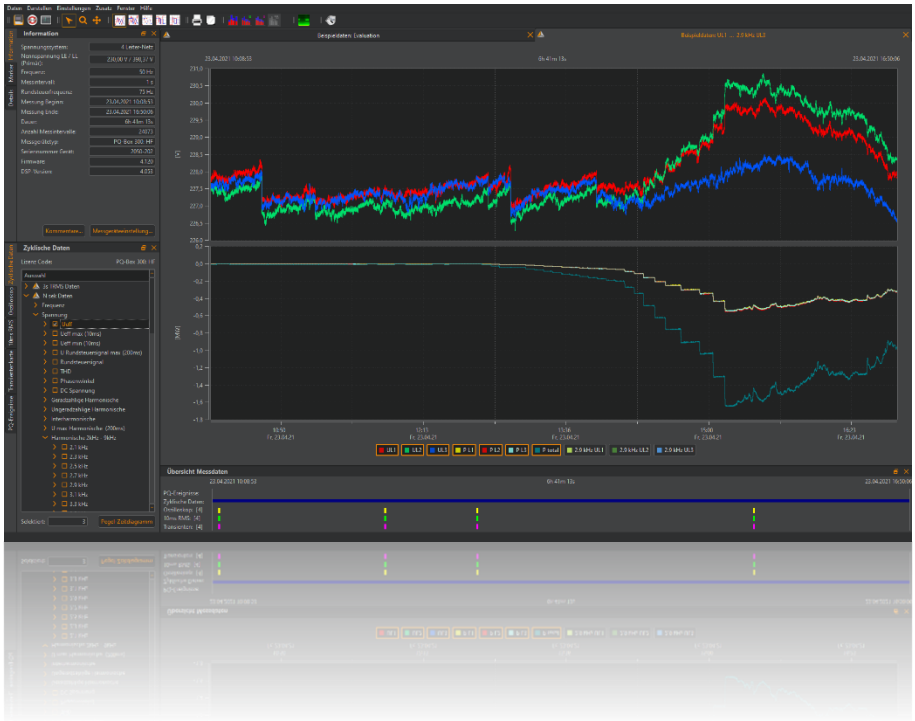
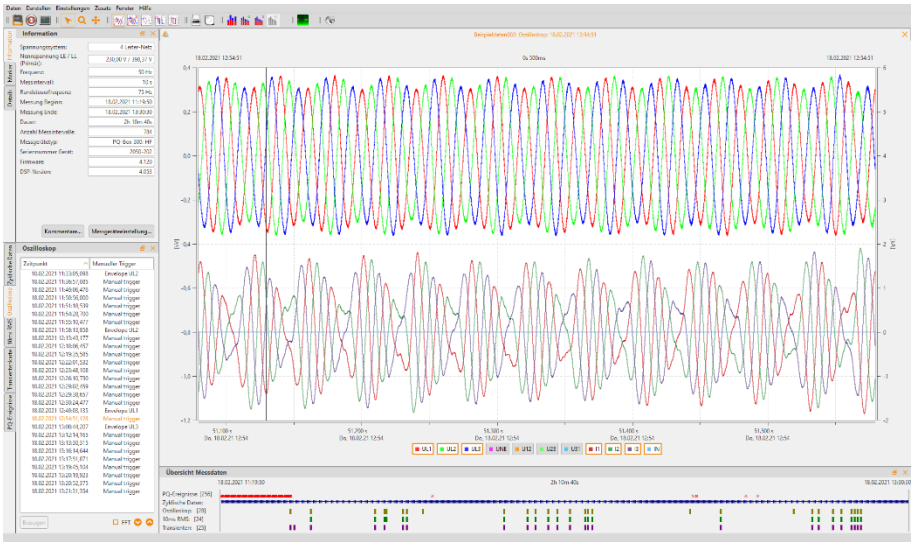
a-eberle

Operating Manual

Power-Quality Evaluation Software





EN

Note:

Please note that this operating manual cannot describe the latest version of the device in all cases. For example, if you download a more recent firmware version from the internet, the following description may no longer be accurate in every point.

In this case, either contact us directly or refer to the most recent version of the operating manual, available on our website (www.a-eberle.de).

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Inhaltsverzeichnis

1. Evaluation software WinPQ mobil 6
1.1 Software – Installation / Removal / Update 7
1.2 Software Wizard 9
1.3 WinPQ mobil start screen 10
1.4 General Software Settings 11
1.4.1 Changing the language 11
1.4.2 Changing the colours of lines 11
1.4.3 Export preferences 12
1.4.4 Common Setup 13
1.4.5 Visualization of Harmonics 15
1.4.6 Changing the WinPQ mobil design 16
1.5 TCP/IP Settings 17
1.6 Transferring measurement data from PQ-Box to the PC 18
1.6.1 Data administration 19
1.6.2 Transferring measurement data while a measurement is in progress 20
1.6.3 Fast data transfer in USB disk mode 21
1.7 Evaluation of Measurement Data 22
1.7.1 Start screen after loading a measurement file 24
1.7.2 Restriction of the evaluation period in the measurement data 26
1.8 Definition and Management of Norm Templates 27
1.8.1 Statistics 29
1.8.2 Report Settings 31
1.8.3 Harmonics 2-50 32
1.8.4 Frequency bands 2-9 kHz 33
1.8.5 Supraharmonics 9-150 kHz 34
1.9 Setup of limits for current harmonics 35
1.9.1 Basic settings 36
1.9.2 Harmonics 2 to 50 37
1.9.3 Supraharmonics 2 - 9 kHz 38
1.10 Standard evaluation according to EN50160 or other standards 39
1.10.1 Creating a standard report 43
1.11 Evaluation of voltage harmonics 44
1.11.1 Visualization of Supraharmonics 9-150kHz (PQ-Box 300 only) 46
1.12 Evaluation of current harmonics 48
1.13 Evaluation of current harmonics according to D-A-CH-CZ or VDE-AR-N 4100/4110 50
1.14 IEEE 519 Report 53

1.15 Q diagram for reactive and active power ... 54
1.16 Timing diagrams of long-term data ... 55
1.16.1 Set markers ... 57
1.16.2 Vertical Marker ... 58
1.16.3 Plot line type options ... 58
1.16.4 Further functions in the context menu (right mouse button): ... 58
1.16.5 Limit marker line ... 60
1.16.6 Insert comment ... 61
1.16.7 Oscilloscopic records ... 62
1.16.8 Half-period TRMS Records ... 65
1.16.9 Switching directly to recorder for this event ... 66
1.16.10 Transient recorder (only PQ-Box 200, PQ-Box 300) ... 67
1.16.11 Ripple control signal recorder ... 69
1.16.12 PQ Events ... 70
1.16.13 Data export as CSV ... 73
1.16.14 Data Export as PQDIF ... 75
1.16.15 Additional functions ... 76
1.16.16 Compare two different measurement files ... 77
1.17 Menu 'support' and menu 'Help' ... 78
2. Parameters and standard limits of PQ-Box ... 79
2.1 Setup – Basic settings ... 81
2.1.1 Measured value recording of PQ-Box ... 83
2.1.2 Transducer factor of VTs and CTs ... 86
2.1.3 Power calculation setup ... 87
2.1.4 AUX Input ... 88
2.1.5 THD Calculation and grouping of harmonics ... 88
2.2 Setup – PQ Events ... 89
2.3 Trigger settings of Oscilloscope Recorder ... 90
2.3.1 Explanation of trigger conditions ... 91
2.4 Trigger settings of half-period recorder ... 92
2.5 Automatic Trigger ... 93
2.6 Trigger via binary input (only PQ-Box 200/PQ-Box 300) ... 94
2.7 Trigger by AUX input (only PQ-Box 200/PQ-Box 300) ... 94
2.8 Ripple control signal analysis ... 95
2.9 Transient board setup (only PQ-Box 200 with Option T1) ... 96
2.10 High Frequency module (PQ-Box 300 only) ... 97
2.11 Scheduled Operation ... 98

2.12 Network configuration PQ-Box 98
2.13 Firmware Update 101
2.14 Lizence upgrade PQ-Box 102
2.1 Offline-Parametrierung einer PQ-Box 102
3. Edit measurement data 103
3.1 Data converter 103
3.2 Combining partial measurements into a total measurement 104
4. Online-Analysis 105
4.1 Oscilloscope 106
4.2 HF-Oszilloskop (only PQ-Box 300) 108
4.3 FFT Spectrum 109
4.4 HF Spectrum (only PQ-Box 300) 111
4.5 Harmonics 113
4.6 Interharmonics 114
4.7 Supraharmonics 2-9 kHz / 2-20 kHz 115
4.8 Timing Chart 116
4.9 Power Harmonics 117
4.10 Details 120
4.11 Phasor diagram 121
4.12 Power 3D 122
4.13 Online Status 123
5. Measurement Data 124
5.1 Measured quantities 124
5.2 PQ-Box Measurement Procedure / Formulas 124

1. Evaluation software WinPQ mobil

The power quality analysis software WinPQ mobil supports the portable network analyzers **PQ-Box ONE, PQ-Box 50, PQ-Box 100*, PQ-Box 150, PQ-Box 200** and **PQ Box 300**.

* As of **WinPQ mobil 8**, the software no longer supports the parameterization and online analysis of a **PQ-Box 100** for compatibility reasons. However, its measurement data can still be opened and analyzed.

The legacy version of WinPQ mobil is required for parameterization and online analysis of a PQ-Box 100. All versions can be downloaded free of charge at

www.a-eberle.de/winpq-mobil-software-en

It was developed in collaboration with power supply companies with the goal of creating an easy-to-use and adaptable solution for the evaluation of power quality parameters in energy distribution networks.

The network analyzer software is suitable for evaluations in low, medium and high voltage networks.

The purpose of the program is to process the stored power quality measurement data and fault records for the viewer and display them on the PC screen in an appropriate manner. To this end, the program provides tools for the efficient selection of stored data and a set of graphical and tabular presentations of the parameters of power quality according to standard **EN50160**, **IEC61000-2-2, IEEE519** or the standard for industrial networks **IEC61000-2-4**. Many more standards from all over the world are included in the software, too.

- **Automatic reporting according to the compatibility levels of EN 50160, IEC 61000-2-2, IEC 61000-2-4, IEEE 519, etc.**
- **Information about faults in the network by means of fault records**
- **Management of many measurements**
- **Data acquisition of long-term data and events**
- **Statistical long-term analyses**
- **Correlation of events and different measurement data**
- **User-friendly, user-oriented evaluation**

1.1 Software – Installation / Removal / Update

System Requirements:

Operating system: Microsoft Windows 8, 10 or 11

Memory, at least 2 GB

The WinPQ mobil software is available free of charge in 64-bit versions.

Installation of the evaluation software:

To start the installation of the evaluation software, place the installation CD in your CD-ROM drive. If the Autostart function is activated, the installation program starts automatically. Otherwise, go to the root directory of your CD-ROM drive and start the program by double-clicking the file **setup.exe**.

The installation complies with the Windows standard including uninstalling the program using the "software" system control. The installation location of the program (target directory) can be freely selected during installation.

Please install the software in a directory in which you have the rights to read and write data files.

The start icon **WinPQ mobil (64bit)** is created automatically on your PC's Desktop.

Uninstalling the software using the system control:

The components are removed from the PC using the Windows "System control“.

Under "Programs“, select “WinPQ mobil” and delete the evaluation software with the “Remove” button.

All parts of the program, including the generated links, are completely removed after a single confirmation. Before uninstalling the program, all running components must be closed.

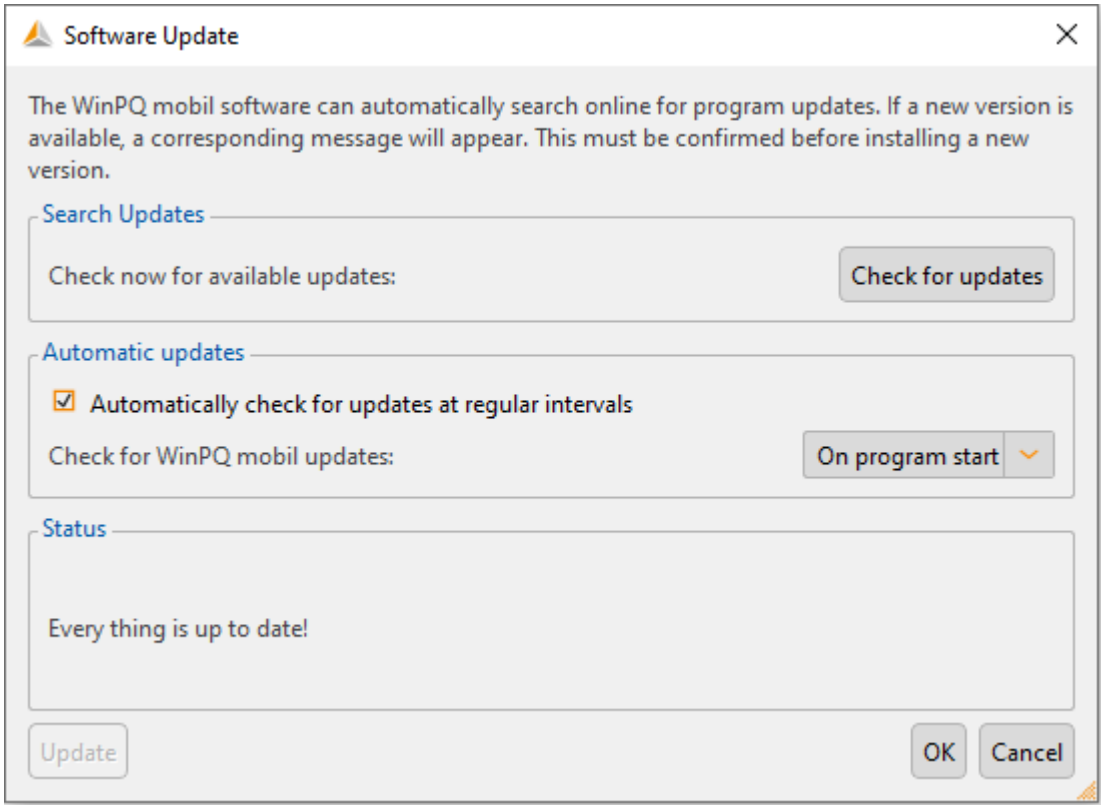
Software Update

The evaluation software and all updates are available free of charge on our website under the category "Power Quality":

www.a-eberle.de/winpq-mobil-software-en

Automatic software update

An automatic software update can be set up under the menu item "Settings/Software update".

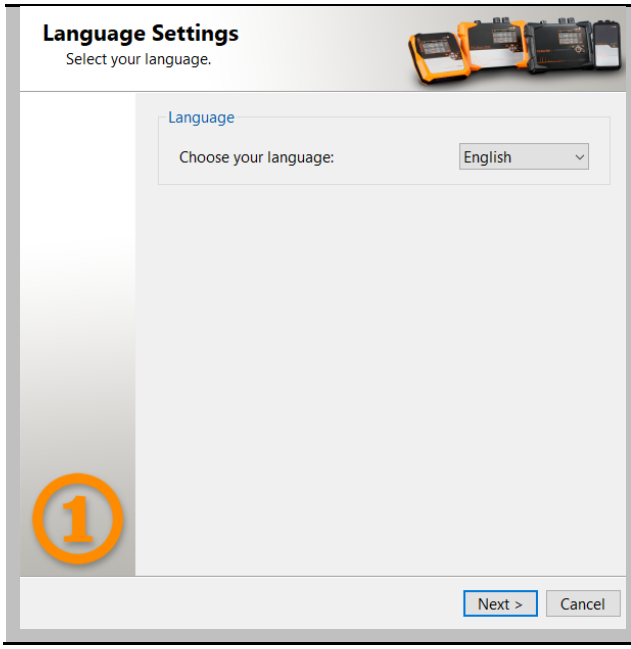


Please update both, the software and the firmware of the PQ-Box, to avoid problems.

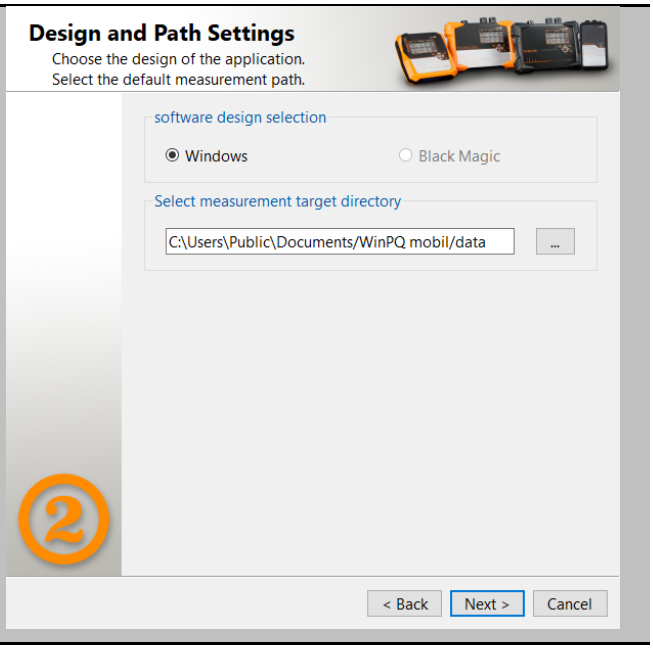
1.2 Software Wizard

If you install the software on a new PC, after the first opening, a setup assistant will start. Customer and country-specific settings are automatically queried and copied into the software. All settings can be changed later in the Software General Settings.

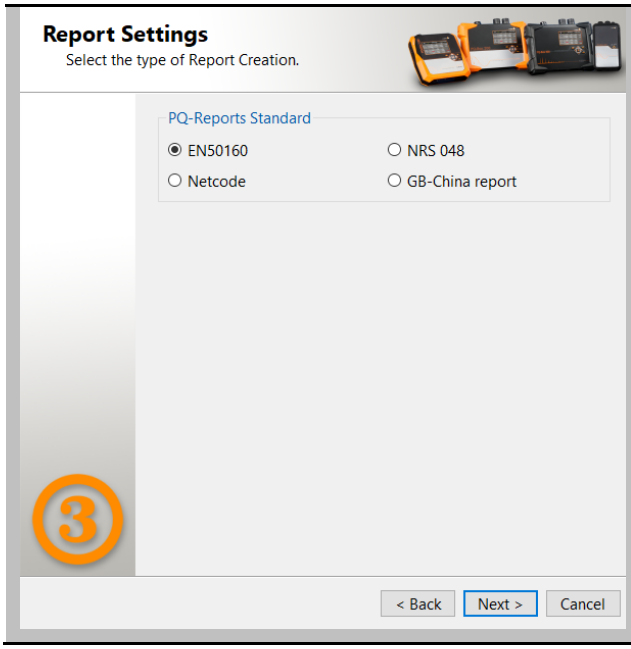
Select language



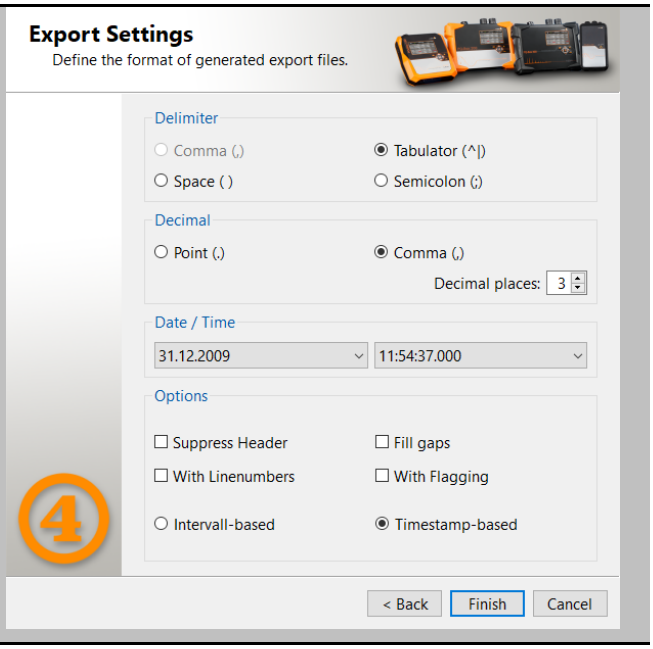
Select design and target directory



Select country specific settings



Export settings



1.3 WinPQ mobil start screen

In the start screen of the WinPQ mobil evaluation software, 4 buttons are available for accessing the different sections of the software:

