USER'S MANUAL

SONEL ANALYSIS 3
software
Applies to power quality analyzers:
PQM-700, PQM-701(Z, Zr), PQM-702(T),
PQM-703, PQM-707, PQM-710, PQM-711

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Note:
Due to continuous development of our software, the actual appearance of some screens may slightly differ from that presented in this operating manual.
This manual describes the software and analyzers in the following versions:
Sonel Analysis – v3.0.0
PQM-700 – v1.07
PQM-701Z/Zr – v1.16
PQM-702, PQM-703, PQM-710, PQM-711 – v1.17
PQM-707 – v1.00

Note:
The latest version of the software may be downloaded from our website:
www.sonel.pl.

Note:
Detailed information about the analyzer functions may be found in the operating manuals of specific analyzers.

PQM-700 *The icon with the analyzer name (here: PQM-700) is placed next to sections of the text that refer to specific features of the analyzer, particularly to availability/unavailability of a given program function.*

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1 Installing and starting the program

"*Sonel Analysis 3*" is an application required to work with power quality analyzers of PQM-7XX series. It enables the user to:
- configure the analyzer,
- read data from the device,
- real-time preview of the mains,
- delete data in the analyzer,
- present data in the tabular form,
- present data in the form of graphs,
- analyze data for compliance with EN 50160 standard (reports) and other user-defined reference conditions,
- independent operation of multiple devices,
- upgrade the software and the device firmware to newer versions.

It is possible to simultaneously run multiple instances of *Sonel Analysis*.

> **Note**
>
> *Sonel Analysis 3 software is available in two versions:*
> - **desktop version**, *for use with all PQM-7XX family analyzers, installed on desktop PC,*
> - **tablet version**, *installed on tablets that are supplied with PQM-710 and PQM-711 analyzers. This version differs from the desktop variant in screen and controls look, mainly due to adaptation to tablet screen resolution and touch panel operation.*
>
> *Unless otherwise noted, the screenshots presented in this manual are taken from desktop version.*
>
> *Hardware requirements described in sec. 1.1 and installation process described in sec. 1.2 apply to desktop version. Unless otherwise noted, the functionality of both versions is the same.*
>
> *Both versions of software are available for download from manufacturer's website: www.sonel.pl. Only one instance (version) of software can be installed on PC or tablet.*

1.1 Minimum hardware requirements

Tab. 1 presents the minimum and recommended configuration of a PC running "*Sonel Analysis 3*" software.

Tab. 1. Minimum and recommended PC configuration.

Configuration	Minimum	Recommended
Processor	1.5 GHz	3.0 GHz
RAM	1 GB	4 GB
Free space on hard disk	200 MB	16 GB
Graphics card	32 MB, resolution 1024x768	128 MB with support for OpenGL, resolution 1920x1080
USB	•	•
Internet access (for automatic updates)		•
Operating system	Windows XP, Windows Vista, Windows 7, Windows 8, Windows 10	

1.2 Installation of the program

> **Note**
> **In order to facilitate installing drivers for the analyzer, it is recommended to install "Sonel Analysis 3" software (including drivers as described in the following instructions) before connecting a USB cable.**
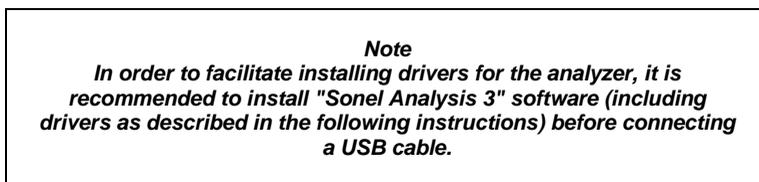
To start the installation of "*Sonel Analysis 3*" software, run the installation file (e.g. " *Setup Sonel Analysis 3.0.0.exe*") included on the disk supplied with the analyzer or downloaded from the manufacturer's website www.sonel.pl.
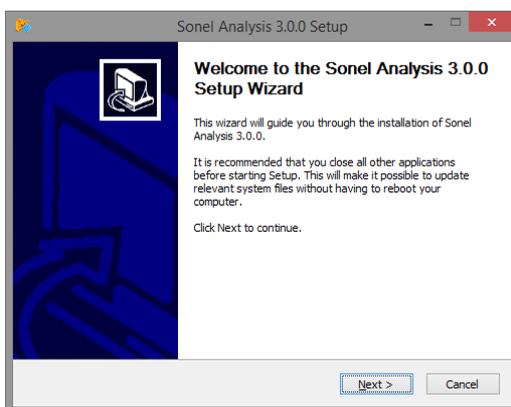
Fig. 1. Installer - the initial screen.

Click "Next>". Please read the software license agreement and click "I agree". On the next screen, specify location for the application to be installed and click "Next>".
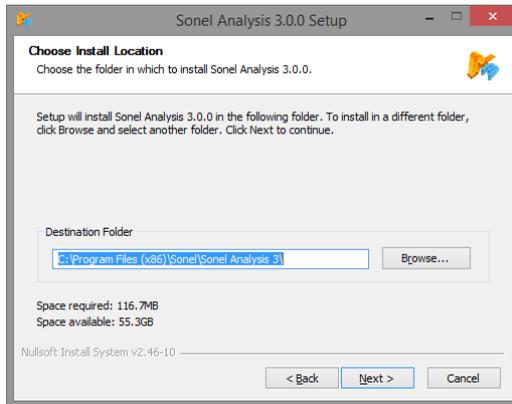
Fig. 2. Installer – program location settings.
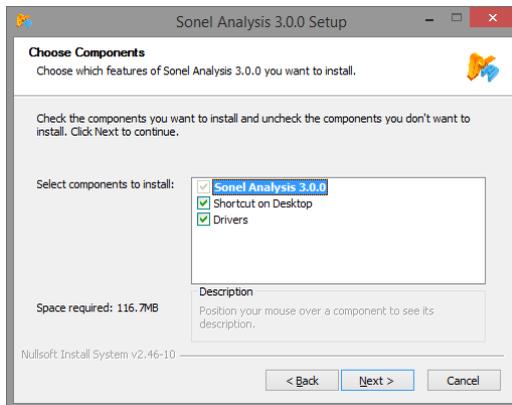
Fig. 3. Installer – choosing components.

Use component selection screen to select "Drivers" option and optionally tick "Create shortcut on the desktop". Then click "Next>"

The final step is to determine the location and name of the program, which will appear in the **Start** menu. The installer is ready to install the program.

To begin the installation, press "Install".

In the final part, the program installs the drivers (if the user has chosen this option). Drivers for OR-1 wireless module and for PQM analyzer also must be installed (unless the analyzer does not support communication via OR-1, e.g. PQM-710). Depending on the operating system, the installation wizard may look slightly different than the one shown in the presented screenshots. After the installation wizard for drivers is displayed, follow the on-screen instructions. For Windows XP, select "Install the software automatically (recommended)". For Windows Vista, Windows 7 and Windows 10, just select "Next>" and after installation is completed close the wizard, by clicking "Finish" button.
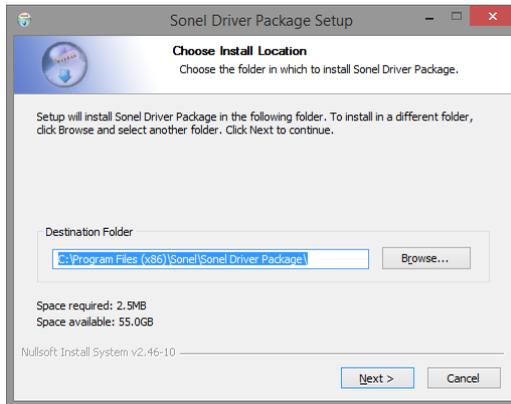
Fig. 4. Installer of driver package.
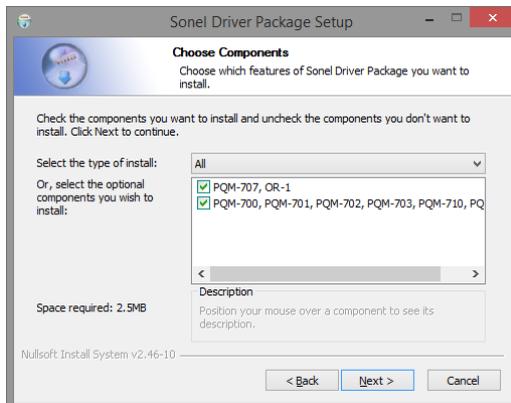
Fig. 5. Installer – selecting drivers to be installed.

At the end of the software installation when computer reboot is required, the window shown in Fig. 6 will be displayed. Otherwise when "Launch *Sonel Analysis 3*" box is selected, then after pressing "Finish" button, the application will be launched.
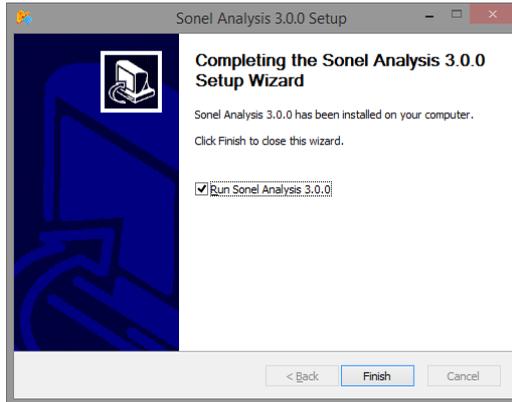
Fig. 6. Finishing the installation.

At this point, the analyzer may be connected to a PC. The system should automatically recognize the connected device.

If the installation was successful, the computer is ready to cooperate with the analyzer.

1.3 Starting the program

When the program starts, the main window appears as shown in Fig. 7. The individual icons have the following meanings:

- **OPEN** – depending on the context, it enables the user to load the analyzer configuration (files *.settings*), saved analysis (files *.analysis*), or saved recording from the disk (files *.pqm7XX*),
- **SAVE** – depending on the context, it enables the user to save the analyzer configuration on the disk (while editing the configuration), save raw data or present analysis files (during the analysis),
- **SETTINGS** – measurement configuration module of the analyzer,
- **LIVE MODE** – the mode of reading current, real-time values of mains,
- **ANALYSIS** – the module for data analysis directly from the analyzer or from the memory card,
- **CONTROL** – window for controlling recording and changing the measuring point,
- **ANALYZER DATABASE** – module for managing analyzers cooperating with *Sonel Analysis*,
- **PROGRAM CONFIGURATION** – module for configuring options of *Sonel Analysis*,
- **DISCONNECT** – ends the communication session with the analyzer.

Extensions of the files created by "*Sonel Analysis 3*" software are as follows:
- *.settings* – analyzer configuration files (for measurement points),
- *.config* – "*Sonel Analysis 3*" configuration files,
- *.pqm7XX* – recorded data files (source format of the analyzer),
- *.analysis* – analysis files.

The user may select commands from the top menu, by clicking icons with the mouse, or by using keyboard shortcuts (they are valid in the whole program):
- F3 – analyzers base,
- F4 – current analyzer settings (including time and security),
- F5 – analyzer configuration,
- F6 – Live mode - reading current values,
- F7 – Control window,
- F8 – data analysis,

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- F9 – *Sonel Analysis* settings,
- CTRL+S – saves the analysis on the disk or saves a screenshot in the live mode,
- CTRL+O – opening of a file stored on disk.

There are many other keyboard shortcuts. Most of them are visible in the menu next to the name of an item.

Tip
The user may select commands using a mouse / keyboard (standard operation similar to Windows, ENTER - select option, ESC - Cancel, TAB - move to the next button, etc.).
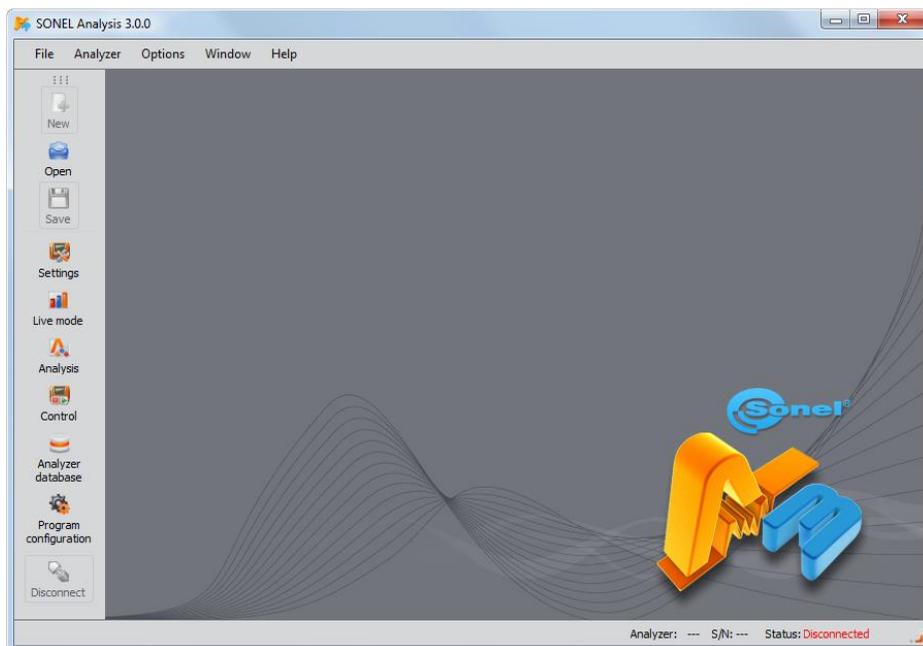
Fig. 7. The main screen.

1.4   Selecting the analyzer

Before sending any data from/ to the analyzer, it is necessary to select the analyzer to which "*Sonel Analysis 3*" software will connect. In order to establish the connection with the analyzer,
- select any option that requires an active connection e.g. **SETTINGS**, **LIVE MODE** or **ANALYSIS**,
- use **ANALYZER DATABASE** and connect to the indicated analyzer by selecting it from the list, then use the **CONNECT SELECTED** option.

After choosing one of the above options (when no previous connection was established), the program displays window **CONNECTION** and starts scanning in the search for available analyzers (see Fig. 8). The analyzers are searched via cable (USB) and using wireless connections (when

OR-1 is connected to a PC and when a given analyzer offers this function). The user may also activate the option in the program settings of searching analyzers connected via GSM (applies to analyzers with built-in GSM modem) after enabling option **TCP/IP OVER GSM** in program configuration. Analyzers operating with Wi-Fi may be found after they are correctly configured (see sec. 2.4 and the manual of the analyzer) and after selecting option **WIFI** in section **ACTIVE MEDIA**.

After a successful scan, the list of detected analyzers appears on the screen. Analyzers are displayed with their model, serial number and the type of communication link. Clicking on the selected analyzer and pressing **SELECT** icon approves the analyzer selected from the list. The analyzer may be also selected by double clicking on its field. Pressing **SEARCH AGAIN** restarts scanning in the search for the analyzers.

It should be noted that the first listed option search for all analyzers listed in the analyzer database and those directly connected with a USB cable, which extends the search process. At the other hand, the second option (connecting to the analyzer indicated in the database) is trying to find just the indicated analyzer, which significantly shortens the connection process, when the analyzer database is extensive. Particularly large delay is related to the search of analyzers via the GSM network.

After selecting the analyzer, the program asks the user to enter PIN code, which protects it against unauthorized access. It consists of three digits (0...9). By default PIN is set in the factory at 000.

Note
When wrong PIN is entered three times in a row, data transmission is blocked for 10 minutes.

PQM-707 PQM-707 does not require a PIN code when connecting.
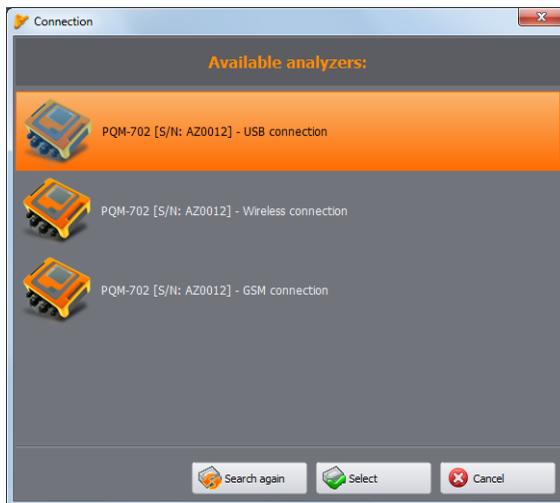
Fig. 8. Analyzer Selection Window.

> ***Notes***
> - *Detecting an analyzer via OR-1 wireless module, Wi-Fi or GSM is possible only when the unique serial number of this analyzer was earlier entered into the analyzer database (doesn't apply to PQM-707). Basing on this number, the software filters other analyzers (e.g. those within the range of radio interface) which are not owned by the owner of a given software copy.*
> - *The serial number may be entered into the database manually (section 2.4) or after connecting the analyzer via USB, entering correct PIN code and selecting* STORE PIN IN DATABASE *option (see Fig. 9). Then the analyzer is added to the database of the analyzers (doesn't apply to PQM-707).*

If the **STORE PIN IN DATABASE** option is checked in the authorization window, the serial number and the entered PIN will be associated, to avoid the need to entry it again during the next connection (serial number and analyzer model are automatically added to the analyzer database). After a successful connection, a window should appear to confirm the connection with the analyzer – see Fig. 10. This screen displays the analyzer information, such as its serial number, firmware and hardware versions.

If automatic log-in is unsuccessful, the window shown in Fig. 9 is displayed again.
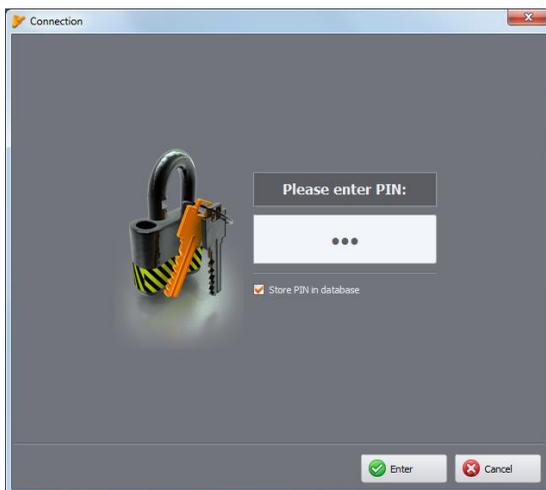
Fig. 9. PIN code verification.
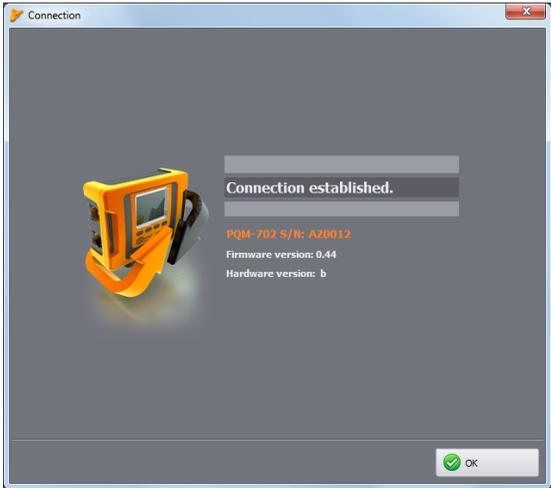
Fig. 10. The successful connection with the analyzer.

Entering incorrect PIN results in displaying window shown in Fig. 11.

Note
When the transmission is blocked after three unsuccessful attempts to enter the PIN, during the next attempt to connect to the analyzer, the window will appear with the following message "Communication blocked! Incorrect PIN code!"
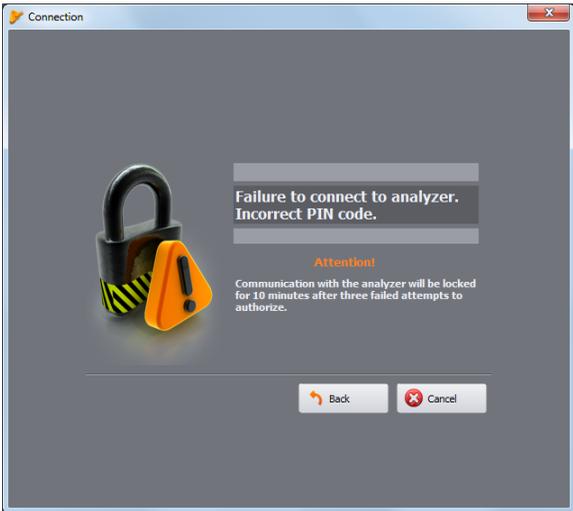
Fig. 11. Incorrect PIN.

An unsuccessful attempt to connect the analyzer for reasons not attributable to PIN will trigger the error message. Press **RETRY** button to repeat the attempt, or go to the analyzer selection window and select another analyzer, or rescan for available analyzers.

When during the communication the analyzer is switched off or the USB cable is plugged out, or other event would prevent receiving answer from the analyzer, the message shown in Fig. 12 will be displayed.

Fig. 12. Connection lost.

2   Analyzer Measurement Settings

PQM-707 *Note: The analyzer measurement settings module is not available in PQM-707.*

After selecting option **ANALYZER→SETTINGS** from the main menu (or clicking the icon) **SETTINGS** window will be displayed as shown in Fig. 13. It is the most important part of the analyzer configuration. Here the user determines which parameters will be recorded by the analyzer; the mains type and nominal values of the parameters.

The left part of the screen is divided into two parts (Fig. 13): **LOCAL** and **ANALYZER**. Top part (**LOCAL**) is used by the user for parameters modification, whereas the bottom part (**ANALYZER**) shows the current analyzer settings and is of read-only type. Each part has a drop-down tree divided into four **MEASUREMENT POINTS** and **ANALYZER SETTINGS**.

PQM-700 PQM-700 has only one measurement point.
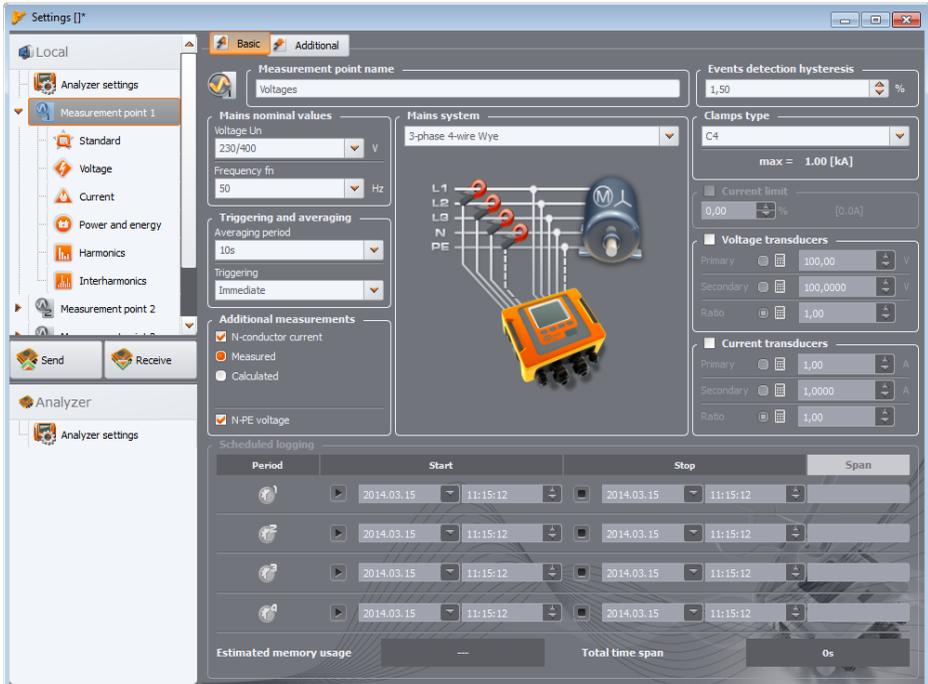
Fig. 13. Configuration of measurement points - settings tree.

Each of the four measurement points represents an independent measurement configuration of the analyzer. This is the place where the user defines the mains system, nominal voltage, frequency, type of clamps and parameters for recording and detecting events.

The icons next to the measurement points may be displayed in various colors:
- grey - no connection with the analyzer,
- green - present configuration is synchronized with the analyzer configuration and with the configuration saved on the disk.
- blue - current configuration is compatible with the analyzer, but differs from the one saved to the disk,
- yellow - the configuration is not compatible with the analyzer, but is compatible with the one saved to disk,
- red - the current configuration is not compatible with the analyzer and not compatible with the one saved to disk.

RECEIVE button is used to read the analyzer current settings in order to edit them in the computer. If the settings have been previously modified by the user, a warning message will be displayed. The correct reading is also confirmed by a relevant message. Then all icons in the measurement point tree will change to blue, which means that the settings in the application and in the analyzer are identical.

SEND button is used to send the settings from the top part (**LOCAL**) to the analyzer. Before sending the settings, the user is asked to confirm the operation (Fig. 14).

Fig. 14. Confirmation of entered settings.

> *Note*
> *Sending new configuration will erase all data on the memory card.*
> *The user should read data previously collected from the analyzer*
> *and save it to local disk.*

> *Note*
> *Saving new settings in the analyzer is not possible when the device is in*
> *the recording mode (an appropriate message will be displayed to inform*
> *about this – Fig. 15).*

Fig. 15. Programming impossible due to recording in progress.

2.1 Analyzer settings

The first element to be configured in the left-hand side of the configuration window is **ANALYZER SETTINGS**. This part is divided into three tabs:

- **ANALYZER TYPE**: allows the user to choose the analyzer model for which the settings will be modified. As the software provides support for several models of analyzers with different capabilities, the user should pre-select the analyzer type from the list, to match the settings with analyzer performance. If the user is already connected to the analyzer, the analyzer type is selected automatically. In addition, the user may specify the type of the default analyzer in the program configuration (see section 5.3.1),

- **PQM-701** **PQM-702** **PQM-703** **PQM-710** **PQM-711** **MEMORY ALLOCATION**: this tab (Fig. 16) allows user to allocate space of the analyzer's memory card to the individual measurement points. Use four sliders to allocate desired amount of memory to a given point (in MB and %). In the middle part of the screen you will see a visualization of memory allocation. All available card memory (100%) may be freely divided among the four measurement points. It is possible to allocate 100% of the memory to a single measurement point; in such case recording in other points is impossible - for them only "live" preview of mains parameters is available. All measurement points have linear recording in the memory, when the memory allocated to a given point is used up, the recording stops. Please remember that modification of memory allocation will require deleting all data from the memory card. Thus, it is advisable to download such data and save it on a local disk. New memory allocation is sent to the analyzer after clicking **SEND** button (along with configurations of all measurement points).

- **PQM-702** **PQM-703** **PQM-710** **PQM-711** **GPS SYNCHRONIZATION**: two parameters included here are provided to define the behavior of the analyzer when the time measurement source changes during recording.

  TIME RESYNCHRONIZATION THRESHOLD defines the time difference (in seconds) between the RTC (Real Time Clock) of the analyzer and UTC (Universal Time Clock) received from the GPS satellites. If the difference between the two clocks is greater than the time entered in the field, then the analyzer immediately change its time to UTC. If the difference does not exceed the threshold value, the analyzer will gradually reach UTC without the immediate (step) change. **TIME RESYNCHRONIZATION THRESHOLD** set to zero disables the immediate time shifting and ensures a gradual resynchronization. The speed of the re-synchronization is controlled by **RESYNCHRONIZATION FACTOR**. It is a percentage value from 0 to 100, which defines how fast the internal analyzer time will achieve UTC time during in the resynchronization process. When the **RESYNCHRONIZATION FACTOR** is equal to 100%, then in every second, half of the second time is skipped (shifted) forward or backward. At lower values of the factor, such correction is proportionately slower, prolonging the re-synchronization time.

  If the recording process is not active, then the change in the internal time is always immediate.
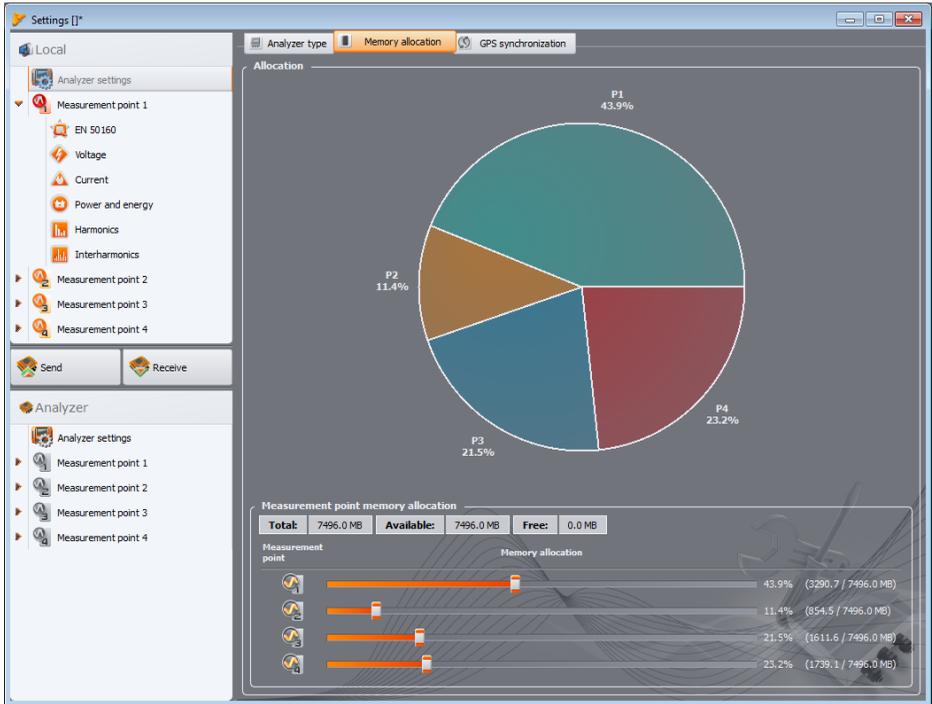
Fig. 16. Window memory allocation.

2.2 Measurement point configuration

To drop down the "tree" of a measurement point, click once on the triangle at the measurement point, or double-click on a given measurement point.

Highlighting (by single-clicking) selected measurement point will result in displaying its **main settings** on the right side of the screen. Main settings consist of two tabs: **BASIC** and **ADDITIONAL**. After dropping down selected measurement point, the following list is displayed:

- **STANDARD** – settings for recording in accordance with EN 50160 and other standards,
- **VOLTAGE** – settings of voltage-related parameters, divided into two tabs: **BASIC** and **ADDITIONAL**,
- **CURRENT** – current parameters,
- **POWER AND ENERGY** – power and energy parameters divided into three tabs: **POWER**, **ADDITIONAL** and **ENERGY**,
- **HARMONICS** – harmonics parameters divided into three tabs: **VOLTAGE**, **CURRENT** and **ADDITIONAL**,
- **INTERHARMONICS** – interharmonics parameters divided into three tabs: **VOLTAGE**, **CURRENT**, **MAINS SIGNALLING**.

It is possible to transfer settings between different measurement points. To copy the settings from one point to another, right-click on the header of **MEASUREMENT POINT X** (where **X** is the number of the point) in the tree of measurement points and select **COPY**. Then, to transfer these settings to

another point, right-click them (as above) and select **PASTE (POINT X)** (where **X** is the number of the point).

The next chapters presents the description of the main settings screen, and its individual cards.

2.2.1   Main Settings

2.2.1.1 BASIC Tab

Main settings screen of the measurement point and **BASIC** tab is shown in Fig. 17. It is divided into a few sections: the mains-related settings are grouped in the top part, whereas the part located below relates to recording according to the schedule and time intervals. In addition, here the user may assign desired name to a measurement point and assign the hysteresis used during the event detection.
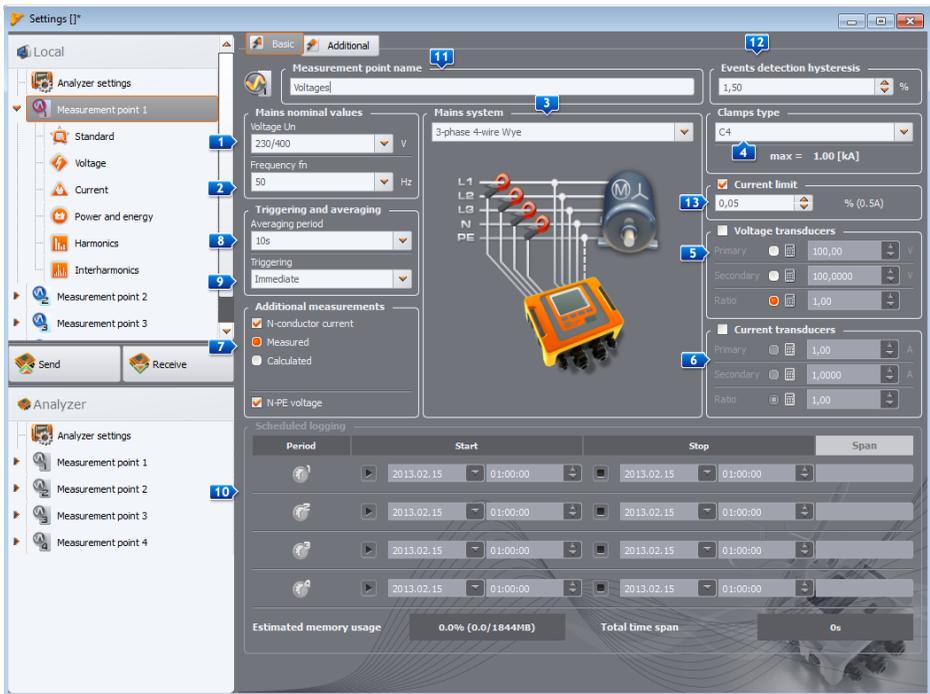
Fig. 17. Setting the mains parameters, nominal mains parameters and transducers.

The following parameters are defined in the part related to the mains:
- **1** **VOLTAGE UN**: nominal voltage 64/110 V, 110/190 V, 115/200 V, 120/208 V, 127/220 V, 220/380 V, 230/400 V, 240/415 V, 254/440 V, 277/480 V, 290/500 V, 400/690 V (phase /phase-to-phase, depending on the mains type; in case of two-phase network, the phase-to-phase voltage is twice the phase voltage),
- **2** **FREQUENCY FN**: Mains nominal frequency – 50 or 60 Hz,
- **3** **MAINS SYSTEM** – one-phase, split-phase, wye with N, delta, wye without N, and Aron's measuring systems; a connection drawing for selected system is shown in the field below the

name. For mains of 3-wire type, the nominal voltage is the phase-to-phase value (the second value specified in **MAINS NOMINAL VALUES 'UN'** field),

- **4** **CLAMPS TYPE** – indicates the type of current clamps used for the measurements. The user may select C-4, C-5, C-6, C-7 CT clamps or F-1/F-2/F-3 flexible clamps. If the current measurement is not required, select **NONE** option.

- **5** **VOLTAGE TRANSDUCERS** – they define the voltage transducers ratio (when used). Please select one of the three possible parameters of the transducer that will be calculated using the other two:

    - Selecting **PRIMARY** will grey out the primary voltage, which is calculated basing on two other parameters that may be changed by the user: the voltage of the secondary circuit - **SECONDARY** and **RATIO**. Primary voltage is calculated as the product of secondary voltage and ratio.
    - Selecting **SECONDARY** will grey out the secondary voltage, which is calculated by the software, basing Primary voltage and Ratio. Secondary output voltage is equal to the quotient of the primary voltage and ratio.
    - Selecting **RATIO** will grey out "Ratio" field. The division is determined by defining the primary and secondary voltage. Ratio is calculated as the ratio of the primary and secondary voltage.

    After turning the option of voltage transducers field **VOLTAGE UN** is greyed out; a new nominal voltage is the primary voltage of the transformer.

- **6** **CURRENT TRANSDUCERS** – define the current transducer ratio. The measuring range of selected clamps may be extended using external current transducers. The same method for determining the ratio is used as in the case of the voltage transducers. Select one of the three parameters, which will be calculated automatically based on the other two. The resulting measuring range (primary current which does not exceed the nominal range of used clamp) is displayed below the clamp selection list.

- **7** **ADDITIONAL MEASUREMENTS** – use the additional option fields to define possible measurements of additional parameters, such as neutral conductor current (with another clamp, if the system type is appropriate) and the N-PE voltage (for systems with separate N and PE conductors). Please note that the analyzer will not measure these parameters, if they are not checked in this place.

