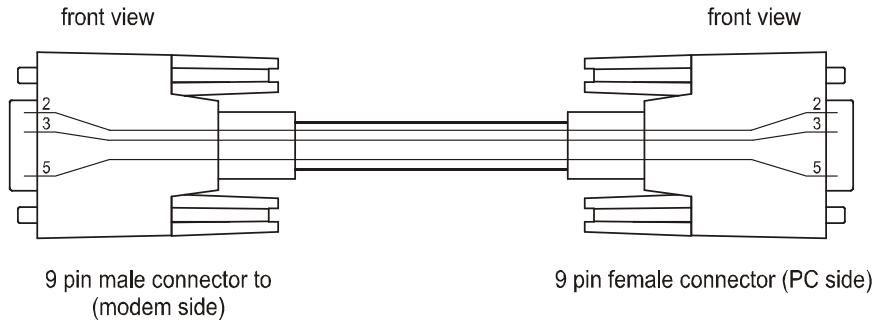
Instrument should be configured before communicating with the PC via modem communication. The following procedure is required:
- Modem should be connected to the instrument.
- Switch the instrument on.
- Switch the modem on.
- In **SYSTEM** menu select **SER.PORT RATE / GSM/SMS PARAM.** / DISABLED for Standard (analog) modem.
- In **SYSTEM** menu select **SER.PORT RATE / GSM/SMS PARAM.** / ENABLED for GSM modem (it enables sending of SMS messages).



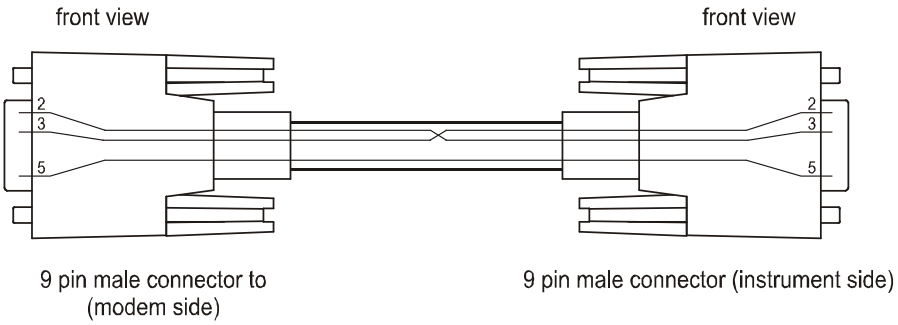
- Enter PIN code using cursor keys: UP/DOWN to increment/decrement selected number and LEFT/RIGHT to select previous or next number (for GSM modem).
- Press ENTER to confirm entry or ESC to discard it.

I you want to disable sending of SMS messages (when using GSM modem) you should set GSM/SMS PARAM. to DISABLED and set SERIAL PORT RATE to 9600.
If a GSM modem is used on the PC side and Standard modem is used on the instrument side, baud rate of 9600 bps must be used for the standard modem.

4. MODEM CONNECT. WITH PC AND INSTRUMENT

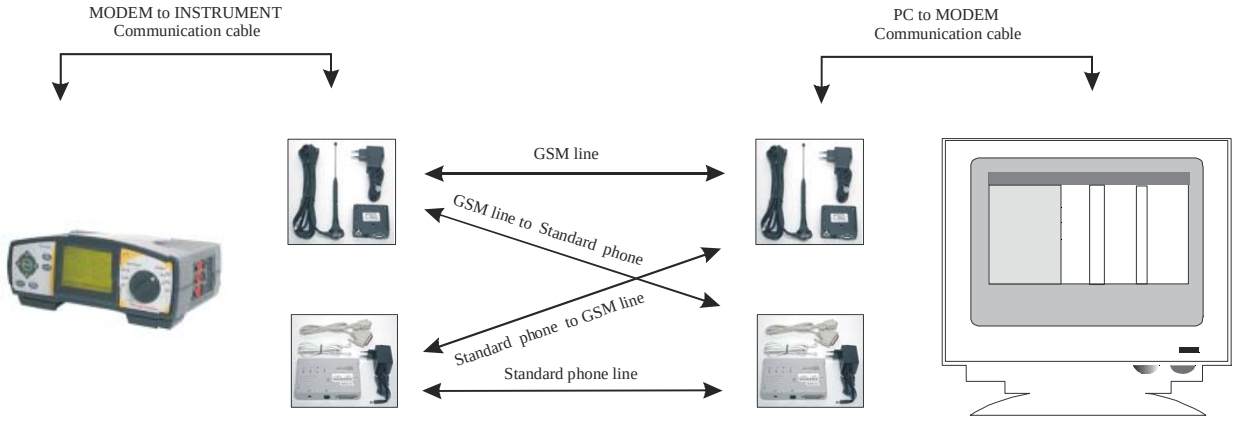


PC to MODEM communication cable



MODEM to INSTRUMENT communication cable

RS 232 communication cables



MODEM, INSTRUMENT and PC connection

5. CONNECTING AND DISCONNECTING MODEMS

When the modems are connected and suitably set at the instrument and the PC, just click the "**Make modem connection**" button in Power Link toolbar or select "**Make modem connection**" in **Modem** menu. It takes a few seconds (up to 30 s) to establish communication link. The instrument operates as it is connected directly to the PC via RS232 interface. It means that all interface functions are active, e.g.: receive / transmit instrument settings, data download, manipulating of the recording function, clear memory.

To disconnect just click on "**Hang-up modem connection**" button on Power Link toolbar or select "**Hang-up modem connection**" in **Modem** menu.

6. SMS MESSAGES

The instrument has possibility to send an SMS message to the mobile phone when GSM modem communication is enabled. Messages are intended to inform the operator about some events regarding the instrument.
The following events can be sent as SMS messages:

- Less than 50% of recording memory is free.
- Less than 20% of recording memory is free.
- Recording memory is full.
- WAVEFORM, FAST LOGGING, TRANSIENT, EN50160 or PERIODICS recording is finished.

For SMS messaging prepare the following configuration:

ENABLE PASSW.		
GSM/SMS PARAM.	=>	ENABLED >> DISABLE
DATE/TIME		CPIN :
LANGUAGE		DEST: XXXXXXXXXXXX
SYSTEM REINIT.		USERID: XXXXXXXXXX
CLR.REC.MEM.		SEND TEST MESSAGE

- Enter Destination phone number "**DEST:**" (phone number of the mobile phone that will receive SMS messages from the instrument) using cursor keys.
- Enter user ID "**USER ID**": (optional instrument identification string) using cursor keys as described in chapter 3.4.
- Provide PIN card of modem terminal with the number of your local.
- It can be done with "SEND TEST MESSAGE" command in GSM/SMS PARAMETERS menu of the instrument.

Press Enter to confirm settings or ESC to discard them.

Note:

- SMS message cannot be sent if modem communication is established.

If you do not want the instrument to send SMS, disable GSM/SMS PARAM. and set baud rate to 9600

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