Opening a measurement from the hard disk

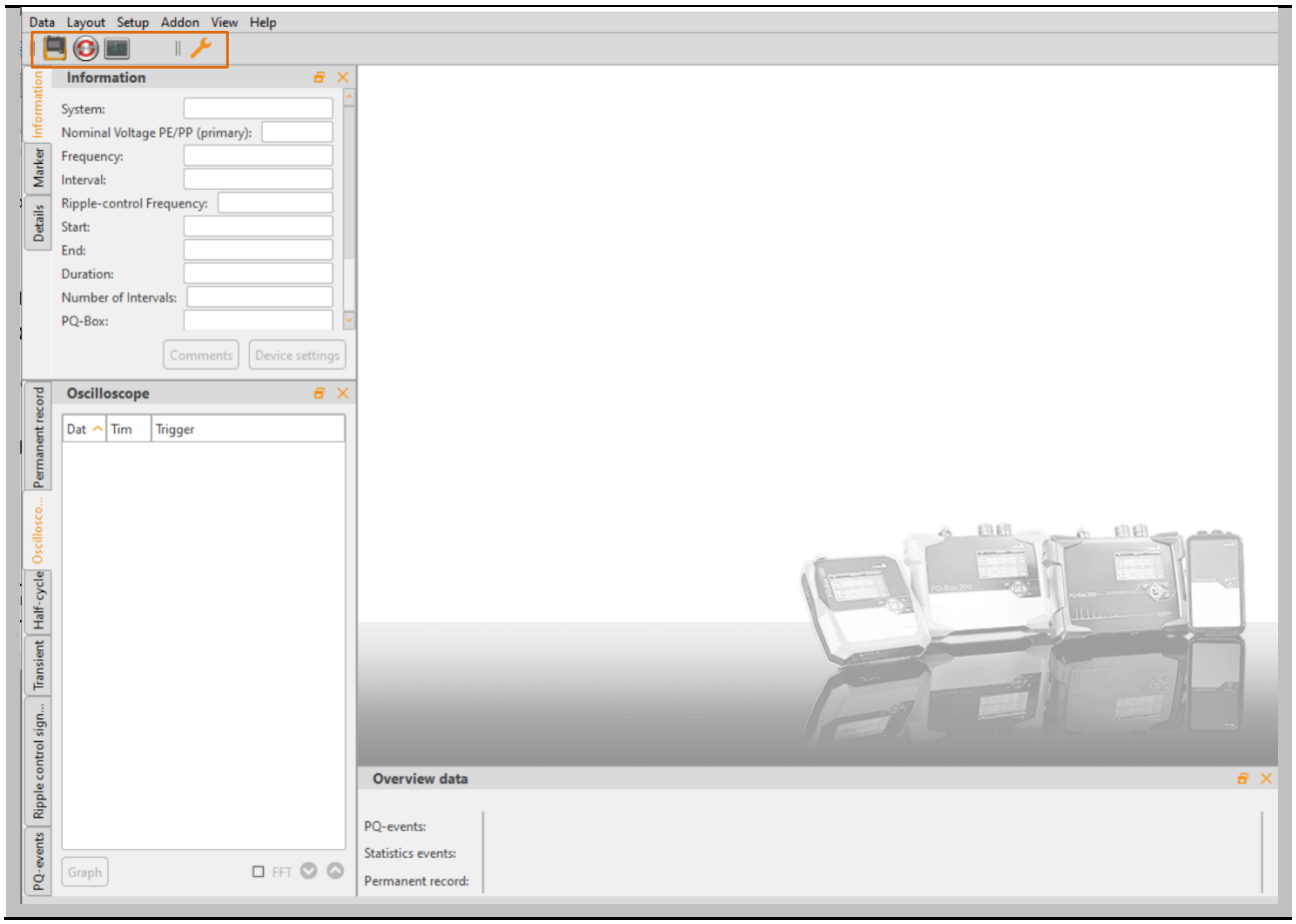
Loading the measurement data of the PQ box

Change settings (See chapter 2: Parameters and standard limits of PQ-Box)

Online measurement (See chapter 4 Online-Analysis)

Correction of data (See chapter 3.1 Data converter)

Icons in the start screen of WinPQ mobil software

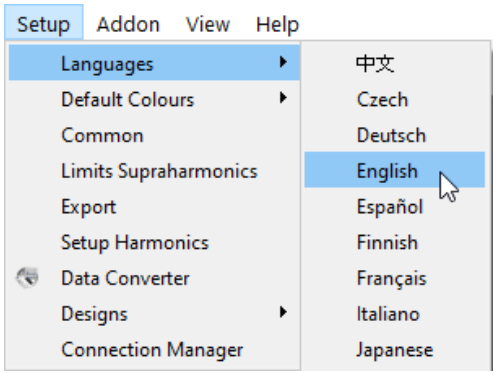


WinPQ mobil aumatically scans the PC for connected PQ-Boxes when the software is started, a device is connected via USB, or the F5 key is pressed.

1.4 General Software Settings

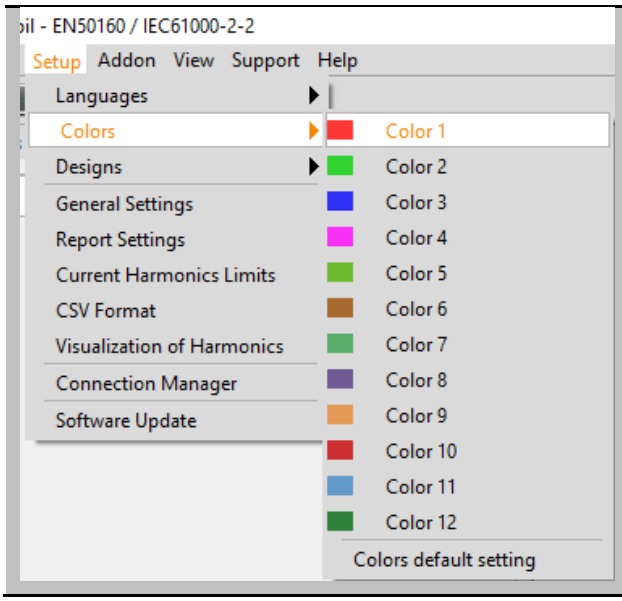
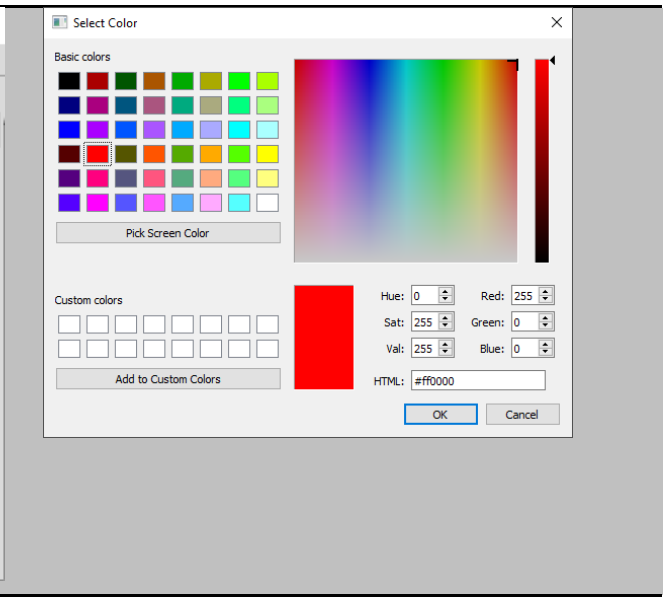
1.4.1 Changing the language

The evaluation software language can be changed in the “Settings” menu. After changing to a new language, the software must be restarted for the change to take effect.



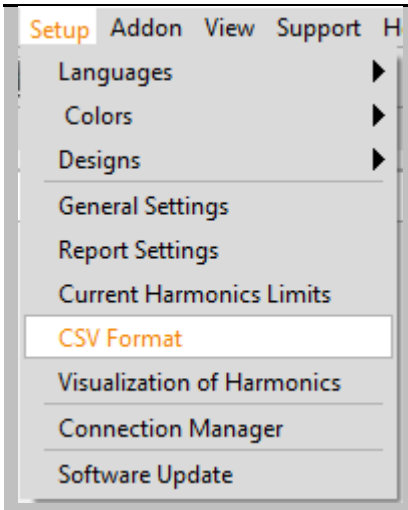
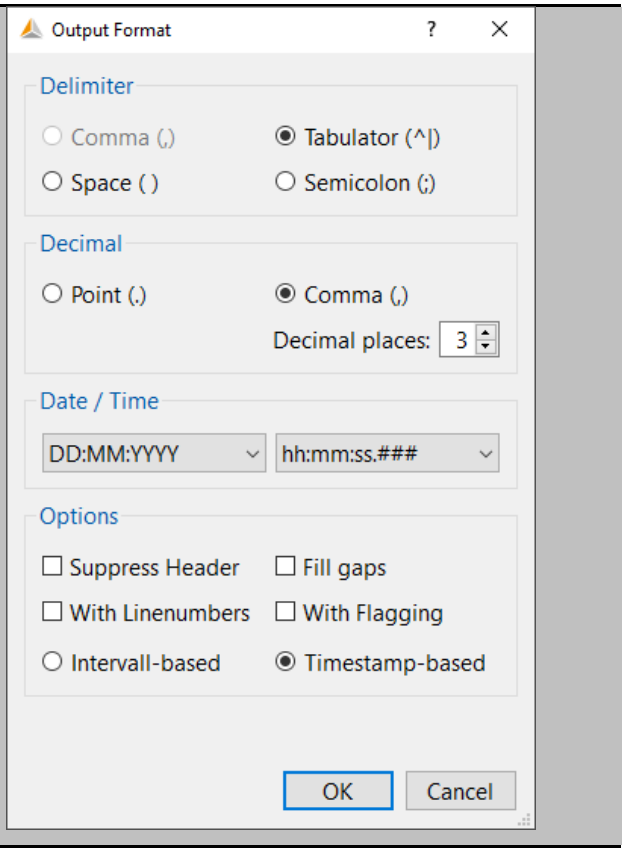
1.4.2 Changing the colours of lines

Each measuring channel can be assigned to a specific colour. There are two different settings possible: Windows native and Black magic. For print always the colors Windows native are used. Colors can be reset to default settings, too.

Colour settings menu	Colour selection
	

1.4.3 Export preferences

In the menu option data export the format of exported CSV files can be defined. Besides delimiter, decimal separator and date/time format there are more options available.

Export settings menu	Change output format
	

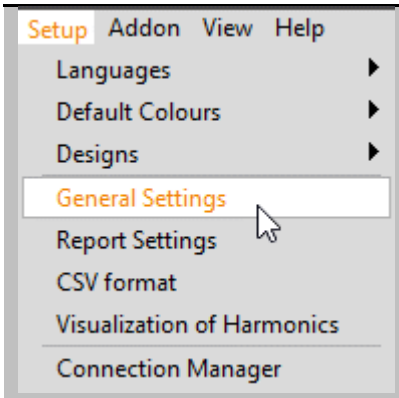
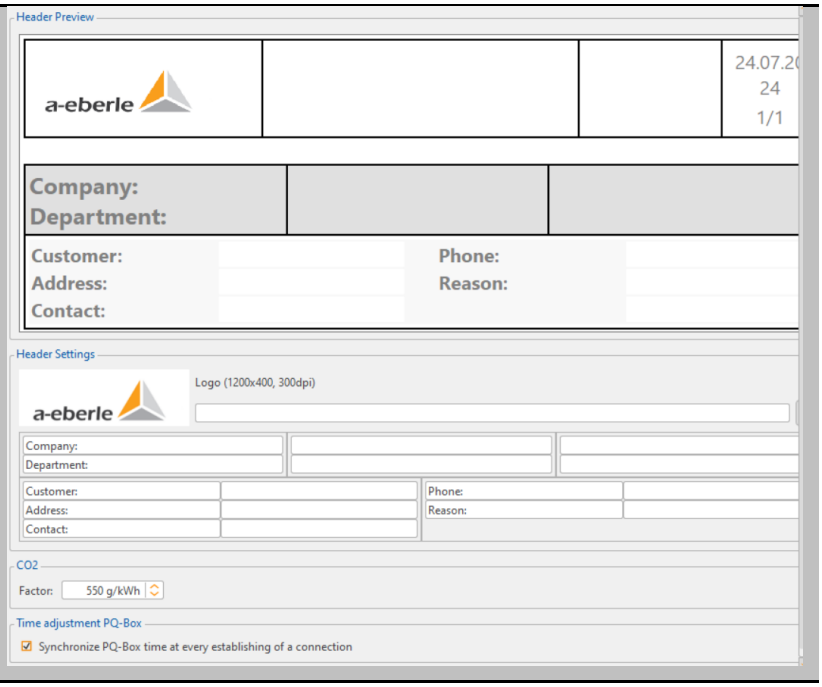
Options:

- **Suppress Header:** Information such as designation of measuring job, device number and measuring interval are not displayed in the header.
- **Fill Gaps:** Gaps in the measurement are filled with 0 in case of interruptions of the measuring job. All time intervals are continuous with constant interval.
- **With Flagging:** Display whether measurement data were marked due to a fault according to IEC 61000-4-30 in the data export or not.
- **With Line numbers**
- **Interval-based:** Extreme values of voltage and current are displayed with the time stamp of the respective interval.
- **Timestamp-based:** Extreme values of voltage and current are displayed with an exact time stamp (accurate to the millisecond).

1.4.4 Common Setup

In the general settings, the properties of PQ reports can be edited.

The **Logo** section offers the possibility to define a customized logo for the header of all automatic PDF reports.

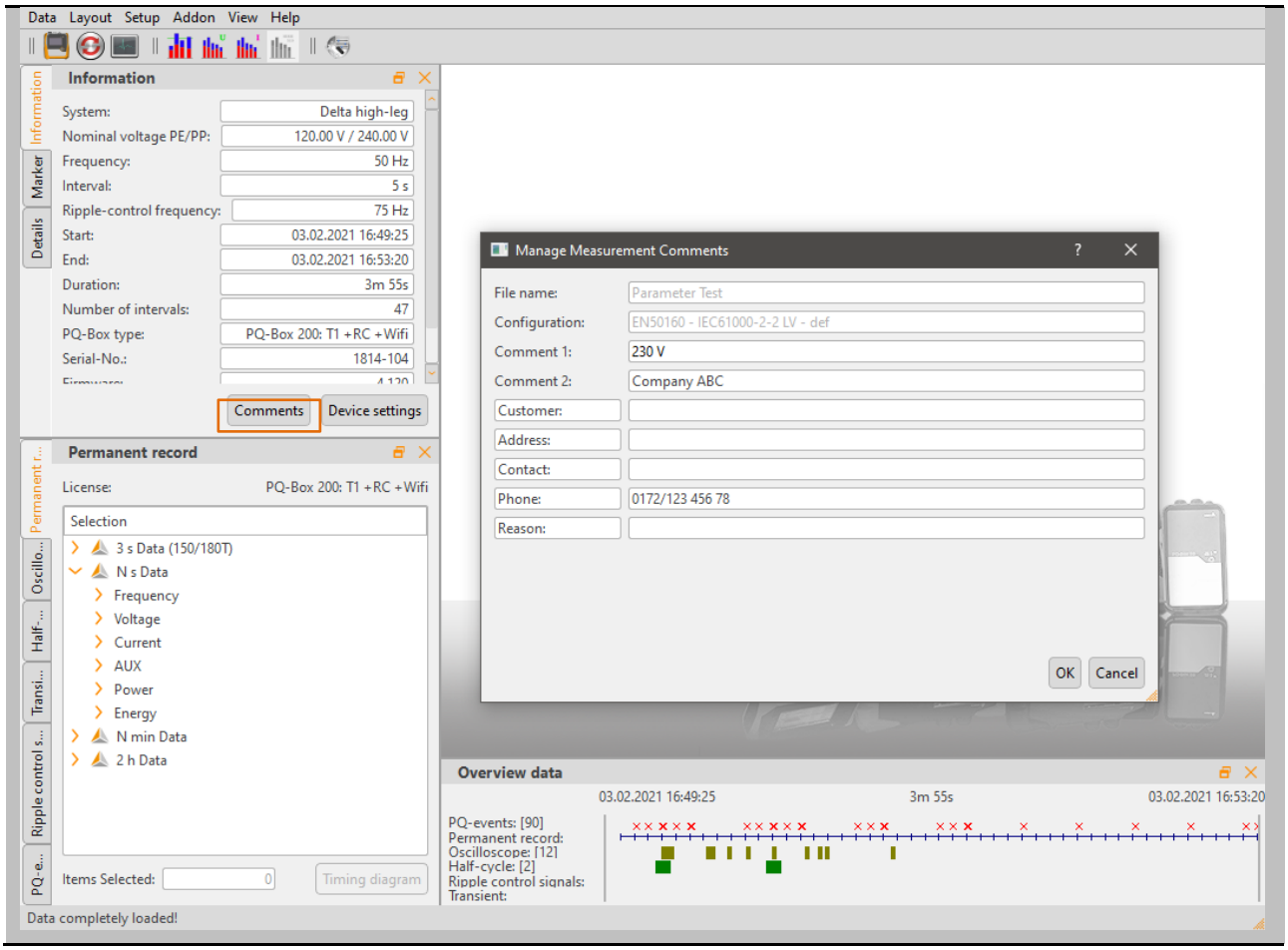
General Settings	Change common settings
	

In section **Header Labels** it is possible to define the title of 5 comment fields in the header of the reports.

The **CO2** section provides definition of an individual CO2 factor, which can be used to calculate the produced ammount of CO2 in long-term data.

Time synchronization of the PQ box
If the "Time synchronization" check box is active, the PQ-Box is automatically synchronized with the time on the PC time as soon as they are connected.

Enter comments to the measurement

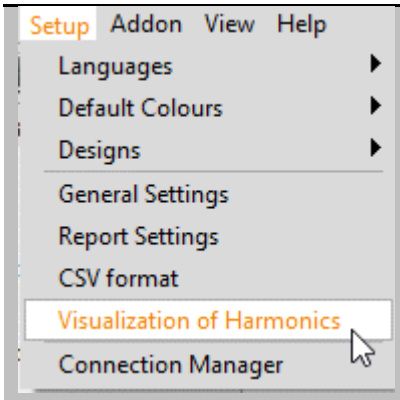
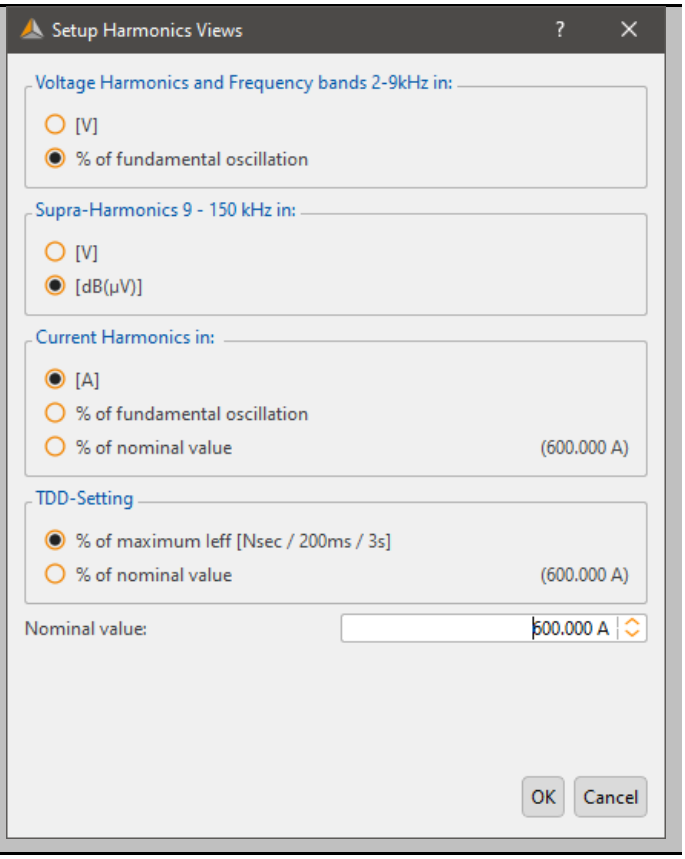


The fields **File name** and **Configuration** can only be edited via the File Management dialogue.

1.4.5 Visualization of Harmonics

The type of display of harmonics can be set via Setup -> Visualization of Harmonics. The change-over of the voltage harmonics to "V" or "%" has an influence on all sectors of the software (online analysis as well as long term data and statistical evaluation).