    PQM-700 *Note: In PQM-700 analyzer the N-PE voltage measurement is not available.*

- **8** **AVERAGING PERIOD** for measurements – use this field to define the basic results averaging period. Available times (a set of available values may be different for different types of analyzers) are as follows: half-period (special mode, only voltage and current $RMS_{1/2}$ values are recorded), 200 ms, 1 s, 3 s, 5 s, 10 s, 15 s, 30 s, 1 min, 3 min, 5 min, 10 min, 15 min, 30 min, 60 min, 120 min,

PQM-700 **PQM-701** *Note: For PQM-700 and PQM-701, if the user turned on the option of standard-compliant recording in STANDARD tab, it will result in setting the averaging time on 10 minutes and the selection list block averaging period selection list. To change this settings, the user must first disable the standard-compliant recording in the tab.*

- **9** **TRIGGERING** of recording – enables the recording activation mode:
    - **IMMEDIATE** – immediate measurement after pressing START/STOP button or starting the recording process from the software,
    - **SCHEDULED** – scheduled measurement; after recording starts (by pressing the button or from the PC) the analyzer compares the present time with intervals defined in the schedule and uses them to start and stop the recording,

- **THRESHOLD** – measurement after the limit for any active event is exceeded – after activating, the device analyses the mains and waits until a parameter is exceeded - this event triggers recording - at this moment data are recorded (logged) on the memory card.

Other elements of the settings screen (Fig. 17):

- **10 SCHEDULED LOGGING** (recording) – four time periods may be specified. After selecting a given period by clicking the arrow, enter the start date and time (optionally you may specify the end date/time). If the user sets the recording start without defining its end, the device will operate until it is manually stopped or until the memory is filled-up. Time intervals must not overlap - the program does not allow you to configure overlapping ranges. The following time intervals must be set chronologically.

  PQM-700 *PQM-700 analyzer allows only one time period to be defined.*

- **11 MEASUREMENT POINT NAME** – the user may assign a name for selected measurement point; it may consist of maximum 32 characters,

- **12 EVENTS DETECTION HYSTERESIS** – it determines the size of the hysteresis used in determining event detection thresholds. It may be set within the range of 0.01…10.00%. The typical size of the hysteresis is 2%. More about this issue may be found in the operating manual of the analyzer.

- **13** **PQM-702** **PQM-703** **PQM-710** **PQM-711** **CURRENT LIMIT** – when current measurement is enabled, then selecting this option enables user to set the threshold of RMS current, below which the value will be zeroed with all related parameters. See additional description in the operating manual of the analyzer.

2.2.1.2 ADDITIONAL tab

PQM-700 **PQM-701** *Note: In PQM-700 and PQM-701 analyzers this tab is not available.*

Fig. 18 presents the screen after selecting **ADDITIONAL** tab at **MAIN SETTINGS** of the measurement point. Sliders are available in this screen for defining recording time of several types of waveforms and plots:

- **WAVEFORMS** – determining the recording time for instantaneous voltage and current (sampling frequency of 10.24 kHz) accompanying events detected by the RMS voltage (swells, dips and interruptions, exceeding max. threshold values of U_{N-PE}), DC voltage component, RMS current (exceeding minimum and maximum values) and transient events. The user may specify:
  - recording time from 100 ms to 1 s, in 20 ms steps,
  - pretrigger time from 40 ms to 960 ms, in 20 ms steps.

Note: Recording time of waveforms may be different from the stated here, depending on the type of the analyzer. Appropriate times can be found in the user's manual for individual analyzers.

Waveforms are recorded both at the beginning and at the end of the event.
Pretrigger time defines the portion of the total recorded time that will be assigned as "pre-triggering" period (both for starting and stopping). This time cannot be longer than the recording time.
Cyclic waveforms (recorded once per every averaging period) always have fixed time equal to 3 periods and this setting does not applies to them.
To simplify the process, recording and pretrigger times are provided in seconds or milliseconds, but in fact the analyzer records with an accuracy of a single period of mains. For example, setting the waveform recording time at 560 ms and pretrigger time at 380 ms, results in a recording a total of 28 periods of mains and pretrigger equal to 19 periods (for 50 Hz mains). This is important if the mains frequency deviates significantly from the nominal 50 Hz. In case

of mains with 60 Hz the situation is similar, but the number of periods is rounded down after dividing the time set by the nominal period time of 16.67 ms.

In order to enable recording of the waveforms, select option **RECORD WAVEFORMS AND RMS1/2** at **VOLTAGE** card and **BASIC** tab.

- **RMS1/2** – determining the recording time for voltage and current $RMS_{1/2}$ values accompanying events detected by the RMS voltage (swells, dips and interruptions, exceeding max. threshold values of U_{N-PE}) and RMS current (exceeding minimum and maximum values). The following features may be set:
  - recording time from 1 s to 30 s, in 0.1 s steps,
  - pretrigger time from 0.1 s to 4.9 s, 0.1 s in steps.

Note: Recording time of $RMS_{1/2}$ waveforms may be different from the stated here, depending on the type of the analyzer. Appropriate times can be found in the user's manual for individual analyzers.

$RMS_{1/2}$ values are recorded both at the beginning and at the end of the event.
Pretrigger time defines the portion of the total recorded time that will be assigned as "pre-triggering" period (both for starting and stopping). This time cannot be longer than the recording time.

Similarly to waveforms, recording and pre-trigger times are specified in seconds or milliseconds, but in fact the analyzer records a specified number of $RMS_{1/2}$ values, assuming one half-period as 10 ms in 50 Hz networks and 8.33 ms in 60 Hz networks.
In order to start recording $RMS_{1/2}$, select option **LOG WAVEFORMS AND RMS1/2** at **VOLTAGE** card and **BASIC** tab.

- **PQM-703** **PQM-711** **TRANSIENT CHARTS** – for determining recording time of high speed waveforms for voltage channels, where transient events were detected. The following features may be set:
  - recording time (depending on the selected sampling frequency of transients), up to 2 ms for sampling rate 10 MHz and 200 ms for 100 kHz (recording range always includes from 2000 to 20000 samples),
  - pretrigger time is between 10% and 90% of the recording time.

In order to start recording transient graphs, select option **LOG WAVEFORMS AND TRANSIENT CHARTS** at **VOLTAGE** card and **BASIC** tab.

- **PQM-702** **PQM-703** **PQM-710** **PQM-711** **MAINS SIGNALLING** - for defining recording time of ripple control signal waveforms, after detecting exceeded threshold of control signal amplitude (as specified in settings). Consequent 10/12-period values are recorded (i.e. at approximately 200 ms) for the time indicated by slider: from 10 s to 120 s. After recording the entire waveform it is possible to detect the following events of this type with successive time graphs.
Recording of control signals waveforms is activated after selecting **LOG EVENTS (AND TIME PLOT)** at **INTERHARMONICS** card and **MAINS SIGNALLING** tab.

- **PQM-702T** **TEMPERATURE** – temperature recording of external sensor may be activated (only PQM-702T with ST-2 temperature probe). Temperature is recorded with the same averaging time as the other parameters (**AVERAGING PERIOD** parameter in **BASIC** tab), provided that the temperature readings are performed with a frequency of approx. 1 time per second. For averaging periods shorter than this period, recorded temperatures will repeat.
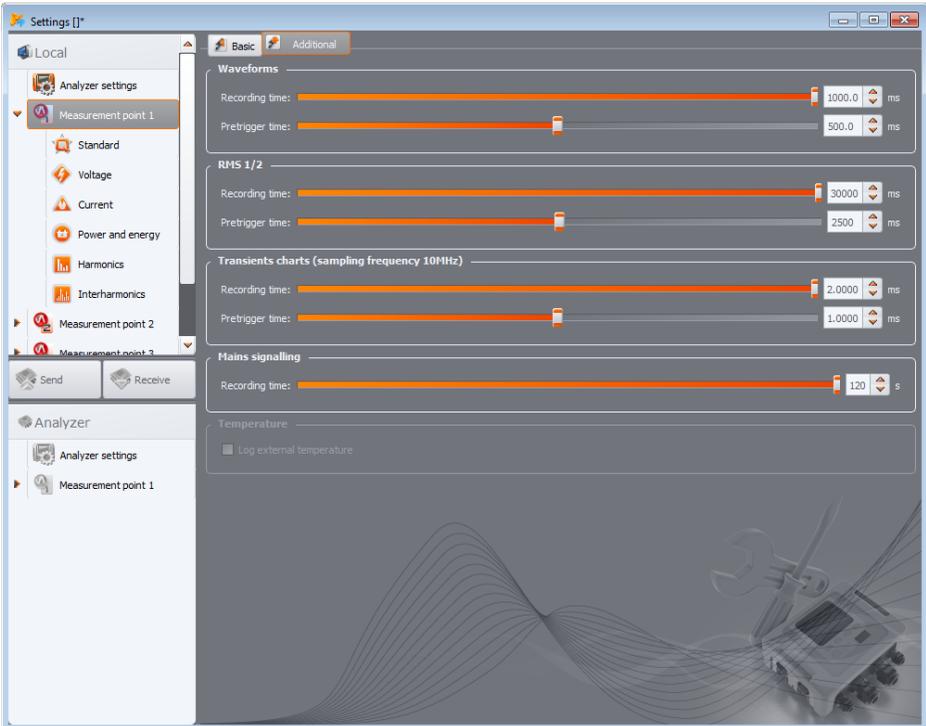
Fig. 18. Additional settings of the measurement point.

2.2.2 Analyzer settings according to Standard

After selecting **STANDARD** position from the selection tree, the user may quickly choose analyzer settings according to EN 50160 or other Standard (Fig. 19). This standard specifies the characteristics and quality criteria that should be met by the distribution networks of low, medium and high voltage. Settings shown in the list are defined in the program settings in the location: **OPTIONS →PROGRAM CONFIGURATION→ ANALYZER SETTINGS→ DEFAULT STANDARD SETTINGS**.

> **Note**
>
> The procedure of measurements for standard compliance is different for different types of the analyzers:
>
> • **PQM-700, PQM-701(Z, Zr), PQM-707:** *activating standard-compliant recording (by ticking box ENABLE LOGGING ACCORDING TO STANDARD) sets the required configuration parameters and blocks them to prevent their modification by the user. Only the parameters required by the selected standard are recorded.*
>
> • **PQM-702(T), PQM-703, PQM-710, PQM-711:** *activating the standard-compliance recording does not prevent the user to set the recording parameters in the user configuration, as the analyzer allows simultaneous recording of parameters required by the standard and completely independent recording according to the user configuration (dual recording). The only exception to the rule of independence are the thresholds of voltage events, which are set in accordance with the standard requirements and cannot be changed. The option of such simultaneous recording is available in the specified analyzers, starting from firmware version 1.17. When you want to record only the standard parameters, turn off (uncheck) all parameters in the recording configuration (leave only ENABLE LOGGING ACCORDING TO STANDARD field active and optionally enable recording of control signals).*

PQM-700 **PQM-701** After choosing from the list a specific Standard, the analyzer marks on the selection tree (of the measurement point) the parameters necessary to perform measurements according to chosen Standard and locks them to prevent inactivating them by the user. For example, if the averaging time was previously set to 3 seconds, after selecting "Enable logging according to standard" and choosing specific Standard from the list, it will change into 10-minutes and it will be grayed out, preventing any further changes. Additionally the following measurement parameters are marked: average voltage, THD voltage, voltage harmonics, etc.

PQM-702 **PQM-703** **PQM-710** **PQM-711** After selecting a specific Standard profile from the list, the program modifies in the configuration only the thresholds of voltage events, leaving all other options available to the user. The analyzer will automatically record all the parameters necessary to generate a report on compliance with the Standard (switching on the recording of control signal is left to the user). The recorded Standard parameters will also be available for viewing. Regardless of recording data for compliance with the standard, the user may adjust almost all parameters for own recording (except for the above mentioned thresholds for voltage events), according to own averaging time and types of parameters. Such recording is called dual recording – both sets of recorded parameters may be independently analysed in the **ANALYSIS** module. For example, it is possible to enable recording for compliance with the standard (e.g. 10-minute averages will be recorded for RMS voltage and harmonics, 10-second for frequency values) and the simultaneous recording for diagnostic purposes covering the specified parameters with 1-second averaging (including the average of 1-second voltage).
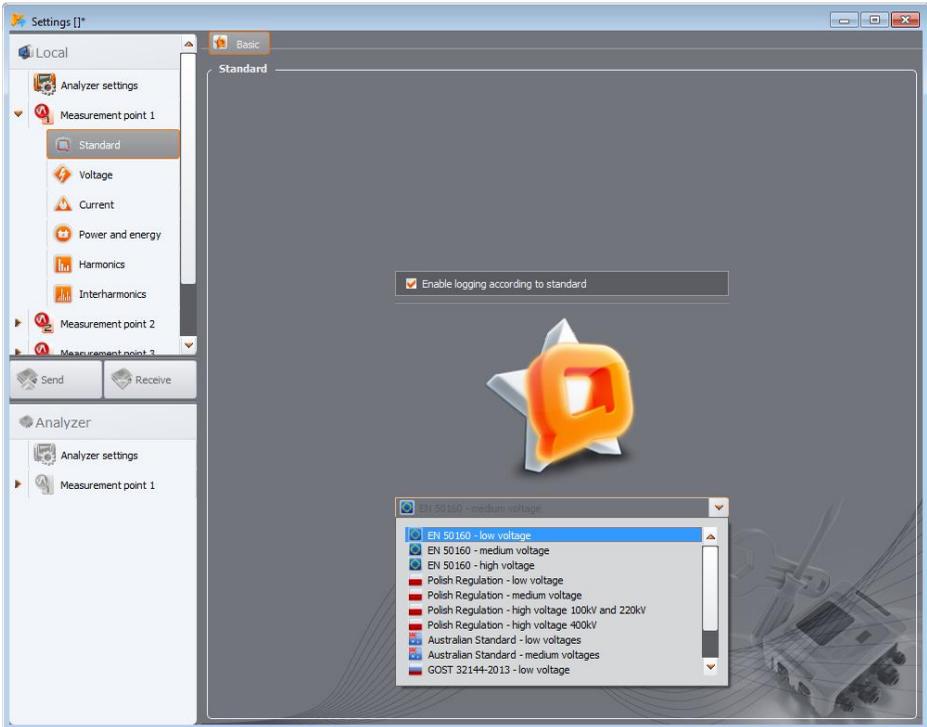
Fig. 19. 'Standard' tab for measurement point settings.

Basic mains measurement time, according to EN 50160, is one week. In this time, the following parameters are measured: RMS voltage, frequency, Total Harmonic Distortion, levels of individual voltage harmonics, unbalance (in three-phase mains), flicker. Because the week-long measurements are related to gathering a large amount of data, it was decided to use averaging algorithms. All the evaluated parameters, excluding the frequency and long-term flicker, are averaged over 10 minutes. Thus, within a week, the user obtains 1008 values for each of these parameters. These values are then evaluated by comparing them to the criteria defined in the standard.

If all parameters are within the specified thresholds, it can be concluded that the measured mains meets the quality requirements of EN 50160.

Example
Nominal voltage 230 V, 50 Hz frequency, measurement time 1 week.
Out of 1008 values of the average RMS voltage, 95% i.e. 958, must be within the range of 207 V…253 V.
However, all measurements of RMS voltage must be within the range of 195.5 V ... 253 V.
Within one week of, the number of 10-second frequency measurements is 60480 and 99.5% of this value (i.e. 60178), must be in within the range of 49.5 ... 50.5 Hz. All frequency measurements must be within the range of 47 ... 52 Hz.

Tab. 2 contains the current criteria for measurements according to EN 50160 in LV networks (up to 1 kV) and MV networks (36 kV). These settings are used by selecting the default settings for EN 50160 profile.

Tab. 2. Criteria for power quality according to standard EN 50160 for mains voltage up to 1 kV (low voltage networks).

Parameter	Basic measurement time	Criterion
Slow changes in voltage (RMS voltage)	10 minutes	For LV networks: for 95% of the measurements the deviation from the nominal voltage shall be within the range of ±10% U_{nom} for 100% of the measurements: –15%...+10% U_{nom} For MV networks: for 99% of the measurements the deviation from the nominal voltage shall be within the range of ±10% U_{nom} for 100% of measurements: ±15% U_{nom}
Frequency	10 seconds	For networks connected synchronously: for 99.5% of the measurements the deviation should be within ±1% f_{nom} (i.e. for 50 Hz it is 49.5…50.5 Hz) for 100% of measurements: –6%...+4% f_{nom} (47…52 Hz) For networks connected asynchronously (e.g. island networks): for 95% of the measurements the deviation should be within ±2% f_{nom} (i.e. for 50Hz it is 49…51 Hz) for 100% of measurements: ±15% f_{nom} (42.5…57.5 Hz)
Rapid voltage changes (flicker)	2 hours	for 95% of the measurements the long-term flicker severity P_{LT} should be ≤ 1
Voltage unbalance	10 minutes	for 95% of the measurements of the negative-sequence unbalance factor should be ≤ 2%
Total Harmonic Distortion (THD-F)	10 minutes	for 95% of measurements, THD-F should be ≤ 8%
Voltage harmonics	10 minutes	For 95% of the measurements, the level of each voltage harmonic component related to the fundamental component should be less than:

Odd order harmonics		Even order harmonics	
Order	Relative level	Order	Relative level
3	5.0%	2	2.0%
5	6.0%	4	1.0%
7	5.0%	6 … 24	0.5%
9	1.5%		
11	3.5%		
13	3.0%		
15	0.5%		
17	2.0%		
19	1.5%		
21	0.5%		
23	1.5%		
25	1.5%		

The procedure for setting the analyzer on the measurement compliant with the standard is as follows. On the main screen for the measurement point settings, the user should set the correct mains type, nominal voltage, frequency, type of clamps, or select the appropriate transducers.

Then select **STANDARD** tab and enable **ENABLE LOGGING ACCORDING TO STANDARD** option. This causes unlocking the standard version list. Then, from the list select the appropriate element.

After completing the settings, and after sending the configuration to the analyzer the user may trigger the recording process from the PC program or by using **START/STOP** button. Before that make sure that the correct measurement point is selected in the analyzer.

The user has the ability to edit the standard default settings defined in the preferences. It may be useful in situations where the criteria defined in the Standards will change. The user will be able to adjust the settings yourself without the need to upgrade *Sonel Analysis* software.

Although the EN 50160 standard does not provide for current measurement or testing the mains parameters associated with the current, because of the frequent need to test 15-minute power and tanφ average values, the analyzer allows simultaneous measurement of the mains for conformity with EN 50160 and 15-minute average values of active, reactive and apparent powers, as well as tanφ. To enable the recording of these parameters, select one of the Polish EN 50160 configurations from the presented list. Profiles dedicated to Polish conditions: "Low Voltage", "Medium Voltage" and "High Voltage" have enabled the recording (by default) of 15-minute average parameters: tangentφ, and active, reactive and apparent power. The user must on its own activate the current measurement in the measurement point settings (choose the correct type of clamps and optionally set transducers).

2.2.3 Configuring the analyzer according to user settings

PQM-700 **PQM-701** If the user did not chose recording in accordance with the standard, then all available parameters may be freely controlled by the user.

PQM-702 **PQM-703** **PQM-710** **PQM-711** In PQM-702, PQM-703, PQM-710 and PQM-711 analyzers, due to the dual recording functionality, activating the standard-compliance recording does not limit control over recording acc. to the user settings (excluding the modification of threshold event voltage events).

All settings are included in the main card of the measurement point (**BASIC** and **ADDITIONAL** tabs) and five other cards (and their tabs): **VOLTAGE**, **CURRENT**, **POWER AND ENERGY**, **HARMONICS** and **INTERHARMONICS**.

In most cases, the settings for the selected parameter may be divided into a section of cyclical recording of parameter values according to the selected averaging time, and into the section related to event detection. The user may select to record the value of average, minimum, maximum and instantaneous parameter. For voltage and current the user may define an additional averaging time that is used for detecting minimum and maximum values (depends on analyzer type). To clarify these issues let us use an example.

Example

Global averaging time has been set to 1 minute, while min/max determination period for voltage has been set to 5 seconds. All four voltage options have been checked: recording of average, minimum, maximum and instantaneous values.

Question: How these values are determined and what is recorded on the memory card?

1. Average value is determined as the RMS (root mean square) from 10/12-period measurements (approx. 200 ms). There will be approx. 300 of such measurements per 1 minute. Average voltage value is calculated as the square root of arithmetic mean of squared input values:

$$U_{avg} = \sqrt{\frac{\sum_{i=1}^{k} U_i^2}{k}}$$

where:
U_{avg} – 1-minute RMS voltage,
k – number of gathered 10/12-period values,
U_i – RMS voltage of 10/12-period type.

2. Min/max averaging equal to 5 seconds means that firstly the analyzer averages 25 successive U_i values (using the method described above). Minimum and maximum values are selected from all 5-second average values gathered during 1 minute. Both, minimum and maximum values will be recorded.

3. Instantaneous value is the last 10/12-period voltage value measured during 1-minute averaging period. This value will also be saved on the card.

For most of parameters the user may enable detection of events. "Event" is the term, which describes the situation, when the measured value exceeds the threshold(s) set by the user. Depending on a parameter, the number of thresholds may be as follows: only one (e.g. for negative-sequence unbalance factor - exceeding the maximum value), two (e.g. for frequency - exceeding the upper and lower limits), three - for voltages (exceeding the threshold of swell, dip and interruption).

Information about the event is recorded by the analyzer on the memory card at the time of its completion. Then the following information is recorded:

- start time of the event,
- end time of the event,
- threshold value,
- parameter extreme value during the event,
- parameter average value during the event.

If the recording is interrupted during an event, information about this event is also saved, but only within the following scope:

- start time of the event,
- threshold value,
- extreme value of the parameter recorded by the end of the recording process.

For the following parameters: RMS voltage and RMS current, the recording of waveforms and RMS$_{1/2}$ values may be enabled – at the beginning and end of the event. Recording time of waveforms and RMS$_{1/2}$ is set in **ADDITIONAL** tab, of the card for the measurement point settings (see sec. 2.2.1.2.)

2.2.4 VOLTAGE card

VOLTAGE card is divided into two tabs: BASIC and ADDITIONAL.

2.2.4.1 BASIC Tab

Fig. 20 presents basic settings for recording voltages. Depending on the mains type, the settings relate to phase-to-neutral voltages (single-phase, split-phase, three-phase 4-wire systems) or phase-to-phase voltages (three-phase 3-wire systems). As a standard, the user may check the recording of the average value (AVG), minimum (MIN), maximum (MAX) and instantaneous (INST) of the RMS voltage. Option ALL selects all four, or remove them all. The same set of options is available for the DC component of the voltage.

Measurement of minimum and maximum value is performed with the user-defined averaging time (option MIN/MAX CALCULATION PERIOD). Available averaging times: ½ period, period, 200 ms, 1 s, 3 s or 5 s.

> **Note**
> Averaging times 200 ms, 1, 3 and 5 sec. are actually expressed as multiples of the mains basic period:
> - 200 ms – 10/12 periods (50/60 Hz)
> - 1 second – 50/60 periods
> - 3 seconds – 150/180 periods
> - 5 seconds – 250/300 periods

For systems with phase-to-neutral voltages (split-phase and three-phase with a neutral conductor N), there is an additional option of recording RMS phase-to-phase voltages. In such case only the average value is recorded.

Checking option LOG WAVEFORMS AFTER EACH AVERAGING PERIOD results in recording three voltage waveform periods after each successive averaging periods (for example every 10 minutes).

The part related to events is located on the right side of the screen. Checking option LOG EVENTS activate the fields for voltage threshold values. They may be entered as percentage or absolute values. The setting ranges are as follows:

- SWELLS: 0.00…+20.00% with a resolution of 0.01% or in volts within the same range,
- DIPS: 0.00…-99.90% with a resolution of 0.01% or in volts,
- INTERRUPTIONS: 0.00...-100.00% with a resolution of 0.01% or in volts up to 0.00 V (the dip level cannot be lower than the interruption level).

Switching between the threshold percentage values to absolute values results in automatic calculation to selected unit.

For mains with neutral conductor, it is possible to set also the maximum N-PE voltage level – option N-PE VOLTAGE OVER LIMIT. Exceeding this threshold in volts will trigger an event. Setting the threshold to zero disables the detection of events of this type.

Entering a value in MAX. field in the PHASE VOLTAGE DC part triggers an event after detecting a voltage DC component higher than the value (threshold) entered in volts (the absolute value of the DC component is checked, so both positive and negative DC voltage can be detected). Setting the threshold to zero disables the detection of events of this type.
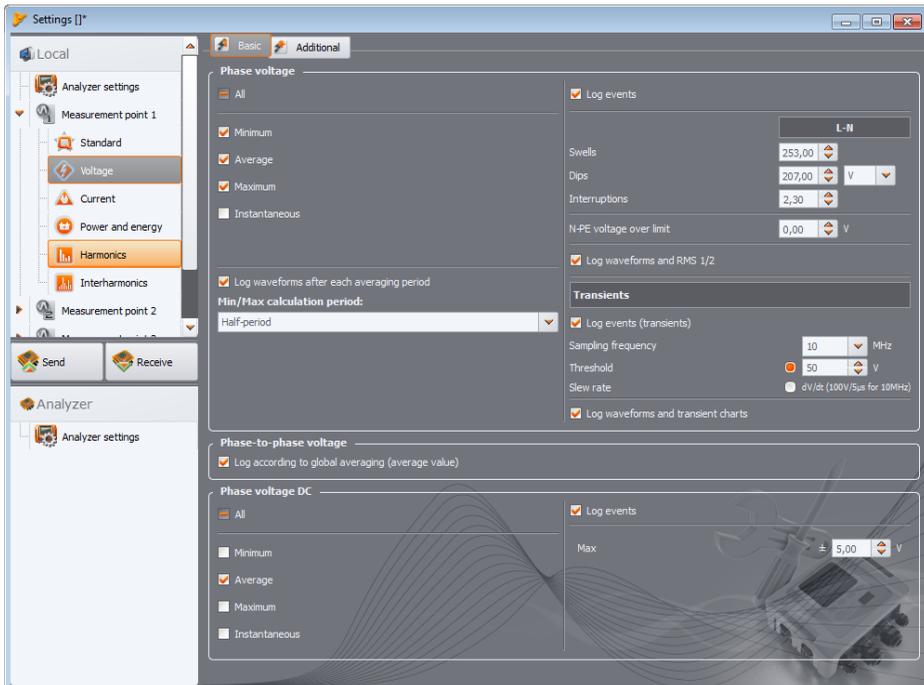
Fig. 20. Basic settings for voltage measurements.

> **Note**
> *When the user changes mains nominal voltage after the event threshold have been set, the thresholds expressed in percentage values will remain on the same levels.*

After selecting **LOG WAVEFORMS AND RMS1/2** option, the analyzer will record the defined number of periods for voltage and current waveforms and RMS$_{1/2}$ values, at the beginning and the end of an event. Recording time is set in **ADDITIONAL** tab, of the card for the measurement point settings, see sec. 2.2.1.2.

PQM-703 **PQM-711** In case of PQM-703 and PQM-711 analyzers the card includes a set of controls enabling the user to activate and configure the block of transient detection (fast and short-term disturbances in the mains voltage). The detection is triggered after selecting option **LOG EVENTS (TRANSIENTS)**. The user may set the following parameters:

- **SAMPLING FREQUENCY** - it is the sampling frequency of the transient detection block. One out of five frequencies may be chosen: **100 KHZ** (slowest), **500 KHZ**, **1 MHZ**, **5 MHZ**, **10 MHZ** (fastest). The sampling frequency must be chosen depending on the expected frequency content of disturbances in the network.
- Detection method: **THRESHOLD** or **SLEW RATE**. After selecting **THRESHOLD** option, set the minimum amplitude of disturbances in the range from **50 V** to **5000 V** that should be detected as an event and its recording. After selecting **SLEW RATE** the analyzer detects disturbances with slew

rate exceeding the value specified next to the selection box. Slew rate is changed indirectly, by selecting the sampling frequency (from 100 V/500 μs for 100 kHz to 100 V/5 μs for 10 MHz)

- Recording time charts of detected transients with related 10.24 kHz waveforms may be activated by selecting option **RECORD WAVEFORMS AND TRANSIENT CHARTS**. Recording time is set in **ADDITIONAL** tab, of the card for the measurement point settings, see sec. 2.2.1.2.

2.2.4.2 ADDITIONAL tab

In this tab (see Fig. 21) the user defines recording parameters for the mains frequency, Crest Factor, voltage flicker and voltage unbalance. Similarly to other parameters, the user may select recording of average, minimum, maximum and instantaneous values. In the case of unbalance, the recorded parameters include: three symmetrical components in volts (zero, positive and negative sequence voltages) and two unbalance factors (in %): zero and positive unbalance. Additionally, the user may enable event recording. The setting ranges are as follows:

- frequency: 40 ... 70 Hz with a resolution of 0.01 Hz or 0.01%, whereas the minimum value cannot be higher than the defined mains reference frequency, and the maximum value cannot be lower this reference value,
- crest factor: 1.00 ... 10.00, resolution 0.01,
- negative sequence unbalance : 0.00…20.00% every 0.01%,
- flicker (short-term P_{ST} and long-term P_{LT}): 0.00 ... 20.00 in 0.01 steps.
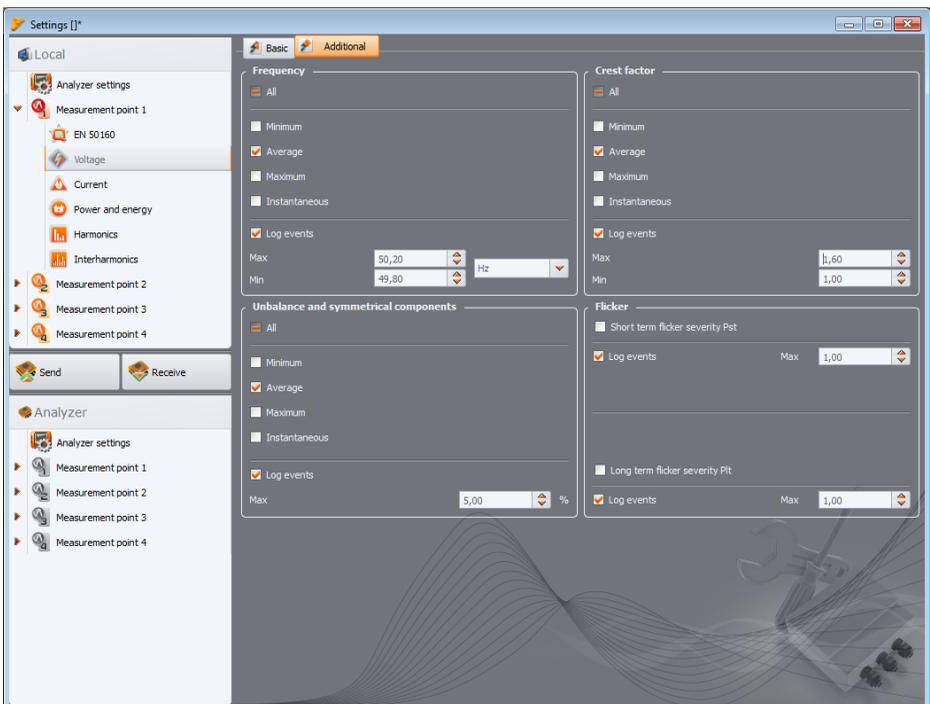
Fig. 21. Additional settings for voltage measurements.

2.2.5 CURRENT

Screen of Basic settings is shown in Fig. 22.

> **Note**
> *This tab is not available if the current measurement was disabled in the main measurement point configuration by selecting* **NONE** *option in* **CLAMPS TYPE** *field*

The following elements are grouped here:
- recording RMS current,
- selection list of averaging times to determine minimum and maximum values (similarly to voltage, the available times include: ½ period, period, 1, 3 and 5 seconds),
- recording current crest factor,
- recording unbalance factors and current symmetrical components (as in the case of voltage unbalance),
- DC current component (only when C-5(A) current clamps are selected).
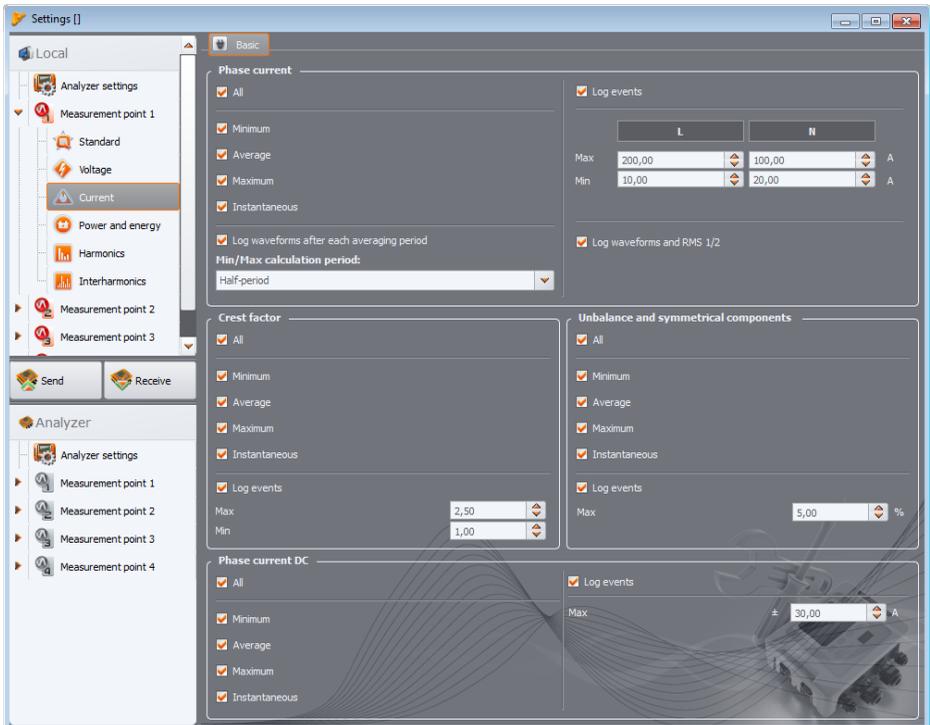
Fig. 22. Current measurement settings.

For each parameter, the user may enable event logging:
- for RMS current two thresholds may be set : the maximum (upper limit) and minimum (lower limit) value. The settings range is from 0.00 A up to the rated current measuring range (clamps

and possibly current transducers). The minimum value cannot be greater than the maximum value. For mains with neutral conductor, the user may set different thresholds for phase channels and for neutral channel (if current measurement in N conductor is enabled).

- current crest factor: two thresholds (minimum and maximum); adjustment range: 1.00…10.00; in 0.01 steps
- negative sequence unbalance: one threshold (maximum), range 0.0…20.0%; in 0.1% steps.
- for the DC component a current threshold can be defined. If the absolute value of DC current exceeds the limit, the event will be recorded. This kind of event can be enabled only when current clamps with DC measurement capability are selected, that is C-5(A).

2.2.6 POWER AND ENERGY

The configuration part relating to the power and energy settings has three tabs: *POWER*, *ADDITIONAL* and *ENERGY*.