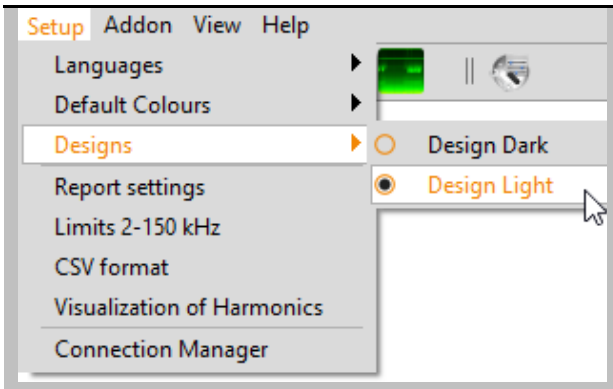
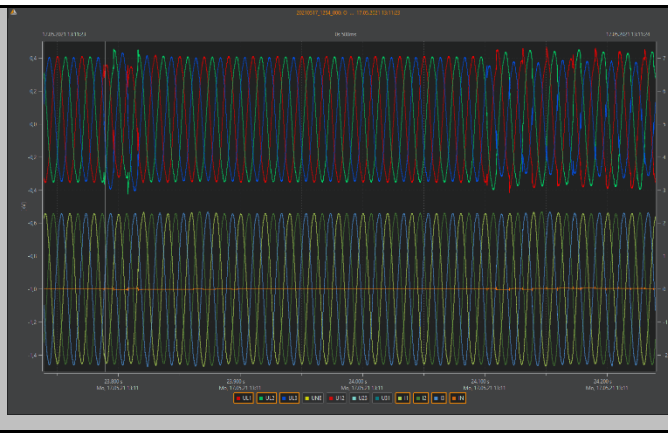
- **Voltage harmonics and 2-9 kHz frequency bands:**
  Display in “V” or “% of fundamental oscillation”
- **Supraharmonics 9 - 150 kHz:**
  Display in “V” or “dB(µV)”
- **Current harmonics / THD Current:**
  Display in “A”, “% of fundamental oscillation” or “% nominal value“
- **TDD Setting**
  “% of maximum Ieff” or “% of nominal value“

Harmonics setup menu	**Change setup**
	

1.4.6 Changing the WinPQ mobil design

WinPQ mobil offers two different designs for screen displays.

- Design Dark
- Design Light

Design menu	Example „Design Dark“
	

In the "Design Dark" setting, all print jobs are printed in light design.

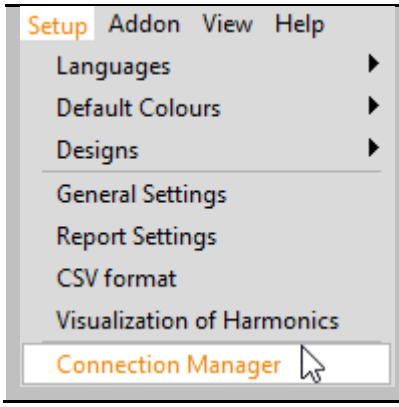
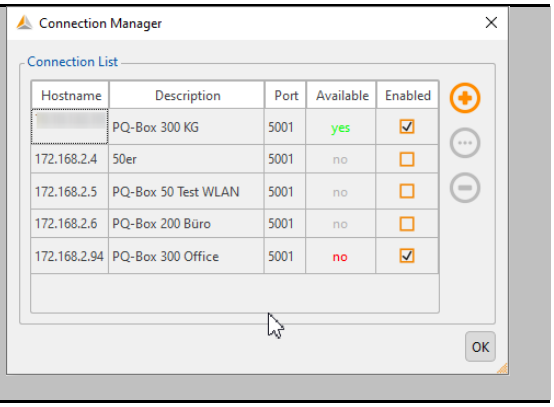
1.5 TCP/IP Settings

In order to establish a connection with the PQ-Box via TCP/IP or WLAN interface, it must be created once in the connection manager. Any number of boxes can be added to the list.
The WinPQ mobil evaluation software tries to reach these set connections every time it is opened. In the menus of the device parameterization, online software and read out measurement data, available devices are offered via USB, TCP/IP or WLAN connections.

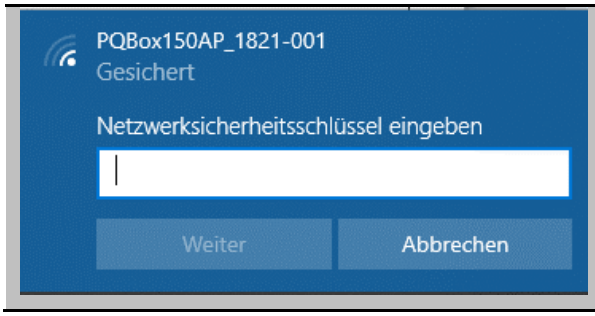
Add new connection.

Edit selected connection.

Delete the selected connection.

Connection Manager Menu	Add connections
	

In order to establish a connection via WLAN, the PQ-Box must be at first registered as a WLAN router on the PC. The network key corresponds to the last 8 characters of the network name of the box. In the example below, the key would be "1821-001".

Windows WLAN Settings	Connection successful
	

Note on PQ-Box 50
The WLAN IP address of PQ-Box 50 is pre-set and cannot be parameterized.

PQ-Box 50 with serial number less than 2301.xxx is 192.168.2.4

PQ-Box 50 with serial number higher than 2302.xxx is 172.168.2.4

1.6 Transferring measurement data from PQ-Box to the PC

Connect the power analyzer to the PC via the supplied USB cable or TCP/IP connection. Alternatively, the device can also communicate via WLAN interface. The power analyzer must be supplied with voltage via the power supply unit.

Open file management and choose the tab Hard disk.

Select target directory.

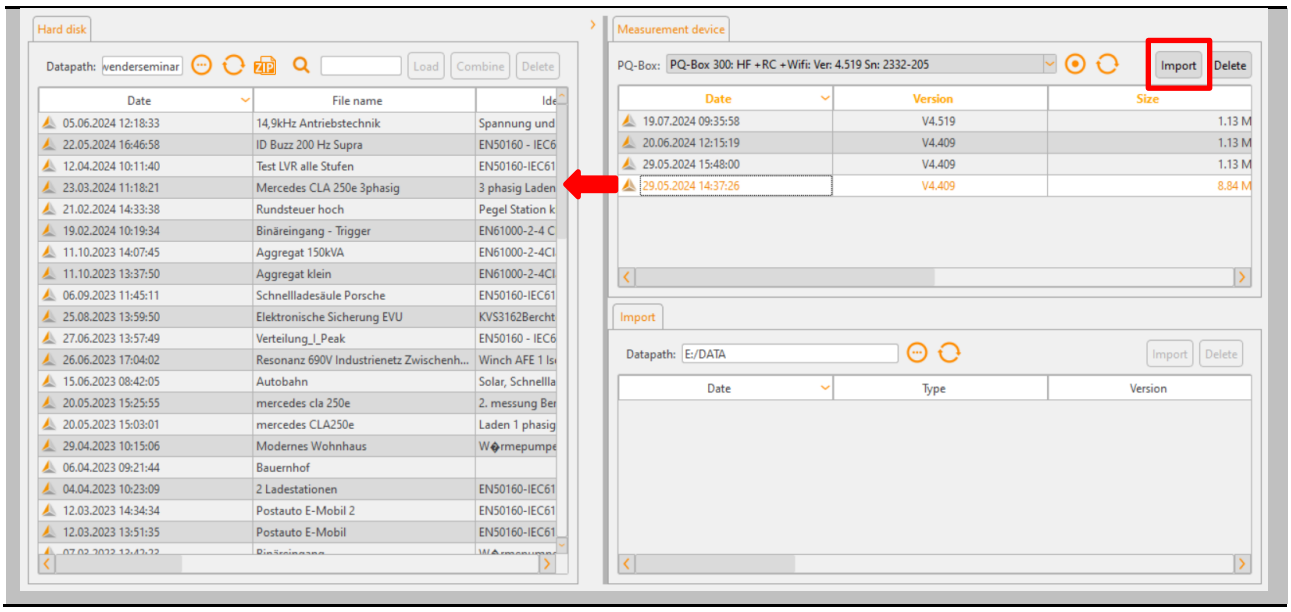
Measurement device Switch to tab “Measurement device” and choose the PQ-Box to be read out.

Show all available data records.

Import Import selected data files to the PC.

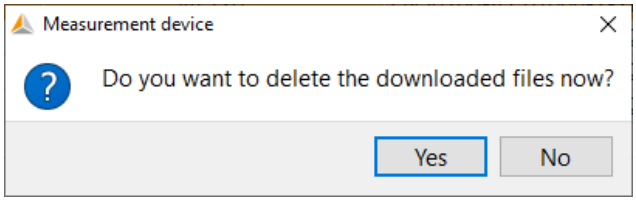
The displayed list shows all measurements that are located on the device memory. By left-clicking on the "Import" button, the selected files are transferred to the previously defined target folder. A multiple selection is possible by holding the shift key.

Download data records from PQ-Box



The Recorder button can be used to start or stop measurements directly from the software.

After successful transfer of the measurement data from the measuring device to the PC hard disk, the message "Should the measurement data now be deleted in the PQ box?" appears.



Yes Measurement data is deleted and the previously occupied memory on the device is available.

No The measurement data remains stored in the meter and can be downloaded from additional PCs.

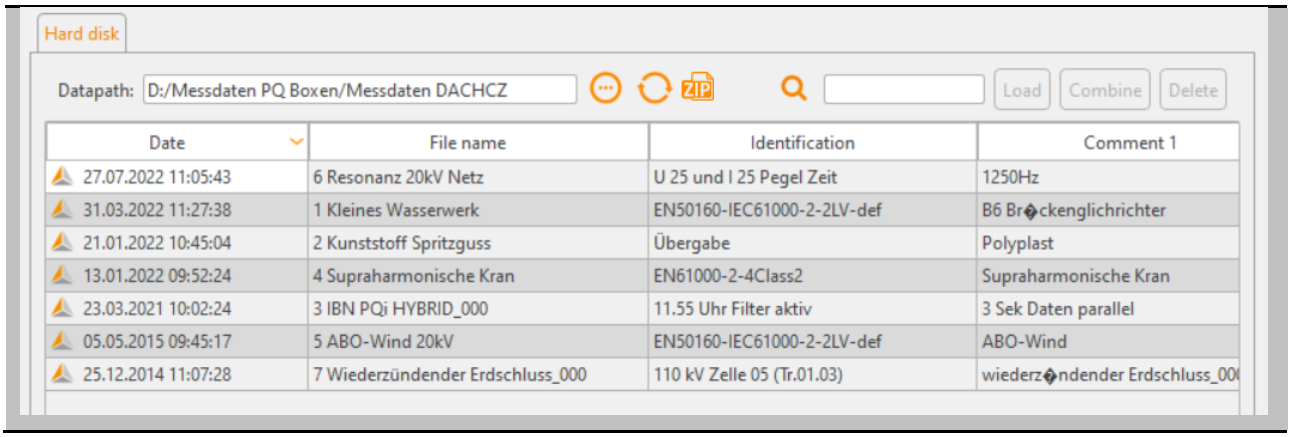
We recommend deleting the measurement data from the device memory after the download to avoid filling the memory of the measuring device unnecessarily.

1.6.1 Data administration

The tab “Hard disk” provides an overview of all measurement data stored on the PC. In addition to the date and type of the measuring device, 4 comment columns are available. These can be edited via double click.

The search function can be used to filter all comments and descriptions by a search term.

Data administration with comment fields



Date	File name	Identification	Comment 1
27.07.2022 11:05:43	6 Resonanz 20kV Netz	U 25 und I 25 Pegel Zeit	1250Hz
31.03.2022 11:27:38	1 Kleines Wasserwerk	EN50160-IEC61000-2-2LV-def	B6 Br►ckenglichrichter
21.01.2022 10:45:04	2 Kunststoff Spritzguss	Übergabe	Polyplast
13.01.2022 09:52:24	4 Supraharmonische Kran	EN61000-2-4Class2	Supraharmonische Kran
23.03.2021 10:02:24	3 IBN PQi HYBRID_000	11.55 Uhr Filter aktiv	3 Sek Daten parallel
05.05.2015 09:45:17	5 ABO-Wind 20kV	EN50160-IEC61000-2-2LV-def	ABO-Wind
25.12.2014 11:07:28	7 Wiederzündender Erdschluss_000	110 kV Zelle 05 (Tr.01.03)	wiederz►ndender Erdschluss_00

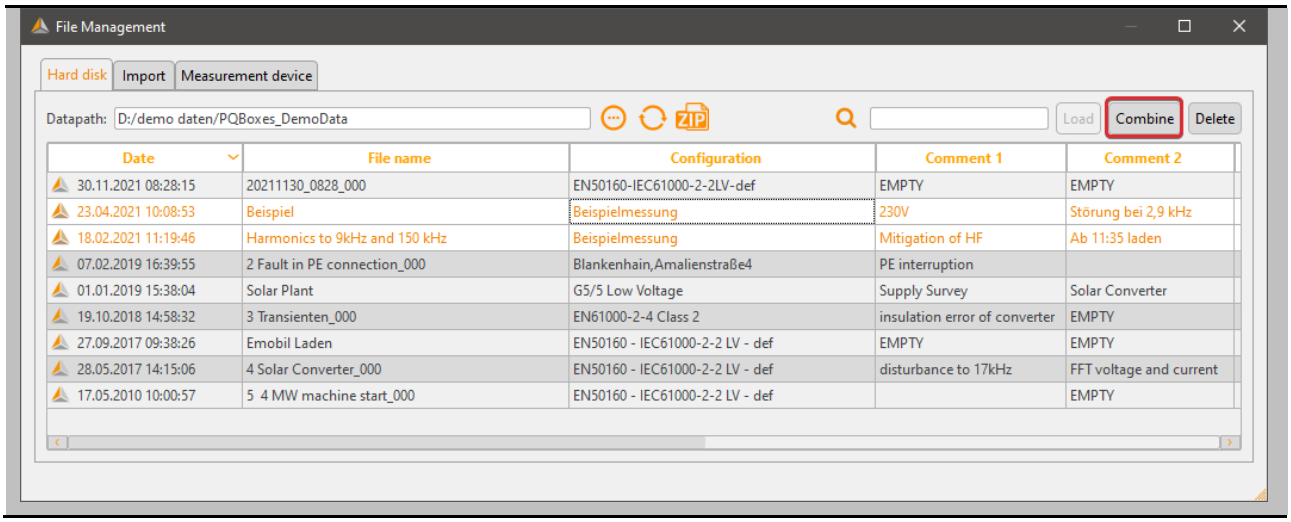
File name Determines the name of the measurement data folder in the file system.

Identification Name of the PQ box configuration.

Comment 1 to 4 Free comment e.g. location

Using the **Combine** button, several partial measurements can be combined into a new measurement file, when multiple measurements are selected.

Combine partial measurement files

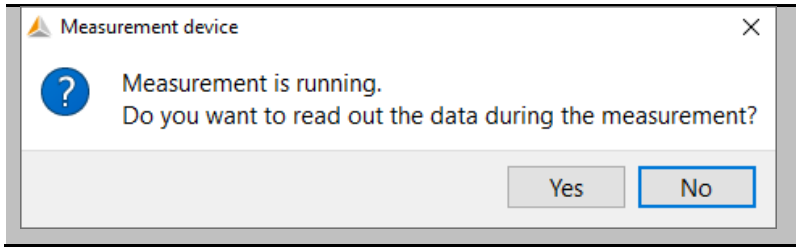


Use the icon to conveniently and easily compress and save measurement data as a zip-file. Multiple selection is also possible: Press CTRL + select several recordings with the left mouse button.

1.6.2 Transferring measurement data while a measurement is in progress

In order to be able to read out the measurement data from the measuring device during a started recording, the measurement is briefly paused for the duration of the data transfer. Confirm the question "Do you want to transfer the measurement data during recording?" with "Yes".

Confirm the pause of the measurement

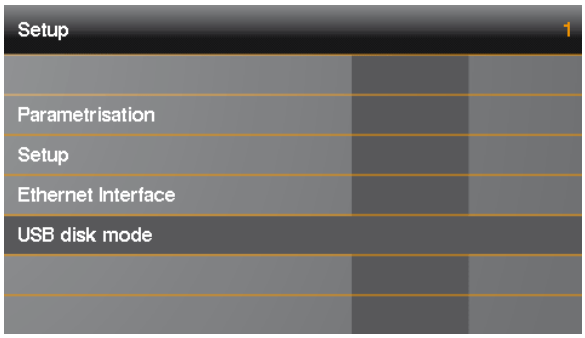


After data transmission, the measurement can be restarted by clicking on the flashing pause button.

Measurement is running again (recorder button flashes).

1.6.3 Fast data transfer in USB disk mode

The PQ-Boxes 150, 200 and 300 can be run in the "USB data carrier" mode, which means that very large amounts of data can be transferred to a PC very quickly.



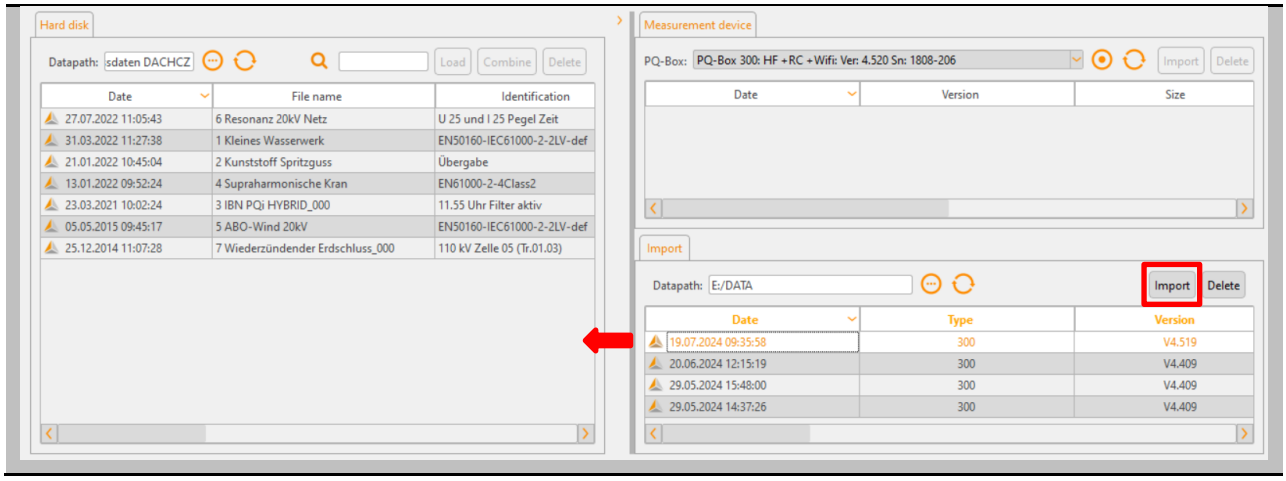
Via the "Import" tab, the PQ-Box appears as a data carrier. All measurement data of the device is located in the "DATA" folder.

Open the measurement data management and select the "Import" tab.

Choose PQ-Box/DATA directory.

Import Transfer data via 'Import'-button.

Select PQ-Box as data carrier



We recommend this way for data files >500MB

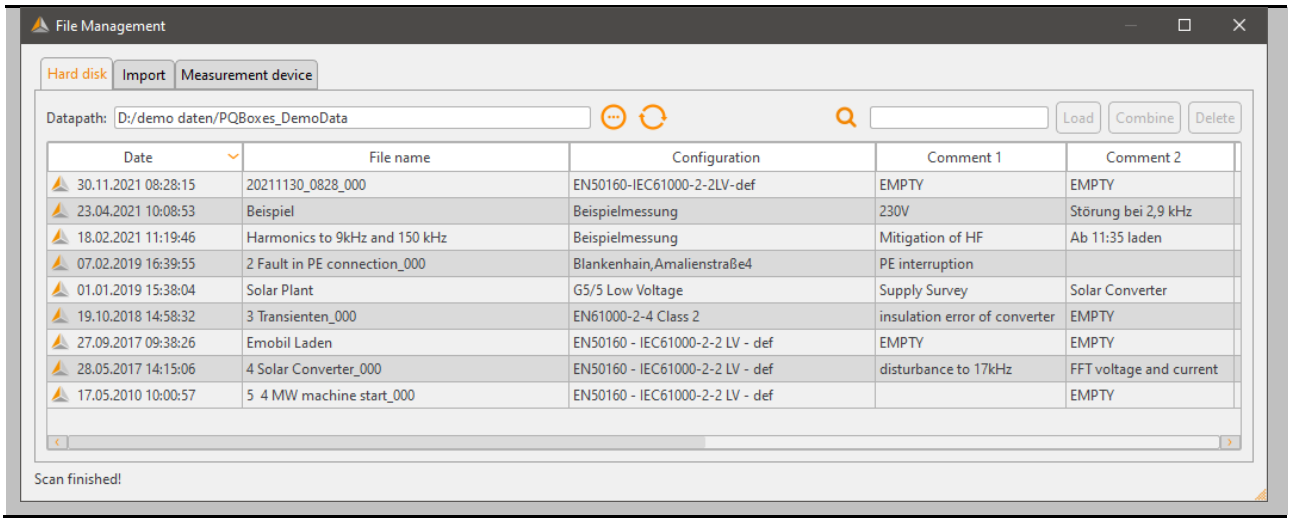
1.7 Evaluation of Measurement Data

Open the measurement data management and select the "Hard disk" tab.