Note
*These tabs are not available if the current measurement was disabled in the main measurement point configuration by selecting **NONE** option in **CLAMPS TYPE** field*

2.2.6.1 POWER tab

Fig. 23 presents **POWER** tab.
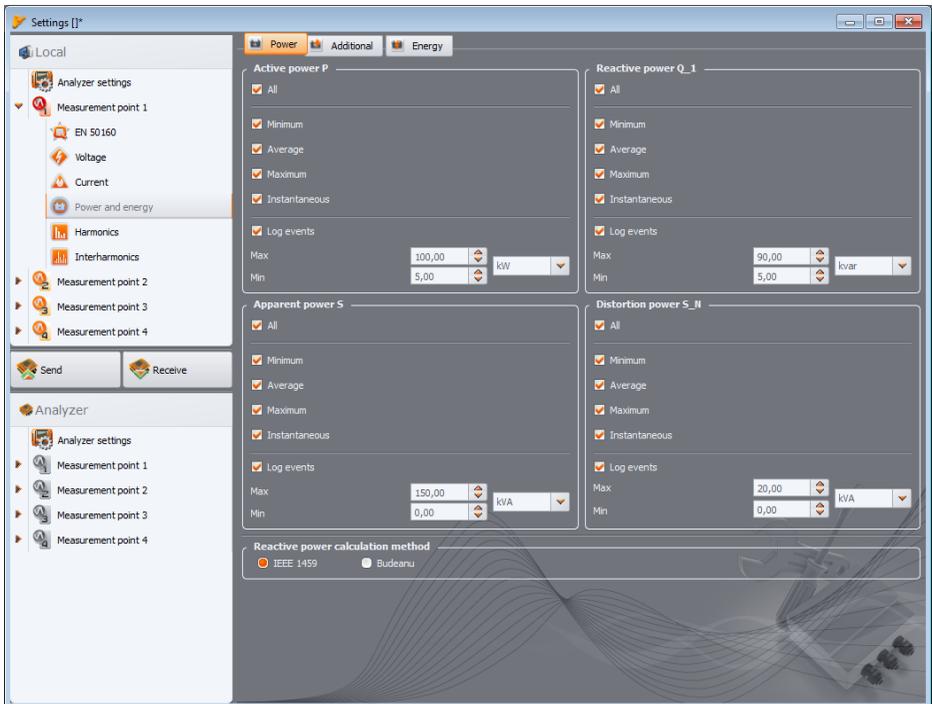
Fig. 23. Power and energy – Power tab.

Similarly to voltage and current, the user may set recording average, minimum, maximum and instantaneous values. The user may activate registering of the following parameters:
- active power,
- reactive power,
- apparent power,
- distortion power / apparent distortion power.

For each of these power types, the user may enable event recording (logging). Two thresholds can be set for each power type (minimum and maximum) and the analyzer will detect every case of their exceeding.

The setting range is 0.00 W ... 999.9 MW (for active power), 0.00 var ... 999.9 Mvar (for reactive power), 0.00 VA ... 999.9 MVA (for apparent power), 0, 00 var / VA ... 999.9 Mvar / MVA (for distortion power/ apparent distortion power).

At the bottom of the screen, the user may see the method for calculating reactive power. Two alternative methods are available:
- as required by IEEE 1459-2000 standard,
- according to Budeanu's power theory (this method is not recommended).

Fig. 24. Power and energy – Additional tab.

This option has been added due to the doubts about the power measurement according to traditionally used Budeanu's method. IEEE 1459-2000 standard suggests slightly different calculation methods 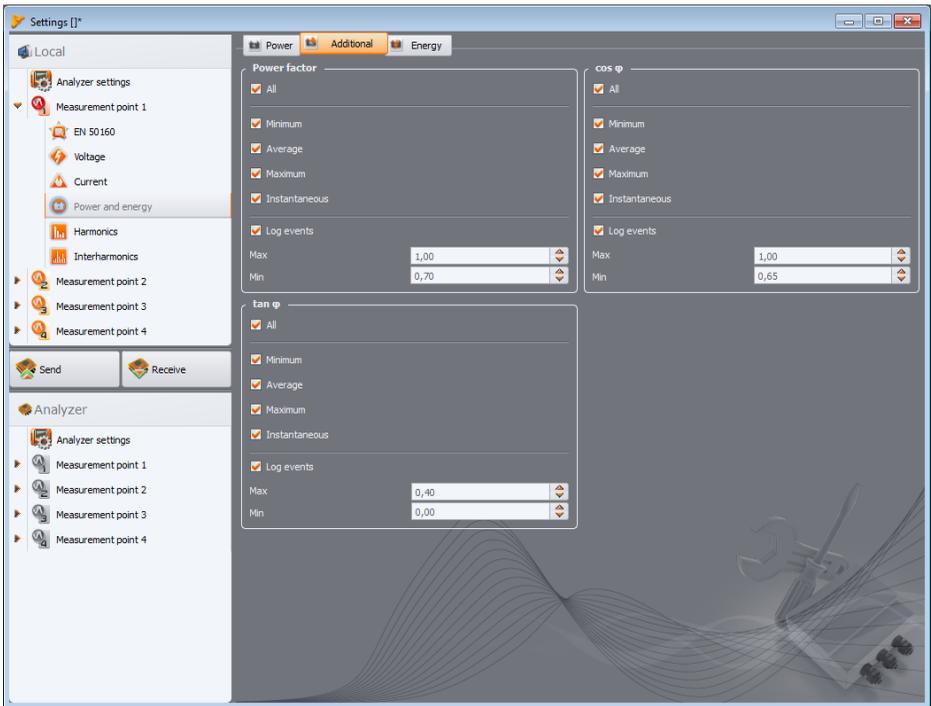for this power, providing correct results also in unbalanced systems with distorted current and voltage waveforms. More about this issue may be found the operating manual of the analyzer.

After selecting Budeanu option both reactive power Q and distortion power are calculated by the analyzer based on the Budeanu's theory. After selecting IEEE-1459 option, the reactive power is the Q_1 reactive power of the fundamental component, and S_N non-fundamental apparent power (expressed in VA) is calculated instead of the distortion power.

2.2.6.2 ADDITIONAL tab

ADDITIONAL tab (Fig. 24) shows parameters related to the power measurements:
- Power Factor: event threshold setting range 0.00 ... 1.00 in 0.01 steps,
- Displacement power factor / cosφ: event threshold setting range 0.00 ... 1.00 in 0.01 steps,
- tanφ, which is the ratio of reactive to active power: event threshold setting range 0.00…10.0 in 0.01 steps.

In every case both positive and negative values within the range are checked.

2.2.6.3 ENERGY tab

ENERGY tab is shown in Fig. 25. Apart from the option of enabling the recording process of energy values with a defined averaging period, the user may also define event detection when energy exceeds a given threshold. The setting ranges are as follows:
- Active energy E_P: 0.00 Wh…9.90 TWh, with resolution of 0.01 Wh,

- Reactive energy E_Q: 0.00 varh…9.90 Tvarh, with resolution of 0.01 varh,
- Apparent energy E_S: 0.00 VAh…9.90 TVAh with resolution of 0.01 VAh.

For active and reactive energy, the analyzer separately measures two parameters: consumed (received) and supplied (delivered) energy. The indicated threshold refers to both values (i.e. the analyzer checks the exceeding threshold for both, consumed and supplied energy).
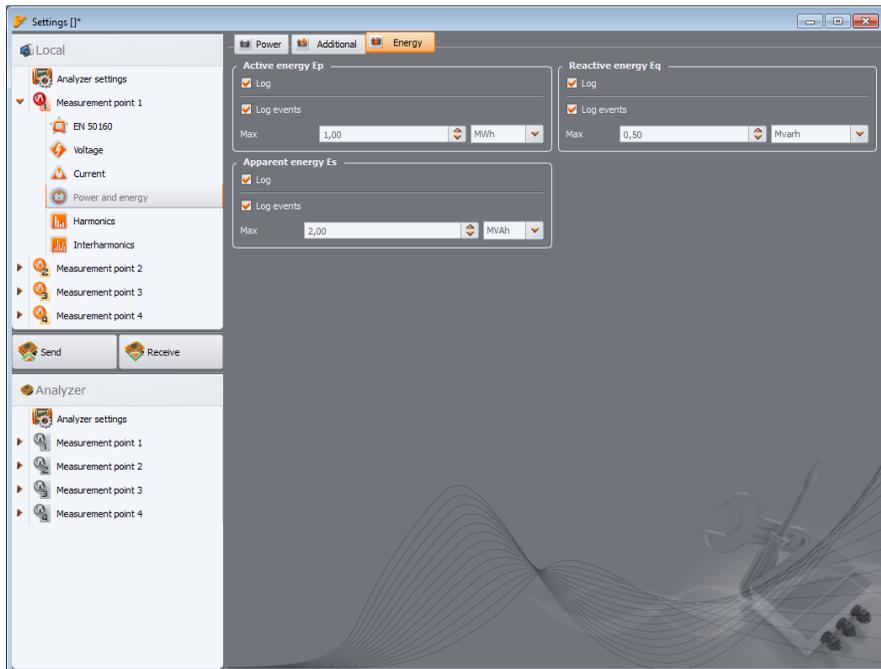
Fig. 25. Power and energy – Energy tab.

2.2.7 HARMONICS

In **HARMONICS** card the user may configure recording method and event detection for voltage and current harmonics and other parameters directly related to them. The card has three tabs: **VOLTAGE**, **CURRENT** and **ADDITIONAL**.

PQM-700 *PQM-700 measures harmonics only to the 40th order.*

2.2.7.1 VOLTAGE tab

Screen of this tab is shown in Fig. 26. The user may choose recording of minimum, average, maximum and instantaneous values for THD in voltage and voltage harmonic amplitudes. The user may also activate the event recording for THD and harmonics amplitudes:
- for THD in voltage, an event will be recorded after THD exceeds the threshold set by the user. Event threshold setting range is 0.00 ... 100.00% in 0.01% steps
- Detection thresholds for events of voltage harmonics may be set independently for each of 49 harmonics (from 2 to 50). The user may select units: volts or percentage. The adjustment range for event thresholds: in volts 0.00…U_{nom} in 0.01 V steps, as percentage values 0.00... 100.00%

in 0.01% steps. Setting the threshold to zero disables the event detection for the specified harmonic.

Setting limits for individual harmonics may be performed in two ways: completing the table below the graph or directly on the graph. When the table is filled, after values are approved, the graph located above presented the table visualization.

To change the limit on the graph, double-click on a selected harmonic and then holding down the left mouse button, set the desired level.

By clicking a harmonic in the table, the user may use the following keys:

- SPACEBAR- used to enter the editing selected harmonic (the user may also immediately start typing the threshold),
- ENTER - confirming values
- TAB – confirming values and moving to the next harmonics,
- UP and DOWN arrow - changing the value of the limit,
- LEFT and RIGHT arrow - used for moving to the previous or next harmonics
- HOME and END - used to toggle between the first and last harmonics.

Note
The level of THD and harmonics presented as a percentage value is referenced to the fundamental component.

The user also has the option to decide how many harmonics will be used to calculate THD: 40 or 50 harmonics. This setting is automatically transferred to the second tab – *CURRENT* (and vice versa).

Fig. 26. Voltage harmonics settings.

2.2.7.2 CURRENT tab

Screen of this tab is shown in Fig. 27. Available options are identical as those in **VOLTAGE** tab: recording THD (with event detection option) and recording current harmonics (with setting of event thresholds for individual harmonics).

The event threshold setting range is as follows:

- for THD: 0.00…200.00% every 0.01%,
- for harmonics: in amperes 0.00…I_{nom} in 0.01 A steps, as a percentage value 0.00…200.00% in 0.01% steps. Setting the threshold to zero disables the event detection for the specified harmonic.
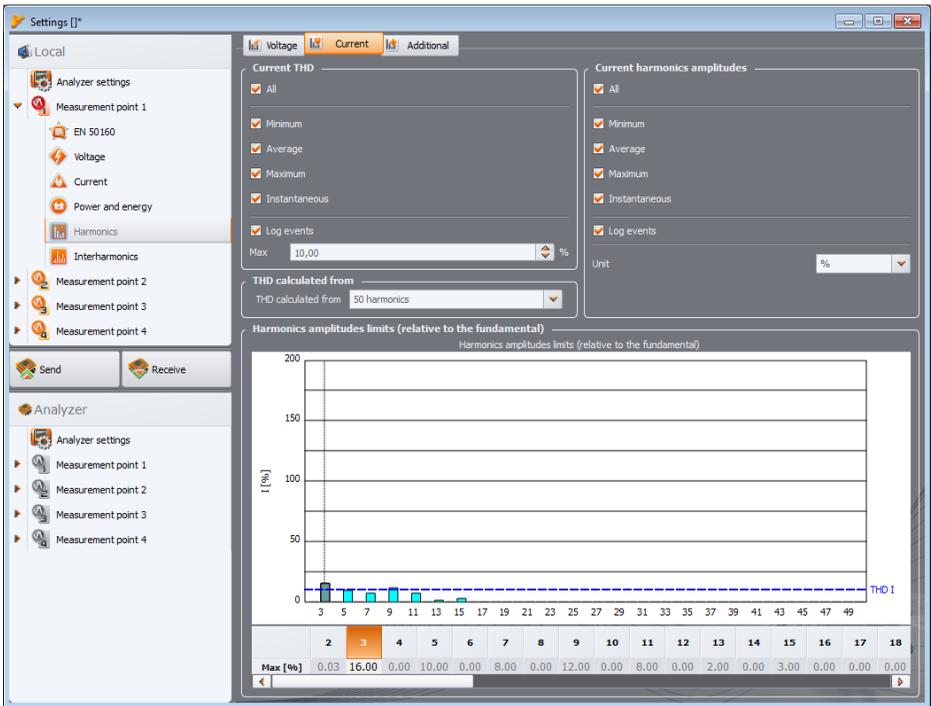
Fig. 27. Current harmonics settings.

2.2.7.3 ADDITIONAL *tab*

PQM-700 This tab is not available in PQM-700 analyzer.

ADDITIONAL tab (Fig. 28) includes the following parameters:
- K-factor: the user may activate the recording and event detection when the threshold is exceeded. The threshold may be set in the range of 0.00 ... 50.00 in 0.01 steps.
- Angles between voltage and current harmonics: the user may activate the recording – the angles are recorded for 1..50 harmonics,
- Harmonics active power: cyclical recording of active power for the 1..50 harmonics (minimum, maximum, average and instantaneous values),
- Harmonics reactive power: cyclical recording of reactive power for the 1..50 harmonics (minimum, maximum, average and instantaneous values),
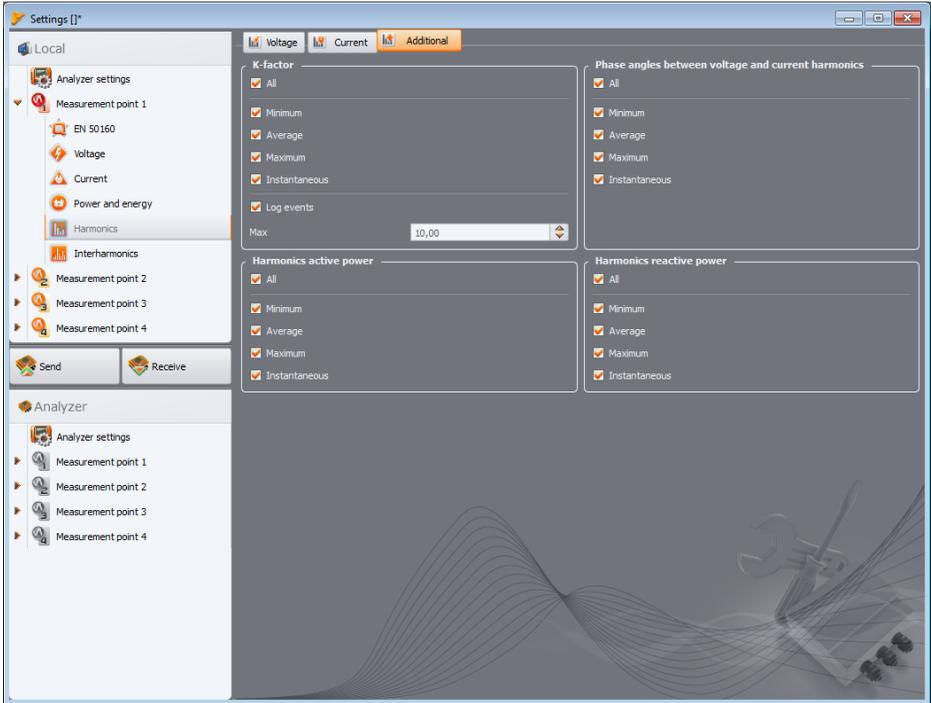
Fig. 28. Additional settings of harmonics.

2.2.8 INTERHARMONICS

PQM-700 **PQM-701** *In PQM-700 and PQM-701 analyzers the options for measuring interharmonics and mains signalling is not available.*

In **INTERHARMONICS** tab, the user may configure the manner of recording and event detection from current and voltage interharmonics, TID and mains signalling. The card is divided into three tabs: **VOLTAGE**, **CURRENT, MAINS SIGNALLING**.

2.2.8.1 VOLTAGE tab

Screen of this tab is shown in Fig. 29. The user may choose recording of minimum, average, maximum and instantaneous values for TID in voltage and voltage interharmonic amplitudes. Similarly as in case of harmonics, the user may also enable event logging for TID and interharmonics amplitudes:
- for TID in voltage, an event will be recorded after TID exceeds the threshold set by the user. Event threshold setting range is 0.00 ... 100.00% in 0.01% steps
- Detection thresholds for events of voltage interharmonics may be set independently for each of 51 interharmonics (from 0 to 50). The user may select units: volts or percentage. The adjustment range for event thresholds: in volts $0.00…U_{nom}$ in 0.01 V steps, as percentage values 0.00...100.00% in 0.01% steps. Setting the threshold to zero disables the event detection for the specified interharmonic.

Setting limits for individual interharmonics is carried out in the same way as for the harmonics.

Note
The level of TID and interharmonics presented as a percentage value is referenced to the fundamental component.
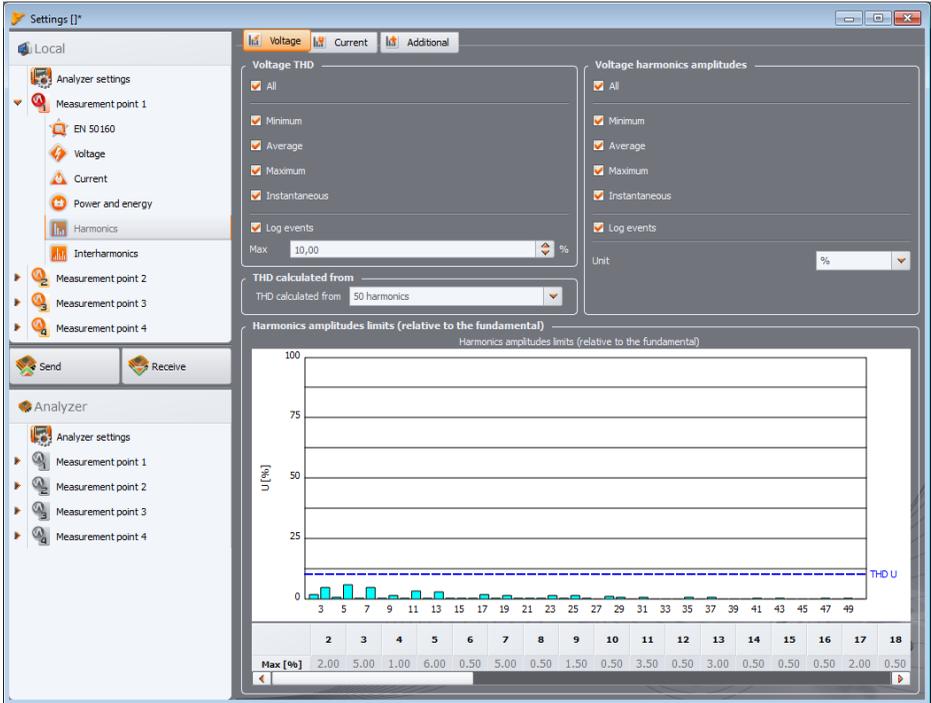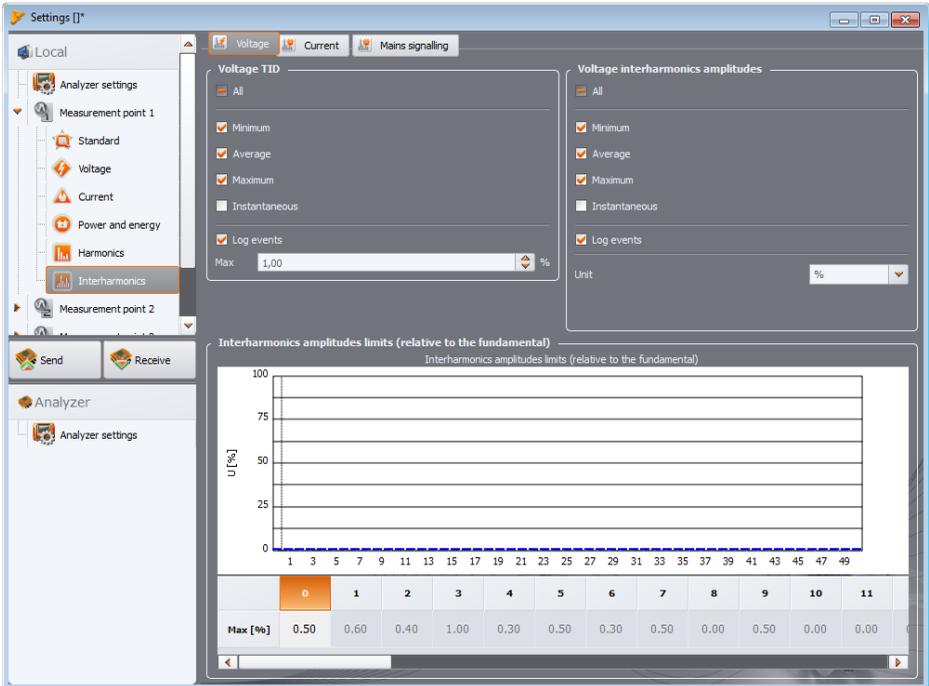

Fig. 29. Voltage interharmonics settings.

2.2.8.2 CURRENT tab

Screen of this tab is shown in Fig. 30. Available options are identical as those in **VOLTAGE** tab: recording TID (with event detection option) and recording current interharmonics (with setting of event thresholds for individual interharmonics). The event threshold setting ranges are as follows:

- for TID: 0.00…100.00% in 0.01% steps,
- for interharmonics: in amperes 0.00…I_{nom} in 0.01 A steps, as a percentage value 0.00…100.00% in 0.01% steps. Setting the threshold to zero disables the event detection for the specified interharmonic.
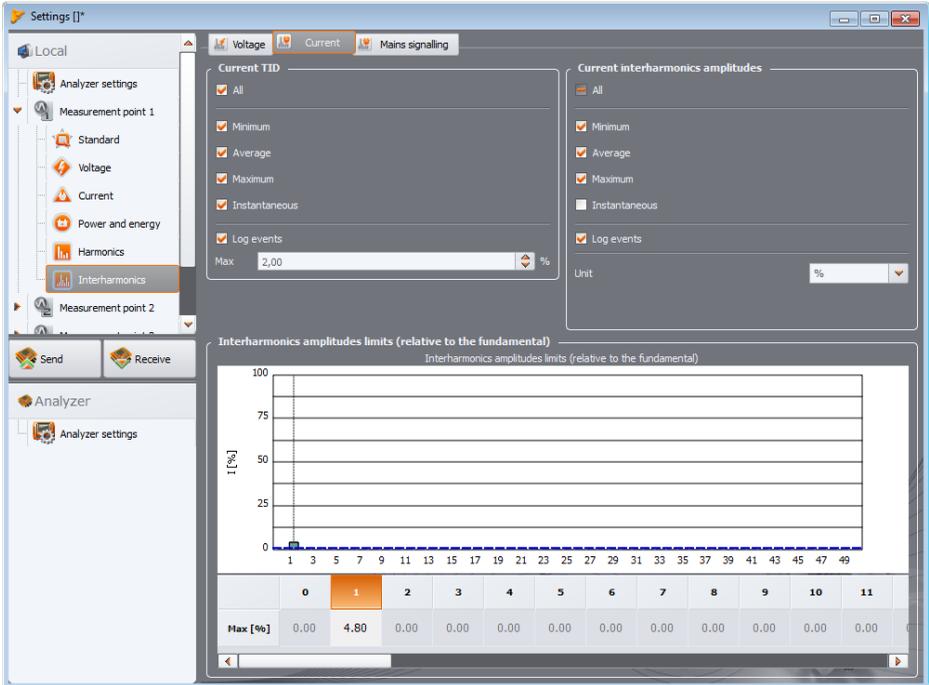
Fig. 30. Current interharmonics settings.

2.2.8.3 MAINS SIGNALLING tab

PQM-700 **PQM-701** *MAINS SIGNALLING tab is not available for PQM-700 and PQM-701 analyzers.*

Screen of this tab is shown in Fig. 31. The user may configure two monitored frequencies of ripple control signals: UR_1 and UR_2. The frequency of each may be set in the range of 5...3000 Hz. The meaning of each option is as follows:

- **AVERAGE** – selecting it activates recording of the average value of a given control signal in the averaging interval,
- **MAXIMUM** - selecting it activates recording of the maximum value of a given control signal in the averaging interval (out of 10/12-period values)
- **LOG EVENTS (AND TIME PLOT)** – activates recording of an event when specified threshold is exceeded by the control signal (as specified in volts or percentage values of the nominal voltage). The exceeded value triggers recording of the signal time plot. Recording time is set at **ADDITIONAL** card in main settings of the measurement point (see sec. 2.2.1.2).

In case of recording in accordance with EN 50160 (and related), in addition to averages, all the 3-second mean values are also recorded.
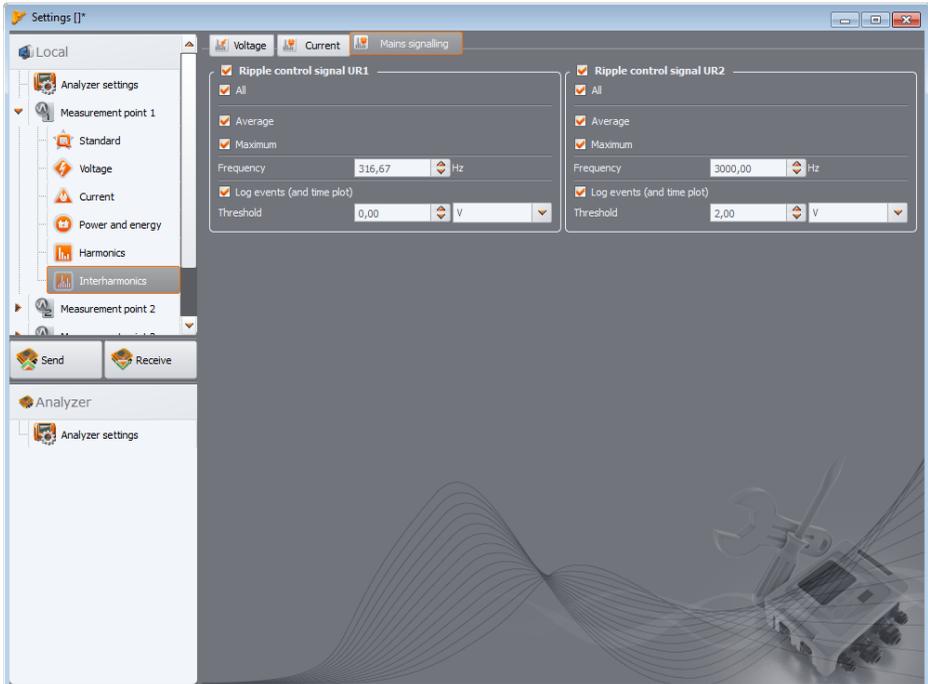
Fig. 31. Mains signaling settings.

2.2.9 Default configuration profiles.

After installing, the application applies the default settings of the analyzer, where the following measurement point profiles are saved:

- Voltage,
- Voltage and current,
- Power,
- Power and harmonics.

Names of these profiles are entered in the names of measurement points (MP1 - Voltage, MP2 - Voltage and current, MP3 - Power, MP4 - Power and harmonics). Parameters recorded in individual profiles are shown in Tab. 3.

Tab. 3. The list of recorded parameters for the profiles of default measurement points.

Voltage	Voltage and current	Power	Power and harmonics
Voltage U	Voltage U	Voltage U	Voltage U
Crest Factor U	Crest Factor U	Crest Factor U	Crest Factor U
Frequency	Frequency	Frequency	Frequency
Symmetrical components and unbalance factors U	Symmetrical components and unbalance factors U	Symmetrical components and unbalance factors U	Symmetrical components and unbalance factors U
	Current I	Current I	Current I
	Crest Factor I	Crest Factor I	Crest Factor I
	Symmetrical components and unbalance factors I	Symmetrical components and unbalance factors I	Symmetrical components and unbalance factors I
		Active power P	Active power P
		Reactive power Q	Reactive power Q
		Apparent power S	Apparent power S
		Distortion power D	Distortion power D
		Cos φ	Cos φ
		Power Factor	Power Factors
		Tan φ	Tan φ
			K factor
			THD U
			THD I
			Harmonics U
			Harmonics I
			Flicker P_{st} and P_{lt}

Recording in default profiles is done without saving the waveforms after the averaging period. Only average values of parameters are recorded and event detection is disabled. Network type is set as 3-phase wye system with a neutral conductor and the averaging time is 10 seconds. For profiles that require current measurements, flexible clamps are selected.

2.3 Actual settings

After selecting from the main menu: **ANALYZER**→**ACTUAL SETTINGS** (or use a short-cut key F4) the window shown in Fig. 32 is displayed. The following cards are available:
- **TIME AND SECURITY**,
- **CLAMPS PHASE**,
- **WIRELESS CONNECTION** (only PQM-702(T), PQM-703, PQM-710, PQM-711),
- **SERIAL CONNECTION** (only PQM-701Zr)
- **ADDITIONAL SETTINGS**.

2.3.1 <Time and security> card

Here (Fig. 32) the user may set the time and parameters important for the analyzer security. Current date and time of the analyzer is shown on an on-going basis in **ANALYZER TIME** field. In order to set desired date and time of the analyzer, use the drop down menu in **USER TIME** field, enter desired values and confirm by pressing **SET** button on the right. PC system time may be also sent to the analyzer by simple pressing **SET** button next to **SYSTEM TIME** button.

PQM-702 **PQM-703** **PQM-710** **PQM-711** *In the upper left part of the window, an icon and status of GPS signal is displayed. When correct time from the GPS satellite was received, 'GPS signal' icon turns green and message "YES (2D + Time)" is displayed. In the absence of GPS signal, the icon is grey and message "NO SIGNAL" is shown.*

Date and time of the analyzer for devices with built-in GPS (PQM-702 (T), PQM-703, PQM-710 PQM-711) are displayed in orange if there is no synchronization with GPS time or green, if the synchronization is achieved.

Note: If the memory card of the analyzer contains any data saved with a date later than the set date, the time change is not possible - appropriate message is displayed. To change time in this situation, you must first delete all the data on the memory card (use the formatting options, or send a new configuration to the device; first read the previously recorded data).

PQM-702 **PQM-703** **PQM-710** **PQM-711** **TIME ZONE** field allows user to specify the time shift between the local time and the UTC. For example, in case of Poland, select UTC +01:00. Many countries in summer months use additional shift of one hour. For compatibility of the analyzer clock with local time, when applying Daylight Saving Time, check **DST** box. Time change to daylight saving time takes place at different times in different countries. Analyzer does not automatically adjust DST. Checking DST box adds 1 extra hour to the displayed time (local time). Its internal clock is always UTC clock.

Checking **KEYBOARD LOCK** box, results in immediate key locking after the recording is activated. In this case, the user will have to enter the 3-digit code (using three buttons of the analyzer) to unlock the keys. This code is independent from PIN number and may be changed by pressing **CHANGE** button, next to **KEYBOARD LOCK** box. "Keyboard Lock" function prevents stopping an active recording process by unauthorized persons.

PQM-702 **PQM-703** **PQM-710** **PQM-711** *In meters with a built-in GPS module and GSM modem (PQM-702(T), PQM-703, PQM-710, PQM-711), the* **ANTI-THEFT** *option is available. Check this box will enable this mode. More information on this issue may be found in the instruction manual of these analyzers.*

SLEEP MODE makes the screen blank 10 seconds after activating the recording process.

2.3.2 CLAMPS PHASE card

In case of a reverse clamp connection to the measured circuit (right direction is the one where the arrow on the clamp indicates the receiver), select the option from menu **ANALYZER→ACTUAL SETTINGS** and selecting **CLAMPS PHASE** (Fig. 33). Click a clamp icon in the selected channel to reverse the phase by 180°, which is equivalent to reverse placement on the clamp on the test lead. The change of direction applies to all measurement points and occurs immediately. The reversal effect can be verified on the phasor diagram screen, waveforms screen or by change of active power sign in the channel. The clamp phase cannot be reversed while the recording is in progress.
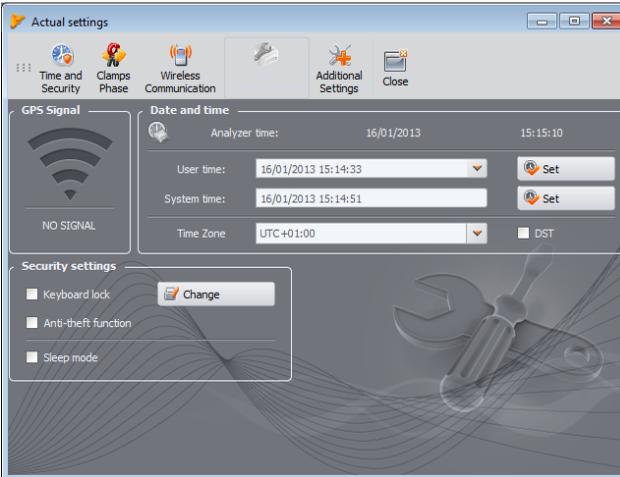
Fig. 32. Setting the time and security measures during recording.

Fig. 33. Reversing the clamp phase.

2.3.3 WIRELESS CONNECTION *card*

PQM-700 **PQM-707** *This tab is not available in PQM-700 and PQM-707 analyzers.*

PQM-701 *PQM-701(Z, Zr) has neither GSM communication options nor Wi-Fi.*

WIRELESS CONNECTION (Fig. 34) includes the following elements:
- **OR-1 COMMUNICATION ENABLED** button – used for enabling/disabling radio interface to communicate with the receiver OR-1.

- **GSM COMMUNICATION ENABLED** button – used for enabling/disabling the built-in GSM modem. Disabling the modem is recommended when GSM communication is not used.
- **WI-FI COMMUNICATION ENABLED** button – (available only in tablet version of *Sonel Analysis*) – it enables / disables the built-in Wi-Fi module (valid for PQM-710 and PQM-711). Disabling the module is recommended when Wi-Fi communication is not used.

> *Note*
> *Be careful when disabling interfaces, as the user may turn off both interfaces when connected to the analyzer via selected device. In such case, a warning is displayed informing that further communication is impossible, and re-activation will be possible by connecting the analyzer with other active medium.*
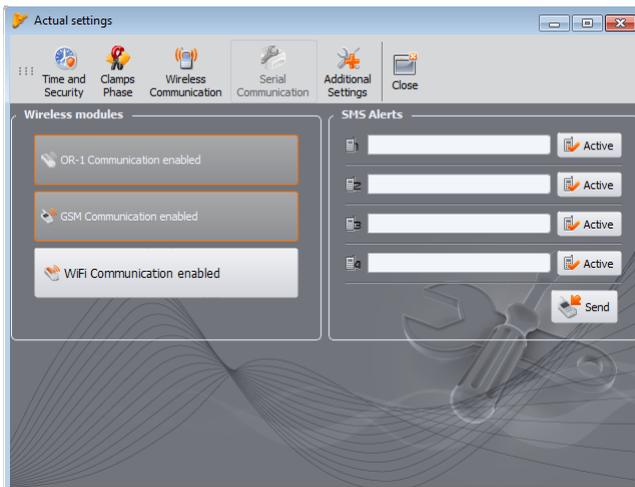

Fig. 34. Actual settings – Wireless connection.

- **SMS ALERTS** - here the user may enter up to four telephone numbers, to which SMS Alerts will be sent. It is recommended that the phone numbers start with "plus" and the country code (e.g. +48 for Poland). SMS will be sent in the following situations:
    - recording starts,
    - recording ends,
    - analyzer is switched-off due to discharged battery,
    - analyzer is switched-on due to power supply return,
    - analyzer re-location was detected (when the anti-theft function is activated).
    - GPS signal is lost for longer than 5 minutes (when the anti-theft function is active),
    - GPS signal is available after interruption longer than 5 minutes (when the anti-theft function is active).
  ACTIVE button, next to the field with number is used to activate and deactivate of a given number. After entering the numbers and choosing activities, data must be sent to the analyzer by clicking **SEND** button.
  SMS messages contain the time of the event (acc. to the analyzer time, adjusted to local time) and the serial number of the analyzer.
  SMS alerts require active GSM modem for proper operation (with a SIM card).