Select measurement data directory via Explorer window.

All existing measurement data in the selected folder are displayed than. By clicking in the header, the files can be sorted by date, measuring device type, version, size and comments.

Measurement data management with comment fields



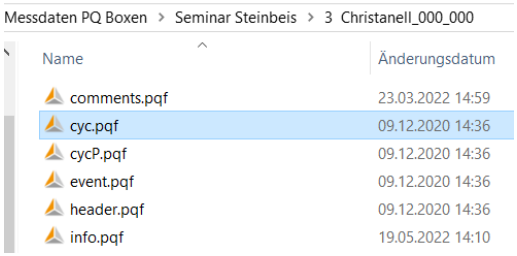
Date	File name	Configuration	Comment 1	Comment 2
30.11.2021 08:28:15	20211130_0828_000	EN50160-IEC61000-2-2LV-def	EMPTY	EMPTY
23.04.2021 10:08:53	Beispiel	Beispielmessung	230V	Störung bei 2,9 kHz
18.02.2021 11:19:46	Harmonics to 9kHz and 150 kHz	Beispielmessung	Mitigation of HF	Ab 11:35 laden
07.02.2019 16:39:55	2 Fault in PE connection_000	Blankenhain,Amalienstraße4	PE interruption	
01.01.2019 15:38:04	Solar Plant	G5/5 Low Voltage	Supply Survey	Solar Converter
19.10.2018 14:58:32	3 Transienten_000	EN61000-2-4 Class 2	insulation error of converter	EMPTY
27.09.2017 09:38:26	Emobil Laden	EN50160 - IEC61000-2-2 LV - def	EMPTY	EMPTY
28.05.2017 14:15:06	4 Solar Converter_000	EN50160 - IEC61000-2-2 LV - def	disturbance to 17kHz	FFT voltage and current
17.05.2010 10:00:57	5 4 MW machine start_000	EN50160 - IEC61000-2-2 LV - def		EMPTY

Load Open the selected measurement for evaluation. This function is also possible by double-clicking with the left mouse button.

Delete Delete the selected measurement (multiple selections possible).

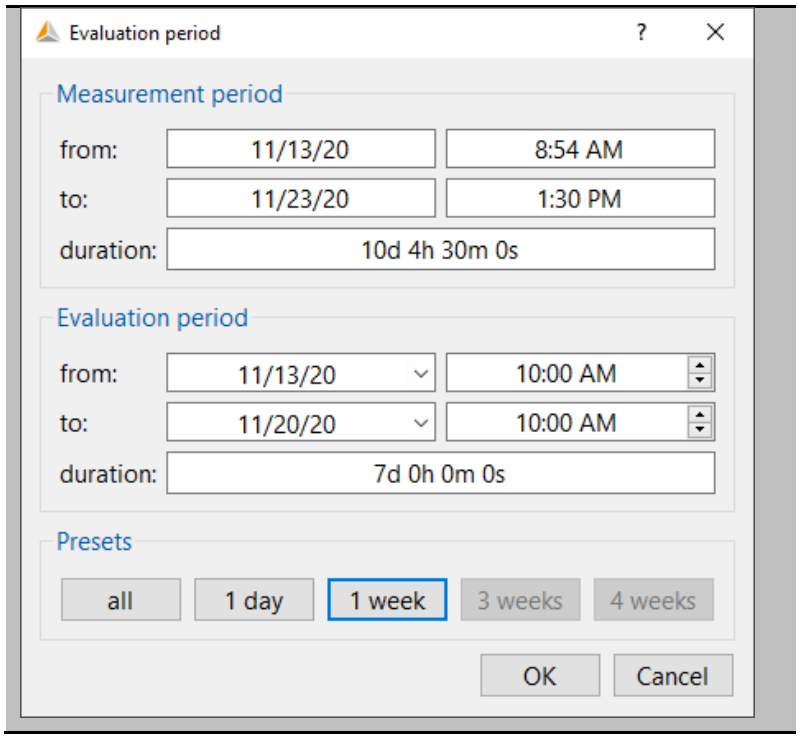
Deleted measurements are moved to the Windows Recycle Bin and can be restored or permanently deleted from there.

The measurement data can also be opened via Windows Explorer by double-clicking without starting WinPQ mobil. By opening the measurement data folder, you can load the measurement by double-clicking on one of the .pqf icons. WinPQ mobil starts automatically and displays the selected measurement.



After opening a measurement file, the information about the entire measurement period appears. In the field "Evaluated period" you have the possibility to select a certain period within the measurement and to evaluate only this period.

Selection of measurement period



Example: A measurement was performed over 10 days. However, the standard report is to be created for a fixed period of one week (7 full days). Via the "1 week" button, the measurement data are firmly limited to one week.

After pressing the "OK" button, the selected measurement is opened with the defined period. All measurement data and evaluations shown in the following have been created with demo measurement data, which are included in every installation.

1.7.1 Start screen after loading a measurement file

After opening a measurement, 3 buttons are available in the header for an automatic report generation.

These functions do not exist in the basic version of PQ-Box 50, PQ-Box 100 and PQ-Box 150.

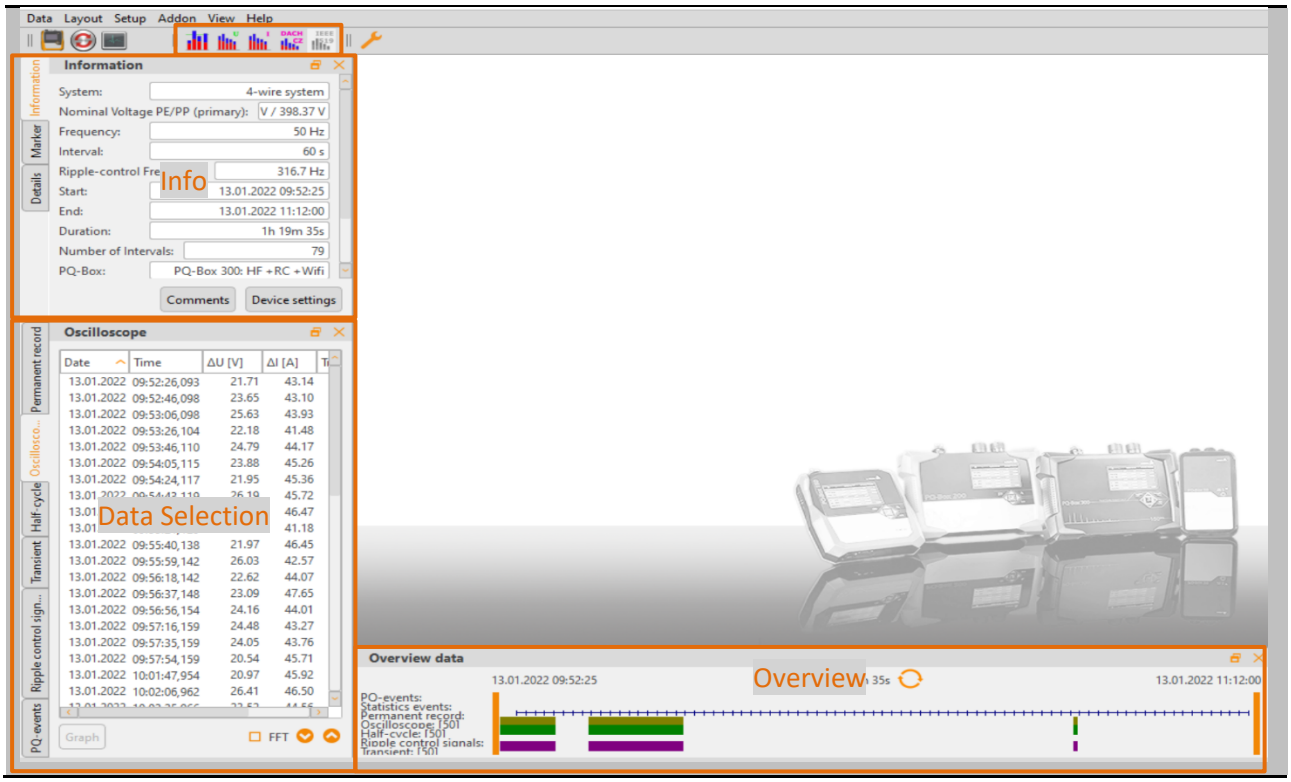
Generate automatic report according to EN 50160, IEC61000-2-2 or IEC61000-2-4.

Generate voltage harmonics report.

Generate current harmonics report or D-A-CH-Z evaluation.

Create an IEEE519 Report. This report can only be generated, if the measuring interval is set to 600s and 3s data recording is activated.

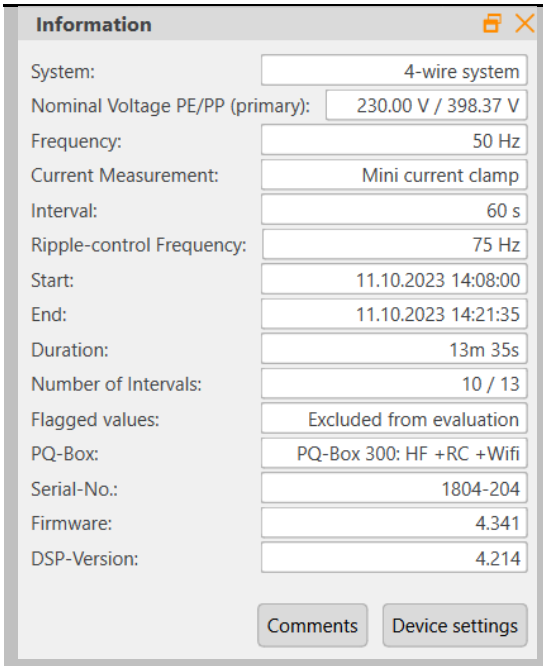
Start screen after loading a measurement



The area on the left side of the surface is used for displaying general information about the measurement as well as for data selection of cyclic data, fault records and PQ events.

The window at the bottom gives an overview of the time sequence of disturbance records and PQ events during the measurement.

Information about the selected measurement file (upper left)

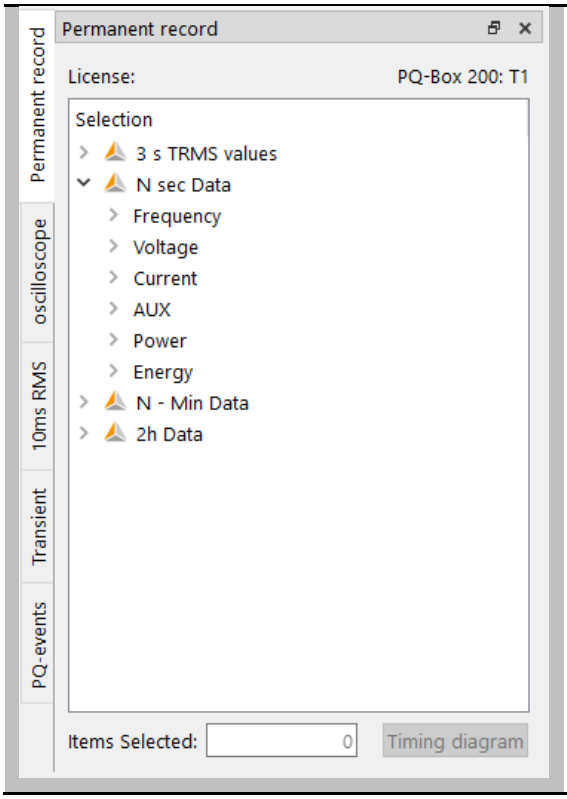


- Voltage system
- Nominal voltage and frequency
- Information of the current clamp used
- Ripple-control frequency
- Start and End of selected time window
- Total duration
- Number of intervals (for a measurement with 10 min interval, 1008 measurement intervals per week are recorded)
- Include or exclude flagged values from evaluation (can be changed at setup → report settings)
- Device type & Firmware

- **Commens**
  8 comments can be entered here relating to the measurement.

- **Device settings**
  Detailed listing of all settings for the called measurement (trigger settings, limit values, transducer factors ...)

Data selection field (bottom left)



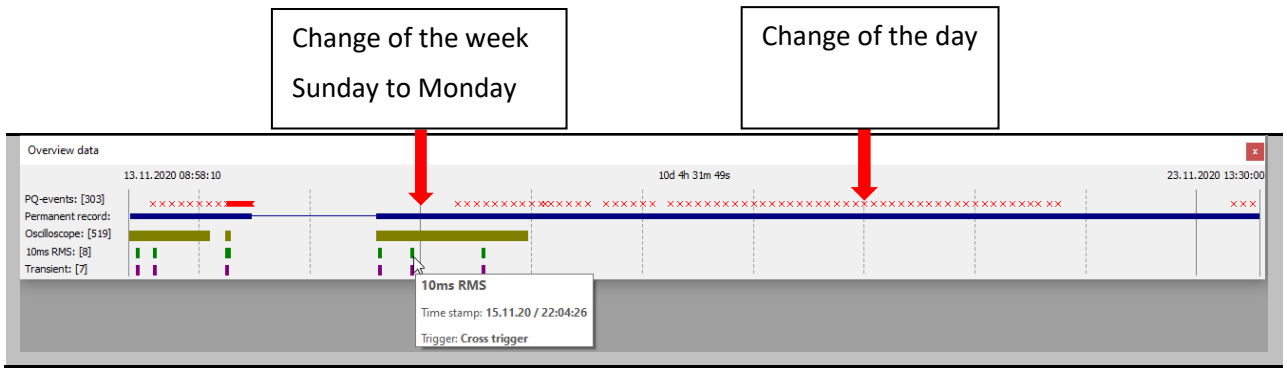
6 Selection cards:

- Cyclic data
- Oscilloscope recorder
- 10ms RMS recorder
- Transient recorder
- Signalling voltage recorder
- PQ Events

A selection of measured variables or fault recordings can be plotted graphically via left mouse click.

In the lower area of the window, the temporal overview of the measurement data is displayed. A dashed vertical line marks Day changes. If the mouse pointer is hovered over an oscilloscope or RMS recorder symbol, information about this event is displayed.

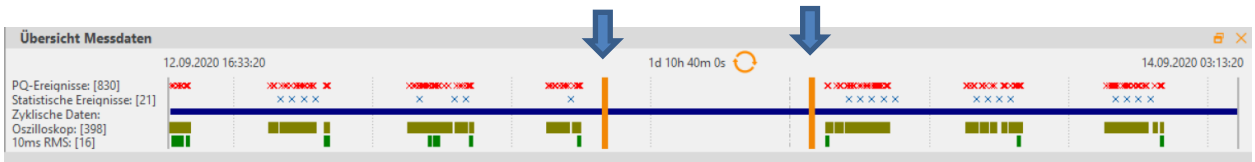
Chronological overview of the measurement data (bottom)



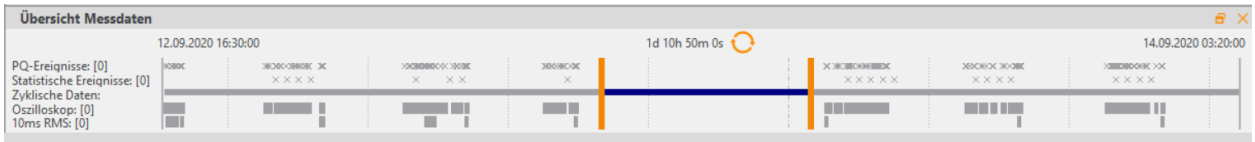
By clicking on a symbol for oscilloscope image, RMS recorder, ripple control signal or transient recorder, the corresponding disturbance record opens automatically.

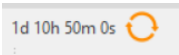
1.7.2 Restriction of the evaluation period in the measurement data

If you want to limit the period of the measurement data for an evaluation, this is to be done as follows.



Move the orange lines from the left and right side to the desired start and stop time.



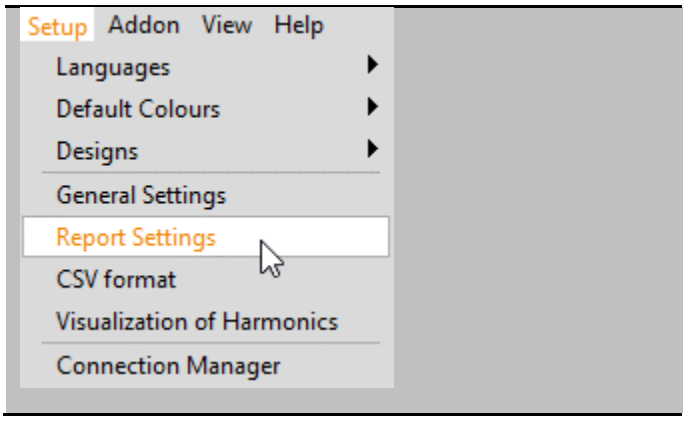
When you click the button 

only the selected time range for the standard report and all evaluations becomes active.

1.8 Definition and Management of Norm Templates

The menu Setup -> Report Settings offers the possibility to setup individual statistical evaluation with WinPQ mobil software. The number of pages in a standard report can vary between 5 pages and a maximum of 12 pages, depending on the selection made.

Setup menu for selection of norm templates



The report menu consists of five different tabs:

- **General**
  Setup oft he general report settings.
- **Limits / Statistics**
  Setup of limit fort he individual norm parameters.
- **Harmonics 2-50**
  Setup of limit for individual voltage harmonics up to 50th order as well as for interharmonic signals.
- **Frequency bands 2-9 kHz**
  Limit value definition for 2-9 kHz bands.
- **Supraharmonics 9-150 kHz**
  Limit value definition for supraharmonics signals between 9 and 150 kHz.

By clicking OK, WinPQ mobil automatically applies the set limit values for PQ norm evaluation, online analysis, as well as for limit value lines in long-term data evaluation. The name of the currently used template is displayed in the header of the software. The next time WinPQ mobil is started, these settings are automatically reloaded.

Naming of norm templates: the name of the template can be edited here

Load Load a norm template.

Save Save changes.

Default Settings Reset all settings and limit values to default (EN50160 / IEC61000-2-2 combined).

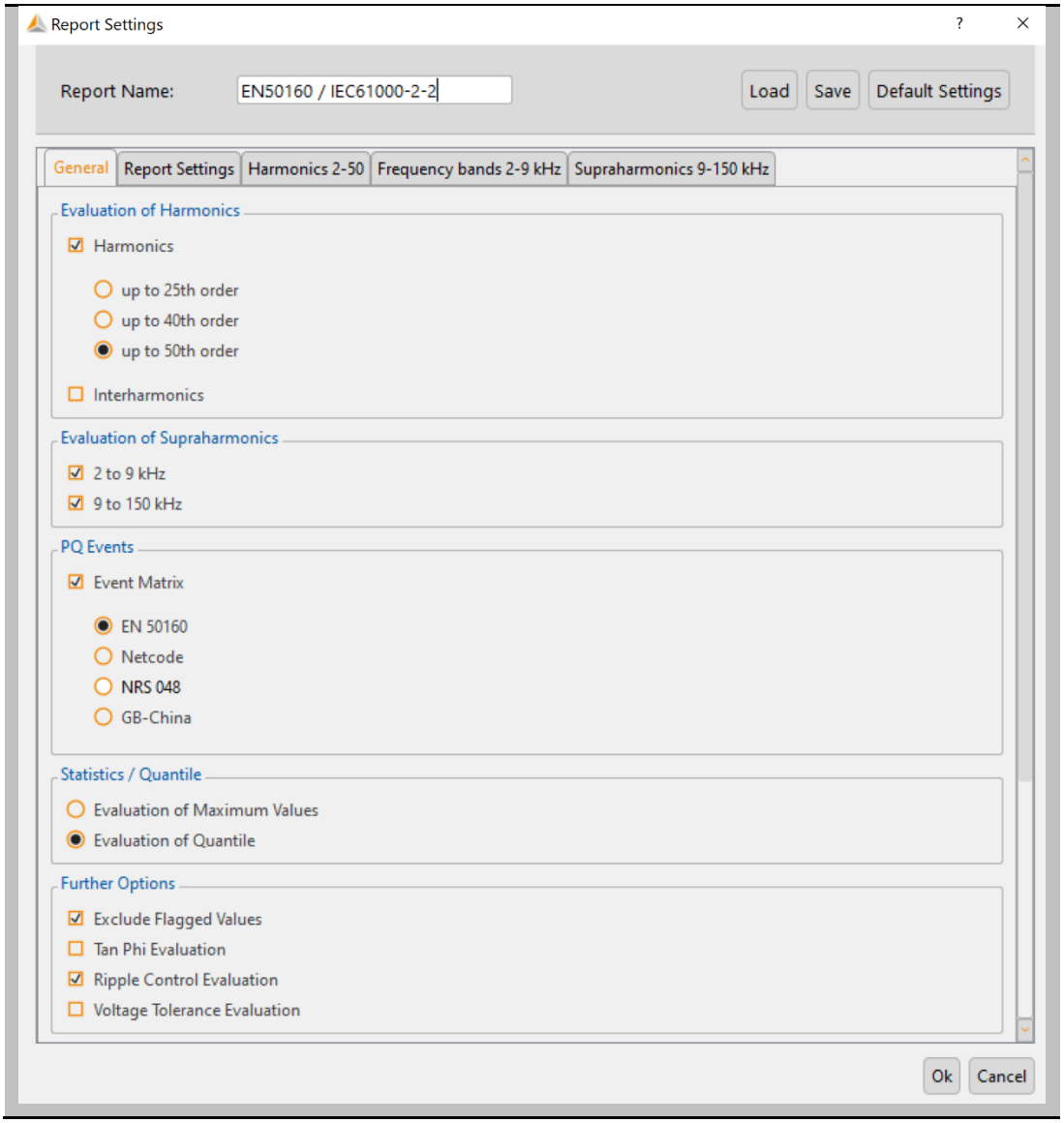
This file Limits_uharm_default can be modified by the user as required.

1.8.1 Statistics

In the statistics settings of the standard evaluation menu, the general parameters of the automatic report generation can be parameterized.

The settings in this menu directly influence the automatic norm evaluation (see chapter 1.9). Templates provided by A.Eberle as well as own templates can be saved and loaded.

General settings of norm evaluation menu



Parameter	Definition
Harmonics	Activate/deactivate the evaluation of harmonics up to 25th, 40th or 50th order.
Interharmonics	Activate/deactivate the evaluation of interharmonics.
2 - 9 kHz	Activate/deactivate the evaluation of 2-9 kHz frequency bands.
9 - 150 kHz	Activate/deactivate the evaluation of supraharmonics.
Event Matrix	Activate/deactivate PQ Event evaluation.

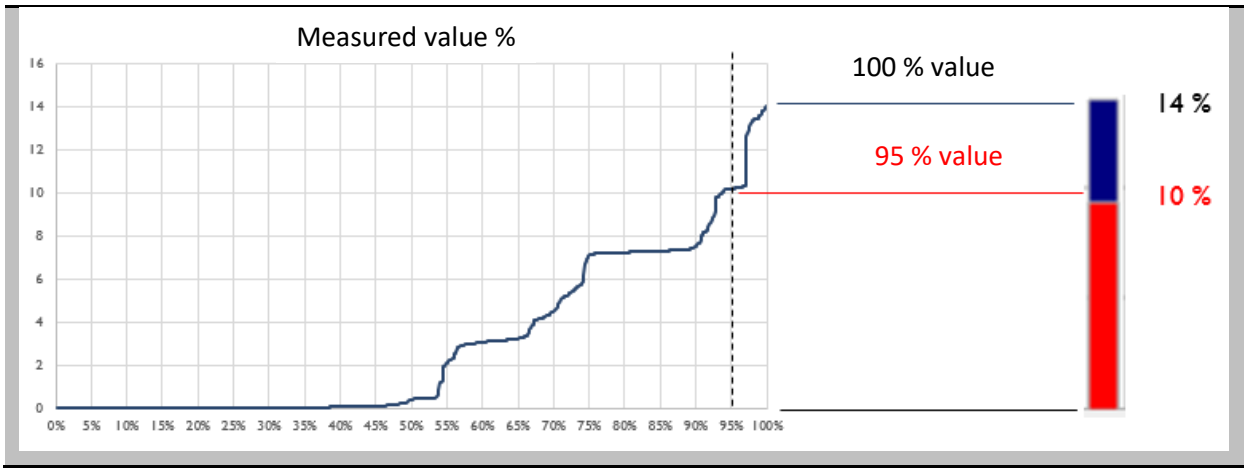
Hint:

The settings in this menu only affect the automatic norm evaluation (see chapter 1.9). The special harmonics reports (voltage harmonics 1.11 and current harmonics 0) always evaluate all available frequency components of the signals.

In the second section of the menu the statistical evaluation of the measured data can be influenced. Here you can choose whether the evaluation of the measured values against the limit value should be carried out on the basis of the maximum values or the quantiles on the basis of the ordered statistic line of all measured data.

Many standards such as EN 50160 evaluate the 95 % value. In medium and high voltage the 99 % value is often used. The maximum value evaluation can be interesting for shorter measurements.

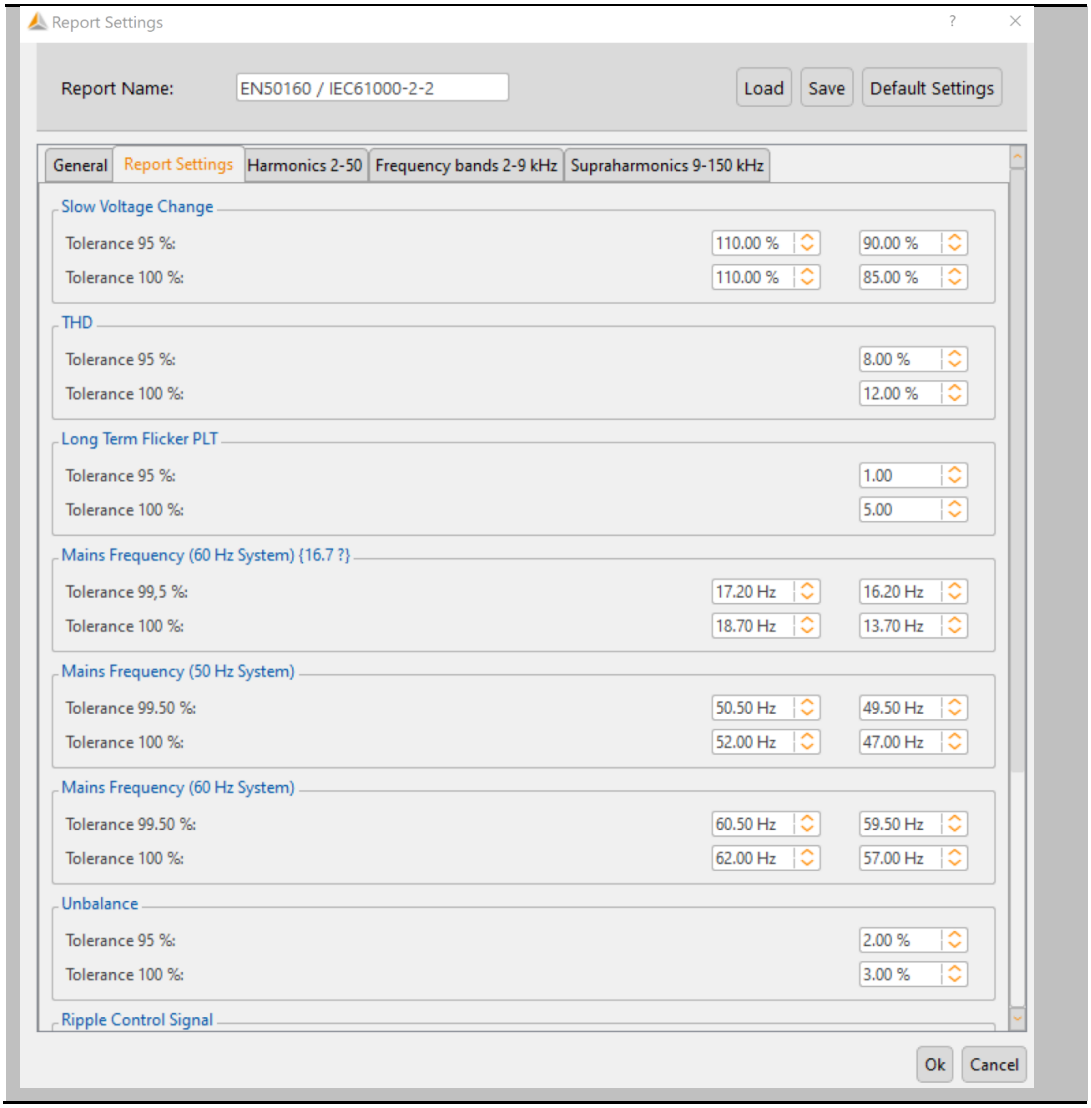
Quantiles Evaluation - ordered statistic line



1.8.2 Report Settings

In the **Report Setting** tab the threshold values for all Power Quality relevant parameters can be set individually.

The individual parameters have a limit value for the quantile value and the maximum value. Depending on the setting in the "Statistics" tab, the labels adapt automatically.

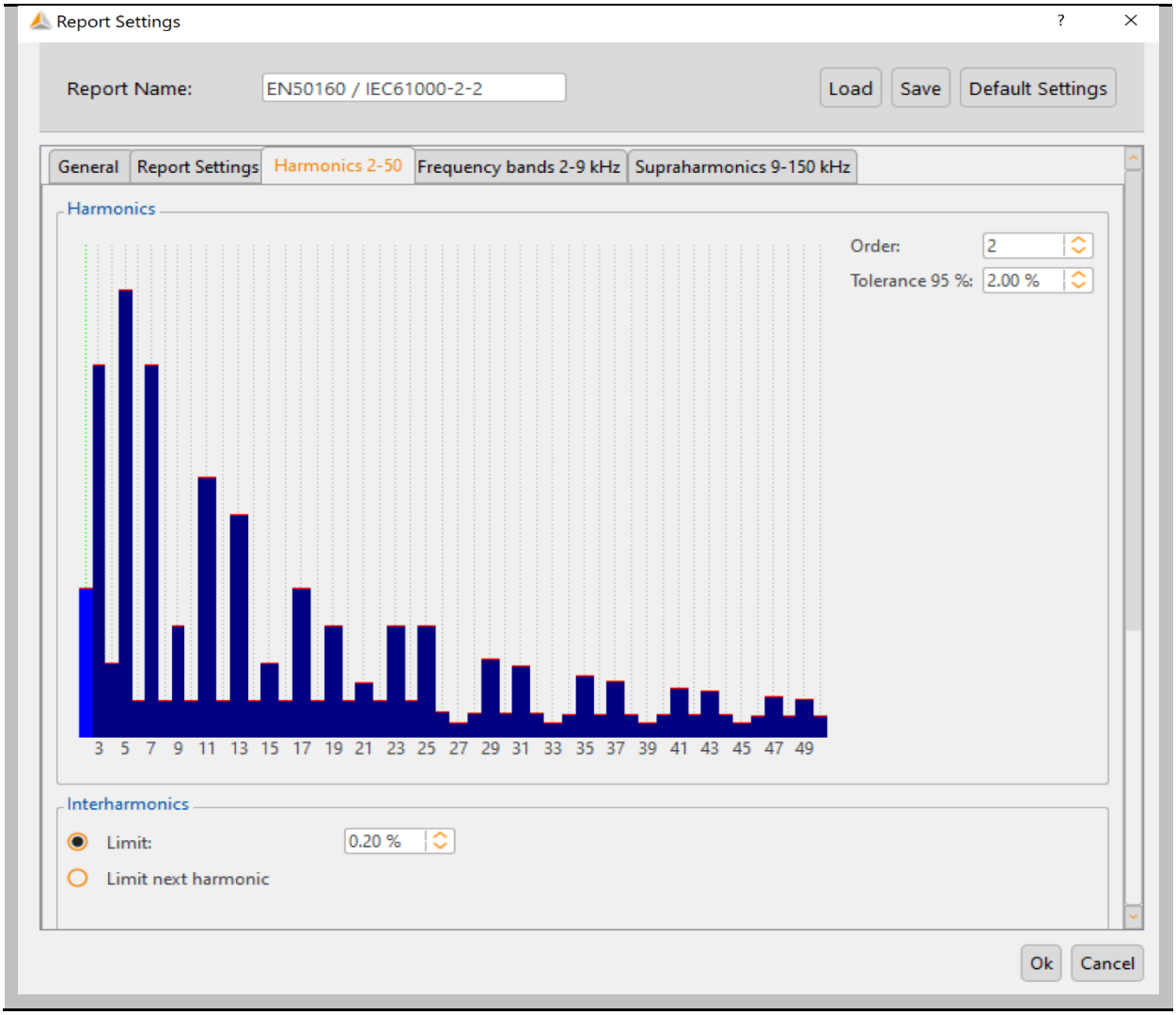


1.8.3 Harmonics 2-50

In this tab the limit values for voltage harmonics are set. With left click on the corresponding bar the individual harmonics can be selected and edited in the submenu on the right side.

In the second part of the settings window the limit value for all interharmonics (1 to 49) is set.

Limit values for individual harmonics



The following options are available for the interharmonics:

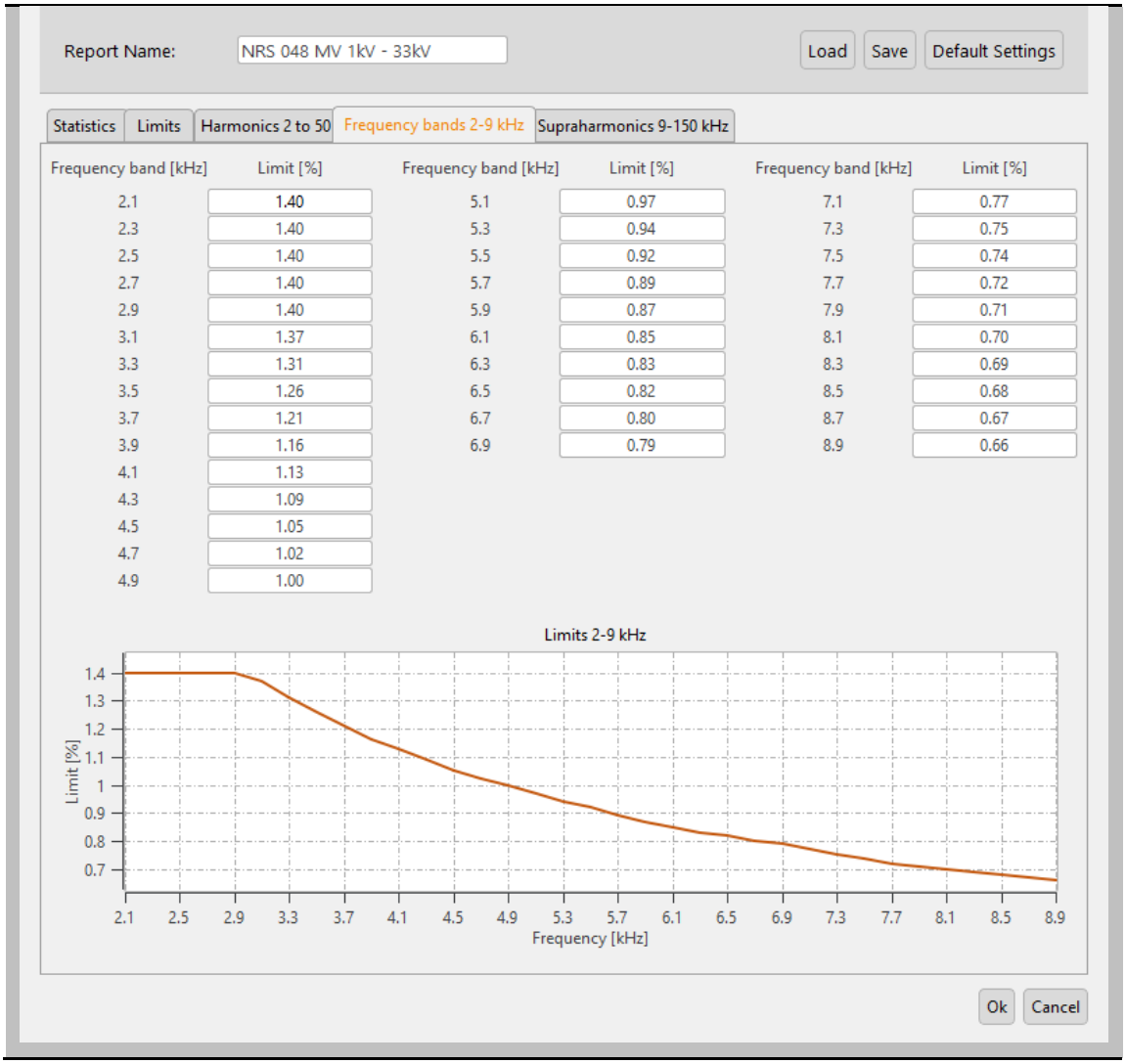
- - Fixed limit over all frequencies
- - Set the limit of the interharmonics to the value of the next harmonic

1.8.4 Frequency bands 2-9 kHz

In this tab the limit values for the frequency bands in the 2-9 kHz report can be set.

The basic settings correspond to the IEC 61000-2-2 standard, which applies to public low-voltage networks.

Limit values dialogue for 2-9 kHz frequency bands

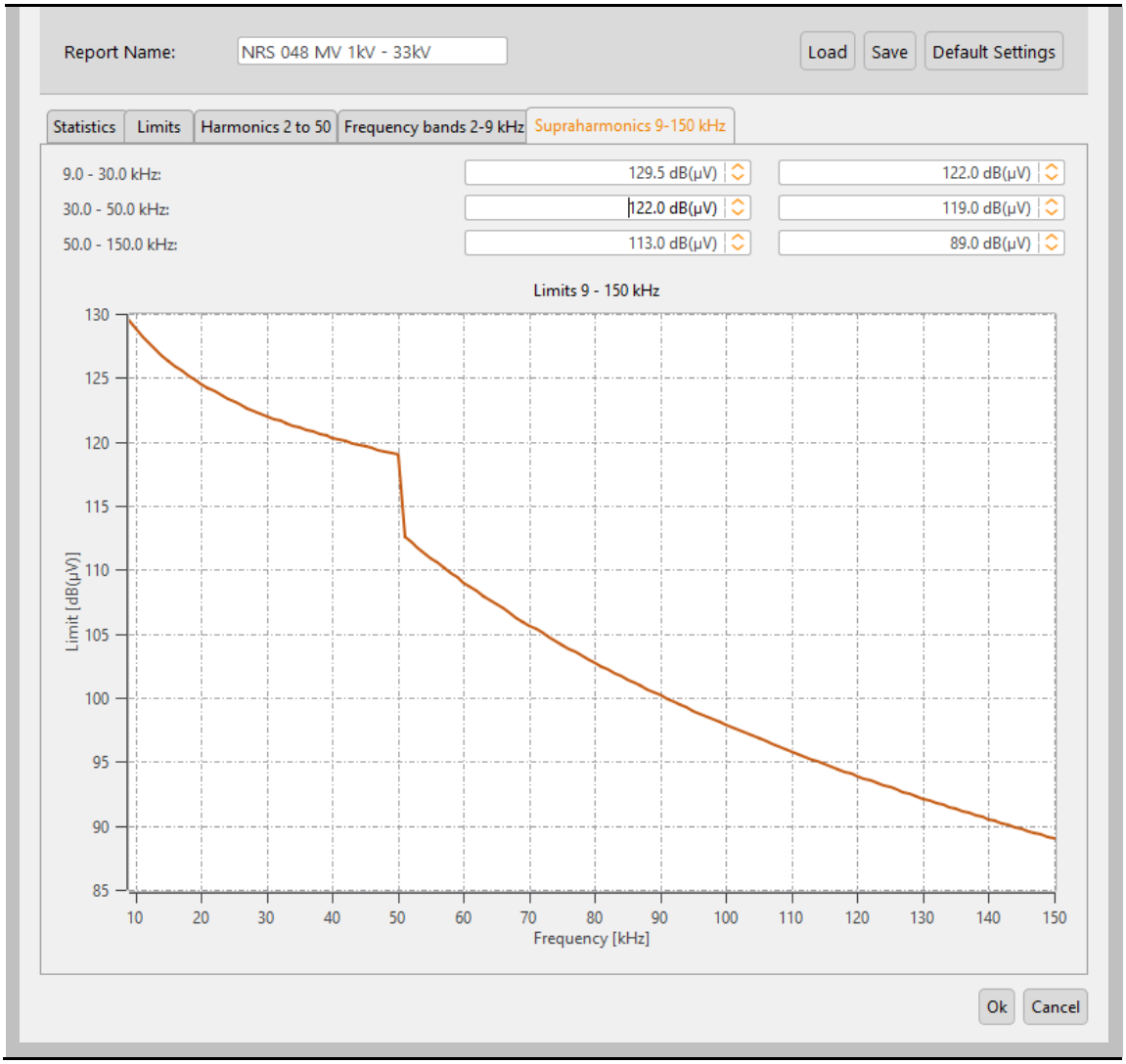


1.8.5 Supraharmonics 9-150 kHz

In this tab the limit values for the supraharmonic frequency range are defined in the unit dB(µV).