2.3.4 SERIAL CONNECTION *card*

PQM-701Zr *This card is available only in PQM-701Zr.*

This window allows user to change the settings of the serial port in PQM-701Zr. The user may change:
- parity (even, odd, none),
- flow control (disabled or hardware)
- the number of stop bits (1 or 2),
- bit rate (range from 2400 to 921600 bit/s).

The change is made immediately after **CHANGE** button is pressed and the connection is not interrupted (as is the case with the RS-232 connection).

Settings cannot be changed if the connection to the analyzer is made via an external GSM modem.
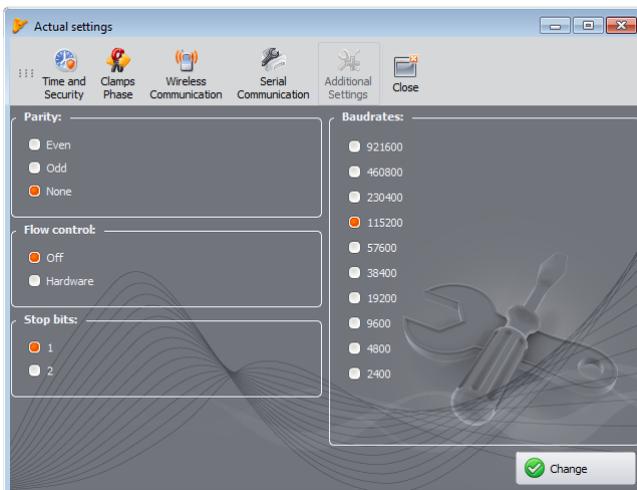
Fig. 35. Changing the settings of the serial port in PQM-701Zr.

2.3.5 ADDITIONAL SETTINGS *card*

ADDITIONAL SETTINGS card includes two elements:
- **LANGUAGE** selection list that allows user to set the language used on the analyzer screen.

PQM-700 **PQM-701** **PQM-707** *Language selection of the analyzer's interface is not available for PQM-700, PQM-701(Z, Zr) and PQM-707.*
You can select from the following languages:
- Polish,
- English,
- German,
- Russian,
- Chinese Simplified,
- Chinese Traditional.

- **HEATER ENABLED** button is used for switching on/off the heater that heats the interior of the analyzer when ambient temperatures are below 0°C. When the analyzer is activated in temperature below zero, it controls the temperature inside the analyzer by enabling the heater to maintain the temperature inside above 0°C. This results primarily from the need to provide positive temperature to built-in lithium-ion battery, as charging the battery in temperatures below zero Celsius is not allowed.

Fig. 36. Language and heater settings.

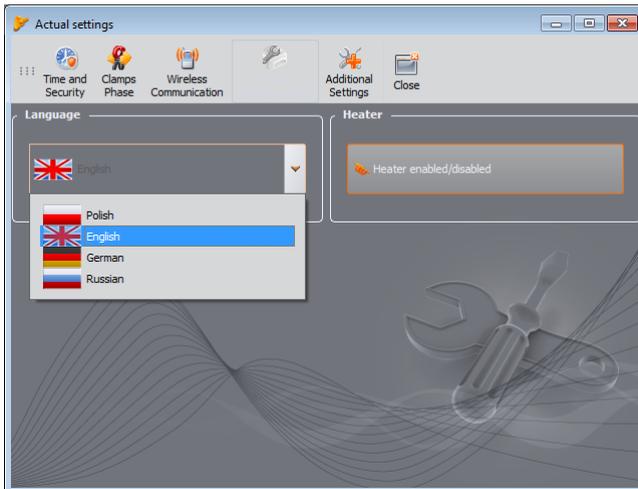**Note**: The heater should always be activated. The heater may be turned off only when the analyzer is operated at a temperature above 0°C or when it is necessary to reduce the power consumed by the analyzer, e.g. during measurements with voltage transformers, from which the analyzer is to be supplied.

2.4   Analyzer database

Select from the main menu **OPTIONS→ANALYZER DATABASE** - here you may add or edit existing analyzers (Fig. 37).

Only analyzers entered by the user into the database will be displayed in the selection box when searching analyzers via radio. Serial number entered into the database must match the serial number of the analyzer, which you want to connect with. Analyzers with other serial numbers are rejected by the program and not shown in the selection window (it does not apply to USB search).

Column **AUTO PIN** informs, whether the program requires PIN code before transmission. If the box is disabled, the user will be required to enter PIN.

In addition, the user may activate the option of reminding about the need for re-calibration. The manufacturer specifies the time after which the user should perform a calibration of the instrument, in order to maintain its declared accuracy. The accuracy degrades due to the ageing of components. To unlock this feature, select option **CERTIFICATE OF CALIBRATION**. If it is checked, then the following lists are active **VALIDITY PERIOD** and **REMIND BEFORE**. They are used for:

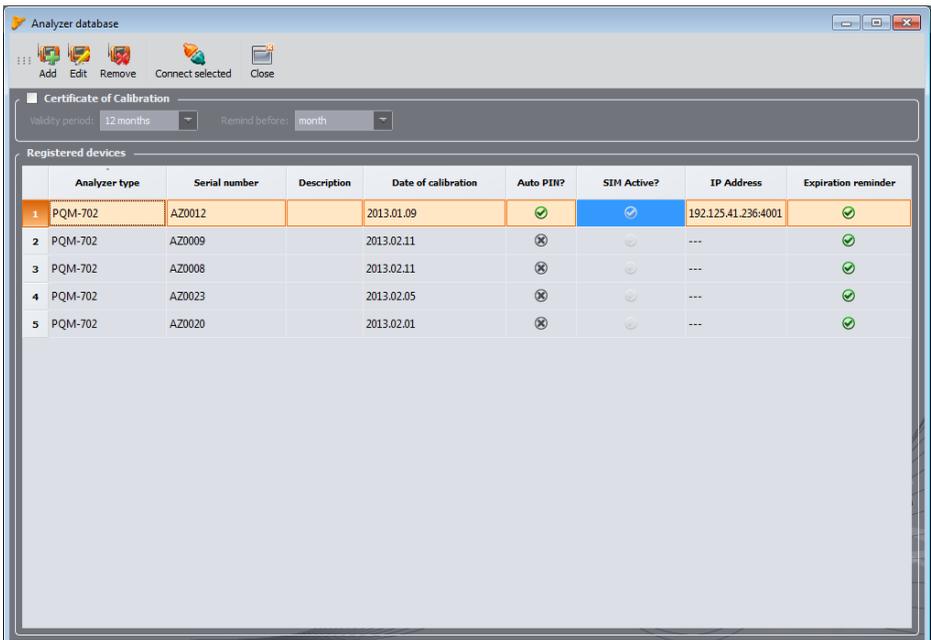- **VALIDITY PERIOD** (may be set at 6, 12, 18 or 24 months) – it defines the frequency of instrument calibration,

- **REMIND BEFORE** (may be set at week, two weeks, month) – it specifies the period for which the program is required to generate the reminding message.

Checking the list of analyzers for validity of their calibration certificate occurs during start-up of *Sonel Analysis* – a window is displayed appear with a reminder.

The remaining columns in the table:
- **CALIBRATION DATE** indicates the date of last calibration,
- **DESCRIPTION** - brief text description related to the analyzer,
- **DATE OF CALIBRATION** – the date of analyzer's calibration as set by the user,
- **AUTO PIN?** – if checked it means that the user doesn't have to enter the analyzer's PIN each time when connecting (the PIN is stored in database),
- **SIM ACTIVE?** – indicates whether the SIM card is correctly configured in the analyzer (applies to analyzers with a built-in GSM modem and is set after correct connection of the analyzer via GSM),
- **GSM IP address** - the IP address of the analyzer in GSM network is displayed (in analyzers with built-in GSM modem and PQM-701Zr),
- **Wi-Fi IP address** – the IP address of the analyzer in Wi-Fi network (local or Internet) (applies only to tablet version of PQM-710 and PQM-711 analyzers),
- **Wi-Fi MAC address** – displays the MAC address of configured analyzer (applies only to tablet version of PQM-710 and PQM-711 analyzers).

Fig. 37. Analyzer database.

Clicking **ADD** enables user to add an analyzer - as shown in Fig. 38. Please select a model analyzer, enter its serial number and optional description. The calibration date may be also entered and the program will use it to alert the user before the expiry date of the calibration certificate. Changing PIN code and GSM settings is possible only after connecting to the analyzer.

REMOVE icon allows the user to delete the selected analyzer from the database (after confirming it by the user).

EDIT icon allows the user to change the parameters of the analyzer and GSM configuration.

Click **CHANGE PIN** button to change PIN. The new code must be entered twice and then accepted.

In case of analyzers with built-in GSM modem, it is necessary to properly configure the parameters to connect the analyzer to a GSM network and allow connection of *Sonel Analysis* with a remote analyzer. To do this, click **CHANGE GSM SETTINGS** button. Two main applications of this function are available:

- Configuring the analyzer to operate in a GSM network (first activation of this function in the analyzer requires to connect the analyzer via USB)
- Adding a remote analyzer to the database, (when analyzer has already configured connection to GSM network).
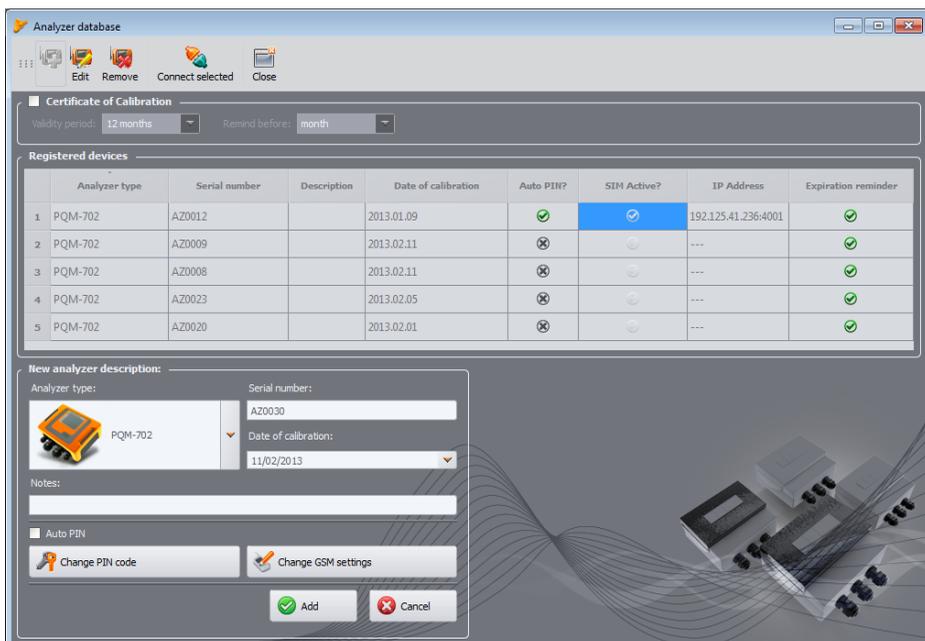
Fig. 38. Adding an analyzer to the database.

In the first case, enter the following data in the appropriate fields:

- IP number assigned to your SIM card,
- The name of the access point (APN),
- User name and password (not always required).

After confirming the settings, a window will be displayed to enter the PIN code of SIM card. Then, the analyzer will initiate the procedure to log into GSM network, applying specified settings. All parameters should be provided by the SIM card provider.

In the second case, the analyzer may be in another location. In order to connect to the analyzer, the user must know its IP address. Adding the analyzer to the database is carried out as follows:

- Click **CHANGE GSM SETTINGS** button.
- "Search window" will be displayed - click 'Cancel'.
- Message "The analyzer is not connected" will be displayed with a panel for GSM settings in offline mode, in order to enter the IP number of the analyzer (Fig. 39).
- Enter the IP address of the remote analyzer and click 'OK'.
- You may try to connect to the analyzer (e.g. by using option **CONNECT SELECTED** or by applying the standard method). Please note that the application searches analyzers via the Internet only if you selected **TCP/IP OVER GSM** option in program settings.

PQM-701Zr Using the procedure shown above, the user may add PQM-701Zr (with an external GSM modem) to the database of analyzers. Modem configuration is performed using the software provided by the manufacturer of the modem.
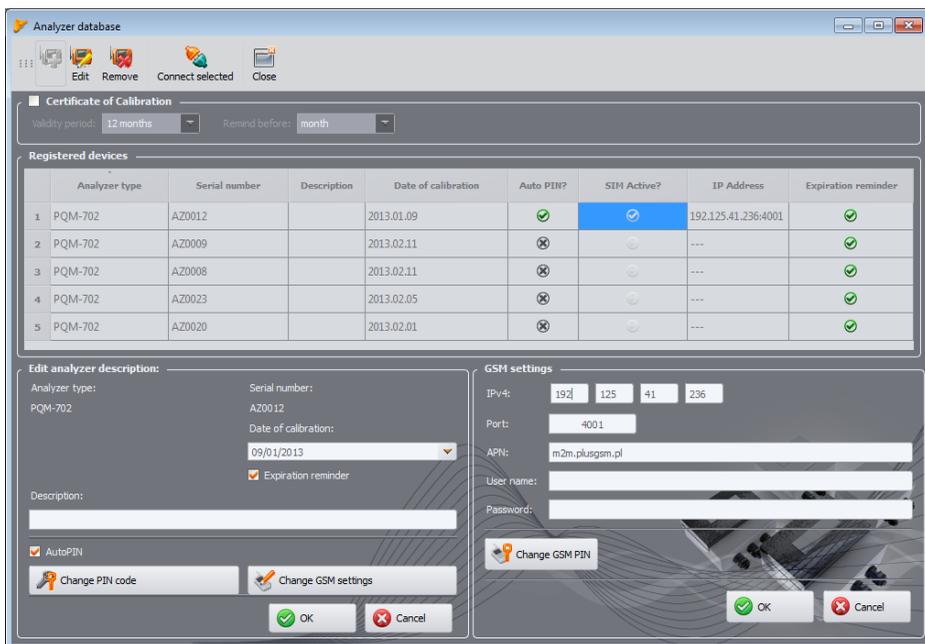
Fig. 39. Entering GSM settings in the analyzer database.

PQM-710 **PQM-711** The PQM-710 and PQM-711 analyzers are equipped with Wi-Fi module that can be used for wireless communication with the analyzer. In the analyzer database the user can input all the needed parameters for setting a proper connection of *Sonel Analysis* software with the analyzer. This is the purpose of the configuration panel that appears after selecting **CHANGE WI-FI SETTINGS** button.

There are two distinct modes for this panel:

- *online* mode – when analyzer is connected to the application while editing options in this panel. In this mode all available parameters can be set. This mode is used to change the configuration that is saved by the analyzer, and also the parameters used by *Sonel Analysis* software for communication. It is mainly used for initial configuration of analyzer for operation in Wi-Fi network.

- *offline* mode – when analyzer is not connected (e.g. it is in remote location). In this mode no new configuration data is sent to the analyzer, and only parameters used by *Sonel Analysis* can be modified. This mode is used when user wants to add a new analyzer to the database, which already is configured for Wi-Fi operation. This mode is indicated by the "(offline)" word on top of the configuration panel. If the user wants to change parameters in *offline* mode, and is already connected to the analyzer, the connection has to be terminated first, and then **CHANGE WI-FI SETTINGS** button has to be clicked. In the opened window with found analyzers the cancel button must be selected. A message "Analyzer is not connected" will be displayed and then a configuration panel in *offline* mode will be opened.

In the *online* mode configuration can be performed in the following way:
- Enter the following data: the access point name (**SSID** field) and in case of a secured network tick **MODIFY** box and enter the password (**KEY** field). In case of a non-secured network, "Key" field remains empty, but **MODIFY** box must be ticked.
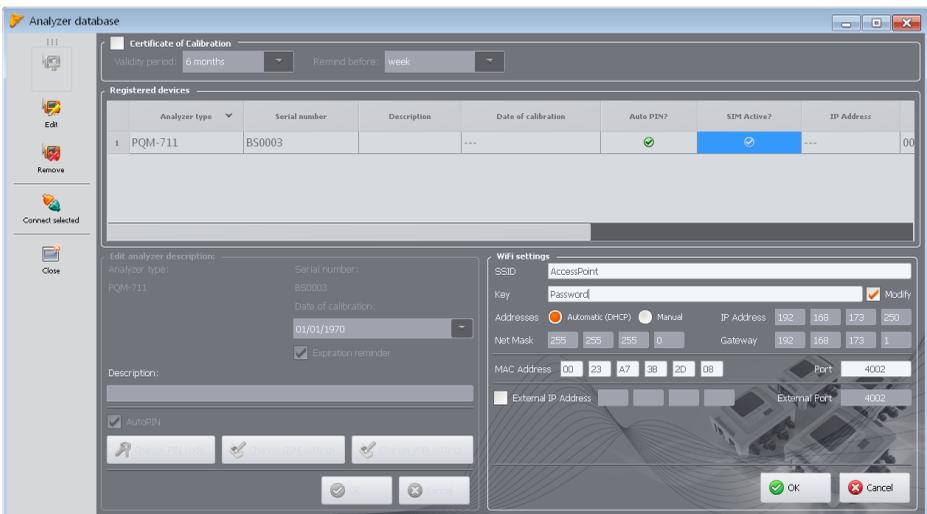
Fig. 40. Wi-Fi configuration screen in *online* mode.

- Select the method for assigning IP address. In case of manual mode - enter appropriate values into fields: **IP ADDRESS**, **NET MASK** and **GATEWAY**. In automatic mode, select **DHCP**.
- With USB connection, **MAC Address** field will be filled-in automatically (as read from the analyzer).
- **PORT** field is not editable, it is always 4002.
- In case of operating in other subnetworks (the Internet), fill-in **EXTERNAL IP ADDRESS** and **EXTERNAL PORT** fields. For a direct connection (tablet ⇔ analyzer), and for working in a local network (tablet ⇔ Wi-Fi router ⇔ analyzer) these fields must be left inactive.
- If the analyzer has a static IP address, the search time may be shortened. To do this, enter IP address of the device in **EXTERNAL IP ADDRESS** field and enter "4002" in **EXTERNAL PORT** field.
- Confirm the settings by pressing **OK.** This will send new data entered in fields: SSID, Key, IP configuration, to the analyzer.
- If the correct data have been entered, the analyzer will try to connect to Wi-Fi access point. After disconnecting, the connection status may be followed on screen **<10/10>**.

The following procedure applies to *offline* mode, when the analyzer was previously configured, and there is a need to add it to the database or to edit Wi-Fi parameters that identify the device.

To properly configure the connection, the following elements will be required:

- Physical Address of the analyzer (**MAC ADDRESS**), this parameter must be read from screen **<10/10>** of the analyzer.
- **EXTERNAL IP ADDRESS** and **EXTERNAL PORT.** The parameters required to work in a different subnetwork than the tablet (computer), especially for connecting to the Internet.

Configure the analyzer in the following manner:

- Select the appropriate analyzer from the database and click **EDIT** or use **ADD** button to add it to the database.
- Use **CHANGE WI-FI SETTINGS** button and fill **MAC ADDRESS** field.
- In case of operating in other subnetworks (the Internet), fill-in **EXTERNAL IP ADDRESS** and **EXTERNAL PORT** fields. For a direct connection (tablet ⇔ analyzer), and for working in a local network (tablet ⇔ Wi-Fi router ⇔ analyzer) these fields must be left **inactive**.
- Note: If the analyzer has a static IP address, the search time may be shortened. To do this, enter IP address of the device in **EXTERNAL IP ADDRESS** field and enter "4002" in **EXTERNAL PORT** field.
- Confirm the settings by pressing **OK**.
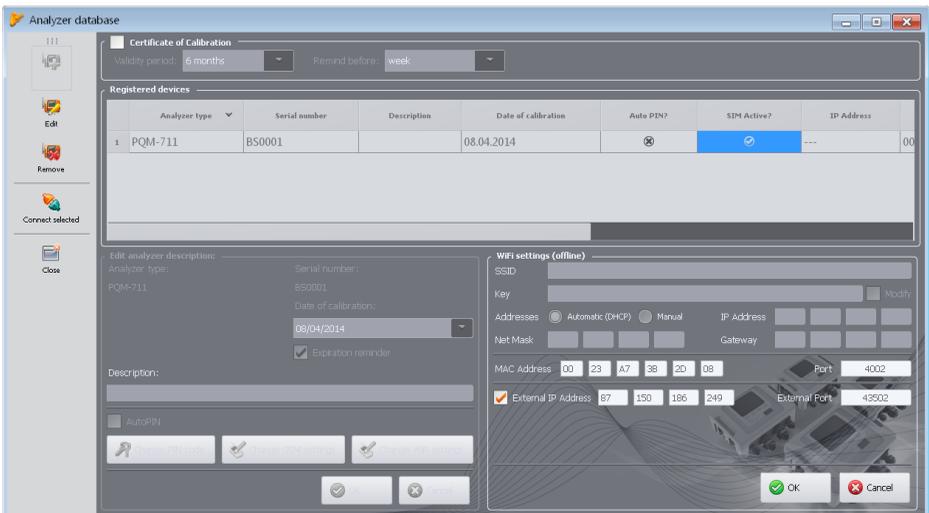
Fig. 41. Example configuration when the analyzer is connected via Internet (offline mode).

The tablet and the analyzer are factory-paired at the production stage. However, in exceptional cases, there is a possibility to conduct the operation in-house using *WiFiPairingWizard.exe.* software.

Pairing process:

- To conduct the pairing procedure connect the analyzer to the tablet using a USB cable.
- To check if the USB connection is working, connect the analyzer with *Sonel Analysis*.
- Close *Sonel Analysis***.**

- Select the Wi-Fi configuration screen on the analyzer **<10/10>.**
- Start the application *WiFiPairingWizard.exe.* The program is in the directory where *Sonel Analysis* has been installed. The default location is *C:\Program Files\Sonel\Sonel Analysis 3.0*.
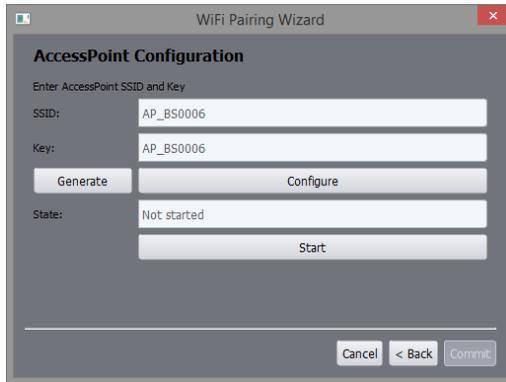
Fig. 42. WiFi pairing Wizard – initial screen.

- Make sure that **NOT STARTED** status is displayed in the **STATE** field. If not, press **STOP**.
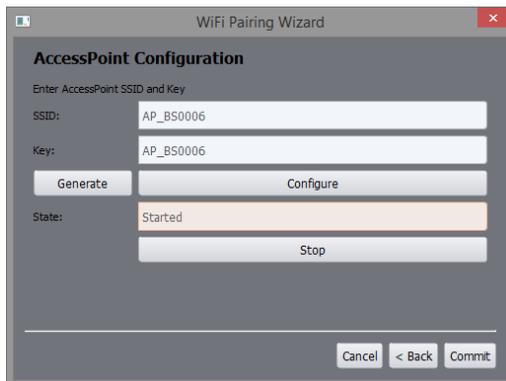
Fig. 43. WiFi pairing Wizard – sample configuration.

- Enter any name and password in the **SSID** and **KEY** fields accordingly.
- The above fields may be filled in with random strings of characters with the **GENERATE** button**.**
- Confirm the changes with the **CONFIGURE** button**.**
- By pressing **START** enable a Wi-Fi access point. The status in the **STATE** field should change to **STARTED**.
- Next, press the **COMMIT** button to go to the analyzer configuration window.
- Select the appropriate analyzer type and confirm with the **CONNECT** button**.**

Fig. 44. WiFi pairing Wizard – selection of the analyzer to be paired with a tablet.

- A list of analyzers connected via a USB interface should appear.
- Select the appropriate analyzer from the list and confirm with the **SELECT** button**.**
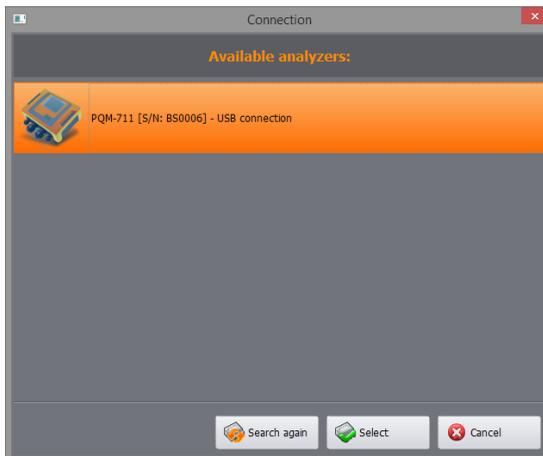
Fig. 45. WiFi pairing Wizard – selection of analyzer to be paired.

- The analyzer configuration will start from that moment. The status of the connection is displayed on the analyzer screen **<10/10>**.
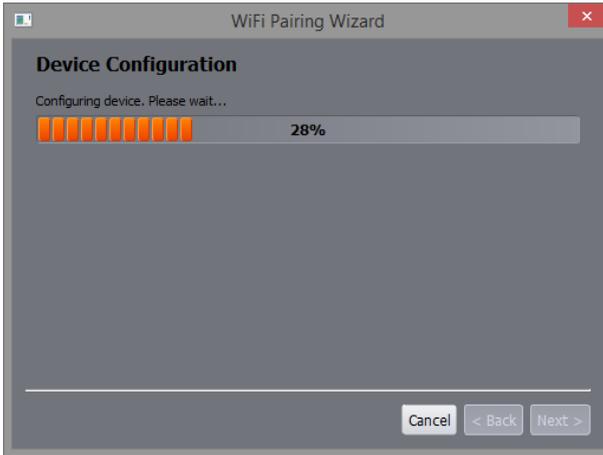
Fig. 46. WiFi pairing Wizard – analyzer configuration.

- Pairing is deemed to be correctly completed after a message *"WiFi Device is now paired with Sonel Analysis running on tablet"* has appeared**.**

Fig. 47. WiFi pairing Wizard – end of pairing.

- It is permissible for the pairing procedure to end with a message *"Unable to pair WiFi Device with Sonel Analysis running on tablet"* if *"Ready"* message appears on the analyzer screen **<10/10>**, and the name of the access point selected at the beginning of the configuration process appears in the **SSID** field.
- By pressing the **FINISH** button or ❌ close program *WiFiPairingWizard.exe*, and then run *Sonel Analysis*.

After starting *Sonel Analysis* a connection with the paired analyzer should be established automatically.

3   Live mode

To enter the live mode, click **LIVE MODE** icon. If the connection to the analyzer has not been previously established, the program goes first to the connection screen (see chapter 1.4 Selecting the analyzer). In this mode, the screen is divided into a few tabs:

- **WAVEFORMS** – it presents waveforms of current and voltages as in a oscilloscope,
- **TIMEPLOT** – presents RMS values of voltage and current as a timeline,
- **MEASUREMENTS** – instantaneous values of measured parameters (phase and total values),
- **PHASOR DIAGRAM** – graphical representation of phasors of fundamental voltage and current components,
- **HARMONICS** – view of harmonic components of individual phases for currents and voltages,
- **INTERHARMONICS** – view of interharmonic components of individual phases for currents and voltages,

The more detailed description of individual tabs is given below.

3.1   Waveforms

The voltage and current waveforms presents two instantaneous waveforms, as they would be seen on the oscilloscope screen. A sample screen is shown in Fig. 48. The graphs are refreshed instantaneously, allowing user to view the mains parameters in real time. All channels are presented in a single graph.
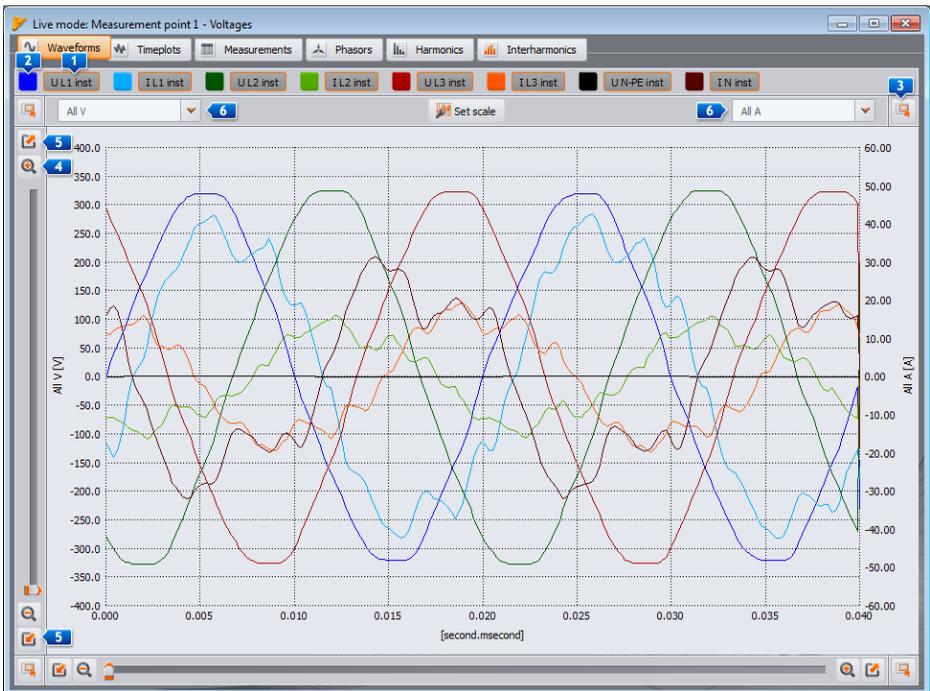

Fig. 48. Live mode screen – waveforms.

The checkboxes above the diagram are used to ![1] enable/disable displaying of a chosen voltage/current channel. Buttons next to the boxes are used ![2] to change the color of presented waveforms.

The graph may be freely expanded in both axes.   In the corners of the window there are four buttons ![3], which activate displaying a window thumbnail with actually displayed area marked in orange. The thumbnail is displayed in one of the four corners of the window, depending on the button used. Four buttons marked by the magnifying glass icon are used for zooming-in and -out ![4]. ![5] buttons are used to select the maximum or minimum zoom of a selected axis. Mouse scrolling wheel may be also used for zooming-in and out. Using the scrolling wheel closer to the vertical edge of the window results in zooming-in of Y-axis, whereas using the scrolling wheel closer to horizontal edge - zooming-in of X-axis.

Zoom the selected area by holding down SHIFT button (the mouse pointer changes to a cross) and select the desired area with the mouse.

It is also possible to move the selected area within the graph. To do so, hold CTRL key (the cursor changes to a hand) and holding the left mouse button, move the display area.

The time scale (X-axis) is updated basing on the measured frequency value (e.g. from 0 to 40 ms for 50 Hz).

Two independent descriptions of Y-axis values are presented. For example, the user may display values in volts (for voltage channels) on the left axis, and in amperes (for current channels) on the right axis. Descriptions of axes are controlled by selection lists ![6]. These lists may include the following items:

- **ALL V** – when more than one voltage channel is measured. In this situation, one scale is selected for all the voltage waveforms, and the waveforms are scaled,
- **ALL A** – when more than one current channel is measured. In this situation, one scale is selected for all the current waveforms, and the waveforms are scaled,
- a separate entry for each measured channels. If the user selects this element from the list, then the screen displays a scale for the selected channel (it may be adjusted automatically or manually if the range was set by the user). **Note: If the graph presents other waveforms (voltage or current depending on the selected scale) then their actual amplitude does not correspond to the indicated scale. The scale applies only to the selected waveform.**

The scale is selected:
- statically - the upper scale range is set at the value close to the nominal voltage or maximum clamp range,
- dynamically - the graphs are automatically scaled to the highest instantaneous value of the waveform.
- manually – to do this use **SET SCALE** button, and then choose waveform(s) for which the scale is to be set manually, disabling the automatic mode and this activity will unlock the options of editing the minimum and maximum values of the axis. After clicking **SET** button, the scale of a given waveform is updated.

Switching between static and dynamic scaling mode is available after clicking the right mouse button on the graph: the context menu includes the following options: **SET SCALE TO NOMINAL VALUE** (for voltage) or **SET SCALE TO CLAMP RANGE** (for current) and **SET SCALE AUTOMATICALLY**, both for voltage and current values. After turning the program on, auto-scaling is turned off.

3.2   Timeplots

Fig. 49 presents the screen with current and voltage timeplot. The configuration elements are identical as those in the waveform screen: its upper part includes controls for switching on/off the display of current/voltage; changing the color of waveforms; zooming-in and the vertical axis.

The time scale is shown in the graph from the moment to entering the Live mode. The time format is mm:ss. After reaching the end of the window, the entire graph shifts to the left by 30

seconds. There is also an option to clear the graph tab in **FILE→CLEAR.** After clearing the screen, the timescale on the plot is shown from the moment of this operation.

The graph is updated regardless of whether the tab is enabled or not, i.e. waveforms are generated in the background, despite viewing for example harmonics.

As in case of waveforms, the user may apply the static scaling (according to the general settings of the measurement point) or dynamic scaling.
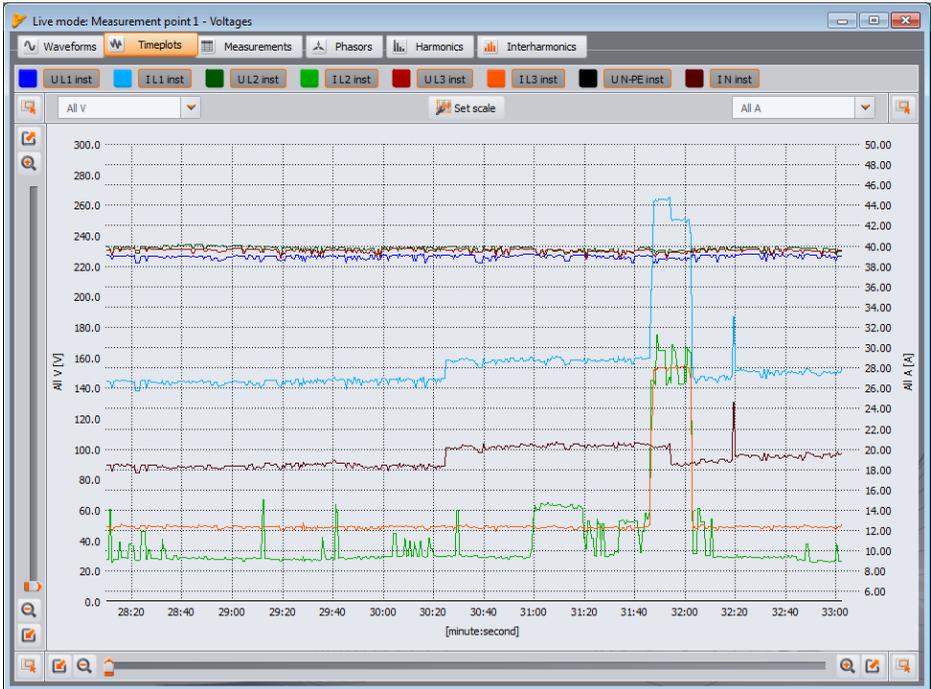
Fig. 49. Graph with values in real time.

3.3 Measurements

MEASUREMENTS tab provides a view of a range of parameters of the measured mains. Fig. 50 presents an example of a screen that shows a summary table of values read from the analyzer and displayed in real time.