The limit value curve has three reference points, between the reference points the limit value level decreases logarithmically. The basic settings correspond to the IEC 61000-2-2 standard, which defines limit values for public low-voltage networks.

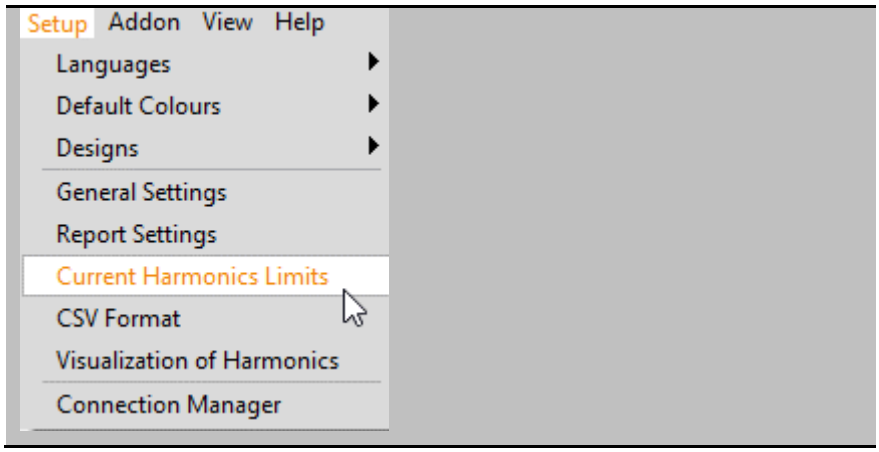
Limit value dialogue for supraharmonics



1.9 Setup of limits for current harmonics

Via the menu item **Setup** -> **Current Harmonics Limits** all limits for the evaluation of current harmonics can be edited.

Menu item for editing current harmonic limits



All limit values are specified in the basic unit [A]. Each standard template can be uniquely assigned by its name. The name of the standard template is displayed in the header of the current harmonic report.

Load Load a norm template.

Save Save changes.

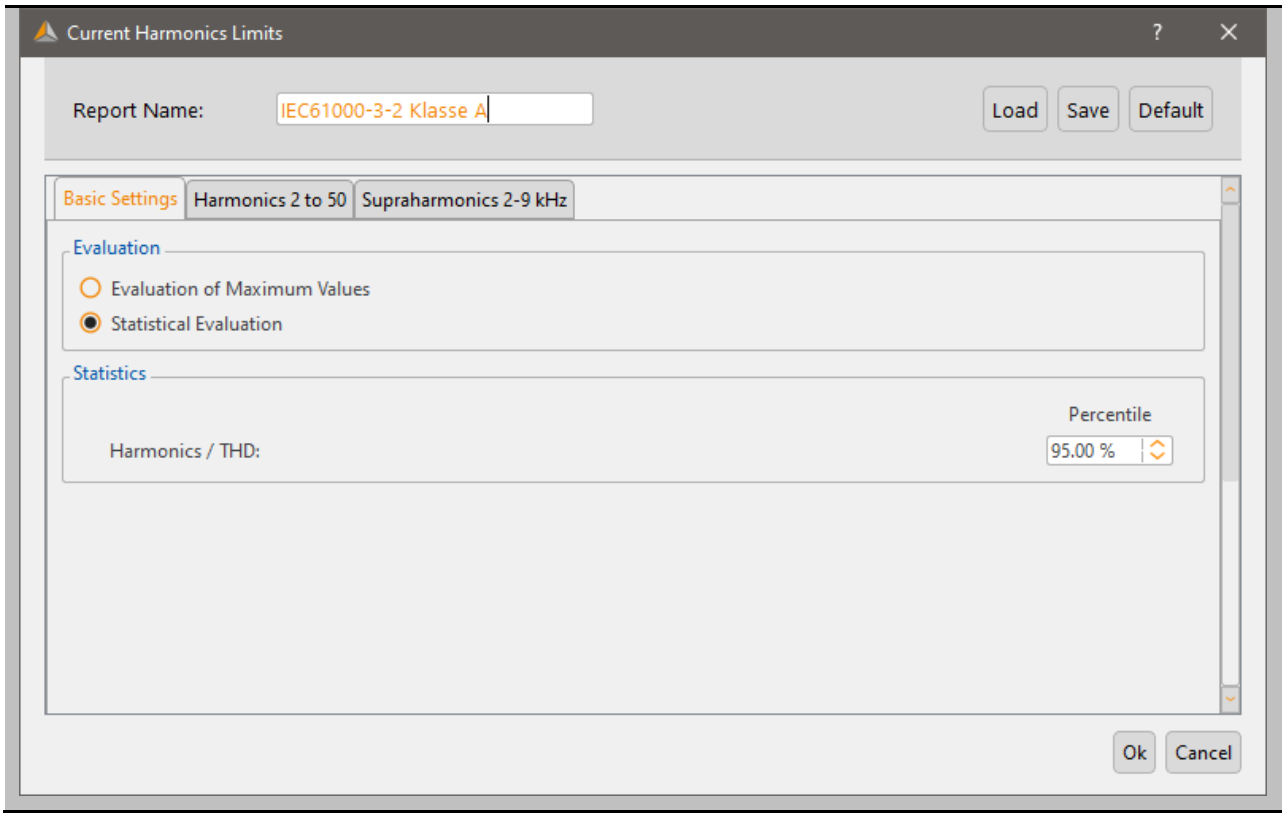
Default Settings Reset all settings and limit values to default.

1.9.1 Basic settings

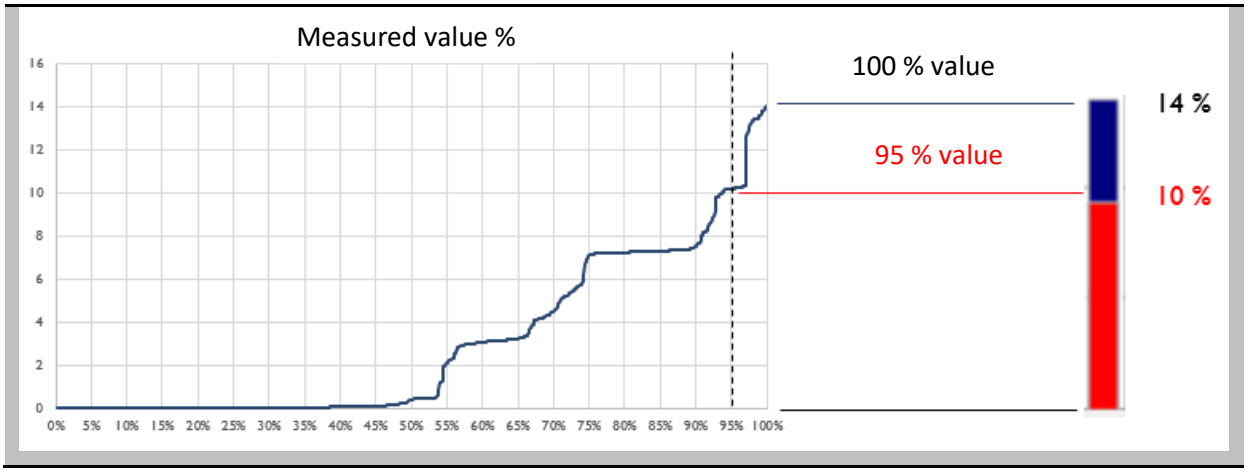
In the basic settings you can define the statistical evaluation method of current harmonics. The following options are available:

- **Evaluation of Maximum Values:** The maximum measured value is evaluated with the respective limit value.
- **Statistical Evaluation:** The x % percentile of all measured data is compared with the limit value.

General settings for the evaluation of current harmonics



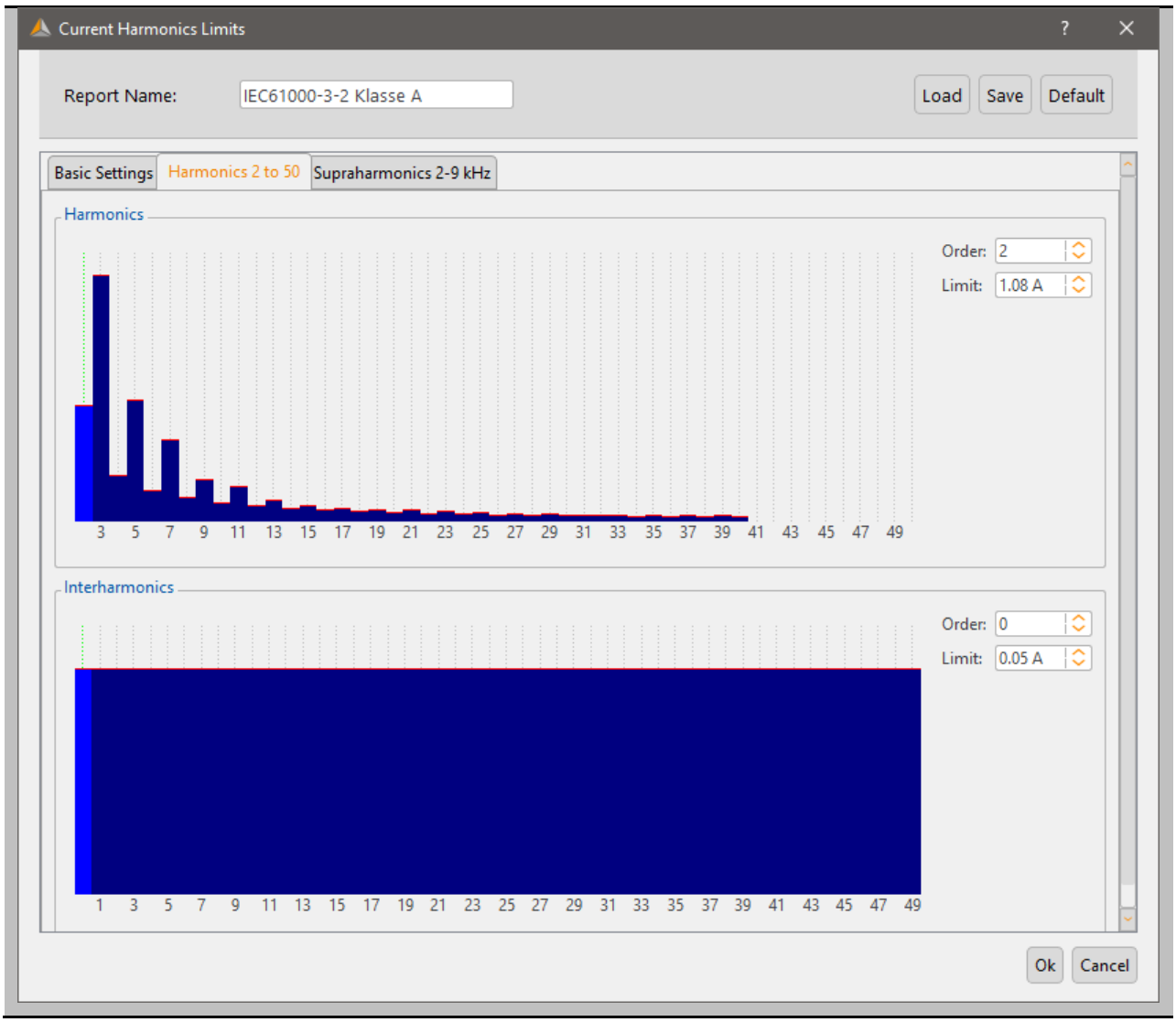
Quantiles Evaluation - ordered statistic line



1.9.2 Harmonics 2 to 50

The limit values for harmonics and interharmonics can be set individually via a graphical user interface.

Limits for Harmonics and Interharmonics



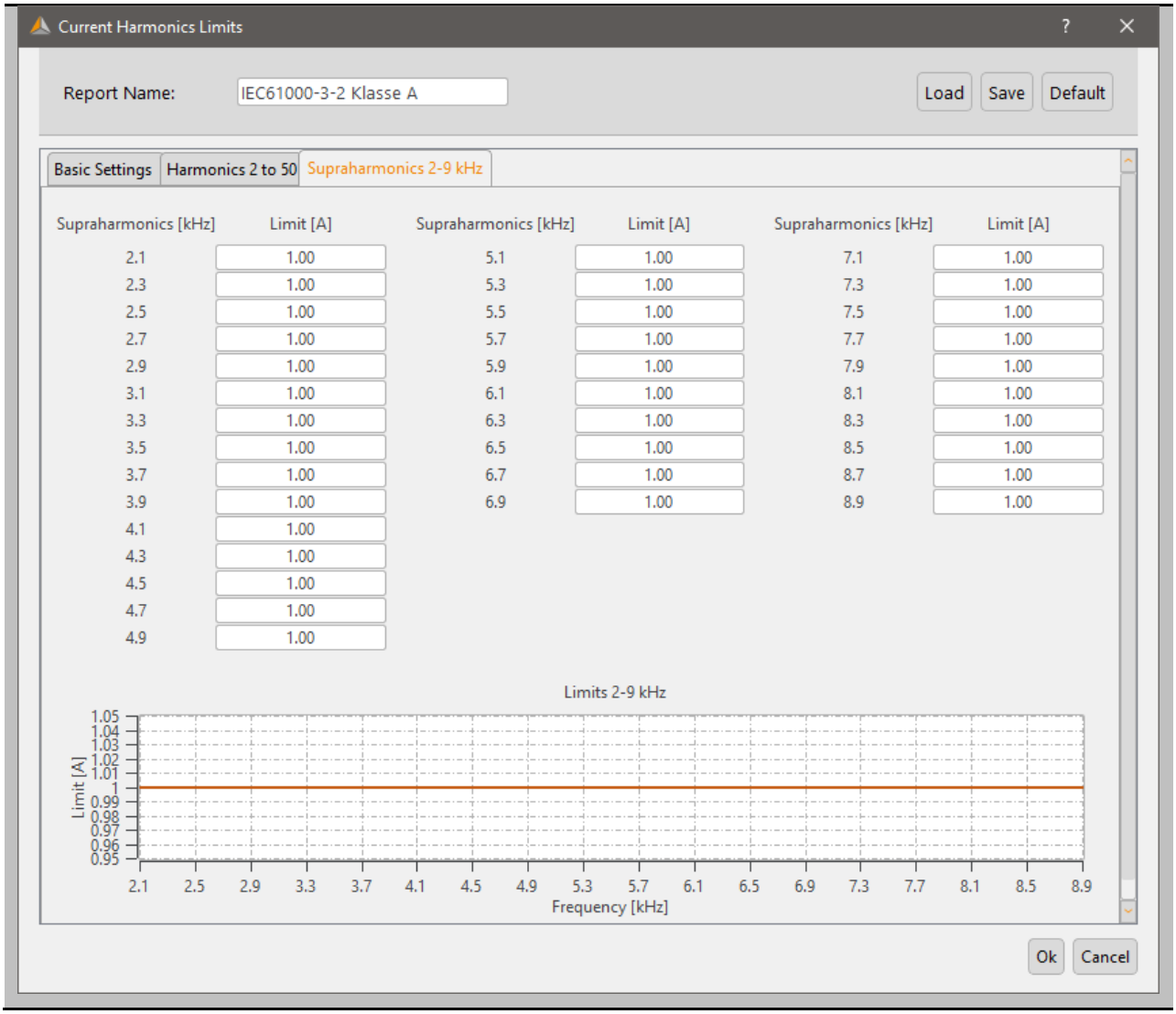
Hint:

Some standards evaluate only integer harmonics or a selection of frequencies. In this case, you can deactivate the standard evaluation for the respective quantity by setting a limit value of "0 A".

1.9.3 Supraharmonics 2 - 9 kHz

In this menu item, limit values for the 200 Hz bands of the current harmonics between 2 and 9 kHz can be set individually. If a limit value of "0 A" is set, the respective frequency band is not evaluated.

Limits for Supraharmonics 2 - 9 kHz



1.10 Standard evaluation according to EN50160 or other standards

Generate and display automatic report according to EN 50160, IEC61000-2-2 or other standards.

This function provides a quick overview of all voltage measurement values, with reference to the compatibility levels of the set standard. In the default setting is the EN50160 and IEC61000-2-2 combined. Depending on the measurement data size, the creation of these statistics can take a few seconds. In a weekly measurement, more than 300.000 measured values are compared with the corresponding compatibility levels and displayed graphically.

Example: EN 50160 Report overview

The bars clearly show the % quantile (usually the 95% quantile) in red and the highest measured value as the “maximum value” in blue.

In the basic settings for the standard evaluation, it is also possible to define a 100% limit value. If the 100% limit value defined in the setup is exceeded, the blue bar is shaded red.

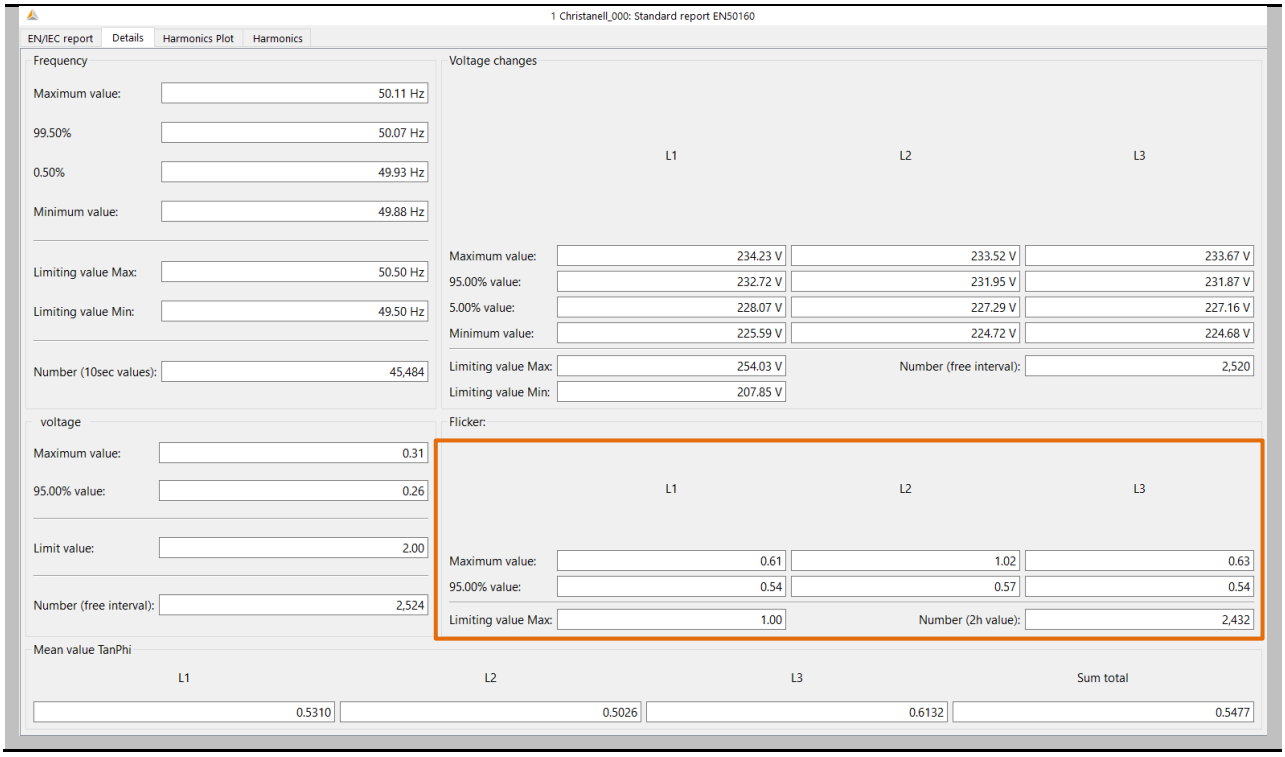
A green tick or a red cross below the respective category shows whether the measured values comply with the limit values. Click on to display a legend with an explanation of the graph.

Harmonics:

The voltage harmonics bar shows all measured values of the 2nd to 50th harmonic with the respective compatibility level of the set standard. In each case, the harmonic that comes closest to or exceeds the associated limit value is displayed. Supraharmonics, if present, are also displayed according to the same principle.

The “Details” card of the standard report provides detailed information on the respective maximum and minimum values, as well as the reference to the standard limit value.

Details of EN 50160 report



<u>Example: Evaluation of Flicker value</u>

The maximum values of the phases are: L1 = 0.61; L2 = 1.02; L3 = 0.63. Since the limit value Plt is 1, the bar of phase L2 in the overview plot exceeds the limit line. The 95% values (red bars) are all far below the limit value.

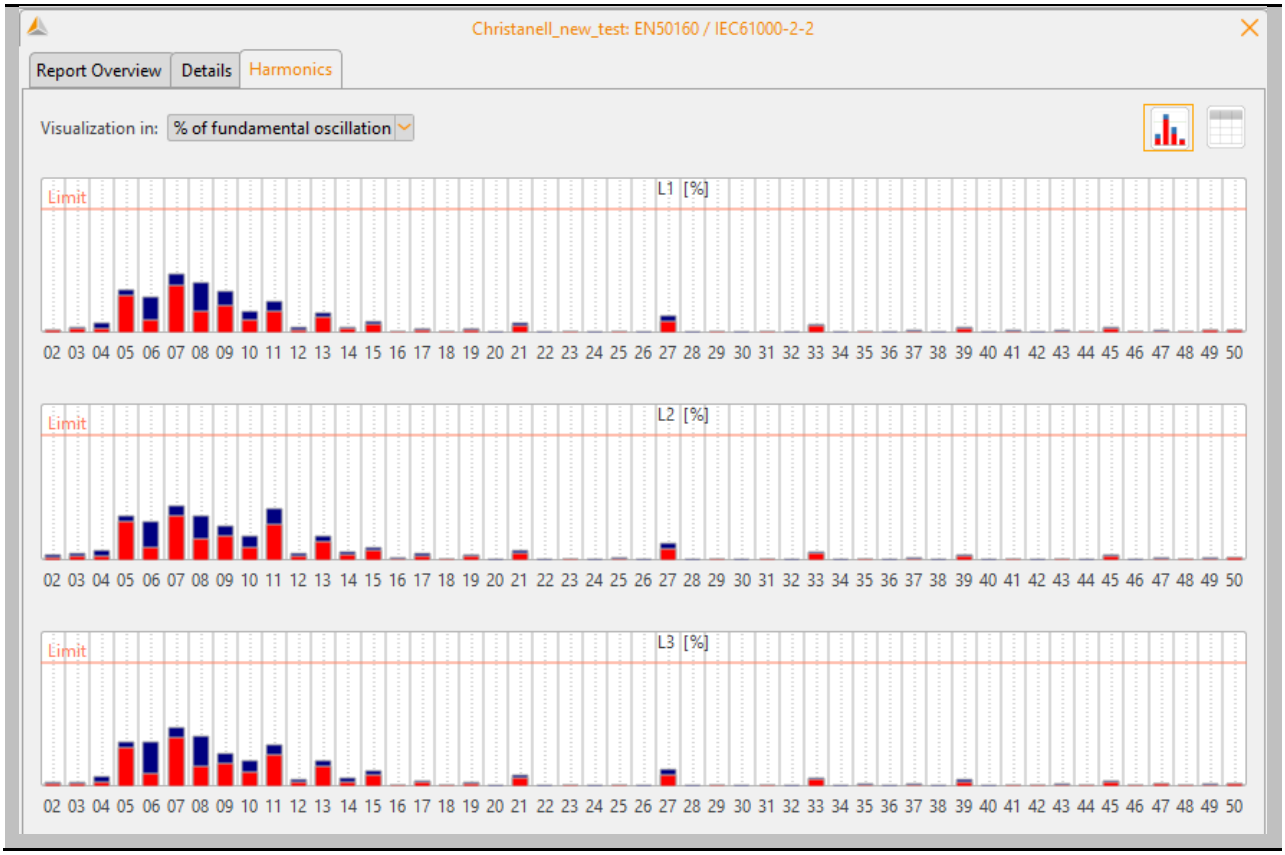
The Harmonics card shows all harmonics in a bar chart. All harmonics are scaled to the respective limit value of the set standard.

Depending on the settings in the menu **Setup** -> **Report Settings**, automatic norm evaluations of:

- **Interharmonics**
- **Frequency bands 2-9 kHz**
- **Supraharmonics 9-150 kHz**

can be added to the standard report.

Overview of voltage harmonics EN 50160 report



The bars show in a simple form the 95% measured value in red colour and the highest occurred measured value "100% value" in blue colour.

The buttons in the upper right corner can be used to switch between the bar view and the tabular view.

Statistical evaluation as bar view.

Display the results as measurement data table.

On the "Harmonics" card, the limit values of the set standard, as well as the 95% values and maximum values of the individual phases are listed in tabular form. If a harmonic violates the limit values, the corresponding line is marked red. The evaluation of phase to phase or phase to neutral measurement data is carried out depending on the network form.

Grid	Evaluated voltages
1-Wire	UL1
4-Wire/3 Phases	UL1, UL2, UL3
2-Phases	UL1, UL2
3-Wire/3 Phases	U12, U23, U31

Detailed view of 2nd to 50th Harmonic and compatibility level

Christanell_new_test: EN50160 / IEC61000-2-2

Report Overview | Details | Harmonics

Visualization in: % of fundamental oscillation

	Limit value [%]	L1 - 95.00% [%]	L1 - Max [%]	L2 - 95.00% [%]	L2 - Max [%]	L3 - 95.00% [%]	L3 - Max [%]
THD	8.00	2.56	3.03	2.50	2.93	2.62	3.08
02	2.00	0.04	0.05	0.04	0.09	0.04	0.06
03	5.00	0.18	0.25	0.19	0.28	0.12	0.16
04	1.00	0.03	0.08	0.03	0.08	0.03	0.08
05	6.00	1.80	2.05	1.86	2.11	1.87	2.14
06	0.50	0.05	0.14	0.05	0.15	0.05	0.18
07	5.00	1.94	2.37	1.77	2.17	1.95	2.35
08	0.50	0.09	0.20	0.08	0.18	0.08	0.20
09	1.50	0.34	0.50	0.29	0.41	0.29	0.40
10	0.50	0.05	0.09	0.05	0.09	0.06	0.10
11	3.50	0.63	0.89	1.00	1.44	0.90	1.19
12	0.50	0.01	0.02	0.02	0.03	0.02	0.03
13	3.00	0.38	0.49	0.43	0.57	0.48	0.62
14	0.50	0.02	0.02	0.02	0.04	0.02	0.03
15	1.00	0.08	0.09	0.08	0.10	0.10	0.12
16	0.50	0.00	0.01	0.01	0.01	0.01	0.01
17	2.00	0.05	0.07	0.06	0.12	0.06	0.10

Limit [%] Compatibility level of the standard

L1 - 95.00% [%] 95%-quantile (L1).

L1 - 100.00% [%] Maximum value (L1).

Via right-click the displayed table can be exported as CSV file.

If one measurement value exceed the limit this value will showed in red in the table

1.10.1 Creating a standard report

The right-click menu “print” function opens a multi-page standard report. The report contains all comments on the measurement as well as the statistical evaluations described in 1.8.

Create a PDF report.

Print preview of EN50160 report

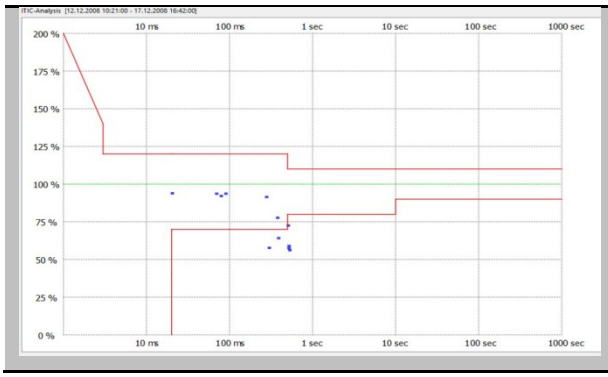
a-eberle	EN50160 / IEC61000-2-2		01.06.2023 Page 1/5

Stadtwerke Weiherhaus Abteilung PQ	Flicker Spannungseinbrüche	Flicker

Abteilung PQ 1		**SW-Version:**	6.3.113.0
System:	4-wire system		
Nominal Voltage PE/PP (primary):	230.00 V / 398.37 V	**Interval:**	600 s
Frequency:	50 Hz	**Ripple-control Frequency:**	75 Hz
Start:	09.09.2020 13:00:00	**End:**	17.09.2020 05:00:00
Duration:	7d 16h 0m 0s	**Number of Intervals:**	1227
PQ-Box:	PQ-Box 100: Expert	**Serial-No.:**	1429-102
Firmware:	2.023	**DSP-Version:**	1.416

In addition, the printed EN50160 report contains an overview of the PQ events that occurred during the measurement period in graphical and tabular form on the last page.

ITIC Overview



PQ Event matrix

Event Matrix

Residual voltage U [%]	Duration t [ms]				
	10 ≤ t < 200	200 ≤ t < 500	500 ≤ t < 1000	1000 ≤ t < 5000	5000 ≤ t < 60000
90 > u ≥ 80	0	0	0	0	0
80 > u ≥ 70	0	1	1	0	0
70 > u ≥ 40	0	2	3	0	0
40 > u ≥ 5	0	0	0	0	0
5 > u	0	0	0	0	0

Swell voltage U [%]	Duration t [ms]		
	10 ≤ t < 500	500 ≤ t < 5000	5000 ≤ t < 60000
u ≥ 120	0	0	0
120 > u ≥ 110	0	0	0

1.11 Evaluation of voltage harmonics

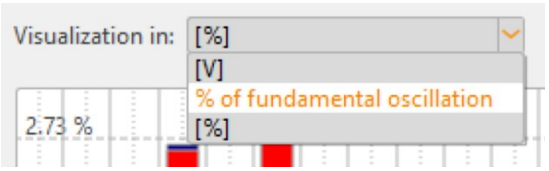
Create voltage harmonics report.

Via the icon shown above, all harmonic levels of the measured voltages are statistically processed and displayed. All graphical representations are also available in tabular form. The display in the software depends on the type and version of the PQ-Box used. The following table provides an overview of the licenses from which the displays are available.

Table 1: Overview of displayed harmonic evaluations depending on the PQ box type

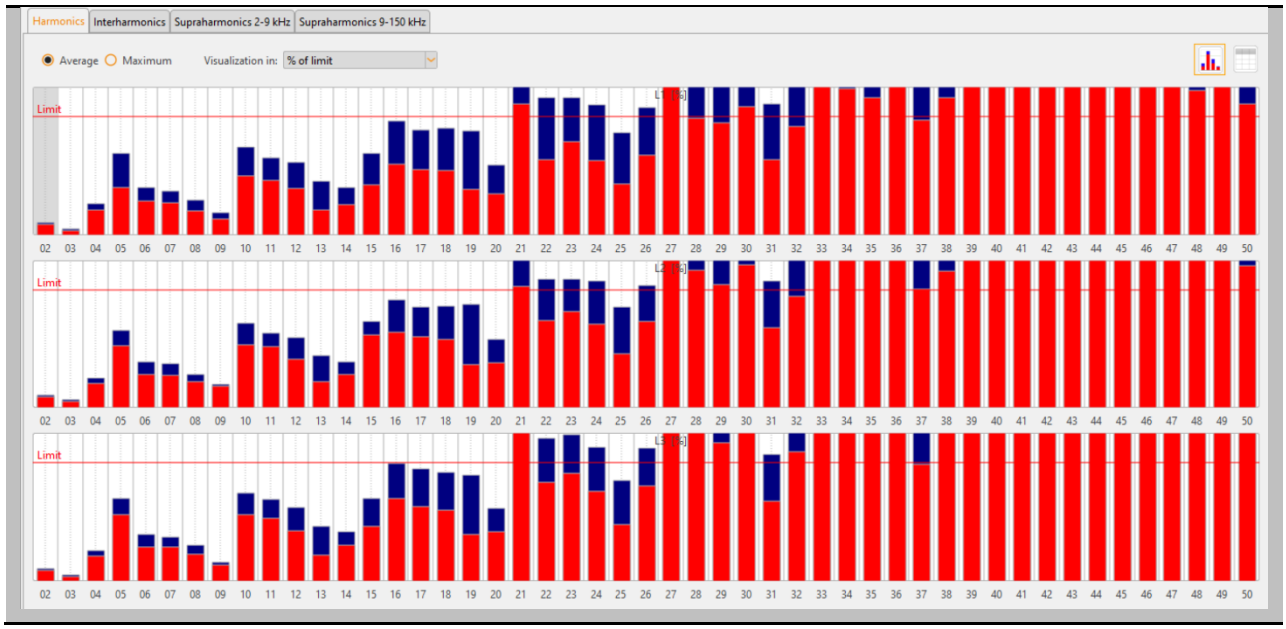
Harmonics group	PQ-Box 50	PQ-Box 100	PQ-Box 150	PQ-Box 200	PQ-Box 300
Harmonics (2 to 50)	**light**	**basic+**	**basic+**	✓	✓
Interharmonics	**light**	**basic+**	**basic+**	✓	✓
Harmonics max. values	**expert**	**light**	**light**	✓	✓
Frequency bands 2-9 kHz	-	-	**expert**	✓	✓
Supra harmonics	-	-	-	-	✓

The graphical display can be switched between three display variants directly in the header.



- absolute values [V]
- relative values [%] scaling to the limit
- relative values [%] scaling to the fundamental voltage

Bar chart with representation of voltage harmonics in [%]



You can switch between graphical and tabular display using the buttons in the upper right corner.

In the case of relative evaluation, a limit line is automatically displayed in the view of the voltage harmonics on the basis of the stored limit values and the bars in the display are normalized to these limit values.

Statistical evaluation (bar view).

Display all results as table view.

Representation of all harmonics as a heat map

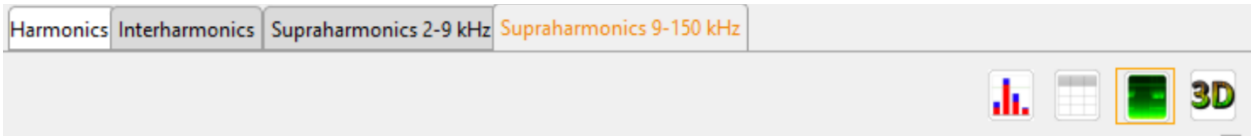
Representation of the harmonics as a 3D graphic

Print the selected tab as PDF.
(Page 1: bar view, page 2: table view)

Also in the table view it is possible to switch between the units [%] and [V] at any time.

The blue bar in the plot describes the maximum measured value during the measurement. The red bar indicates the 95% quantile (low voltage) or 99% quantile (medium and high voltage).

1.11.1 Visualization of Supraharmonics 9-150kHz (PQ-Box 300 only)

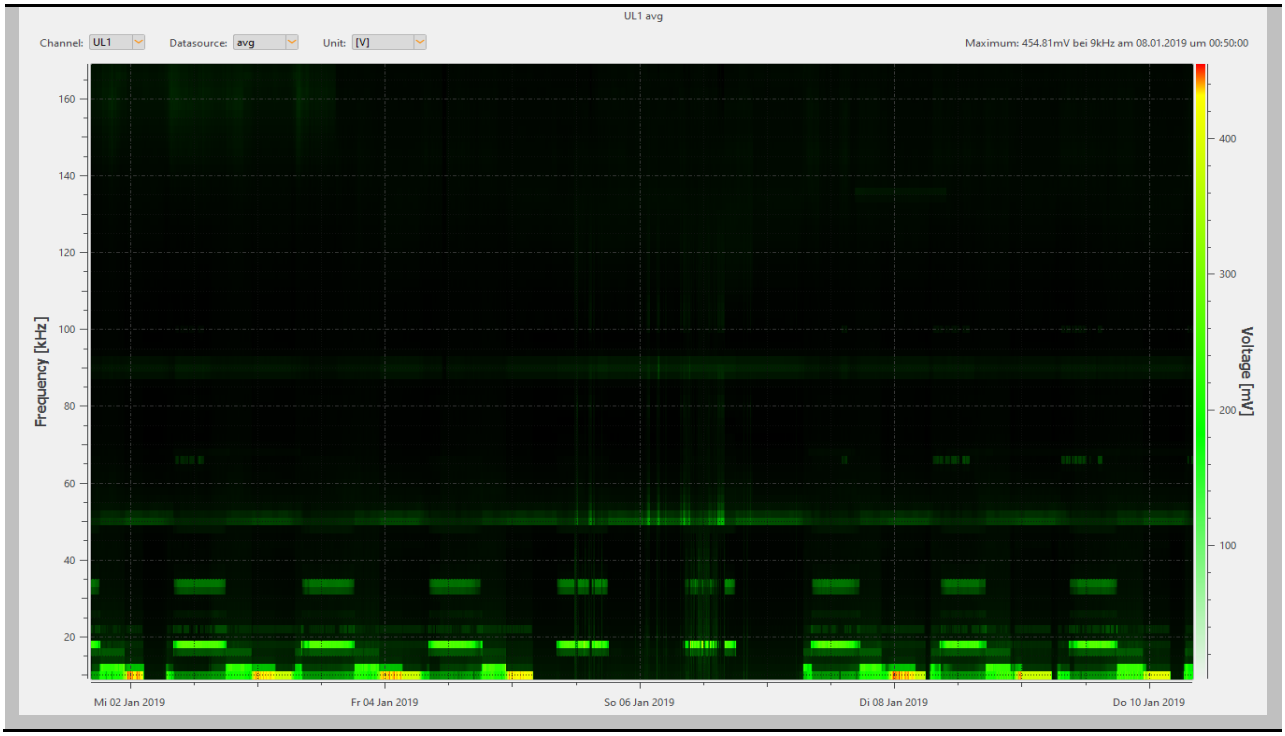


Heat map of supraharmonic voltages

When using measurement data from a PQ-Box 300, the icon shown above is displayed in the header. A click on the button displays all supraharmonics of the voltages UL1, UL2, UL3, UNE from 9 kHz to 160 kHz with 200Hz frequency bands.

The measurement data is displayed in a heat map representation over the complete measurement time. The left axis represents the frequency. On the right side of the diagram, the measured value of the frequency components is scaled by colour. The colour gradient runs from 0 = black via green to red = highest occurred measured value.

Graphical evaluation of supraharmonic voltages



The biggest occurred measured value of the selected voltage is indicated directly in the upper right corner with magnitude and frequency.

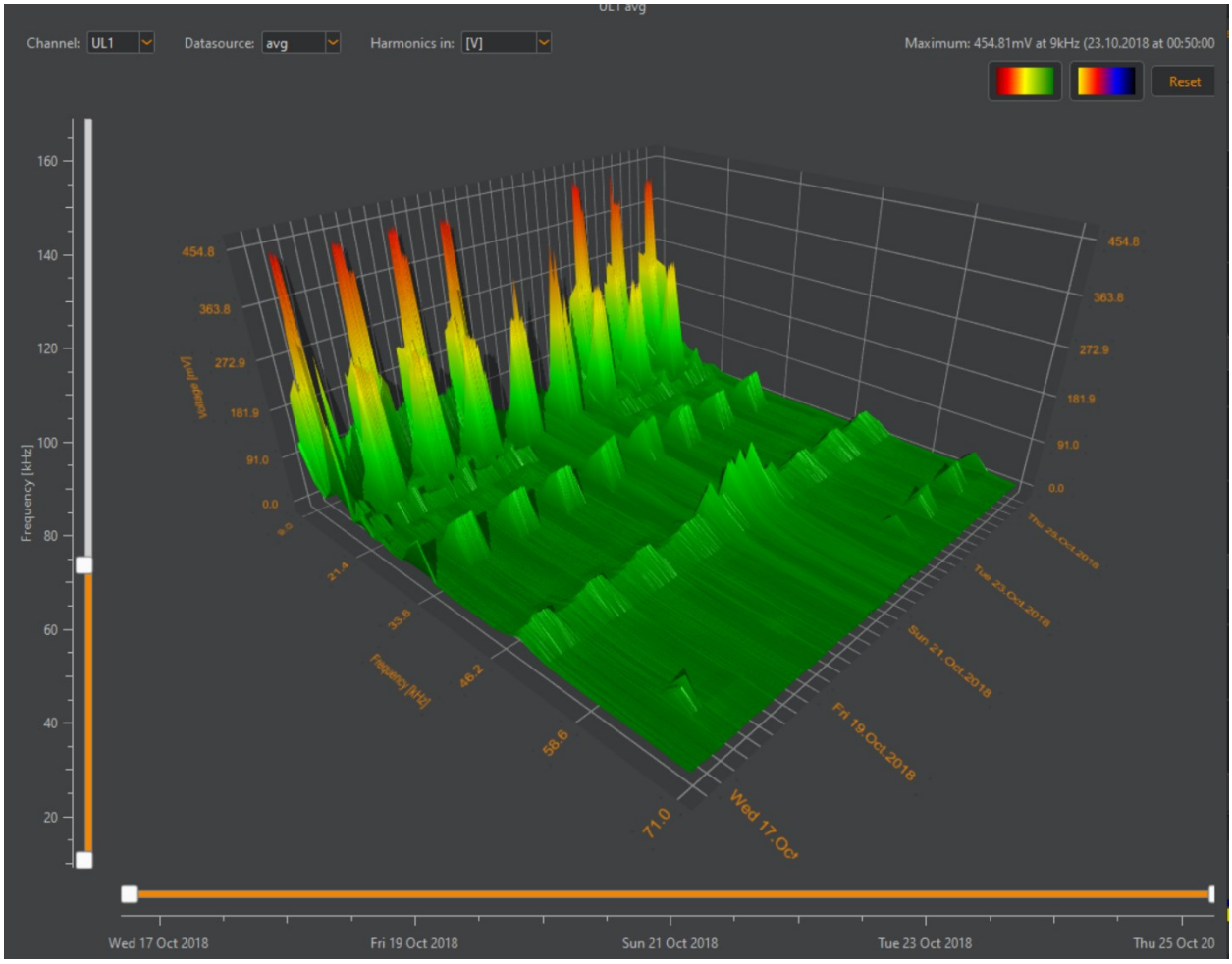
The channel selection can be switched between the voltage inputs L1, L2, L3 and NE. Within the channel selection it is possible to switch between the average values (free interval) and the recorded extreme values (200ms max). The display of the extreme values depends on the device setup. The recording of the extreme values must have been activated before starting the measurement.