In the following rows the individual parameters are grouped into several categories:

- **VOLTAGE** – RMS voltage U, DC component U_{DC}, frequency f,
- **CURRENT** – RMS current I, DC component I_{DC},
- **POWER** – active power P, reactive power Q_B (according to the Budeanu theory) or non-fundamental apparent power Q_1 (acc. to IEEE 1459), apparent power S, distortion power D (acc. to Budeanu) or distortion apparent power S_N (acc. to IEEE 1459),
- **ENERGY** – consumed active energy E_{P+} and supplied active energy E_{P-}, consumed reactive energy E_{Q+} and supplied reactive energy E_{Q-} (acc. to Budeanu or IEEE 1459), apparent energy E_S,
- **FACTORS** – Power Factor PF, Displacement Power Factor/cosφ, tanφ, THD for voltage and current, Crest Factors for voltage and current, flicker P_{ST} and P_{LT},

- **UNBALANCE** – for voltage: zero sequence component U_0, positive sequence component U_1 and negative sequence component U_2, negative sequence unbalance u_2, zero sequence unbalance u_0; or current: zero sequence component I_0, positive sequence component I_1 and negative sequence component I_2, negative sequence unbalance i_2, zero sequence unbalance i_0.
- **TEMPERATURE** – it indicates the temperature of the external sensor (Sonel ST-2) in degrees Celsius. The temperature sensor may be connected only to PQM-702T.
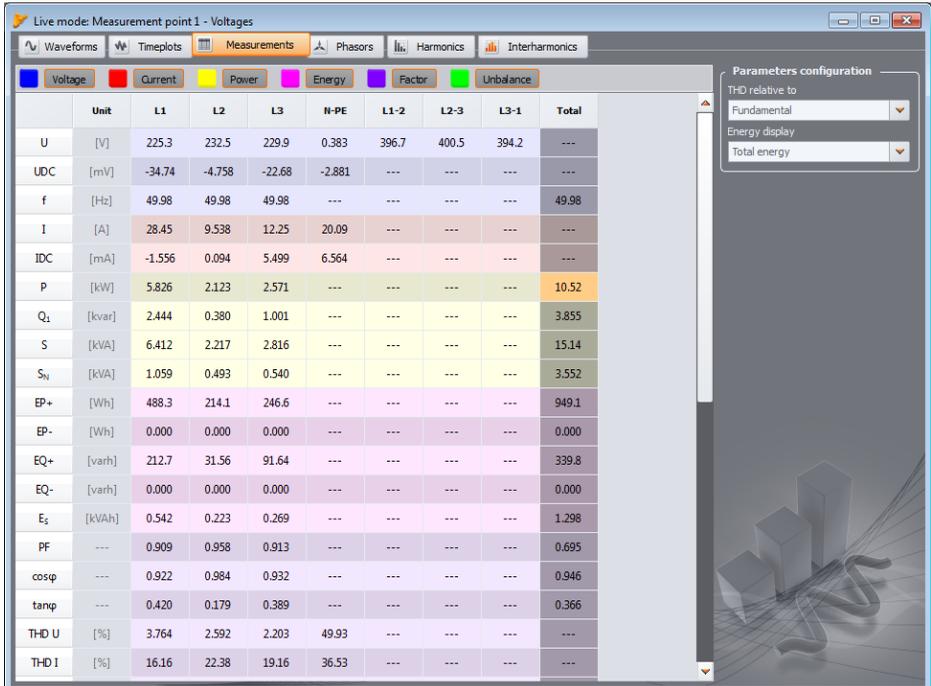
Fig. 50. Indications of phase and total values

Each group may be enabled/disabled independently of the other groups and column background color may be changed using the buttons in the top of the screen.

When the program is started for the first time, the following parameters are shown: voltage, current, power and factor.

Using preferences the user may change the colors of groups and select groups to be displayed (see sec. 5.3.3).

Parameter values are displayed in the consecutive columns, marked as follows:
- **L1** – L1 phase in circuits with a neutral conductor N
- **L2** – L2 phase in circuits with a neutral conductor N,
- **L3** – L3 phase in circuits with neutral conductor N,
- **N-PE** – values of parameters in the N-PE voltage channel or in I_N current channel,
- **L1-2** – L1 phase in circuits without neutral conductor (with phase-to-phase voltages),
- **L2-3** – L2 phase in circuits without neutral conductor (with phase-to-phase voltages),
- **L3-1** – L3 phase in circuits without neutral conductor (with phase-to-phase voltages),
- **TOTAL** – the total value of the entire system or the average value of the phase values.

For example, for a three-phase system with N conductor, the phase parameters values are displayed in columns **L1**, **L2**, **L3**. If the measurement of N-PE voltage and/or I_N current is enabled in the configuration, then in **N-PE** column the analyzer displays also parameter values calculated for this case. **TOTAL** column displays the total values for the whole system.

In case of delta systems, the phase values are displayed in columns **L1-2**, **L2-3**, **L3-1** and **TOTAL**.

If the reset function is activated for currents below the threshold (**CURRENT LIMIT** function), the reset values are marked with an asterisk (*).

Note

In some mains configurations it is not possible to calculate (measure) the values of some parameters. For example, in a delta three-phase system, it is impossible to calculate the cosφ displacement power factor between current and voltage, as the measured voltage is phase-to-phase voltage, and the measured current is line current which is a vector sum of two phase currents.

When in a given mains configuration a selected parameter is not calculated, the screen displays "---" instead of its value.

In the right part of the tab, the user may additionally define the calculation method for THD and TID (list **THD AND HARMONICS VALUES RELATIVE TO**): in relation to fundamental component (THD_F/ TID_F) or RMS value (THD_R/ TID_R).

The displayed energy values depend on **DISPLAYED ENERGY** switch. The user may choose whether the energy counters are related to measuring session (counting started when **LIVE MODE** window is opened) or to total energy counted by the analyzer.

Internal energy counters of the analyzer are reset:
- when the measurement point is changed,
- when recording starts,
- when the analyzer is switched on.

When the energy display mode is selected, the internal energy counters are not modified. The concept of this mode is based on the fact that at the moment of first read-out of values from energy counters (by the software) these values are remembered and the displayed values are the difference between the energy current read-out and the remembered value.

3.3.1 Energy costs calculator

On the right side, in **MEASUREMENT** tab, a button is available for **ENERGY COST CALCULATOR**. After clicking the lower part of the window, a table with **TARIFF CALCULATOR** is displayed, which shows energy values of the current session (from opening tab **MEASUREMENTS**) and energy costs by three tariffs configured in the program settings. Energy is counted by the calculator as long as window **LIVE MODE** is open. The basis for calculating is total active energy input (**E$_P$+**).

To analyze and create reports on energy consumption based on recorded data use the module for reporting energy costs which is in the data analysis section (see sec. 4.4.5).

3.4 Phasor diagrams

Phasor diagram (Fig. 51) is used to present the vectors of fundamental voltage and current components. Angles between the vectors correspond to the angles of phase shift between individual phases. A table with numerical values is displayed on the left side of the graph. Individual rows of the table present:

- U_{H1} – amplitudes of voltage fundamental components,
- φ_{U_H1} – angles of voltage fundamental components in relation to L1 voltage fundamental component (in angle degrees),
- I_{H1} – amplitudes of current fundamental components,
- φ_{I_H1} – angles of current fundamental components in relation to L1 voltage fundamental components (in angle degrees),
- φ_{U,I_H1} – angles between voltage and current vectors (φ_U – φ_I) for a given phase (not available in 3-wire systems),
- **TYPE** – the type of a receiver, indicated by a coil symbol for inductive load or a capacitor symbol for capacitive load (unavailable in 3-wire systems).

Above the table are the on/off buttons for voltage (**U**, **φ_U**), current (**I**, **φ_I**), angle **$\varphi_{U,I}$** and a load type. In addition, the user may change the default background color of the table for these groups.

The vector angles are referenced to U_{L1} vector angle which is always $\varphi = 0°$. The vector amplitude scaling takes place automatically in relation to the highest value, independently for voltage and current.
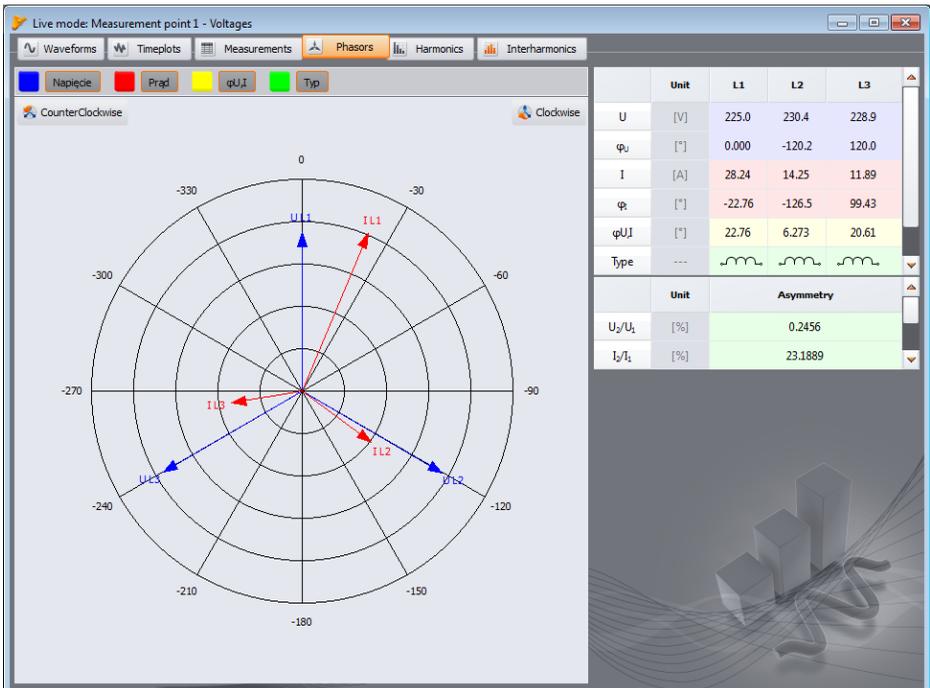

Fig. 51. Phasor diagram for wye connection.

On the diagram two buttons are present for turning the phasor diagram by 90° clockwise or counter-clockwise.

3.5 Harmonics

PQM-700 **PQM-707** *PQM-700 and PQM-707 analyzers have no function for measuring active and reactive power harmonics and K-factor. Moreover, these analyzers measure harmonics only up to 40-th order.*

Harmonics tab enables user to view harmonic values in voltage and current, active and reactive harmonics power, THD and K-factor. A typical screen is shown in Fig. 52. Parameters are displayed for one phase, which is selected by buttons on the right.

A bar graph with harmonics is displayed in the central part of the screen: from DC component, through the first component up to the 50th.

MEASUREMENT 🔟 list on the right side of the window allows selecting one of two options:
- **VOLTAGE, CURRENT**– displays the voltage and current harmonics,
- **HARMONICS POWER** – displays active and reactive harmonics power.

On the left and right side of the graph, axes are displayed and marked with units corresponding to the chosen mode: **VOLTAGE, CURRENT** - left side is assigned to voltage axis, while the right side is to current axis. In **HARMONICS POWER** mode, on the left side, the axis of active power is located, while on the right the axis of reactive power. This arrangement may be changed, using the lists above the axes 🔳.

The tables below the bar graph present (from the left):
- THD factors,
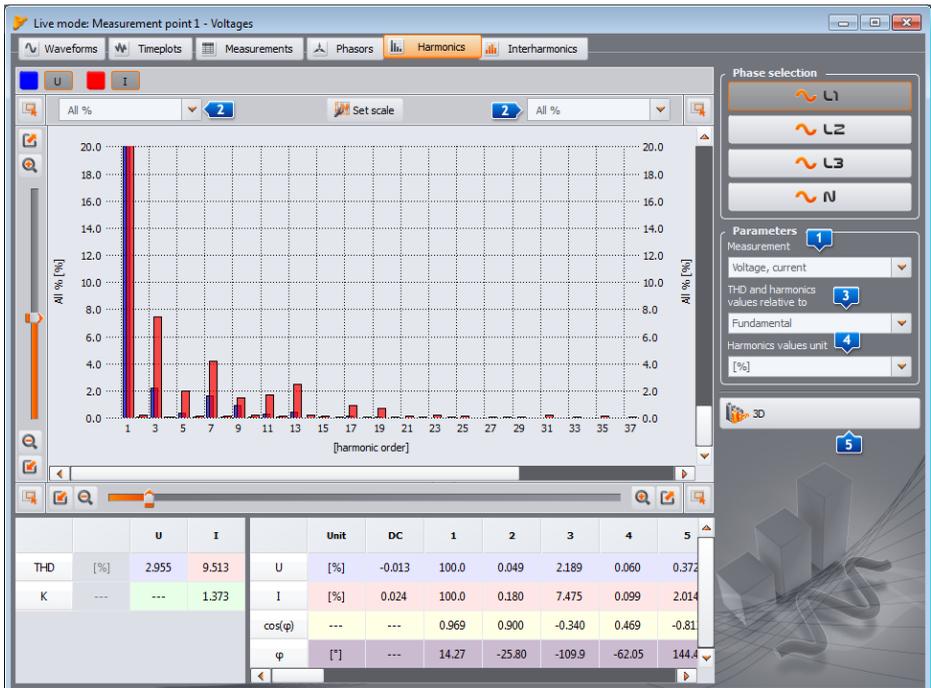- K-factors (only in **VOLTAGE, CURRENT** mode),

Fig. 52. Harmonics on 2D graph.

- a table with numerical values of voltage and current harmonics (in **VOLTAGE, CURRENT** mode) or values of active and reactive power harmonics (in **HARMONICS POWER** mode) and the factors of the phase shift between current and voltage harmonics - **COSφ** and values of angles - **φ** (in angle degrees).

The user has the access to two settings:
- **3** **THD AND HARMONICS RELATIVE TO** – two options are available: relative to RMS or to the first harmonics (this option is active only after selecting the percentage unit – see below),
- **4** **HARMONICS UNIT** – here also two options are available: in absolute units [V], [A], or as percentage values.

A right-click on the graph in **VOLTAGE, CURRENT** mode, displays a context menu with the following options:
- **SET SCALE ACCORDING TO NOMINAL** (for voltage) or **SET SCALE ACCORDING TO CLAMPS RANGE** (for current). Use this option to re-scale the harmonics bars and adapts them to the graph window height, taking into account the nominal value,
- **SET SCALE AUTOMATICALLY**. This feature automatically adjusts the scale.
- **VOLTAGE LIMITS** (option available only for voltage harmonics and after selecting percentage display). This option results in imposing harmonics limits defined in the default standard (the default standard and its limits are determined in **PROGRAM CONFIGURATION**, in section **ANALYZER SETTINGS →-STANDARD DEFAULT SETTINGS**, see also sec. 5.3.2).
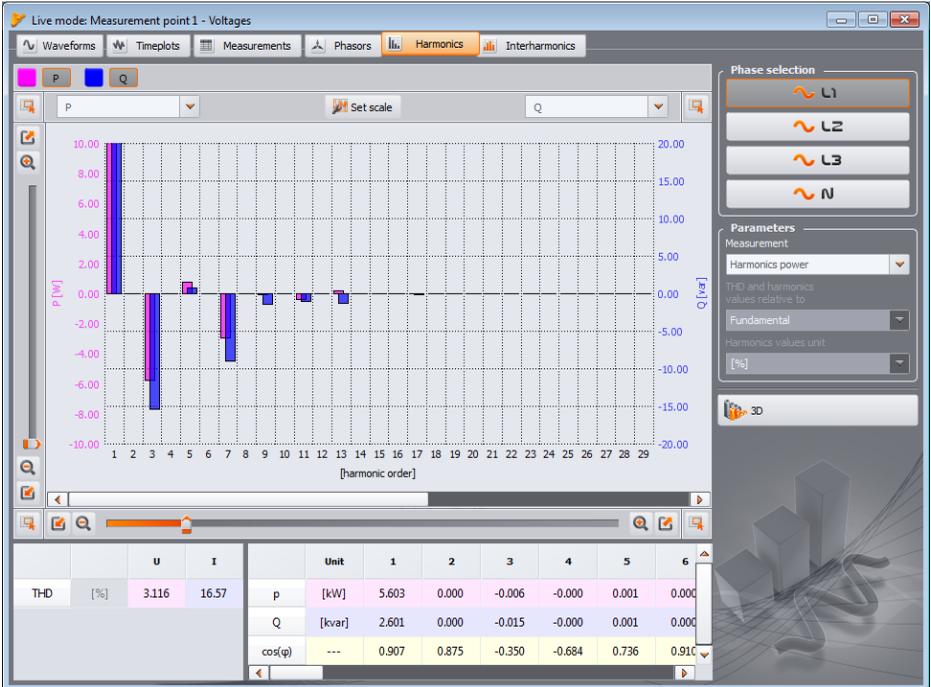- **HIDE FIRST HARMONIC.** This option turns on/off the plot containing the fundamental harmonic.

Fig. 53. The screen with harmonic powers (not applicable to PQM-700).

In the bottom right-hand corner, a button ⑤ is located for switching between 2D and 3D view. After clicking it, the harmonics are presented as a 3D view. After clicking **ANY VIEW** button, the graph may be freely positioned using a mouse. Hold the left mouse button on the diagram and set it in desired position. Hold the right mouse button to zoom in/out the graph. You can use also the sliders on the left side of the window or the mouse scrolling wheel.

3.6 Interharmonics

PQM-700 **PQM-701** **PQM-707** *PQM-700, PQM-701(Z, Zr) and PQM-707 have no option to measure interharmonic components.*

INTERHARMONICS tab enables the view of interharmonics values of voltage and current and TID factors. A sample screen is shown in Fig. 54. Parameters are displayed for one phase, which is selected by buttons on the right.

In the central part of the window, a bar graph with interharmonics is presented: it ranges from the subharmonic group (0) through all other groups interharmonics up to the 50-th.

On the left and right side of the graph, axes are displayed and marked with units corresponding to the chosen mode: **VOLTAGE, CURRENT** - left side is assigned to voltage axis, while the right side is to current axis. This arrangement may be changed, using the lists above the axes. ①

The tables below the bar graph present (from the left):
- TID factors,
- a table with numerical values of interharmonics amplitudes for voltage and current.
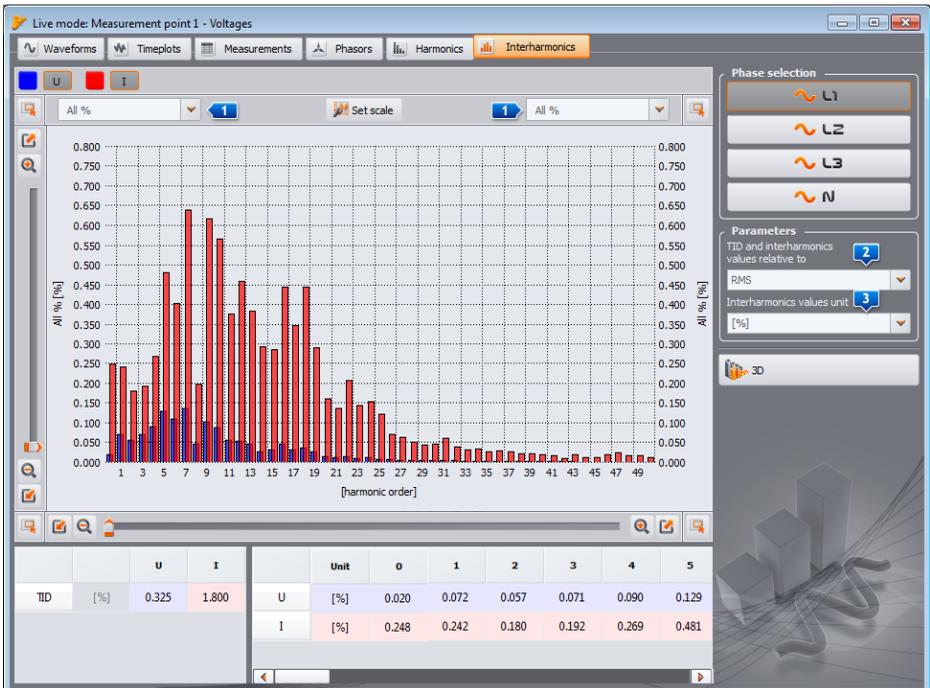
Fig. 54. Interharmonics graph.

The user has the access to two settings:

- **2** **TID AND INTERHARMONICS VALUES RELATIVE TO** – two options are available: relative to RMS or to the first (fundamental) harmonics,
- **3** **INTERHARMONICS VALUES UNIT** – here also two options are available: in absolute units [V], [A], or as percentage values.

A right-click on the graph, displays a context menu with the following options:

- **SET SCALE ACCORDING TO NOMINAL** (for voltage) or **SET SCALE ACCORDING TO CLAMPS RANGE** (for current). Use this option to re-scale the interharmonics bars and adapts them to the graph window height, taking into account the nominal value,
- **SET SCALE AUTOMATICALLY**. This feature automatically adjusts the scale.

4   Data Analysis

The analysis block allows the user to read data collected by the analyzer during the recording, view numerical data and graphical visualization. The user may generate reports that in a clear manner describe the tested system.

PQM-707 *Reading data from PQM-707 analyzer is described in sec. 4.1.1.*

4.1   Reading data from the analyzer

After selecting analysis from the upper menu or clicking **ANALYSIS** icon, when no analyzer-program connection is established, a standard connection procedure is launched to connect the analyzer and the program (sec. 1.4).

After correct connecting the analyzer to a PC, a window is displayed - as shown in Fig. 55 and data may be selected for downloading and further analysis. To do this, select the measurement points from which you want to download the data. On the right side of the bar representing the amount of stored data, the actual amount of data is displayed. To start downloading data from the selected measuring point, click **READ DATA** button.
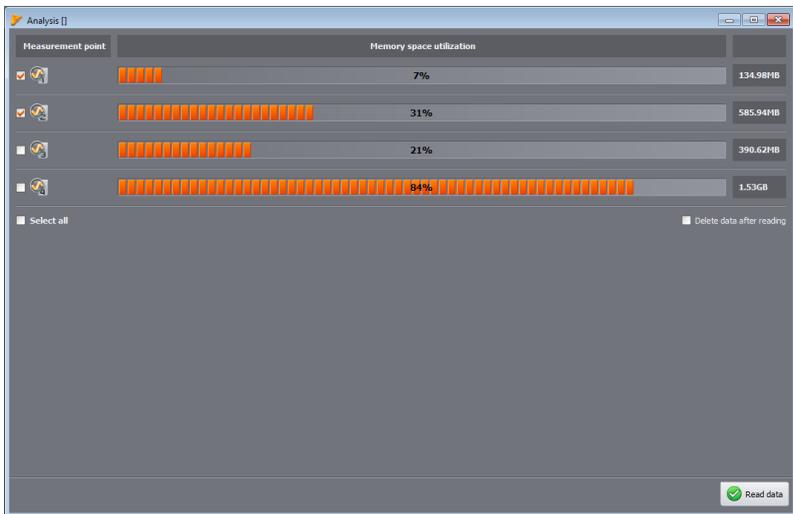
Fig. 55. Selecting data for read-out.

Select **DELETE DATA AFTER READING** option to delete data from the point(s) of the read-out. Therefore, after pressing **READ DATA** button before the transmission, an appropriate warning message is displayed

Data may be deleted from the card at any time by entering **ANALYZER** menu and choosing the option of **ANALYZER→DELETE DATA**. This action may be used to delete data of chosen measurement points (without changing their configuration) or to completely format the card.

During the data read-out, the status bar at the bottom of the window shows the download progress and **CANCEL** button, which may be used for stooping the process.

PQM-702 **PQM-703** **PQM-710** **PQM-711** PQM-702, PQM-703, PQM-710 and PQM-711 analyzers use the built-in mass storage mode to accelerate the readout of data via the USB connection. This mode is used when the amount of data to be downloaded exceeds 1 MB. If the amount of

data is below that limit, a standard (slower) communication mode is used. Other analyzers use only standard communication mode.

Note

When other, additional windows are also opened for displaying on-going (live) data from the analyzer (e.g. LIVE MODE or CONTROL), the standard (slower) communication mode is used for data download. Before pressing READ DATA button, close these additional windows in order to use the high-speed data reading mode.

After data read-out, a window is opened for saving the file *.pqm7xx* (the file extension depends on the analyzer model). In a file with this extension, the software saves identical copy of data read from the analyzer (not processed by the program). Saving this data is not required but highly recommended. Without this file performing a next analysis, basing on recorded data will require another data read-out from the analyzer (this is particularly important if the user reads the data from several measuring points - saving later file *.analysis* concerns only one measurement point selected for the analysis; data from other points need to be re-read). Saving file *.pqm7xx* will also allow you to create multiple analyses and *.analysis* files from a selected (reduced) period of time, which will reduce the size of these files.

Note

*When the user selected DELETE DATA AFTER READING option without saving data before proceeding to data analysis, the source data will be irreversibly lost. It will be possible to perform analysis and save data to a file with *.analysis extension only from one measuring point (selected for analysis), but you will be unable to fully use the source data for further analysis (e.g. from different time range), or from another measuring point.*

4.1.1 Reading data from PQM-707 analyzer

A method of reading data from PQM-707 differs in a few aspects from the description in sec. 4.1. After selecting **ANALYSIS** option the menu, similarly to other analyzers, the procedure of connection with the analyzer is launched (if the connection is not established earlier). After a successful connection the window shown in Fig. 56 is displayed, where the user indicates what type of data will be loaded from the meter: recording data (**RECORDINGS**) or **SCREENSHOTS**.
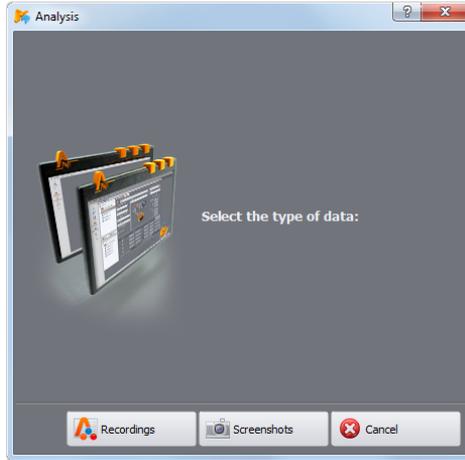
Fig. 56. Reading data from PQM-707 – selecting data type.

After selecting **RECORDINGS**, the user receives the list of recordings that may be downloaded. An example is shown in Fig. 57.

Fig. 57. Reading data from PQM-707 – list of recordings.

The table shows in its columns:
- Name of the recording.
- Recording time range (date and time of recording start and end)
- Data size.

Select one record for downloading by clicking on its line, then click **READ DATA** button

During the data read-out, the status bar at the bottom of the window shows the download progress and **CANCEL** button, which may be used for stooping the process.

After reading the data, a window with save option opens *.pqm707*. In a file with this extension, the software saves identical copy of data read from the analyzer (not processed by the program). Saving this data is not required, but performing a next analysis, basing on recorded data will require to another data read-out from the analyzer. Saving file *.pqm707* will allow you to create multiple analyses and *.analysis* files for the selected the selected time range.

To read screenshots, proceed as follows. After window shown in Fig. 56 is displayed – click **SCREENSHOTS**. A window appears with a list of screenshots saved in the memory of the meter. The table displays the file name and column **SELECT** for selecting files to be downloaded. You can also save all files by checking box **SELECT ALL**. Use **LIST** button to return to the window with selection of data type (Fig. 57).

To start the download, click **READ DATA** button. After its completion, a window appears which indicates the folder for saving screenshot files. These files are graphic files with *.png* extension.

4.2   Reading data directly from the memory card

Alternatively, to read data from the analyzer, as described in sec. 4.1 and 4.1.1 (for PQM-707), in case of analyzers with removable memory cards you may use direct mode to read data from the card. This method may be used with the following analyzers:
- PQM-701 (also 701Z and 701Z versions),
- PQM-700,
- PQM-707.

In these analyzers the memory card (SD or microSD) is removable and available to the user. It is necessary to use a memory card reader that supports SD HC (High Capacity) cards.

Note

To minimize the risk of data loss, it is recommended to always switch off the analyzer before removing the memory card. By doing this you will protect all cached data and ensure their proper saving - the card will not be removed during the saving process.

After inserting a memory card into the reader, proceed as described in sections 4.1 and 4.1.1 – the process begins by selecting **ANALYSIS** option from the toolbar or menu. If the program detects a card reader connected to PC with the card coming from the analyzer, the list of available devices will include the appropriate entry, e.g. "*PQM-707 [S / N: XXXXXX] The combination of the memory card.*" After selecting this position (by double-clicking or pressing **SELECT**), a window appears to confirm the connection, then another window is shown for selecting the data for reading, as described in earlier sections. From this moment the operation of the device is the same as stated in the above sections.

After downloading the data, you may end the connection (**DISCONNECT** option).

Sonel Analysis software enables user to exclude specified devices (disks) from the search area. In cases where the program does not detect the memory card from the analyzer, check whether the device (i.e. the drive letter that assigned to the memory card) is on the 'excluded list. These settings may be found after selecting in menu: **OPTIONS→PROGRAM CONFIGURATION→DATA ANALYSIS→ EXCLUDED DEVICES**.

4.3   Selecting the time interval for analysis

After correct data read-out, a window will be displayed, indicating data that will be taken for further analysis.

At this stage, (if not already done so) you may save the source data by clicking **SAVE** icon on the toolbar or select function **SAVE** or **SAVE AS** from **FILE** menu.

If the user wants to perform many analyses on the read data, after downloading, save such data on a local disk as a file with the extension **.pqm7xx*. Such file will include an identical copy of the read data that may be used at any moment – then the user may return to the analysis time selection screen (Fig. 58). Please remember that if you send a new measurement point configuration, the SD card will be formatted and all recorded data will be irreversibly lost.

Starting the analysis (by pressing **DATA ANALYSIS** button), when the user did not save source data in **.pqm7xx* file, will require a next data read-out from the card, always when the user wants to perform another analysis based on the data stored on the card (when file **.analysis* was not saved or the time period was reduced).

If data from several measurement points were taken to be analyzed, the user must select data from one measurement points and select appropriate time interval. Only data from the specified range will be analyzed and possible saving in **.analysis* file. The dialogue box is shown in Fig. 58. The meaning of the window elements is as follows:

- The list of read measurement points is located on left side 🔲. Below the measuring point, the following information is shown: name of the point (as entered in the configuration) and all time intervals during which the analyzer was recording data. Reasons for start or stop are stated on the right side of the time in brackets, including:
    - o **USER** – start or stop initiated manually by the user,
    - o **BATTERY** – stop triggered by discharged battery,
    - o **MEMORY**– stop triggered by full memory,
    - o **CARD** – stop triggered by removal of the memory card,
    - o **TEMPERATURE** – stop triggered by exceeding the permissible internal temperature of the analyzer,
    - o **RESUME** – restarting after stop caused by the above causes, excluding the case described in section **USER**.
- The middle and right part of the screen present graphically (bars) recording time intervals in all measurement points. After selecting a measurement point, the bars representing the periods from this point change color to red, showing which data can be analyses. At the same time **DATA ANALYSIS** button is enabled.
- Next to the description **MEASUREMENT POINT X** (where **X** is point's number) information is displayed, indicating whether data from this point have been recorded according to the standard (text **STANDARD**) or according to user-defined settings (text **USER**), in case of dual recording supported by the selected analyzers - "**STANDARD, USER**".
- The following three fields define start 🔲, duration 🔲 and the end of the analysis interval 🔲 , which is selected by two sliders 🔲 **S** (*start*) and **E** (*end*). The user may use these sliders, to select a shorter interval for analysis. If you select interval longer that a given period, the whole period will be selected for analysis.
- The central field, marked as **RANGE** 🔲 includes information about the period selected for the analysis. Its format is as follows: "week:day:hour:minute:second". The user may select standard time interval from the drop-down list: 🔲 10-min., hour, day, week. If a selected period is longer than recording, the whole recording is checked.
- A double-click on the time of starting the recording sets slider **S** at the beginning of recording 🔲, whereas a double-click on the time of ending the recording sets slider **E** at the end of recording in a given measurement point.

- Clicking **SUMMARY** buttons moves the user to data analysis of selected interval, similarly as clicking **DATA ANALYSIS**, but in this case additionally two windows will be automatically displayed: **TABLE SUMMARY** (Fig. 68) and **GRAPHICAL SUMMARY** (Fig. 69). See description in sec. 4.4.3.13.
- Clicking **Data analysis** processes the data recorded by the analyzer and moving to analysing data of the selected time period.

> ### Note
> *In rare situations, the program can display a message on detecting a portion of erroneous data. Block of such data is rejected by the application. Other read data are available for analysis.*
>
> *The causes of detecting error data may include:*
> a) *Incompatibility of Sonel Analysis software with the analyzer software, which generated the data. In such case, check whether Sonel Analysis software and the analyzer are updated.*
> b) *Internal error of the analyzer that occurred during recording or an application error when interpreting the data. The analyzer error may be caused by a software error or by external causes such as strong electromagnetic disturbance. In these cases, you may send source data from the analyzer (file: *.pqm7XX) to the manufacturer for analysis and possible repair.*

- Clicking **LIST** button returns the user (after confirmation) to the window with analyzer data read-out (). If downloaded data is not save until this moment, it will be lost.
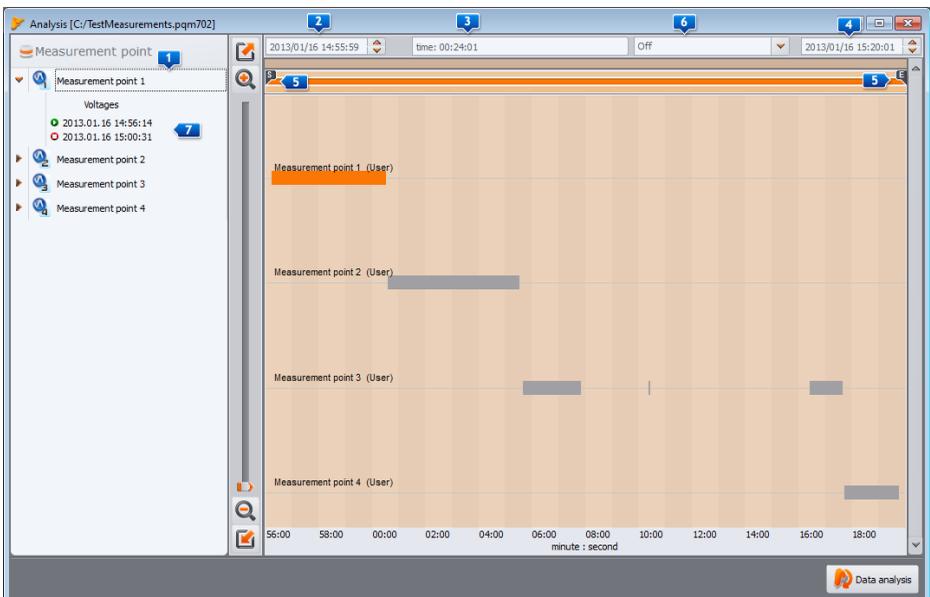
Fig. 58. Selection of time period for the analysis.

4.4 Analyzing obtained data

After a correct data read-out, the main data analysis module window is displayed (Fig. 59). The window is divided into several parts:

- On the left hand side, the user will find buttons that enable displaying of the following data:
  - **GENERAL** – in this view – in the upper part of the window all data of individual types are displayed as dots (Measurements, Events, and Waveforms), and in bottom part – after selecting an event dots or waveform,
  - **MEASUREMENTS** – in the upper part all types of measurements recorded according to the averaging time are displayed as dots (voltage, frequency, etc.), and in bottom part the summary table with values of the parameters,
  - **EVENTS** – in the upper part all types of detected events are shown as dots (voltage dips, swells, interruptions), and in the bottom part the list of events in table form.
  - **CONFIGURATION** – displays the analyzer configuration that was active during the recording.
- Selecting a chosen button results also in displaying relevant data in the table below the graph.
- The fields that include start date, time period and end date are shown above the graph.

4.4.1 GENERAL view

In **GENERAL** view, the user may access a quick preview of waveform and/or event. But the view of the measurements is not available. After pointing the cursor on an event point ![1] and left-clicking the mouse, the screen displays information about this event ![4] and the waveform (when recorded with the event – Fig. 59).

Sometimes the graph may be very dense and a single point may have many overlapping points; in such case placing the cursor over a point displays the event and waveform that were recorded with the earliest date/time. At the same time, above the selected point, information is displayed about the number of events or waveforms.

If there are more events in a point, tabs appear ![2] above the graph. The descriptions of tabs correspond to the type of event or the waveform.

When an even is selected, the displayed waveform is from the beginning of this event.

Use the slider (or the mouse scrolling wheel) to zoom-in the selected area (reduce the time interval). If you select the dot of an event which has the beginning and end waveform, the corresponding waveforms will also be selected. Similarly, if the waveforms were recorded after the averaging period, clicking on the measurement dot ![3], simultaneously highlights the dot of accompanying waveform.
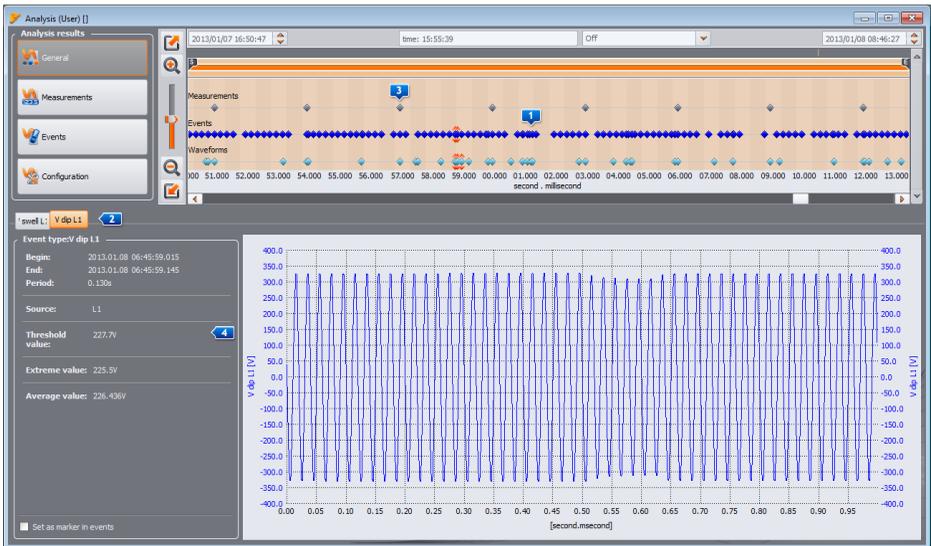
Fig. 59. **GENERAL window with the waveform preview.**

4.4.2 MEASUREMENTS view

Pressing **MEASUREMENTS** button, changes the window image into the one shown in Fig. 60. In the bottom part, the program displays parameters that may be analyzed.

The graph in the upper part shows the dots representing measured parameters over time. In the case of large amount of data, dots may overlap each other.

Similar as in case of choosing the analysis time range, three fields are displayed to indicate the beginning, duration and the end of the selected time range (required time range may be manually entered). The range of data displayed in the table, may be also reduced using two sliders **S** (start) and **E** (end).

Below the dot-graph, a summary table ◼ is displayed with recorded values of the parameters. The table shows only the data for the selected time interval. If the reset function is activated for currents below the threshold (**CURRENT LIMIT** function), the column headers for parameters that may include reset values are marked with an asterisk (e.g. I *L1[A]).

The checkboxes ◼ on the left side are used to include/ exclude some parameters from the table.

If a parameter measured in a few phases is selected (such as voltage), all columns (U L1, U L2, U L3) will be displayed in the table. In order to limit the amount of data displayed in the table, use the buttons ◼ (**L1**, **L2**, **L3**, **N)** on the right side.

Use **DISPLAY HARMONICS** ◼ to display harmonics and inter-harmonics and to switch between the display modes of harmonics in the table:

- **ABSOLUTE** – the data are displayed in absolute units [V] and [A],
- **RELATIVE TO h01** – data are converted and displayed as a percentage relative to the fundamental harmonic,

RELATIVE TO RMS – data are converted and displayed as percentages relative to the RMS value of the parameter.

To filter displayed columns you may also use section **SHOW VALUES** 🔟, which includes the following options: **AVG, INST, MIN, MAX.** The user may check/ uncheck these options to show/hide relevant recorded values.

A right-click within the table area results in displaying a context menu ▣ with the following options:

- **COLUMN WIDTH AUTO-ADJUSTMENT** – enabling/disabling automatic width adjustment for columns with parameters,
- **SELECT ALL** – selecting the whole table with measurements,
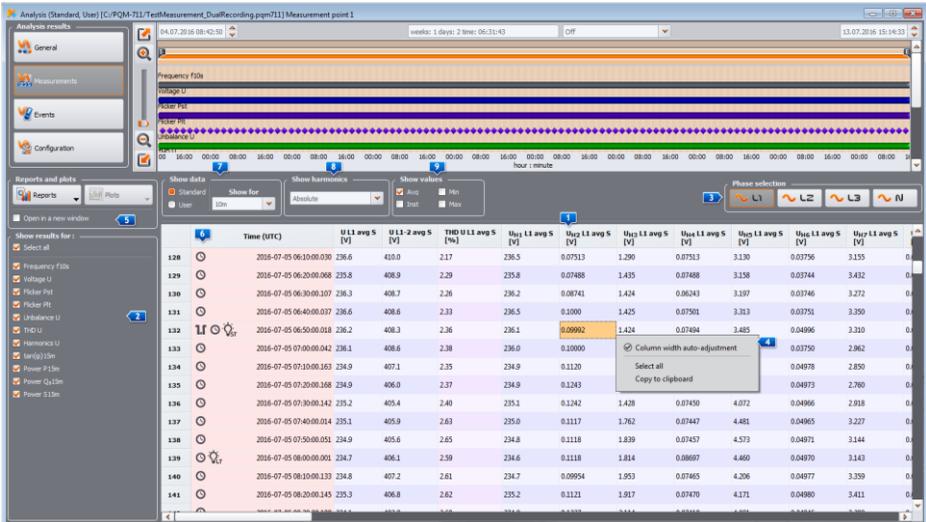- **COPY TO CLIPBOARD** – copying the selected data to the clipboard.

Fig. 60. Measurements view.

Selecting 5️⃣ **OPEN IN A NEW WINDOW** option, a new graph or table will always be opened in a new window. If this option is disabled, a separate window with a graph or table is refreshed.

Data in individual rows may be specially marked with an icon 6️⃣ next located next to the time field, indicating one of several possibilities:

- Icon 🕐 indicates that the parameters were measured without time synchronization with UTC. Thus, these data do not meet all the requirements for a Class A according to IEC 61000-4-30, as for precision in time measurement.

- Icon 🎚 indicates that during this averaging interval, a voltage event occurred e.g. dip, swell, or interruption. The listed types of events may be a cause of incorrect measurements for some mains parameters and IEC 61000-4-30 standard recommends that in such case the whole averaging period is flagged to inform the user that the measured values might be unreliable. The decision how to treat the flagged data is left to the user. Data (lines) marked with this flag are rejected when the standard-compliance report is generated - when you decided to exclude records of events such as dip, swell and interruption.

- Icon 〽 indicates a momentary loss of PLL synchronization, detected during the averaging interval. This could occur e.g. during a voltage dip in L1 channel (reference

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channel for PLL circuit). Parameter values measured in such conditions may be uncertain.

- Icon $\circlearrowleft$ indicates that during this averaging interval time-resync process occurred (adjusting or step time change after acquiring GPS time sync).
- Icon ⑊ indicates an analog/digital converter overflow (input signal amplitude exceeds max. measurement range).
- Icons $\dot{Q}_{ST}$ and $\dot{Q}_{LT}$ indicate that the flicker values (P_{ST} or P_{LT}) of one or more phase in a given line are flagged as required by IEC 61000-4-30. The values of these indicators may be affected by voltage events such as dip, swell and interruption, which is why the standard specifies determination of such values as uncertain. In the standard-compliance report flagged P_{ST} and P_{LT} values are excluded from quality statistics, if the user chose any of the two methods of excluding flagged data.

In general, parameters are recorded according to the averaging time defined in the configuration. For example, if the user defined 10-minute averaging time, every 10 minutes a record is written on the memory card with the average values (and optionally minimum, maximum and instantaneous values) of the parameters. However, in some cases, there are exceptions to this rule. Examples may include the following:

- Long-term flicker severity P_{LT} – it is measured every 2 hours, hence at a 10-minute averaging time, a new P_{LT} value is displayed every 12 averaging periods,
- Frequency - the measurement time of this parameter is 10 seconds,
- Values of 15-minute active and reactive power recorded in accordance with the *Polish System Regulation*,
- The ripple control signals for recording in accordance with EN 50160 - averaging time of these parameters is 3 seconds.

In order to facilitate search for parameters measured with different averaging times, an option has been added for displaying parameters in relation to the indicated averaging period. For example, if the user performed a measurement with 10-minute averaging time and wants to quickly display the records in which P_{LT}, was measured, then in **SHOW DATA** 7 section the user may select value **2h** from **SHOW FOR** list. Then, the table will include only the rows with times being the multiples of 2 hours, during which the next measured value of P_{LT} occurred. Another example of this functionality is selecting from the list item **10s**, in order to display all the 10-second frequencies for recording in accordance with EN 50160.

Data analysis according to EN 50160 (or other standards) is analogous to the analysis of the **USER**. The main difference is that in this mode, the user may additionally generate a report on compliance with EN 50160 standard (or other standard). This report includes only those parameters and events that are important from the point of view of the standard. If the currents were measured, the measured parameters table will show also the 15-minute average values of active, reactive and apparent powers, as well as of tanφ. The report on compliance with *Polish System Regulation* takes into account the values of max. 15-minute power and tanφ.

Some analyzers (e.g. PQM-702) allow dual recording, i.e. simultaneous recording for compliance with the selected standard, and independent recording according to the user settings. To switch between table view between standard data and user data, use the switch in section **SHOW DATA** 7:

- **STANDARD** – standard measurement data are displayed,
- **USER** – measurement data configured by the user are displayed.

To distinguish standard parameters from the user data, name of standard data is marked with "S" letter (S - *Standard*), e.g. "*U L1 aver. S*".

4.4.2.1 Time diagram

The user may generate time plots of parameter value (one or more). To do this use **PLOTS** button and **TIME PLOT** option – after selecting parameter columns (see Fig. 61) and selecting this option, a new window opens with the plot that shows waveform of parameters in time. To include only a part of total time interval in the diagram, in **TIME** column select the period you are interested in. You may select any parameter columns, including individual harmonics e.g. U, I, f, H03, H05 etc. A typical time plot is shown in Fig. 62.
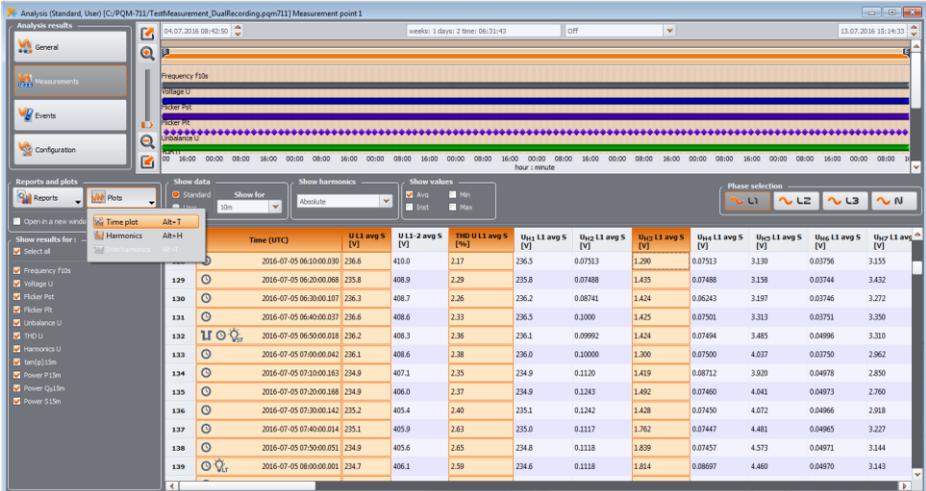

Fig. 61. Selecting data for the timeplot.

Description of the timeplot (Fig. 62):

- the top left part includes section **GRAPH DATA** 1, which informs about start, end and time difference of the plot (horizontal axis),
- information 2 about the values of three independent markers 3 is displayed on the left side at the bottom (two circles on the plot) and differences between them,
- markers may be moved using the left mouse button (grab and move) Next to individual markers their numbers are displayed for easy identification and linking them to numerical parameters displayed on the left side of the graph.
- use left/right arrows to move the markers along the time axis,
- use up/down arrows to move the active marker to the next waveform,
- in the default mode, the grabbed marker "sticks" to the nearest waveform. If after a right-click within the plot area, the user selects **MARKER FREE** option, the marker may be freely set. If there is no waveform near the marker, its colour changes to grey and the coordinates in the X axis refer to its current position.
- after right-clicking the mouse a **COMPARISON MODE** is also available. It sets the markers at the same time point and moving one of them moves the others. It enables users to easily compare up to the three chosen parameters for a given time.
- use the buttons 4 located above the plot to switch on/off individual waveforms and change their colour,
- use the sliders or the mouse scrolling wheel to zoom-in the plot vertically and horizontally (vertically, if the mouse pointer is close to side edges of the plot; horizontally, if it is close to the top or bottom edge)
- keeping SHIFT key pressed, use mouse to select a rectangular area to be zoomed-in,

- keeping CTRL key pressed, left-click within the plot area and still keeping it pressed, move the visible fragment (the cursor arrow turns into a hand)
- the plot has two vertical axes on the left and right side; from the drop-down lists 5, select the scale for the value to be displayed on the plot,
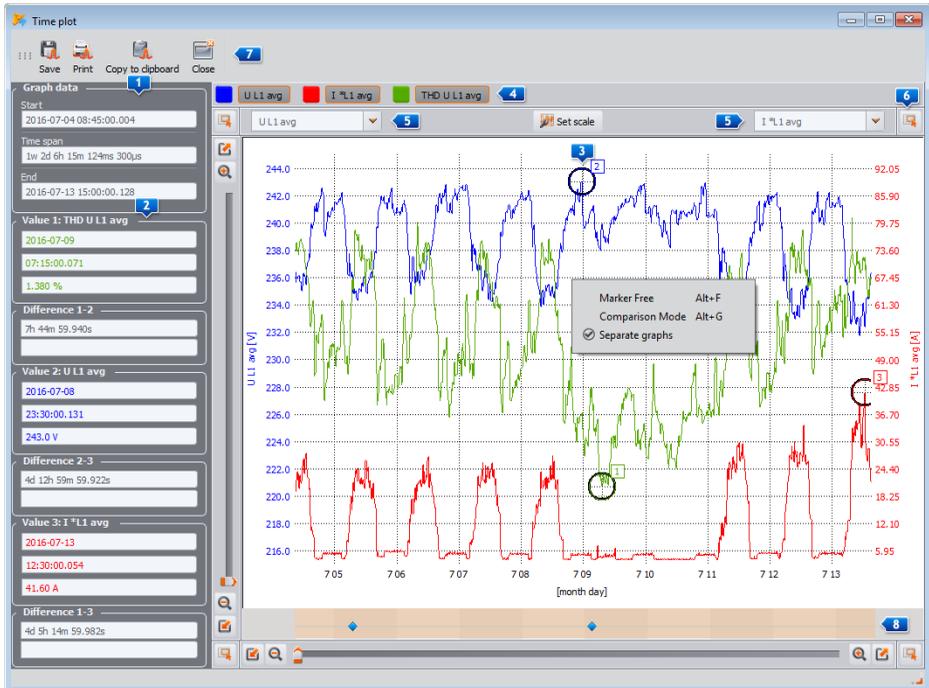

Fig. 62. Timeplot window.

- in addition to the parameters selected by the user (i.e. U L1, I L1, P etc.), the scales drop-down lists include also the group of parameters with the same units (V, A, W, var, VA, %, Hz, [---] - no unit). When a group is selected, one scale is adopted for the plot (e.g. in V) and all waveforms from this group are rescaled to fit the scale,
- selecting a given group for the left-side scale Y, will result in disabling this group and all its parameters on the right scale Y, and vice-versa
- use **SET SCALE** to expand the panel for manual scale adjustment. Unchecking **AUTO** field enables user to enter own axis limits for individual parameters (or groups of parameters). After entering the desired value, press **SET** button to update the plot.
- Function **SEPARATE GRAPHS** (available in the context menu) is useful when the graph presents parameters with two units - in this case, enabling this option will separate graphs vertically by appropriate selection of scales, to avoid their overlapping. For example, if the graph presents a multiple voltages and currents, this option will result in adjusting their scales to show voltages in one half of the window, and currents in the other.
- Bar at the bottom of the window 8 shows dots of voltage events on the time plot (if they occurred - dip, swell, interruption, transient). After clicking selected dot, a window appears with a list of events that occurred at that time and it is shown in the same manner as in view **EVENTS**. Directly from this window, you can also open the windows of RMS$_{1/2}$ plots and waveforms that accompanied the event, if they have been recorded.

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- clicking on icons [6] in the corners of the screen will result in displaying a miniature of the whole plot; the highlighted rectangle illustrates a part of the plot which is currently zoomed in; move it with a mouse on the plot miniature to move the plot in the main window,
- pressing any of the buttons [7] located in the top of the screen results in saving the plot on the disk in a user-selectable format: *jpg*, *png*, *bmp* or *xpm*, copying it to the clipboard, or printing,
- the plot may include maximum of 12 waveforms.

4.4.2.2 Harmonics/interharmonics graph

If the recorded parameters include harmonics and/or interharmonics (for voltages and/or currents) you may generate a bar chart of harmonics. A plot may be generated from one averaging period (after selecting one row) or from many rows (specified period of time) – then the plot is displayed with averaged values of harmonics. One chart may present several measurement channels.

To generate a bar chart:

- Select the time interval – select a cell or range of cells in **TIME** column,
- Select the parameter type and channel – tick at least one column of any harmonic (or inter-harmonic) of the selected channel (and type, e.g. minimum, average, maximum)
- Select option **PLOTS→ HARMONICS** (or **PLOTS→INTERHARMONICS**) to display plot window.

The bar graph displays the level of all harmonics measured by the analyzer. All other selected values (which are not harmonics, such as U, f, I, etc.) are ignored. Pressing keyboard shortcut *Alt-O* may display alternately the graph with or without the first harmonic. The same effect is obtained using the context menu and selecting **HIDE FIRST HARMONIC** (context menu is opened by placing mouse pointer on the graph and pressing right mouse key). Use three markers to indicate specific bars, in order to read their values (amplitude is indicated in [V], [A] or [%] including their order). A sample screen is shown in Fig. 63.
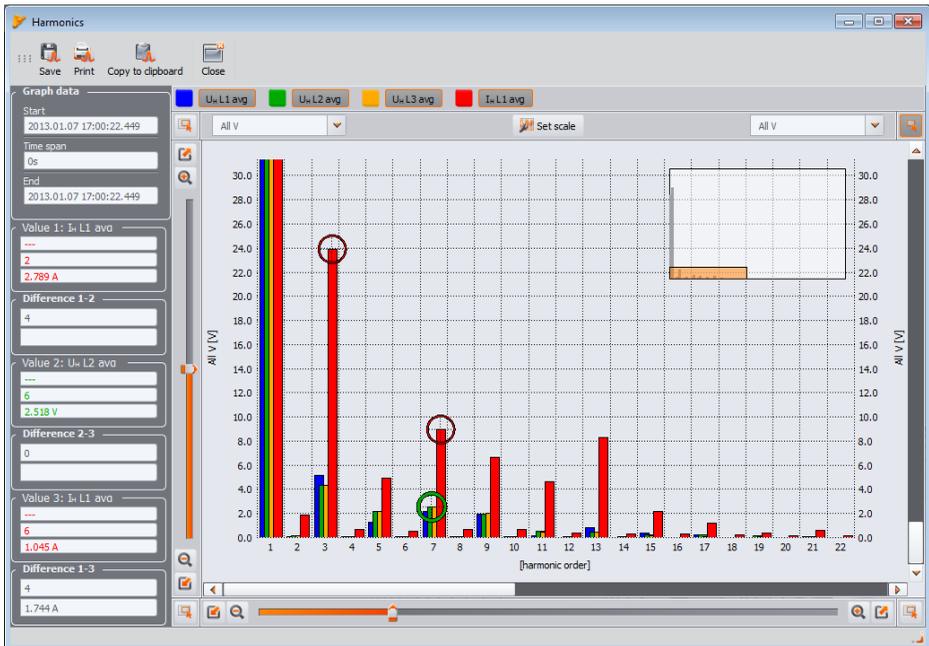
Fig. 63. Harmonics graph.

4.4.2.3 Cyclic waveform plot

If the configuration of the measuring point has active recording of waveforms after the each averaging period (for voltage and/or current), the waveforms may be opened by clicking on the waveform icon in the last column of the table with measurement data.

4.4.2.4 User report

Highlight any column (e.g. f, U L1, THD U, etc.) or any range of cells and click **REPORT** button and then **USER REPORT** to display a new window that will provide options for: saving the selected data in a desired format (*pdf*, *html*, *txt*, *csv*), copying it to the clipboard, or printing. The data refer to the time specified in the selected column (columns or marked cells). Example of a report saved as a *pdf* file is shown in Fig. 64. Maximum 12 columns of data may be generated.

Fig. 64. Sample of report saved as a *pdf* file.

4.4.2.5 Generate report on compliance with standard

If the recording was made for compliance with the selected standards, then after pressing **REPORTS**, an additional option is available - i.e. **REPORT ACCORDING TO STANDARD**. This option allows user to generate a measurement report on compliance with the standard criteria. When selected, a window is displayed as shown in Fig. 65. To generate a report, you must first indicate a number of options that affect the way of generating the final report. In the bottom part of the window (in section **STANDARD PREVIEW**) detailed settings are displayed for selected standard.

At the time of sending the measuring point configuration to the analyzer, when standard-compliance recording was selected, the standard parameters are also saved in the analyzer memory. After completing the recording and reading data for analysis, these parameters are also read, and user may generate a report on compliance with the standard, based on the saved standard profile.

This is not the only option. When generating the report, the user may select also another standard than the one stored in the analyzer memory when sending configuration. In this case, the standard profiles used are stored in the configuration of *Sonel Analysis* software.

Individual options of the window shown in Fig. 65 are described below. Depending on the selected standard, some of the following options are not available, due to the nature of the standard.

Section **REPORT PARAMETERS**:

- **ACCORDING TO RECORDED STANDARD** – generated report will be based on the settings stored in the analyzer,
- **ACCORDING TO STANDARD** – the user may specify a standard from the list, according to which the report is to be generated. In this case, the program uses standard profiles stored in the configuration of *Sonel Analysis*. Remember that in a few cases, e.g. *Polish Regulations*, current measurements record also 15-minute parameters, which are not recorded for other profiles, e.g. EN 50160. If the analyzer was recording in accordance with EN 50160 and then the user tries to generate a report based on the *Polish Regulations*, the section of the report with 15-minute data will be empty due to lack of data.

Section **EXCLUDE DATA**:

This section determines data to be excluded from the statistics in the report. There are three options available:

- **NONE**: report includes all recorded data, including those during which the voltage events occurred,

- **FLAGGED (INTERRUPTIONS)**: statistics of the report are created using data from which the records including interruptions were removed. This is a typical setting, according to which reports should be generated according to the guidelines of EN 50160. Power failures are treated as emergencies in the network operation and as abnormal operation are not included in the quality statistics.
  The definition of an interruption in multiphase systems is consistent with standard IEC 61000-4-30, i.e. a power supply interruption in such a system occurs when in all phases of the system an interruption was detected (at the same time).
  In the report section describing the event, all interruptions are included.
- **FLAGGED (SWEELS, DIPS, INTERRUPTIONS)**: statistics of the report are created using data from which the records including interruptions, dips and swells were removed. In the report section describing the event, these interruptions are included.

Section **GENERATE REPORT**:
- **FOR 25 HARMONICS**: harmonics higher than 25th order will not be shown in the report,
- **FOR 40 HARMONICS**: in addition to the usually shown harmonics up to the 25th order, the report will also show an additional informational section with the levels of higher harmonics of 26 ... 40 order. The quality statistics include 25 harmonics.
- **INCLUDE U L-L**: ticking this option results in including in the report statistics for the phase-to-phase voltages (if recorded). It applies only to 2-phase and 3-phase 4-wire systems.
- **EXCLUDE U L-L**: phase-to-phase voltages in 2-phase and 3-phase 4-wire systems (if recorded) are excluded from the report.

Section **MAINS TYPE**:
    Some standards (e.g. EN 50160) provide separate quality criteria on frequencies for these two types of connections, depending on whether they are connected synchronously with the distribution network:
- **SYNCHRONOUS CONNECTION**: this option is selected in systems synchronously connected to the main distribution network. The report uses the frequency criteria for synchronous connection,
- **NO SYNCHRONOUS CONNECTION**: selected for island systems, isolated from other networks. The report uses the frequency criteria for asynchronous connection.

Fig. 65. Standard-compliance report – report options.

After selecting the settings and clicking **GENERATE** button, the data is processed and a window is shown, in which the user may enter additional data to the report (Fig. 66):

- **REPORT NUMBER,**
- **MEASUREMENT PLACE,**
- **REASON,**
- **MEASURED BY,**
- **NOTES** – in meters with a GPS module, a text is automatically inserted containing the last known GPS coordinates (GPS position is saved after triggering the recording process and after the position of the analyzer is determined),
- **COMPANY LOGO** – you may indicate an image file with your company logo or other picture that will be shown in the report header.

These fields may be also pre-defined in the configuration to serve as a template while generating reports.

The report may be displayed and viewed after clicking **PREVIEW** button. To save the report to a file, select **SAVE**, and then specify the name and file type (*pdf*, *html, csv, txt*).
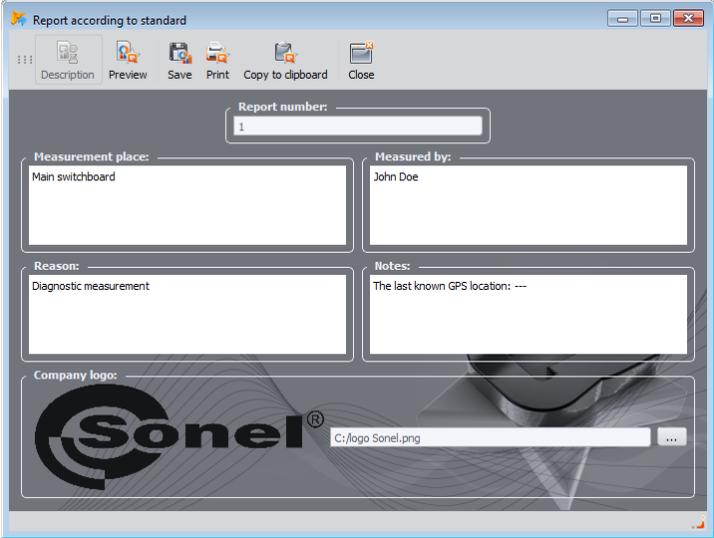
Fig. 66. Entering additional data to the report.

A fragment of a typical report (its first part) is shown in Fig. 67.

Note
*The time interval used in the measurement report depends on the interval selected by the user when the data for analysis were loaded. If this time is shorter or longer than 1 week (required by the standard), the report is still generated, but field **Time** and number of samples are highlighted in red.*

Fig. 67. Standard-compliance measurement report.

4.4.3 *Report according to standard - description*

European standard EN 50160 specifies the characteristics and quality criteria that should be met by the distribution networks of low medium and high voltage. Many countries (including Poland) adopted provisions of this standard, sometimes slightly modifying it, entering own local rules for parameters of the power supply networks.

Standard EN 50160 divides distribution networks, depending on the nominal voltage into three groups:

- Low voltage networks (LV) with voltages U_{nom} ≤ 1 kV (in *Sonel Analysis* the profile for such networks is named "EN 50160 (low voltages)"),
- Medium voltage networks (MV): 1 kV < U_{nom} ≤ 36 kV (profile "EN 50160 (medium voltages)"),
- High voltage networks (HV): 36 kV < U_{nom} ≤ 150 kV (profile "EN 50160 (high voltages)"),

Tab. 4 lists the quality parameters included in standard EN 50160 and the criteria for their evaluation for the low and medium voltage. It should be noted that these criteria relate to the normal operation of the network, excluding periods of power interruptions and other anomalies, e.g. those related to atmospheric phenomena.

Tab. 4. Power quality criteria according to EN 50160 for the low voltage networks (up to 1kV) and medium voltage networks (36 kV).

Parameter	Basic parameter measurement time	Criterion
Slow changes in voltage - RMS voltage	10 minutes	For LV networks: for 95% of the measurements the deviation from the nominal voltage shall be within the range of ±10% U_{nom} for 100% of measurements: –15%...+10% U_{nom} For MV networks: for 99% of the measurements the deviation from the nominal voltage shall be within the range of ±10% U_{nom} for 100% of measurements: ±15% U_{nom}
Frequency	10 seconds	For networks connected synchronously: for 99.5% of the measurements the deviation should be within ±1% f_{nom} (i.e. for 50Hz it is 49.5…50.5Hz) for 100% of measurements: –6%...+4% f_{nom} (47…52Hz) For networks connected asynchronously (e.g. island networks): for 95% of the measurements the deviation should be within ±2% f_{nom} (i.e. for 50Hz it is 49…51 Hz) for 100% of measurements: ±15% f_{nom} (42.5…57.5 Hz)
Rapid voltage changes (flicker)	2 hours	for 95% of the measurements the long-term flicker severity P_{LT} should be ≤ 1
Voltage unbalance	10 minutes	for 95% of the measurements of the negative-sequence unbalance factor should be ≤ 2%
Total Harmonic Distortion (THD-F)	10 minutes	for 95% of measurements, THD-F should be ≤ 8%
Voltage harmonics	10 minutes	For 95% of the measurements, the level of each voltage harmonic component related to the fundamental component should be less than:

Odd order harmonics		Even order harmonics	
Order	Relative level	Order	Relative level
3	5.0%	2	2.0%
5	6.0%	4	1.0%
7	5.0%	6 … 24	0.5%
9	1.5%		
11	3.5%		
13	3.0%		
15	0.5%		
17	2.0%		
19	1.5%		
21	0.5%		
23	1.5%		
25	1.5%		

4.4.3.1 Section GENERAL INFORMATION

Section GENERAL INFORMATION contains general information about measurement parameters, including additional fields, which may be filled by the user when generating the report:
- Measurement performed by,
- Notes,
- Analyzer type and serial number,
- Software (analyzer software version)
- Time of start, end and duration of the measurement (acc. to local time of the analyzer)
- The number of averaged parameter samples, according to different times - this part specifies the number of time periods for which the parameters were measured:
  - o 10 s - the number of frequency measurements,
  - o 10 min - the number of measurement periods for most of other parameters such as RMS voltage, harmonics, THD, symmetrical components,
  - o 15 min – used in reports on compliance with the *Polish Regulation*, where additionally 15-minute parameters are measured e.g. active power, reactive power and tanφ,
  - o 2 h – the number of time periods in which flicker factor P_{LT} was calculated.
- The number of excluded samples - the total number of excluded time periods due to activated option of excluding flagged data (due to interruptions alone or events such dip, swell, interruptions).
- Nominal values of the network:
  - o Mains type,
  - o Nominal phase and phase-to-phase voltage,
  - o Nominal mains frequency.
- Event limits for swells, dips and interruptions.

4.4.3.2 Section MEASUREMENT STATISTICS

Section MEASUREMENT STATISTICS is a graphical summary of the tested network compliance with the standard. Verified parameter type is listed on the left side, while the right side shows the horizontal bars that define percentile of data that meets the quality criteria.

Percentile of a given percentage threshold is the value below which the percentage of all samples is present. Percentile 50% is also called the median; it determines the value for which half of the samples is below the median and the second half is greater or equal to it. In the area of power quality testing, the following percentiles are commonly used: 95%, 99% or 99.5%.

Percentile 0% is the same as the minimum value of the set of samples, whereas percentile 100% is equal to the maximum value of the set (there is no higher value).

For example, standard EN 50160 for the RMS voltage value specifies that 100% of measurements must be within the range of -15%...+10% U_{nom}, and 95% of measurements must be within the range of ±10% U_{nom}.

These two requirements may be written as follows:
- percentile of 100% must be between -15% ...+10% U_{nom},
- percentile 95% must be between -10%...+10% U_{nom}.

To check whether the RMS voltage meets the stated requirements, proceed as follows:
1. all measured voltage samples are sorted from the lowest [1] the highest [N]
2. it is checked whether the maximum value (i.e. percentile 100%, sample with [N] index) is in the range of -15% to +10% U_{nom}, and if yes then this criterion is met,
3. it is checked whether the value of the sorted table with index [N * 0.95] (first integer number greater than or equal to N * 0.95) i.e. percentile 95%, is in the range of -10%...+10% U_{nom}. If yes, this criterion is met.

In case of the report on compliance with the standards and the section on measurement statistics, the length of the bands indicates the percentile of samples (the horizontal axis in the

report ranges from 80% to 100%) that meet this criterion. For the RMS voltage, the statistics section provides two separate parameters, for which separate assessment criteria are set:

- Voltage (95.00% of measurements)
- Voltage (100.00% of measurements)

Bands on the right shows the percentage of samples that meet the specified criteria. For example, for 95% of the voltage measurements, if the band has the value 97%, it means that 97% percent of the samples meets this requirement (above the required 95%), and the band will be green (indicating that the criteria are met). If only 90% of the samples meet this criterion, the band will be red, as the standard criterion is not met.

If the percentage of samples that meet the criterion is less than 80%, then the band displays text in red "**< 80%**", which means that the criterion specified in the standard is not met and the percentile is lower than 80%.

The tested network meets the quality criteria if all percentile bands in section MEASUREMENT STATISTICS are green.

4.4.3.3 Section FREQUENCY

Section FREQUENCY includes detailed statistical information on the network frequency in the tested period.

The first part of the table, provides the percentage values of samples (percentiles), which meet the criteria (**Values within tolerance**) for both of the defined tolerance ranges (column **Tolerance**). The values that meet the criteria are displayed in black. When the criterion is not met, the value is displayed in red with an additional asterisk (*). Column **Tolerance** specifies the range of frequencies, which must be observed in case of all samples, and which is calculated on the basis of the standard provisions.

The second part of this section contains additional information about the distribution of the samples in the tested set. Individual rows of the table present:

- **Maximum** (i.e. percentile of 100%) – the maximum recorded frequency,
- **99.50% value** - percentile 99.5% (99.5% of frequency samples is lower or equal to a specified voltage in volts); the percentile depends on the specified standard and may be different than the one shown here.
- **0.50% value** - percentile 0.5% (0.5% of voltage samples is lower or equal to a specified frequency); this percentile is always selected symmetrically to the previous percentile - to make the distance between two percentiles from the minimum or maximum was the same.
- **Minimum** (i.e. percentile of 0%) – the lowest frequency in the tested set of samples.

As in the first part, the frequency range is specified, where the values should fit to meet quality criteria; if a given value does not meet the criterion, it is displayed in red with an additional asterisk (*).

4.4.3.4 Section VOLTAGE

Section VOLTAGE includes detailed statistical information on the criteria for RMS voltage (phase voltage in systems with neutral conductor and phase-to-phase voltage in 3-phase 3-wire systems).

The first part of the table, provides the percentage values of samples (percentiles), which meet the criteria (**Values within tolerance**) for both of the defined tolerance ranges (column **Tolerance**). The values that meet the criteria are displayed in black. When the criterion is not met, the value is displayed in red with an additional asterisk (*). Column **Tolerance** specifies the range of voltages, which must be observed in case of a specified percentage of samples.

The second part of this section contains additional information about the distribution of the samples in the tested set. Individual rows of the table present:

- **Maximum** (i.e. percentile of 100%) – the maximum voltage value among all samples in the given channel,

- **Value 95.00%** - percentile of 95% (95% of voltage samples have value lower or equal to a specified voltage in volts),
- **Value 5.00%** - percentile of 5% (5% of voltage samples have value lower or equal to a specified voltage),
- **Minimum** (i.e. percentile of 0%) – the lowest voltage value in the tested set of samples.

As in the first part, the voltage range is specified, where the values should fit to meet quality criteria; if a given value does not meet the criterion, it is displayed in red with an additional asterisk (*).

4.4.3.5 Section PHASE-TO-PHASE VOLTAGE

Section PHASE-TO-PHASE VOLTAGE is included in the report only when option **INCLUDE U L-L** is ticked during report generation and when network layout is split-phase or 3-phase 4-wire. Phase-to-phase voltage is also included in the statistics and influences the overall result of the network quality test. The value of phase-to-phase voltage is determined as:

- In split-phase systems: twice the phase voltage (second voltage (i.e. phase-to-phase) in the list of available nominal voltages in the measurement configuration or exact twice the phase voltage in the case of using voltage transducers)
- In 3-phase 4-wire systems: the second voltage (i.e. phase-to-phase) in the list of available nominal voltages in the measurement configuration or the phase voltage multiplied by $\sqrt{3}$ in the case of using voltage transducers)

The percentage criteria for the phase-to-phase voltage are the same as for the phase voltage.

4.4.3.6 Section FLICKER

This section provides information about the flicker severity P_{LT}. The first section provides the percentage of P_{LT} samples within the range required by the standard (e.g. 0...1).
The second specified the percentile value of 95%. Comparing this value with the limit imposed by the standard allows to assess the margin of P_{LT} parameter in the tested network in terms of standard provisions.

If a given value of P_{LT} is flagged after enabling the option for excluding flagged data, it is ignored and not reflected in the statistics.

4.4.3.7 Section UNBALANCE

If the tested network is a three-phase network, the report in its UNBALANCE section specifies details of the negative sequence unbalance factor:

- the percentage of samples that meet the criterion of 95% percentile (or another specified in the standard),
- the actual value of the 95% percentile of the unbalance factor.

4.4.3.8 Section HIGHER ORDER HARMONICS

Section HIGHER ORDER HARMONICS includes statistics and measurements for individual harmonics for which the standard defines level limits (usually harmonics of 2..25) and Total Harmonic Distortion factor THD-F. If a value is not within the limits, it is displayed in red with an additional asterisk (*).

4.4.3.9 Section HIGHER ORDER HARMONICS - ADDITIONAL INFORMATION

Section HIGHER ORDER HARMONICS - ADDITIONAL INFORMATION is present in the report after selecting report for 40 harmonics. It is an informational part, presenting values of percentile 95% for 26...40 harmonics, i.e. those for which the standard does not introduce level limits.

4.4.3.10   Section ADDITIONAL INFORMATION - EVENTS

Section ADDITIONAL INFORMATION - EVENTS contains information about detected voltage events such as swell, dip, interruption. For each of these types, the following information is provided:
- Number of events divided into single phases,
- Extreme value (maximum for swell, minimum for dip and interruption),
- Maximum duration of the event.

4.4.3.11   Section ADDITIONAL INFORMATION - STATISTICS OF POLYPHASE EVENTS

This section provides statistics of polyphase events according to the guidelines of EN 50160 (for swells, dips and interruptions). Events are classified basing on their duration and minimum / maximum values. The table presents the number of events meeting the specified couple of the criteria.

Tab. 5. Statistical distribution of swells, according to EN 50160.

Voltage crest U [%U_{nom}]	Duration time t [s]		
	$0.01 \leq t \leq 0.5$	$0.5 < t \leq 5$	$5 < t \leq 60$
U ≥ 120	S1	S2	S3
110 > U > 120	T1	T2	T3

Tab. 6. Statistical distribution of dips, according to EN 50160.

Residual voltage U [%U_{nom}]	Duration time t [s]				
	$0.01 \leq t \leq 0.2$	$0.2 < t \leq 0.5$	$0.5 < t \leq 1$	$1 < t \leq 5$	$5 < t \leq 60$
90 > U ≥ 80	A1	A2	A3	A4	A5
80 > U ≥ 70	B1	B2	B3	B4	B5
70 > U ≥ 40	C1	C2	C3	C4	C5
40 > U ≥ 5	D1	D2	D3	D4	D5
U < 5	X1	X2	X3	X4	X5

Tab. 7. Statistical distribution of interruptions.

Residual voltage U [%U_{nom}]	Duration time t	
	t ≤ 3min	t > 3min
U < 5	short interruptions	long interruptions

4.4.3.12   Section ADDITIONAL INFORMATION

Section ADDITIONAL INFORMATION is present in reports generated for compliance with the *Polish Regulation of the Minister of Economy*, when currents and 15-minute power values were measured. In such cases the following additional parameters are also recorded:
- 15-minute active power,
- 15-minute reactive power,
- 15-minute apparent power,
- total 15-minute tanφ factor

This section of the report presents the maximum 15-minute values recorded for the four parameters.

In meters supporting 4-quadrant energy counters, values of 15-minute 4-quadrant energy are also recorded to calculate factors tan(φ)L + (quadrant I) and tan(φ)C+ (quadrant IV). These additional tanφ factors are then displayed in the second part of this section.

4.4.3.13   Summary report

If the user in **MEASUREMENTS** tab selects **REPORTS➔QUICK SUMMARY**, two windows will be shown to summarise the whole recording range:

- **TABLE SUMMARY** window, showing the report in a text form, with daily maximum and minimum values the following parameters:
  - RMS values of phase and phase-to-phase voltages (depending on the type of network).
  - RMS values of currents,
  - Power Factor PF (for individual phases and total).

  Minimum and maximum values shown in the summary are selected from among the recorded average values. If these values are not recorded, they are ignored in the summary. If none of these parameters is included in the recording, the summary report is not generated and an appropriate message is displayed.

  Clicking **SAVE** button will save the report displayed in the selected format: *csv*, *pdf*, *html* or *txt*. An example of window with the summary table is shown in Fig. 68.
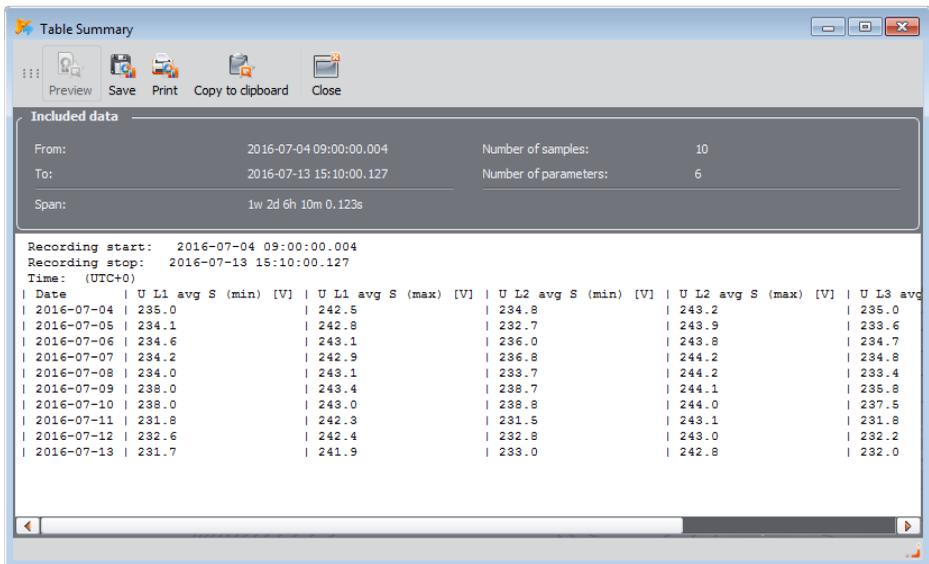
Fig. 68. Example of summary table.

Window **GRAPHICAL SUMMARY**, which presents a time plot of the effective values of voltages and currents in measured channels (average values, as in the summary table), covering the whole recording interval. If none of the required parameters was not measured, the window is not displayed. The window of the plot has the same properties as the standard time plot window described in section. 4.4.2.1. Example of summary plot is shown in Fig. 69.
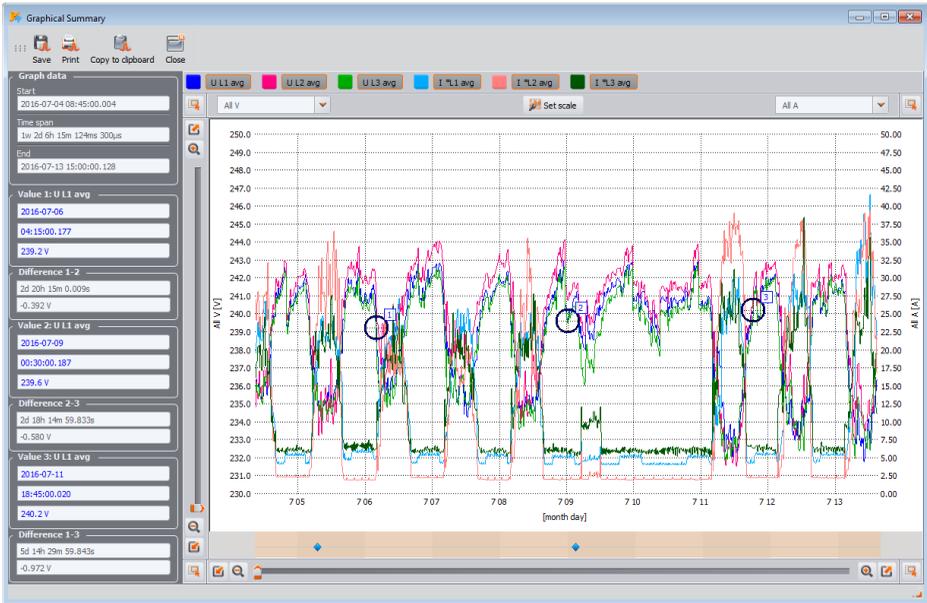
Fig. 69. Example of Graphical summary.

4.4.4 Events

Pressing **EVENTS** button, changes the main window image into the one shown in Fig. 70. This mode may be used to analyze all events recorded by the analyzer.

The recorded events are presented as dots in the graph.

In the bottom left part the selectable parameters are displayed as listed in the table . The user may turn on/off the selected types by checking relevant boxes. The table displays only selected event types.

Description of individual columns:

- **MARK** – a double-click of this cell selects the event along with the waveform (if any) on the dot graph and adds a given event to the list in **MARKER** tab,
- **TYPE** – specifies the event type (voltage swell, dip, exceeding the minimum threshold, etc.),
- **SOURCE** – defines the phase in which the event was detected,
- **START**, **END** – the start and end time of the event,
- **DURATION** – event duration,
- **EXTREMUM** – the lowest or the highest value during the event,
- **AVERAGE** – average value during the event,
- **THRESHOLD** – the threshold value exceeding of which has triggered the event detection (the same as the threshold set during the analyzer configuration),
- **WAVEFORM** – waveform icon means that a waveform is available along with RMS$_{1/2}$ graph for the event.

The analyzers that support polyphase voltage events (e.g. PQM-702) provide a selection list **SHOW POLYPHASE EVENTS** , which has two options:

- **GROUPED** – including multi-phase events, which cover several channels - shown in a grouped form of in one line. Column **SOURCE** shows channels, where the event occurred. Parameters stated in the table, including start and end times, extreme, apply to events considered as multi-phase (according to the requirements of IEC 61000-4-30).
- **SEPARATE** – voltage events are listed separately, each channel is considered independently.

Yellow colour in **SOURCE** column indicates a multi-phase event in accordance with IEC 61000-4-30. This applies to both to **GROUPED** and **SEPARATE** views.

The concept of a polyphase event is used in relation to polyphase networks. Below we present definitions of polyphase events as they are defined in standard IEC 61000-4-30.

- **Polyphase dip** – in polyphase systems, a dip starts when $U_{RMS1/2}$ voltage in at least one measuring channel is lower than the dip threshold and it ends when $U_{RMS1/2}$ voltage in all measuring channels is equal to or greater than dip threshold plus the voltage hysteresis.
- **Polyphase swell** – in polyphase systems, a swell starts when $U_{RMS1/2}$ voltage in at least one measuring channel is higher than the swell threshold and it ends when $U_{RMS1/2}$ voltage in all measuring channels is equal to or lower than the swell threshold minus the voltage hysteresis.
- **Polyphase interruption** – in polyphase systems, an interruption starts when $U_{RMS1/2}$ voltage in all measuring channels is lower than the interruption threshold and it ends when $U_{RMS1/2}$ voltage in at least one measuring channel is equal to or greater than the interruption threshold plus the voltage hysteresis.

These definitions specify that polyphase events include also dips and swell which occur in only one phase in polyphase systems. In turn, a polyphase interruption takes place only when an interruption occurs in all phases at the same time.
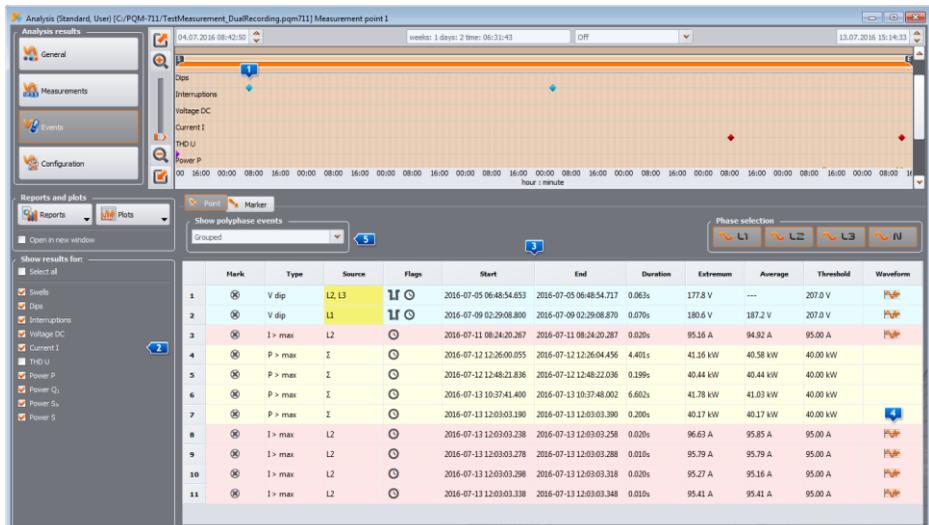
Fig. 70. Event window.

4.4.4.1 Value/duration graph

Fig. 71 shows a graph for **VALUE/DURATION**. In order to display it, select **PLOTS→VALUE/DURATION** option. This graph shows events in the form of dots and enables the program to display a number of events with their mutual relationship between the duration of the

event (horizontal axis) and the extreme value of an event (vertical axis). The graph shows only the types of events that have been selected on the left side.
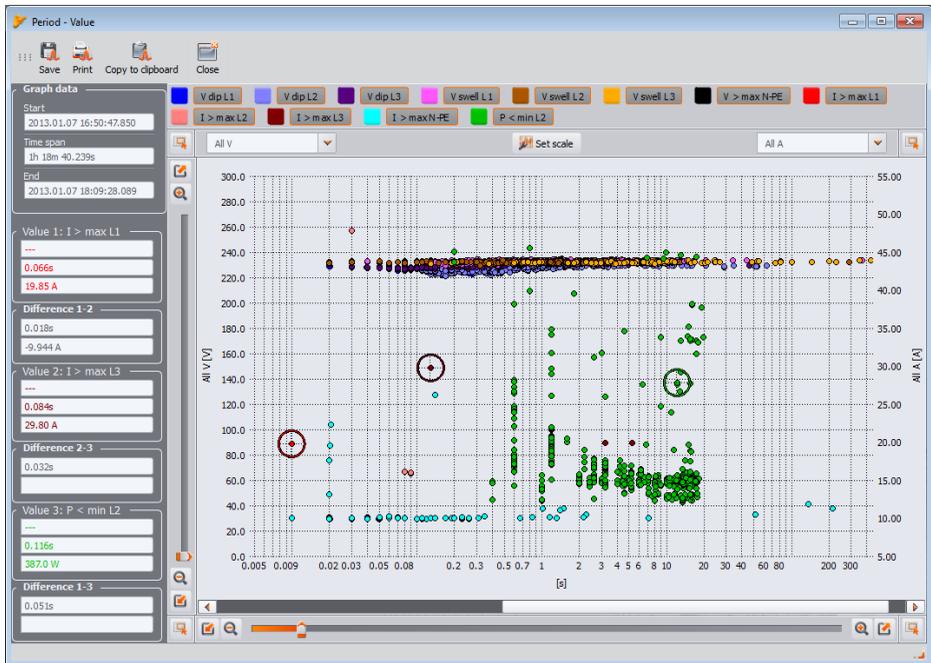
Fig. 71. Event analysis – value/time graph.

4.4.4.2 ANSI/CBEMA graph

When events of voltage dip, swell, or interruption were recorded option **PLOTS➔ANSI/CBEMA** is enabled. When this option is selected, event graph is displayed similar to Value/duration graph, but with overlaid ANSI or CBEMA curves, which are standard in the evaluation of the device in terms of tolerance to fluctuations of the supply voltage. The graph type is selected from the pop-up menu displayed after right-clicking within the graph area and selecting **CURVE TYPE** option and choosing **ANSI** or **CBEMA**. Specific points of the curves may be modified manually in program preferences: **OPTIONS➔CONFIGURATION➔DATA ANALYSIS**. A sample screen is shown in Fig. 72.

More information on ANSI and CBEMA curves may be found in the instruction manual of the analyzer.
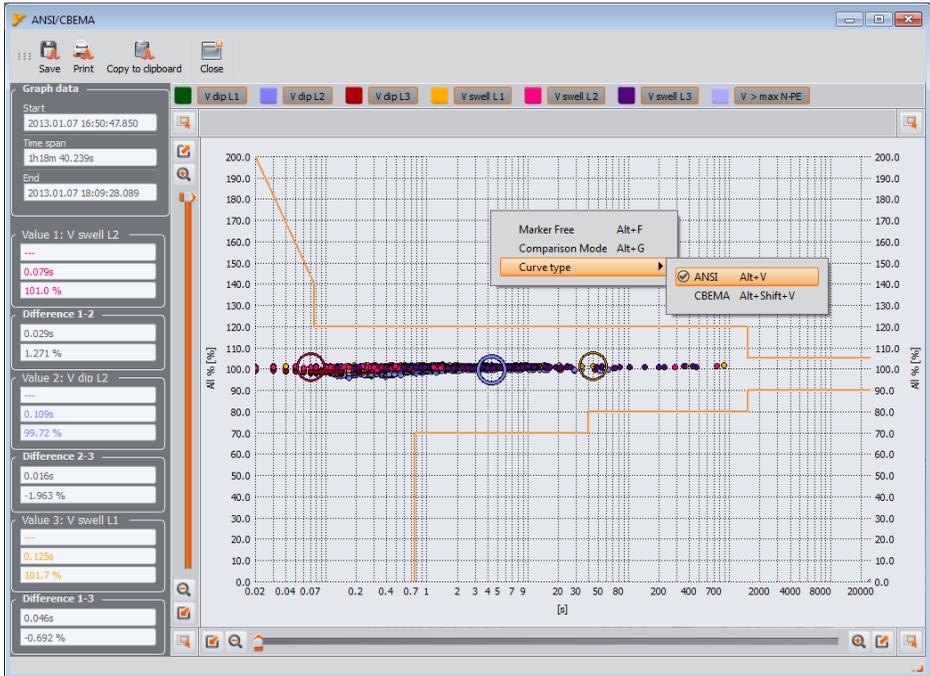
Fig. 72. ANSI/CBEMA graph.

> *Tip*
> *Actions for zooming-in/zooming-out, moving and others (including marker activities) shown in Fig. 71, Fig. 72, Fig. 73 are similar to those shown in Fig. 62.*

4.4.4.3 Waveform/RMS$_{1/2}$ graph

Clicking on Waveform icon ![icon] enables waveform graphs and an accompanying graph showing RMS$_{1/2}$ values (Fig. 73). **Open in a new window** option has the same functionality as in the data analysis. The waveform graph and RMS$_{1/2}$ values may be also displayed by highlighting the line with the chosen event – in place with waveform icon and selecting **Plots→Waveform** option.

Fig. 73. Plot with a start and end waveform.

Fig. 73 presents an example of a waveform. As two waveforms are assigned to this event (start and end of the event), the colored boxes on the diagram mark the beginning (**START**) and the end (**END**) of the event. In case of a short event, the waveform will be continuous. If the event duration is longer, there will be two waveforms (one at the beginning of the event and the second at the end). The plot may be freely zoomed-in according to the principles described in the sec. 4.4.2.1. Operations on the plot are the same as in case of the timeplot.

Waveforms may be saved in CSV format, which allows user to analyze them in spreadsheets. All samples of enabled channels are saved. To save a waveform in this format, select **EXPORT TO CSV** icon and specify a file name and location where you want to save the file.

Arrows **PREVIOUS** and **NEXT** in the toolbar allow you to switch automatically between successive plots in the event list. Both plot windows: waveforms and RMS$_{1/2}$ will be updated.

Tick **SET MARKER** box to add the marked event to the list of selected events (in **MARKER** tab in the event table) and to select **MARKER** next to the event in the table.

4.4.4.4 Event Report

Events listed in the table may be stored in the form of a report, after selecting **REPORT**➔**EVENT REPORT** option. A sample *pdf* report is shown in Fig. 74.

REPORT

Recording start 2013.01.07 16:50:47.850
Recording stop 2013.01.08 08:46:27.150

Type	Source	Start	End	Duration	Extremum	Average	Threshold
tanφ < min	Σ	2013.01.07 18:11:11.400	2013.01.07 18:11:12.000	0.600s	0.0957	0.101	0.1
UDC > max	L1	2013.01.07 18:11:11.400	2013.01.07 18:11:11.600	0.200s	-0.107 V	-0.107 V	0.1 V
U/U > max	L1	2013.01.07 18:11:11.400	2013.01.07 18:11:11.600	0.200s	1.231 %	1.231 %	1 %
V swell	L1	2013.01.07 18:11:11.498	2013.01.07 18:11:11.538	0.040s	234.0 V	233.2 V	232.3 V
V dip	L2	2013.01.07 18:11:11.534	2013.01.07 18:11:11.704	0.170s	225.2 V	225.7 V	227.7 V
Harmonics current no. 5	L1	2013.01.07 18:11:11.600	2013.01.07 18:11:12.200	0.600s	8.998 %	6.826 %	5 %
Harmonics current no. 13	L3	2013.01.07 18:11:11.600	2013.01.07 18:11:11.800	0.200s	7.448 %	7.448 %	7 %
ITHDREF > maks.	L2	2013.01.07 18:11:11.600	2013.01.07 18:11:15.400	3.800s	45.30 %	34.81 %	20 %
V swell	L1	2013.01.07 18:11:11.698	2013.01.07 18:11:17.378	5.681s	235.4 V	233.6 V	232.3 V
UDC > max	L2	2013.01.07 18:11:11.800	2013.01.07 18:11:12.000	0.200s	-0.139 V	-0.139 V	0.1 V
ICF > max	L2	2013.01.07 18:11:12.000	2013.01.07 18:11:15.400	3.400s	4.045	2.689	1.9
Harmonics current no. 7	L2	2013.01.07 18:11:12.000	2013.01.07 18:11:15.400	3.400s	18.98 %	13.85 %	5 %
P < min	L2	2013.01.07 18:11:12.200	2013.01.07 18:11:13.400	1.200s	295.1 W	332.9 W	500 W
tanφ > max	L2	2013.01.07 18:11:12.200	2013.01.07 18:11:13.200	1s	-0.766	-0.734	0.4
Harmonics voltage no. 9	L1	2013.01.07 18:11:12.200	2013.01.07 18:11:14.400	2.200s	2.098 V	1.755 V	1.5 V
Harmonics voltage no. 9	L2	2013.01.07 18:11:12.200	2013.01.07 18:11:14.400	2.200s	3.100 V	2.040 V	1.5 V
Harmonics current no. 9	L1	2013.01.07 18:11:12.200	2013.01.07 18:11:14.400	2.200s	10.86 %	8.119 %	6 %
Harmonics current no. 9	L2	2013.01.07 18:11:12.200	2013.01.07 18:11:13.400	1.200s	11.22 %	9.267 %	6 %
Harmonics current no. 17	N	2013.01.07 18:11:12.200	2013.01.07 18:11:12.400	0.200s	8.858 %	8.858 %	7 %
K factor > max	N-PE	2013.01.07 18:11:12.200	2013.01.07 18:11:12.400	0.200s	20.80	20.80	20
ICF > max	L1	2013.01.07 18:11:12.400	2013.01.07 18:11:13.200	0.800s	2.832	2.232	1.9
Harmonics current no. 5	L1	2013.01.07 18:11:12.400	2013.01.07 18:11:14.200	1.800s	10.62 %	7.755 %	5 %
Harmonics current no. 11	L3	2013.01.07 18:11:12.400	2013.01.07 18:11:14.400	2s	10.61 %	7.534 %	6 %
UDC > max	L2	2013.01.07 18:11:12.400	2013.01.07 18:11:12.600	0.200s	-0.106 V	-0.106 V	0.1 V
ITHDREF > maks.	L1	2013.01.07 18:11:12.400	2013.01.07 18:11:13.400	1s	24.58 %	22.43 %	20 %
tanφ > max	L1	2013.01.07 18:11:12.600	2013.01.07 18:11:13.600	1s	0.431	0.422	0.4
Harmonics current no. 9	L3	2013.01.07 18:11:12.600	2013.01.07 18:11:13.600	1s	6.773 %	6.337 %	6 %
V swell	L2	2013.01.07 18:11:12.834	2013.01.07 18:11:13.804	0.970s	232.8 V	231.6 V	232.3 V
K factor > max	N-PE	2013.01.07 18:11:13.200	2013.01.07 18:11:14.400	1.200s	36.68	29.37	20
ICF > max	L1	2013.01.07 18:11:13.400	2013.01.07 18:11:14.400	1s	3.529	2.676	1.9
tanφ < min	Σ	2013.01.07 18:11:13.400	2013.01.07 18:11:13.800	0.400s	0.0984	0.101	0.1
Harmonics current no. 17	N	2013.01.07 18:11:13.400	2013.01.07 18:11:13.600	0.200s	7.699 %	7.699 %	7 %
UDC > max	L1	2013.01.07 18:11:13.400	2013.01.07 18:11:13.600	0.200s	-0.107 V	-0.107 V	0.1 V
Harmonics current no. 9	L2	2013.01.07 18:11:13.400	2013.01.07 18:11:15.400	1.800s	12.20 %	8.615 %	6 %
Harmonics current no. 13	L1	2013.01.07 18:11:13.600	2013.01.07 18:11:14.400	0.800s	11.75 %	9.744 %	7 %

Fig. 74. Event Report.

MARKER window includes events selected by the user. In this table the user may move rows (events), to arrange them according own choice. Rows are moved using "drag and drop" technique, or by clicking and keeping the left mouse button on any cell in the line you can move it up or down.

All buttons in **MARKER** tab operate identical as in **POINT** tab.

4.4.5 Energy cost report

Sonel Analysis enables user to analyse the energy costs according to a several tariffs defined by the user. A precondition for generating such a report is the presence of consumed active energy (**EP+**) in the recorded data. To generate the report, first enable displaying the total active energy consumed in the table (tick **ENERGY P+** in the left panel, activate **N** button to display total parameters and tick the box with instantaneous values) and then choose the desired period of time (the entire **TIME** column or a range). Then press **REPORTS** button and select **ENERGY COST REPORT**. A window similar to the one shown in Fig. 66 will be displayed, where the user may fill-in some additional fields that appear in the final report. To see the report, click **PREVIEW** on the toolbar of this window. To save the report to a file (*pdf*, *html*, *txt*, *csv*) select **SAVE**, enter a filename and location, select its type and click **SAVE**.

4.4.5.1 Types of tariffs

Sonel Analysis software allows to determine energy costs by three types of tariffs. Because the name of tariffs may be given by the user, the following description will be used for the names of tariffs: A, B, C.

- **Tariff A** (single-zone - default name: *C11*) – the simplest type of tariff, which applies a uniform rate throughout the period, regardless of the season, week and day. In this tariff, you can only specify the cost per kWh.

- **Tariff B** (multi-zone - default name: *C12b*) – a tariff, in which the user can specify from one to three billing zones (time periods during the year are set to the nearest day). Each zone enables may have periods with different rates defined for the morning peak and evening peak. The user may specify days of the week and hours of the peaks. The cost per kWh of energy is determined separately for the morning peak, evening peak and off-peak period.
- **Tariff C** (annual - default name: *C22b*) – a tariff, where three kWh rates (for morning peak, evening peak and off-peak period), where peak hours are the same for all days of the week in a given month. The user may independently set peak periods for each month of the year.

The configuration of tariffs and currency is defined in *Sonel Analysis* (**PROGRAM CONFIGURATION**→**DATA ANALYSIS**→**ENERGY TARIFF SETTINGS**).

4.4.5.2 Energy cost report – description

The energy cost report includes several sections. Description of the report concerns the report in *pdf* and *html* formats.
A fragment of a typical report is shown in Fig. 75.

4.4.5.2.1 Section GENERAL INFORMATION

This section contains additional fields that the user filled when generating the report and general information:
- Measurement location (field filled by the user),
- Measurement cause (field filled by the user),
- Author (field filled by the user),
- Comments (field filled by the user),
- Analyzer type (firmware version, serial number),
- Software (version of *Sonel Analysis*),

Start time, end time and interval taken for the analysis.

4.4.5.2.2 TARIFF SETTINGS section

Section *TARIFF SETTINGS* includes a configurations of three types of tariffs (A, B and C), with parameters defined in the program configuration. It includes rates and billing zones.

4.4.5.2.3 CALCULATION SUMMARY section

Section *CALCULATION SUMMARY* presents the figures for energy costs, according to the three specified tariffs. Individual rows present:
- Morning peak energy [kWh] - total energy charged during the morning peaks,
- Morning peak cost – the total cost (in the indicated currency) of the morning peak energy,
- Evening peak energy [kWh] - total energy charged during the evening peaks,
- Evening peak cost – the total cost the evening peak energy
- Off-peak energy [kWh] - total energy charged outside the peak periods,
- Off-peak cost – the total cost the off-peak energy
- Total energy - energy which is the sum of the energy values specified above,
- Total cost - total calculated cost of energy during the analysed period.

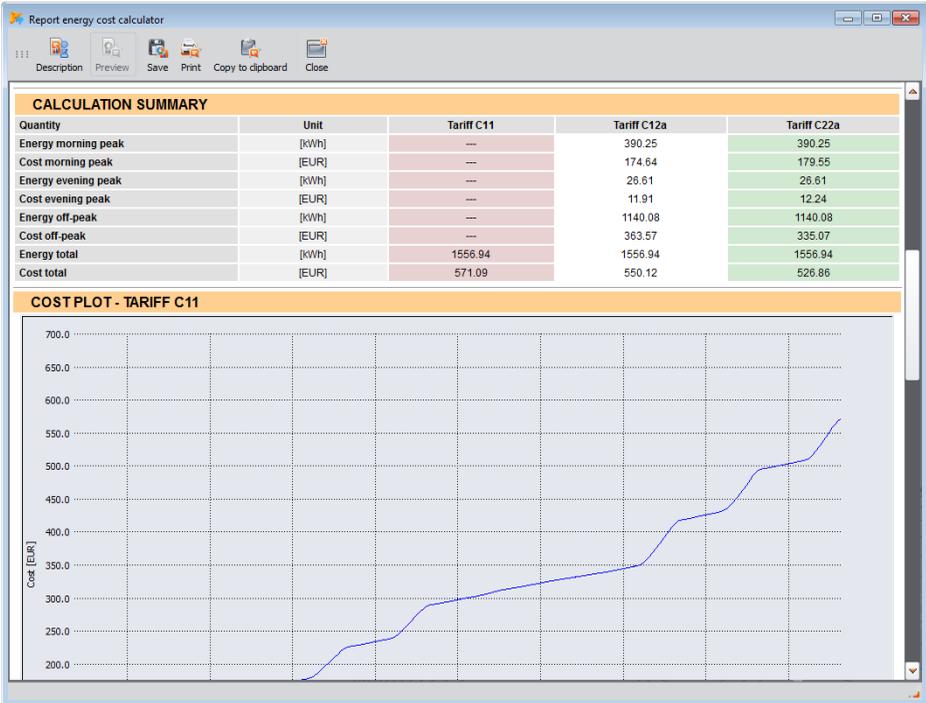The columns include values calculated for the three tariffs.

Fig. 75. Fragment of energy tariff report.

4.4.5.2.4 *COST PLOTS section*

Three sections of *COST PLOTS* include graphical form the energy distribution costs (vertical axis) over time (horizontal axis). The tariffs plots, which apply different rates for peak periods, indicate these periods with vertical stripes - morning peaks in orange and evening peaks in blue.

4.4.6 *Data export*

Measurement data presented in a tabular form, may be selected and saved in a desired file format. This applies both to the data presented in part **MEASUREMENTS** (section 3.10.2) and for Events (section 3.10.3):

- for **MEASUREMENTS**, click the time column and then select the parameters you want to export by selecting chosen columns with data. To instantly select all the data in the table, right-click in the table and choose **SELECT ALL** option. Time range may be reduced by selecting only some of the cells in the time column (holding down SHIFT or CTRL key). The second option of reducing the time range is using two sliders **S** (start) and **E** (end) in the part with the dotted graph. Then press **REPORTS→USER REPORT**. To save the data in a desired file format, select **SAVE**, and then indicate the location, name and format of your file. Available formats:
  - *pdf* (export to this format may contain maximum 12 data columns),
  - *html* (these files may be opened in a web browser)
  - *txt* (standard text files)
  - *csv* (*Comma Separated Values* - files of this type may be easily opened in spreadsheets e.g. in Microsoft Excel)

- for **EVENTS**, the data range (rows) may be reduced by using two sliders **S** (start) and **E** (end) in the part with the dotted graph. Then press **REPORTS→USER REPORT**. To save the data in a desired file format, select **SAVE**, and then indicate the location, name and format of your file. The data formats are the same as described above for the measurements.

  It is possible to export only selected events - mark the icon in **MARK** column next to selected events and then, after choosing the **MARKER** tab, press **REPORTS→USER REPORT** and proceed as described above.

The standard way to export data to *csv* files may be configured by selecting **OPTIONS→PROGRAM CONFIGURATION**, then clock **REPORT SETTINGS** icon and **CSV SETTINGS** tab. The following features may be set here:

- an option for dividing data into files of smaller size. To do this, select **SPLIT FILE** option and set the maximum desired number of lines in a single file. If the report contains more rows that defined in the settings, *csv* report will be divided into several files with names including respective numbers. The first file number is 000000.
- a character for separating the integer part from the decimal (dot or comma)
- a character for separating values (semicolon is used as default),
- a character for separating text fields (e.g. column headers).

5   Other program options

5.1   Analyzer status, starting and stopping recording

Selecting **ANALYZER**→**CONTROL** option in the program menu displays a window as shown in Fig. 76. This window includes a lot of information about the current state of the analyzer - the user may also change the measurement point and start/stop the recording process.

PQM-707 *Window CONTROL in the current version of Sonel Analysis is not available for PQM-707 analyzer.*

The following describes the elements of the status window:
- **ANALYZER TYPE** – model of the connected analyzer,
- **SERIAL NUMBER** – the serial number of the analyzer, which is connected,
- **LOCATION COORDINATES** – geographical position of the analyzer, available only after receiving location data from GPS satellites (only analyzers with a GPS receiver),
- **TEMPERATURE** – displays the current temperature inside the analyzer in Celsius and Fahrenheit degrees. The internal temperature of the analyzer shown in **CONTROL** window is usually higher than the ambient temperature. The declared measurement accuracy of the analyzers shown in the technical specifications relates to ambient temperature and not the internal temperature of the device,
- **CHARGING STATE** – information about the status of charging when power is applied, or about the percentage of remaining battery power (including battery voltage) when device is supplied from the battery,
- **POWER SOURCE** – shows the current power source of the analyzer: battery or mains,
- **SOFTWARE VERSION** and **HARDWARE VERSION** – shows firmware and hardware versions,

Next information on recording:
- **ANALYZER STATUS**: indicates whether the analyzer is recording or not,
- **MEASUREMENT POINT NUMBER** – currently selected measurement point,
- **MEMORY AVAILABLE FOR MEASUREMENT POINT** – percentage value that specifies the amount of space assigned to the measurement point and still available,
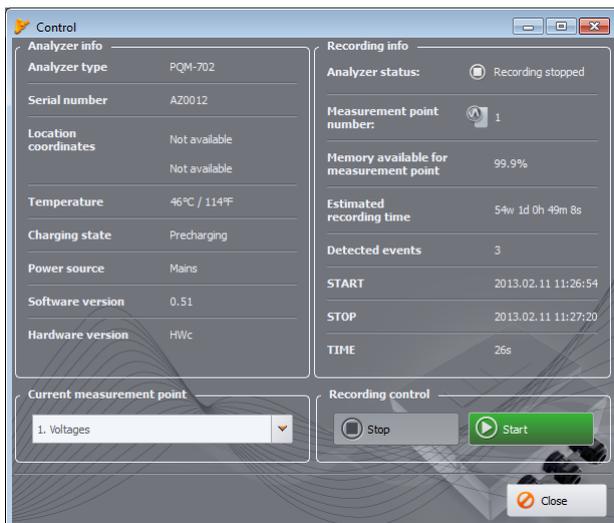
Fig. 76. Control window.

- **ESTIMATED RECORDING TIME** – shows the approximate recording time, according to the current configuration - shown in the following format: weeks(w) days(d) hours(h) minutes(m) second(s),
- **DETECTED EVENTS** – the number of detected events - counted from the last recording start in the measurement point. Sending a new configuration or switching-off the analyzer results in resetting the counters.

This window also enables user to change the active measurement point, and remote starting/stopping of the recording:
- **CURRENT MEASUREMENT POINT** – the user may select one of four measurement points from the list to enable it. The currently used measurement point cannot be changed during recording.
- **RECORDING CONTROL** – two buttons are available: **STOP** and **START**, which may be used to stop and start the recording process.

5.2 Deleting data

After selecting **ANALYZER→ DATA REMOVAL** from the menu, a window is displayed as shown in Fig. 77. In this window, you may select data to be deleted in indicated measurement points without affecting their configuration. To do this, select the check boxes next to the measurement points and press **REMOVE DATA**. If you need to delete all data from the card, it is recommended to format the data card via **FORMAT CARD** option.

PQM-707 *Window* **DATA REMOVAL** *in the current version of Sonel Analysis is not available for PQM-707 analyzer.*
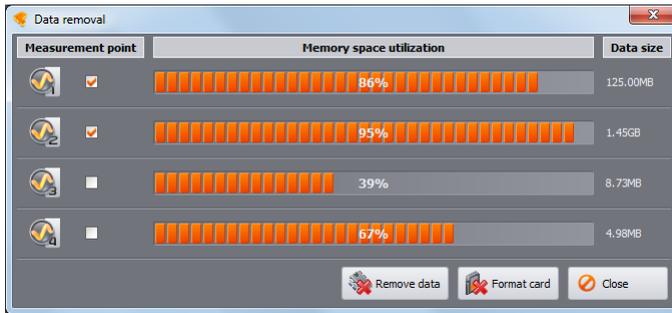
Fig. 77. Deleting data.

5.3 Configuration

The user may change the default application settings after choosing from the program menu
OPTIONS→PROGRAM CONFIGURATION.

The whole settings section, is divided into a few parts, marked by icons located in the top part
of the window

- **MAIN SETTINGS**,
- **ANALYZER CONFIGURATION**,
- **LIVE MODE**,
- **COLOR SETTINGS**,
- **DATA ANALYSIS**,
- **REPORT SETTINGS**,
- **MEDIA SETTINGS**.

After selecting any of them, detailed settings are presented in the middle part of the window -
they also may be divided into tabs.

On the right side of the window, additional buttons are located:

- **FACTORY** – restores default (factory) settings of the program (after confirming by the user),
- **LOAD** – reads program settings from a *.config* file,
- **SAVE AS** – saves the program settings to a *.config* file,

5.3.1 Main Settings,

- **DEFAULT LANGUAGE** – used to select the default language of the application (Fig. 78).
- **DEFAULT ANALYZER TYPE** – allows user to select a default type of the analyzer from a list - it affects
e.g. opening of the analyzer configuration.
- **DISPLAY SETTINGS** – allows user to open the application in full screen mode and displaying
descriptions of the icons on the toolbars.
- **UPDATE SETTINGS** - allows user to enable /disable the option to automatically check for new
versions of *Sonel Analysis* program and for the analyzer firmware. When you tick option **CHECK
ONLINE UPDATES**, each time the program is started - it will be connect to manufacturer's server
and check for new program versions. The user will be informed about a new version and then
may choose to download and install the update. If you select **CHECK FIRMWARE VERSION WHILE
CONNECTING**, the program will check for the latest firmware versions when connection is
established with the analyzer. If found, the program will propose updating.

Fig. 78. Program configuration - Main settings.

5.3.2 Analyzer configuration

In the panel on the left side, the following options are available:

- **ANALYZER DEFAULT SETTINGS** - This option allows the user to specify the default configuration for a specific model of the analyzer after starting the application. Selecting **FROM FILE** option will result in loading the default configuration from a saved file with the *.settings* extension. If the user does not indicated own configuration file in **PATH** field, the application will use the standard file saved in the installation catalogue. When "From file" option is not selected, the program will use the built-in configuration (factory).

- **STANDARD DEFAULT SETTINGS** – this option allows the user to configure individual profiles of EN 50160 standards and its variants. A drop-down tree are have all factory pre-defined profiles, which are available on the drop-down list when you set up the measurement according to EN 50160 (see sec. 2.2.2).

  Tab **DEFAULT** may be used to specify the default standard, and check whether the standard settings have been modified by the user in relation to factory parameters. When the factory settings of the standard have been modified, the name of the standard in column **STANDARD NAME** will be marked as "(MODIFIED)" and column **RESTORE DEFAULTS** will have "RESTORE" button. Clicking this button will restore the factory settings of the standard.

  Expanding the tree of a selected profile, you can view and change (if required) their default criteria:

  - **BASIC** card includes quality criteria for frequency, slow voltage changes, unbalance and flicker,

- ○ **HARMONICS** card includes THD criteria in voltage and voltage harmonics,
- ○ **EVENTS** card includes criteria for voltage events: interruptions, dips and swells

BASIC

Use this card to set the measuring criteria for:
- Frequency – tolerance values that define allowable deviations as a percentage of nominal frequency value and the measurement time limit for the first tolerance (i.e. 99.5% of the week and ±1% f_N),
- Slow voltage changes – RMS voltage: two tolerance values that define allowable deviations as a percentage of nominal RMS voltage value and the measurement time limit for the first tolerance (i.e. 99.5% of the week and 10% U_n),
- Voltage unbalance factor – measurement time limit for a specified threshold,
- Long-term flicker P_{LT} – measurement time limit and the threshold.
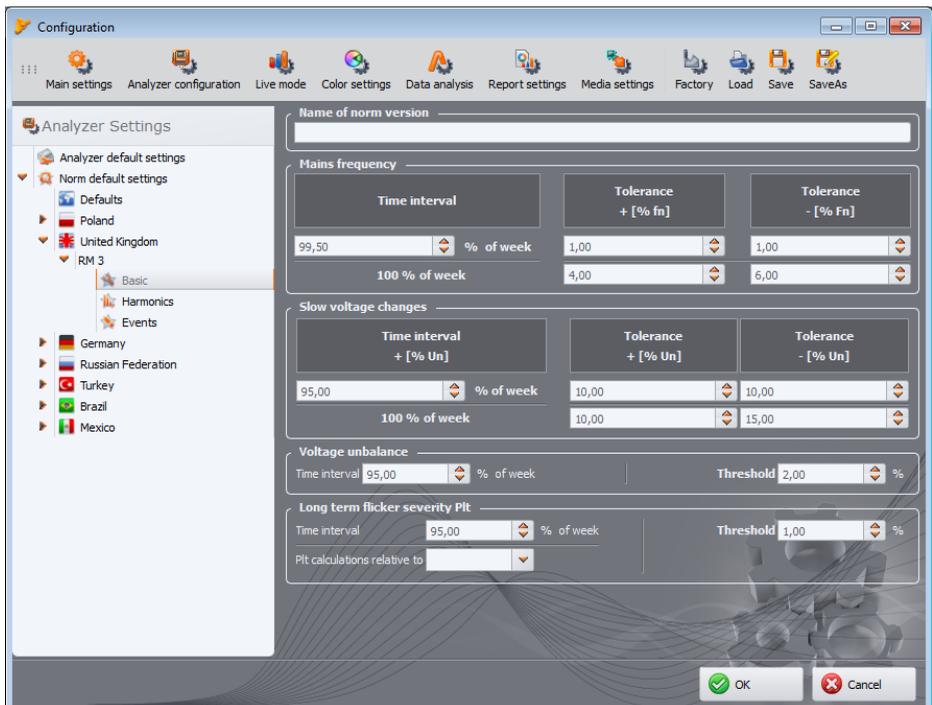
Fig. 79. Recording in accordance with the Standard - basic settings.

HARMONICS

The screen is shown in Fig. 80. Here, the user may set the limits for THD factor, and limit levels for individual harmonics.

Setting limits for individual harmonics may be performed in two ways: completing the table below the graph or directly on the graph. When the table is filled, after values are approved, the graph located above presented the table visualization.

To change the limit on the graph, double-click on a selected harmonic and then holding down the left mouse button, set the desired level. Additionally, after selecting a harmonic, the following keys may be also used:

- SPACEBAR - used to enter the editing selected harmonic
- ENTER - confirming values
- TAB – confirming values and moving to the next harmonics,
- UP and DOWN arrow - change the value of the limit,
- LEFT and RIGHT arrow - used for moving to the previous or next harmonics,
- HOME and END - jump between the first and the last harmonic.

> **Note**
> The level of THD and harmonics is referenced to the fundamental component.
> THD during recording in accordance with EN 50160 is always calculated basing on the first 40 harmonics.
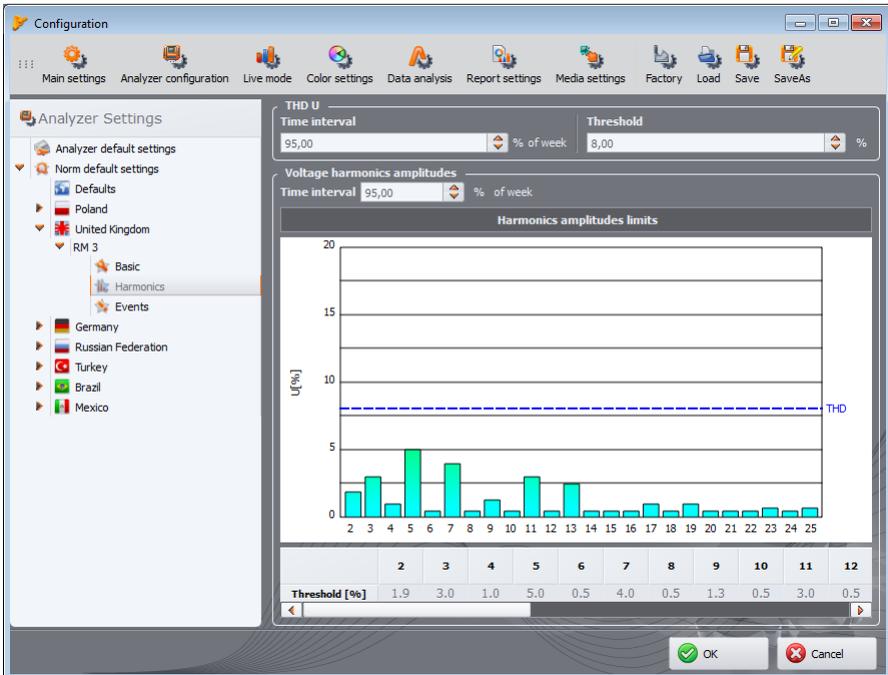
Fig. 80. Recording in accordance with EN 50160 - harmonics settings.

EVENTS

Na Fig. 81 presents screen for recording events according to EN 50160. The following features may be set here:

- thresholds for detecting voltage swells, dips and interruptions. These thresholds are expressed as a percentage of the nominal voltage value that to be added to the nominal value.

For example, swell tolerance of +10% U_n means, that for voltage U_n=230 V, the swell

threshold is $U_{swell} = 230 + 23$ V $= 253$ V.
Interruption tolerance of -95% U_n, means, that event detection with a voltage equal to or less than $U_{intr} = 230 - 227.7$ V $= 2.3$ V.

- Threshold for short-term/ long-term interruption. This value is used for the classification of power-supply interruption events.

> ### Notes
> - *Voltage dip cannot be set lower than interruption.*
> - *Nominal voltage value is taken from measurement point main settings (nominal values of mains system)*
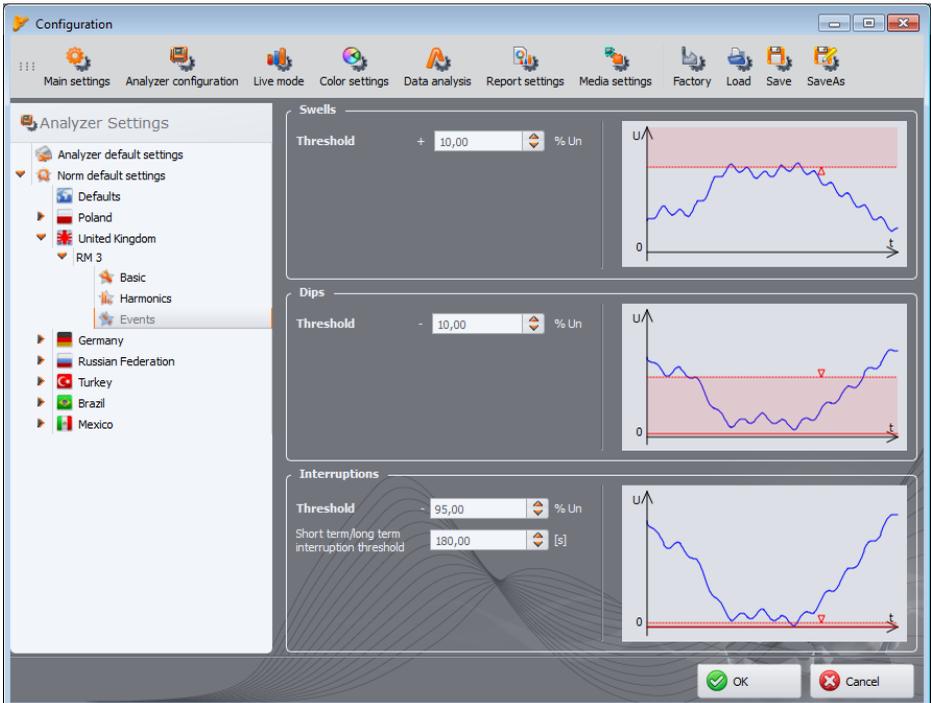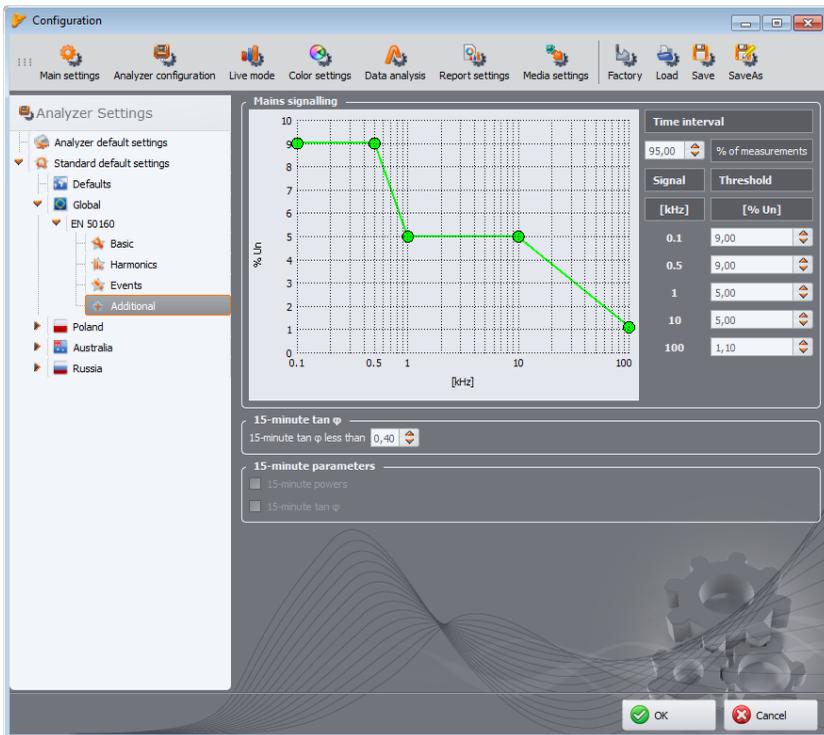

Fig. 81. Recording in accordance with EN 50160 – event settings.

ADDITIONAL

Fig. 82 shows the card for additional settings of EN 50160 standard. It contains:

- **PQM-702** **PQM-703** **PQM-710** **PQM-711** panel for configuring limits for mains signalling,
- threshold limit for tanφ,
- field indicating activation of recording the 15-minute parameters (only for preview).

The criteria contained in the standard profile are sent to the analyzer when sending the configuration. This allows the analyzer records the parameters required by the relevant standard, e.g. Polish Profiles require the measurement of 15-minute average values of power and tanφ which are not present for the remaining profiles. It also allows the user to generate a report on standard compliance, applying the set of criteria (which the user may modify in relation to the default profiles included in *Sonel Analysis*. Additionally, the program enables the user to generate a report, based on the standard profiles stored in the configuration of *Sonel Analysis*.

Fig. 82. Recording in accordance with EN 50160 – additional settings.

5.3.3 Live mode

This part of settings (Fig. 83) allows defining the colors of elements and settings in the live mode. The part is divided into the following cards WAVEFORMS, TIMEPLOT, MEASUREMENTS, PHASOR, HARMONICS, INTERHARMONICS.

The cards include the following groups:
- ACTIVITY - switching-off the preview of a given phase or selecting the active phase after turning on the screen, e.g. in displaying harmonics, the phase is selected by pressing button - this setting allows user to select the active phase after enabling harmonics screen.
- VISIBILITY - allows the user to select which channels are visible by default,
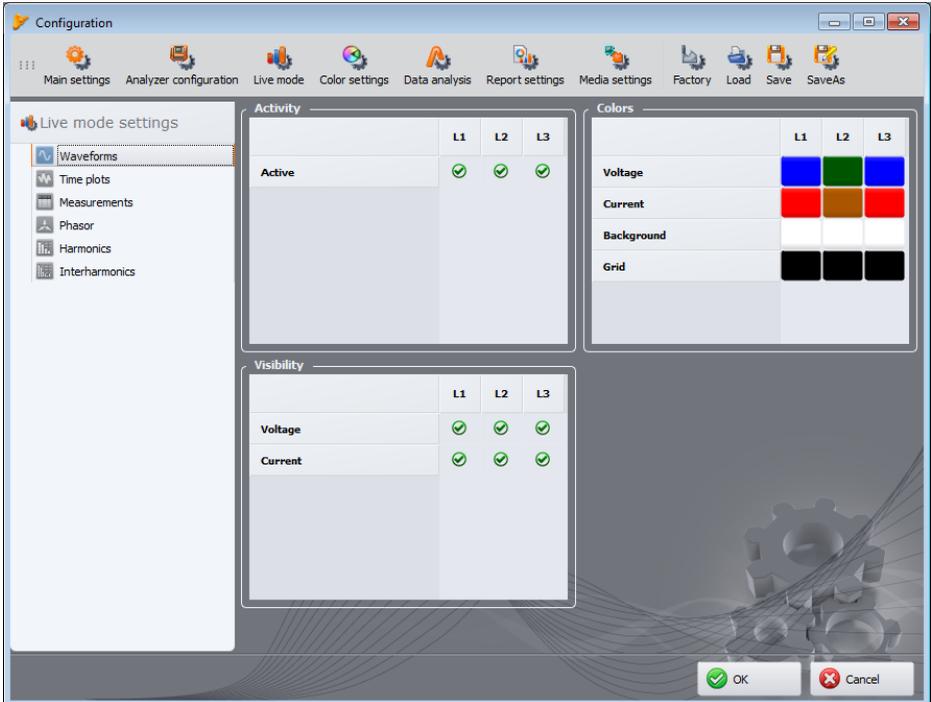- COLORS - in this section you can set colors of individual phases / channels / parameters.

Fig. 83. Program configuration – Live mode settings.

5.3.4 Color settings

Section COLOR SETTINGS allows user to change the colors of individual application components in the part concerning data analysis. It is divided into the following tabs (Fig. 84):
- GRAPH COLORS – colours of timeplots divided into individual parameters and phases,
- GENERAL COLORS – colours of measurement dots, events and waveforms on the dot plot in GENERAL view,
- MEASUREMENTS COLORS – colours of dots and background of table cells in MEASUREMENTS cells, divided into individual parameters,

- **EVENT COLORS** – colours of dots and background of table cells in **EVENTS** cells, divided into individual event types,
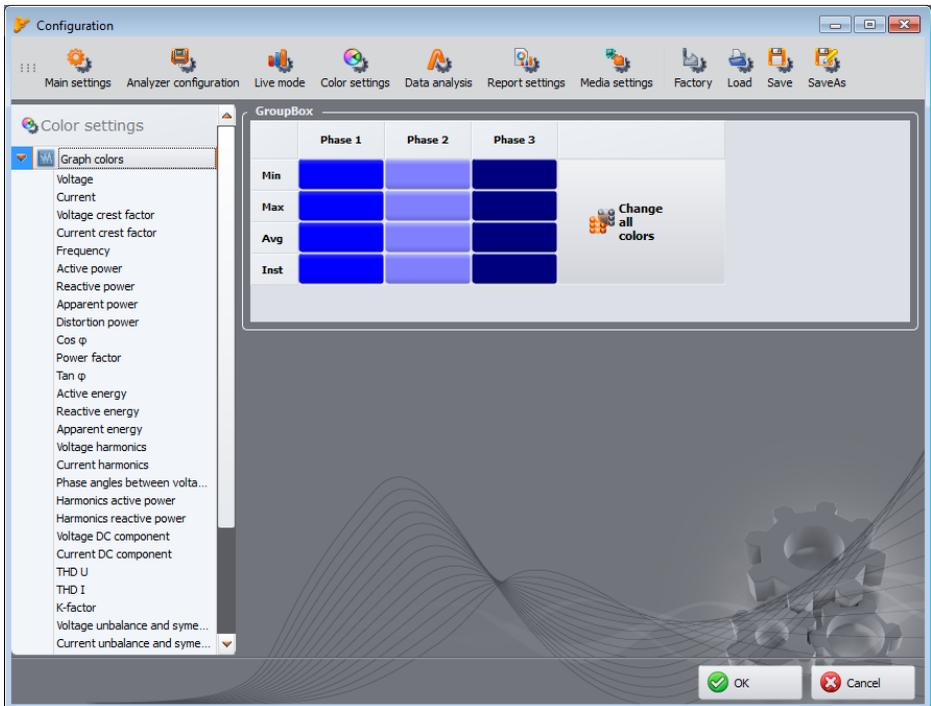

Fig. 84. Program configuration – Color settings.

5.3.5 Data analysis

This section contains the following cards:

- `PQM-700` `PQM-701` `PQM-707` **EXCLUDED DEVICES** - allows user to display devices (disks) that are to be ignored during the search in connected devices with a SD card that include measurements,
- **SETTINGS OF CBEMA GRAPHS** – enables user to change the default criteria for CBEMA graphs. Changes are introduced by changing the position of the nodes in the graph. Default settings may be restored by clicking **RESET GRAPH** button.
- **SETTINGS OF ANSI GRAPHS** – similarly as in case of CBEMA graphs - enables user to change the default criteria for ANSI graphs (Fig. 85). Changes are introduced by changing the position of the nodes in the graph. Default settings may be restored by clicking **RESET GRAPH** button.
- **ANALYSIS TIME SETTINGS** – to record in accordance with local time or UTC (Universal Time Clock). In devices that do not have a GPS receiver, regardless of settings, only local time is used.
- **SETTING ENERGY TARIFFS**– allows you to customize the settings of the energy calculator. It is possible to fully configure three tariffs used to calculate the total active energy consumption and cost. Tariffs and their parameters are described in the sec. 4.4.5.

5.3.6   Report settings

The elements included in this part of the configuration:

- **ADDITIONAL REPORT DATA** - in this section you can fill in additional fields used for the generating measurement reports: "Report's number", "Measurement place", "Author", "Measurement cause", "Notes" and indicate the logo to be added to the reports. These fields may be modified when generating reports. The fields left empty are not added to the reports.
- **CSV SETTINGS** – enables the user to change the default way of generating CSV files: the number of rows for a single file, selecting the character that separates the integer part from the decimal (period or comma), the choice of separator individual values and selection of text delimiter.
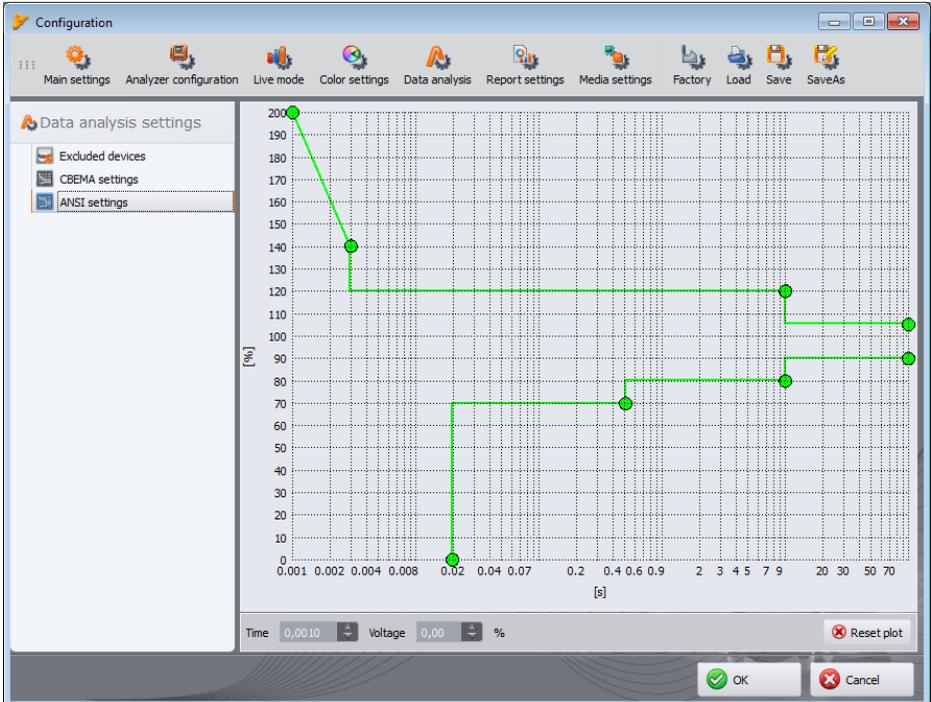

Fig. 85. Program configuration – ANSI graph settings.

5.3.7 Media settings

PQM-700 **PQM-707** *In PQM-700 and PQM-707 analyzers, the user cannot set parameters in this tab. These settings are not supported by these meters.*

PQM-701 I*n PQM-701 it is not possible to scan analyzers via GSM (except for PQM-701Zr), or Wi-Fi.*

PQM-701Zr *Options related to the serial port are available only for PQM-701Zr.*

PQM-702 **PQM-703** *In PQM-702 and PQM-703 it is not possible to scan analyzers via Wi-Fi.*

Media Settings include the following options:
- **ACTIVE MEDIA** – the user may activate scanning the analyzers connected via serial connection (option **SERIAL PORT**), scanning the analyzers connected via GSM (option **TCP/IP OVER GSM**) or Wi-Fi (option **WI-FI**; available only in tablet version of the *Sonel Analyze* application).
- **PQM-701Zr** **SERIAL PORT SETTINGS** (Fig. 87) – allows user to select settings for PC serial port that will be applied for connecting with PQM-701Zr analyzer. The following options are available:
  - **PORTS TO BE SCANNED** - the COM ports detected in the system are listed. If we know the specific port number to which the analyzer is connected then just choose this one. If you do not know the specific port number, select all of them or a group.
  - **PARITY** - indicates the current analyzer parity type,
  - **FLOW CONTROL** – select the flow control method: hardware (CTS/RTS) or off (must be the same as the one set in the analyzer),
  - **STOP BITS** - 1 or 2,
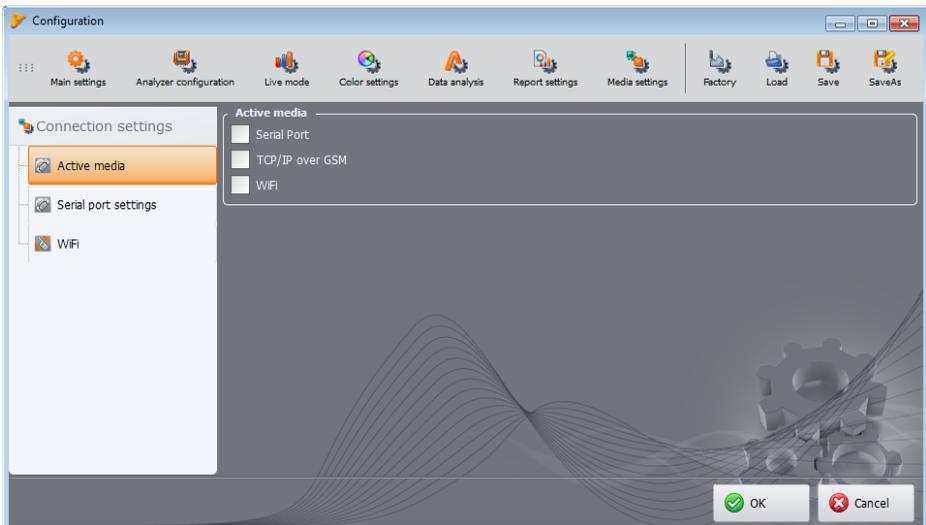- **BAUD RATE** - indicates the transmission speed in bits per second set in the analyzer.

Fig. 86. Choosing active connection types.

To speed up the search for analyzers connected through the serial port the option **DO NOT SEARCH FOR SETTINGS OTHER THAN PREVIOUSLY STORED** has been added. If it is selected the program stores the transmission parameters when an analyzer is found on the COM port to use them exclusively during the next scan. This means that if a different analyzer with different parameters is connected it will not be detected. If this is the case the new analyzer should be connected to another COM port, or the option should be deselected. In both cases ensure that the transmission parameters of the analyzer are specified in the settings selected on the card.

DELETE THE SAVED SETTINGS button causes the removal of settings for the detected analyzers, which means that when a search is initiated all combinations of settings selected in the card are used.

To speed up the analyzer detection process it is advised to narrow down the possible setting combinations.
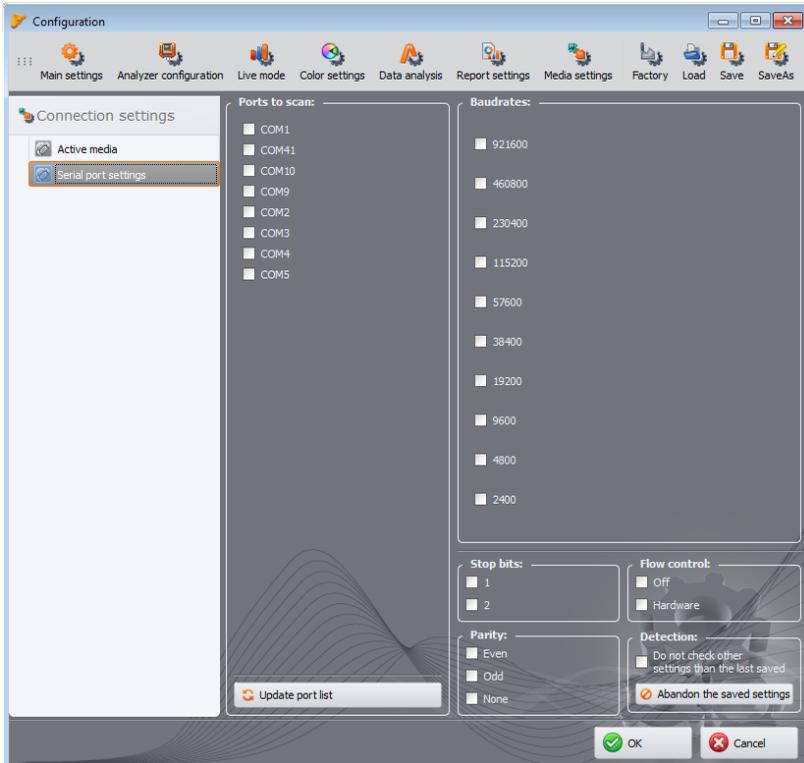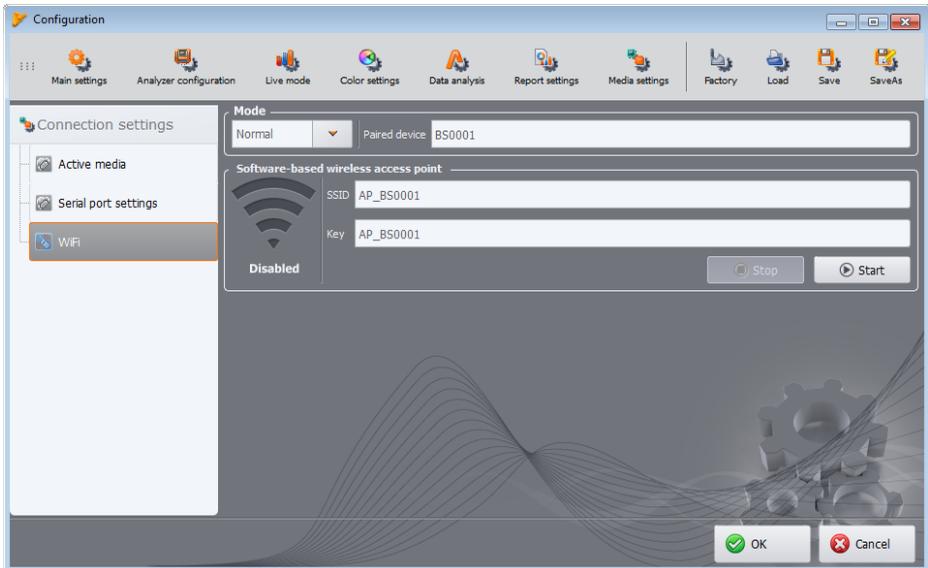

Fig. 87. Program configuration – Serial port settings.

PQM-710 **PQM-711** **WI-FI** option is used to change the access point settings and default software behavior at startup. After selecting it, window shown in Fig. 88 will be displayed.

Fig. 88. Wi-Fi access point configuration.

The window provides the following options:
- enabling/ disabling the access point (**START** and **STOP** buttons).

> **Note**
> Disabling the access point will prevent a direct connection analyzer ⇔ tablet via Wi-Fi.

- changing the software actions at the startup. *Sonel Analysis* software may operate in one of two modes. Default setting is: **PAIRED**. This automatically connects the program with the factory paired analyzer after the program is started. **PAIRED DEVICE** field shows the serial number of the paired analyzer. To make this possible, the access point must be set as **ENABLED**. Selecting **NORMAL** mode starts normal operation of the program. In this case, the automatic connection to the paired analyzer during startup will be disabled.

- Next two fields: **SSID** and **KEY** enable user change the parameters of the access points in the tablet:
- **SSID** field is used to name the wireless access point,
- **KEY** field is used to secure the connection with a password.

In order to properly configure a Wi-Fi access point:
- Disable the current access point (**+** button),
- Enter the access point name (**SSID** field),

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- Enter the password (**KEY** field),
- Press **START** button.

> **Note**
> *In order to enable the connection between the analyzer and the access point in the tablet, the analyzer needs the same name* **SSID** *and* **KEY** *entered.*

5.4   Upgrading software and firmware

Firmware of the analyzer and "*Sonel Analysis*" software must be regularly updated in order to correct discovered errors or introduce new functionalities. When the analyzer software is updated, check whether a new version of "*Sonel Analysis*" is available (and vice versa), if yes proceed with the upgrade.

5.4.1 Automatic software update

Every time the program is started, it checks for updates on the manufacturer's server. This feature may be turned on/off in the preferences (see section 5.3.1). If this option is disabled, the update may be performed manually by selecting **HELP→ON-LINE UPDATE**. To perform the update, an operational Internet connection is required.

If the program detects that a new version of "*Sonel Analysis*" is available, the user may decide to upgrade the current version. After downloading necessary files the new version will be installed and the program will re-start.

The program may also check for a newer version of the analyzer firmware. Firmware update may be performed only after connecting the analyzer with a USB cable. When a new version is available, the user will see information concerning the software version and introduced changes. After confirmation by the user the update proceeds. Then, after it is completed, the analyzer automatically disconnects and re-starts.

6   Manufacturer

The manufacturer of the software and provider of guarantee and post-guarantee services:

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