The unit of the visualized data in [V] or [dB(µV)] can be set directly in the header of the diagram.

3D representation of all supraharmonics 9kHz to 160kHz over the time periode

The time and frequency range can be limited using the horizontal and vertical sliders.

By pressing the right mouse button, this 3D graphic can be rotated as desired in order to be able to analyze the graphic from all perspectives.



1.12 Evaluation of current harmonics

Create current harmonics report.

Via the icon shown above, all harmonic levels of the measured currents are statistically processed and displayed. All graphical representations are also available in tabular form.

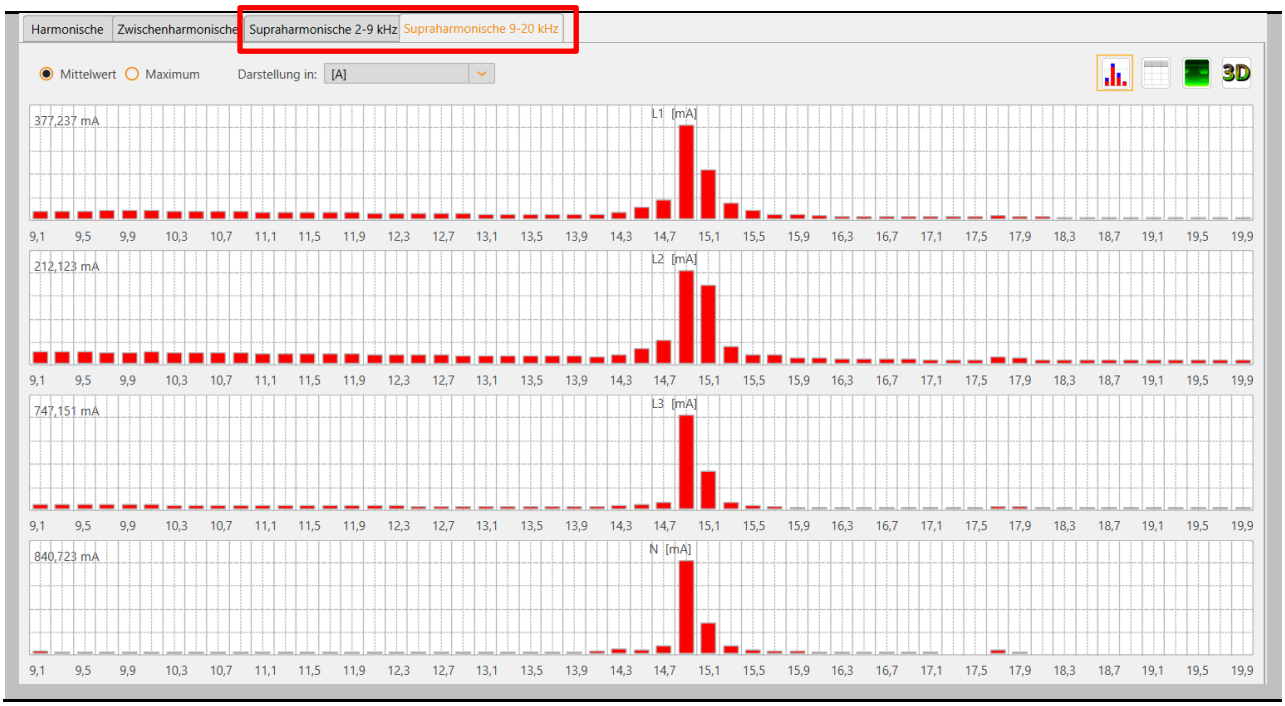
The representation in the software depends on the type and version of the PQ box used. The following table provides an overview of the license from which the displays are available.

Table 2: Overview of displayed harmonic evaluations depending on the PQ box type

Harmonics group	PQ-Box 50	PQ-Box 100	PQ-Box 150	PQ-Box 200	PQ-Box 300
Harmonics (2 to 50)	**light**	**basic+**	**basic+**	✓	✓
Interharmonics	**light**	**basic+**	**basic+**	✓	✓
Harmonics max. values	**expert**	**light**	**light**	✓	✓
Frequency bands 2-9 kHz	-	-	**expert**	✓	✓
Frequency bands 9-20 kHz	-	-	-	✓	✓

The graphical evaluation can be switched between display of absolute values [A] and relative values [%].

Bar chart showing the 2-9 kHz / 9-20 kHz frequency bands of the current [A]



You can switch between graphical and tabular display using the buttons in the upper right corner:

Statistical evaluation (bar view).

Display all results as table view.

Representation of all harmonics as a heat map

Representation of the harmonics as a 3D graphic

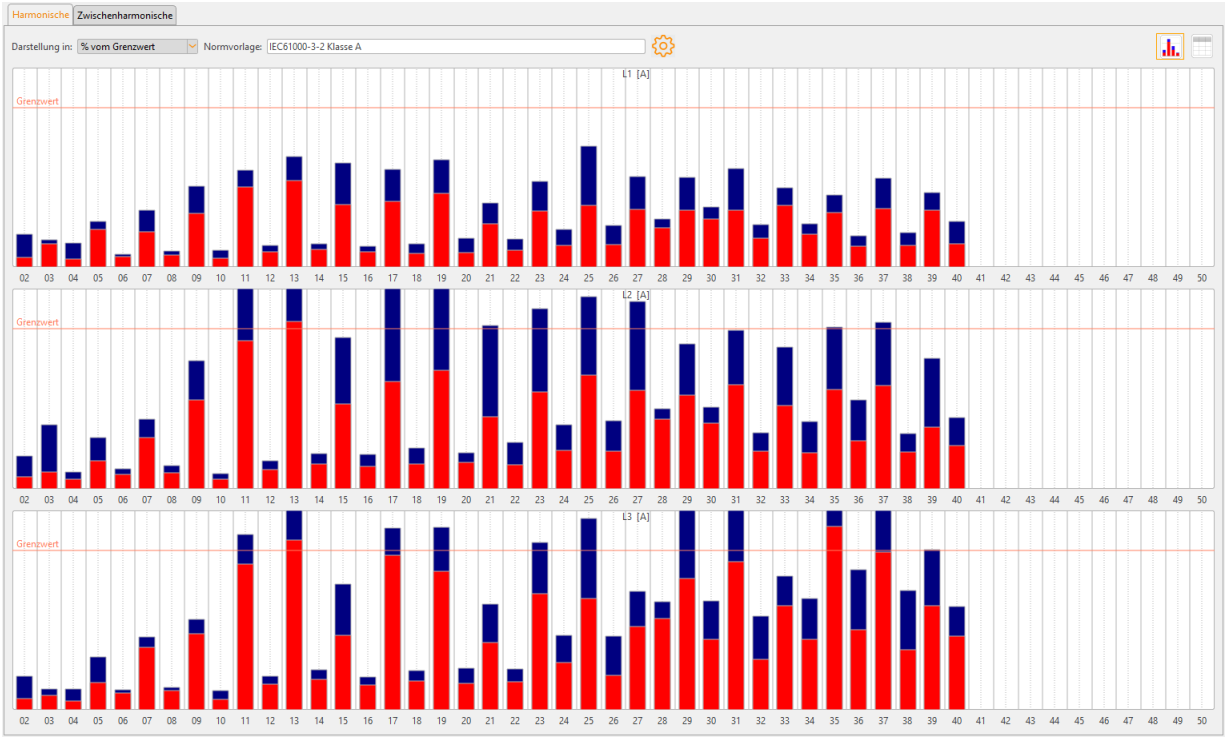
Print the selected tab as PDF.
(Page 1: bar view, page 2: table view)

Also in the table view it is possible to switch between the units [%] and [A] at any time.

The blue bar in the plot describes the maximum measured value during the measurement. The red bar indicates the 95% quantile (low voltage) or 99% quantile (medium and high voltage).

If the setting [% of limit value] is selected, the current harmonics are automatically evaluated according to freely adjustable limit values for harmonics, interharmonics and supraharmonics. In the graphical view, a violation of the norm is indicated by exceeding the limit line. Violations of standards are marked in red in the table view.

Standard templates can be loaded, edited or created using this symbol in the header.

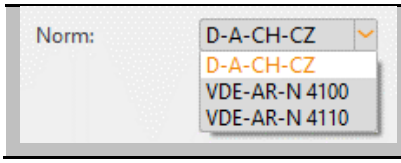


1.13 Evaluation of current harmonics according to D-A-CH-CZ or VDE-AR-N 4100/4110

Create a report according to VDE AR-N-4100/4110 or D-A-CH-CZ. (European standard)

The software menu for the evaluation of current harmonics can be changed interactively. The following quantities are automatically compared with limit values:

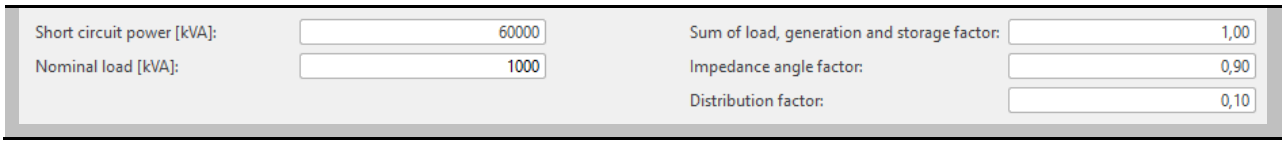
- Current Harmonics of Order 2 to 40
- Current Interharmonics of Order 1 to 39
- Current Supraharmonics from 2 to 9 kHz

Interaktive Norm Selection	Description
	The measured current harmonics are evaluated depending on the selection in this field.

The following parameters can be changed directly in the software module:

- Short circuit power
- Nominal load
- Sum of load, generation and storage factor
- Impedance angle factor X/R (D-A-CH-CZ only)
- Distribution factor (D-A-CH-CZ only, automatic calculation according to short-circuit power)

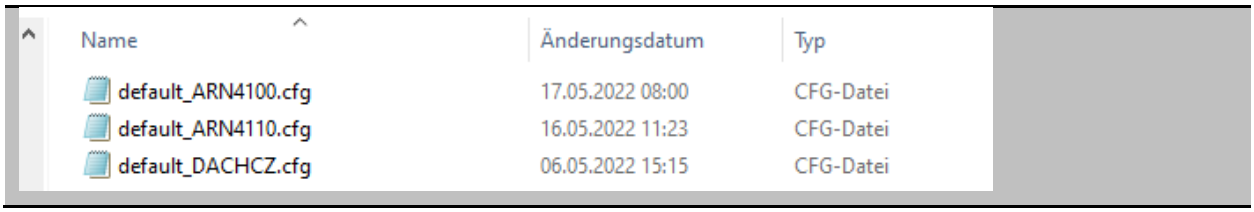
Input boxes for main parameters



The following parameters can be edited via CFG files:

- Proportionality factor of harmonics [pv] and interharmonics [gu]
- Resonance factors of harmonics [kv], interharmonics [ku] and supraharmonics [kb_FB]

Data path of CFG files - C:\Users\Public\Documents\WinPQ mobil\config_I_report



Name	Änderungsdatum	Typ
default_ARN4100.cfg	17.05.2022 08:00	CFG-Datei
default_ARN4110.cfg	16.05.2022 11:23	CFG-Datei
default_DACHCZ.cfg	06.05.2022 15:15	CFG-Datei

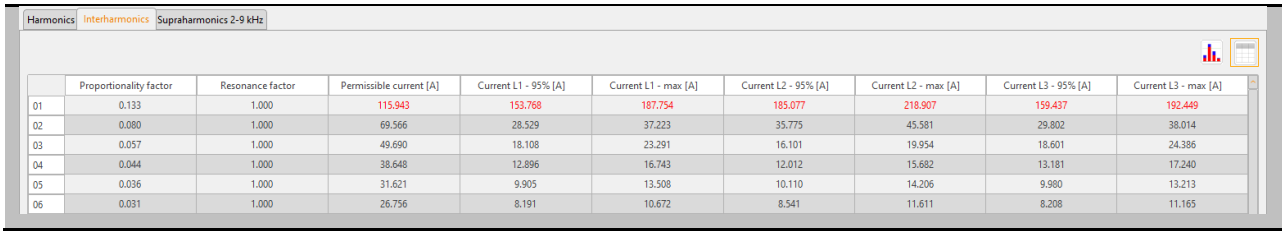
The measured values are compared with the calculated limit values in a table. In the graphical view, an exceeding of the limit line indicates standard violations.

The blue bar in the plot describes the maximum measured value during the measurement. The red bar shows the 95% quantile in the D-A-CH-CZ evaluation. For the VDE-AR-N evaluation, the red bar shows the maximum measured value.

Graphical evaluation (Example D-A-CH-CZ)

Norm violations are highlighted in red color in the table view.

Table view evaluation (Example D-A-CH-CZ)



Harmonics | Interharmonics | Supraharmonics 2-9 kHz

	Proportionality factor	Resonance factor	Permissible current [A]	Current L1 - 95% [A]	Current L1 - max [A]	Current L2 - 95% [A]	Current L2 - max [A]	Current L3 - 95% [A]	Current L3 - max [A]
01	0.133	1.000	115.943	153.768	187.754	185.077	218.907	159.437	192.449
02	0.080	1.000	69.566	28.529	37.223	35.775	45.581	29.802	38.014
03	0.057	1.000	49.690	18.108	23.291	16.101	19.954	18.601	24.386
04	0.044	1.000	38.648	12.896	16.743	12.012	15.682	13.181	17.240
05	0.036	1.000	31.621	9.905	13.508	10.110	14.206	9.980	13.213
06	0.031	1.000	26.756	8.191	10.672	8.541	11.611	8.208	11.165

Via right mouse click and "Print" a PDF report for the D-A-CH-CZ connection guideline or VDE-AR-N 4100/4110 can be created. Depending on the limit values, an automatic evaluation (pass/fail) is given on the start page.

Extract from the printed standard report with listing of parameters and evaluation

Conditions at delivery point	Input
Short circuit power [kVA]:	60000
Nominal load [kVA]:	1000
Impedance angle factor:	0,90
Sum of load, generation and storage factor:	1,00
Distribution factor:	0,10

Explanation of Parameters (Source: Technical rules for the assessment of network disturbances D-A-CH-CZ, Parts A and B)	
Short circuit power S_k	Three-pole short-circuit power provided by the grid operator. Can be determined in LV networks in a simplified way from the rated power and the short-circuit voltage of the MV/LV transformer.
Nominal load S_A	Apparent power to which the network user's equipment is designed.
Impedance angle factor k_{XR}	Factor to consider the influence of the X/R ratio of the short-circuit impedance on the accuracy of the extrapolation of the frequency-dependent network impedance.
Load ratio k_B	Ratio of maximum connectable load of all reference plants and fictive network load S_N.
Generation ratio k_E	Ratio of maximum connectable load of all generating plants and fictive network load S_N.
Storage ratio k_S	Ratio of maximum connectable load of all storage facilities and fictive network load S_N.
Partition ratio r	The partition ratio is used to calculate the permissible supraharmonic currents and depends on the short-circuit power S_k.

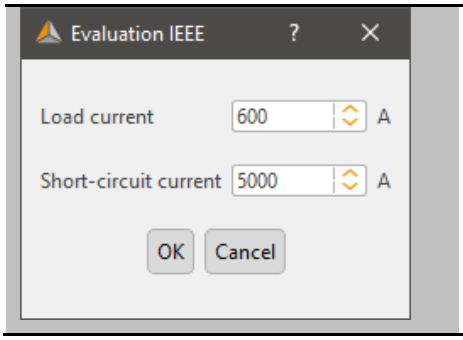
Summary	Recorded values	Evaluation
Harmonics	✓	FAIL
Interharmonics	✓	FAIL
Supraharmonics 2-9 kHz	✓	PASS
Total evaluation		FAIL

The other pages of the report contain a listing of all diagrams and tables.

1.14 IEEE 519 Report

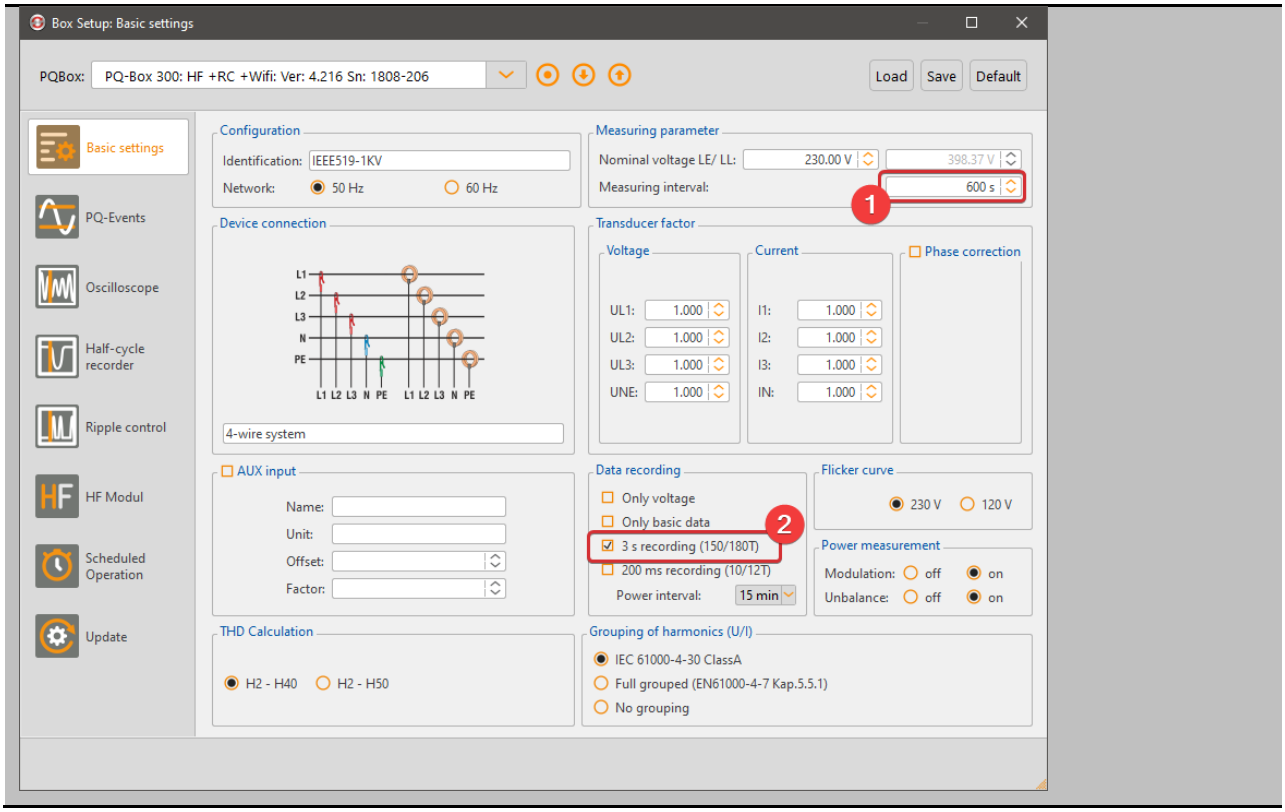
Create a complete IEEE 519 Standard report.

In this report, voltage and current harmonics are automatically compared with limits of the IEEE 519 standard. Before generating the report, the **load current** and **short-circuit** current parameters must be defined via an input mask.

Input mask	Parameter
	• Current harmonic limits are calculated depending on the ratio of load current to short circuit current. • The report can be generated multiple times with different combinations of parameters.

We recommend the use of one of the IEEE 519 parameter templates for parameterization of the PQ-Box.

Required conditions for the creation of an IEEE519 report

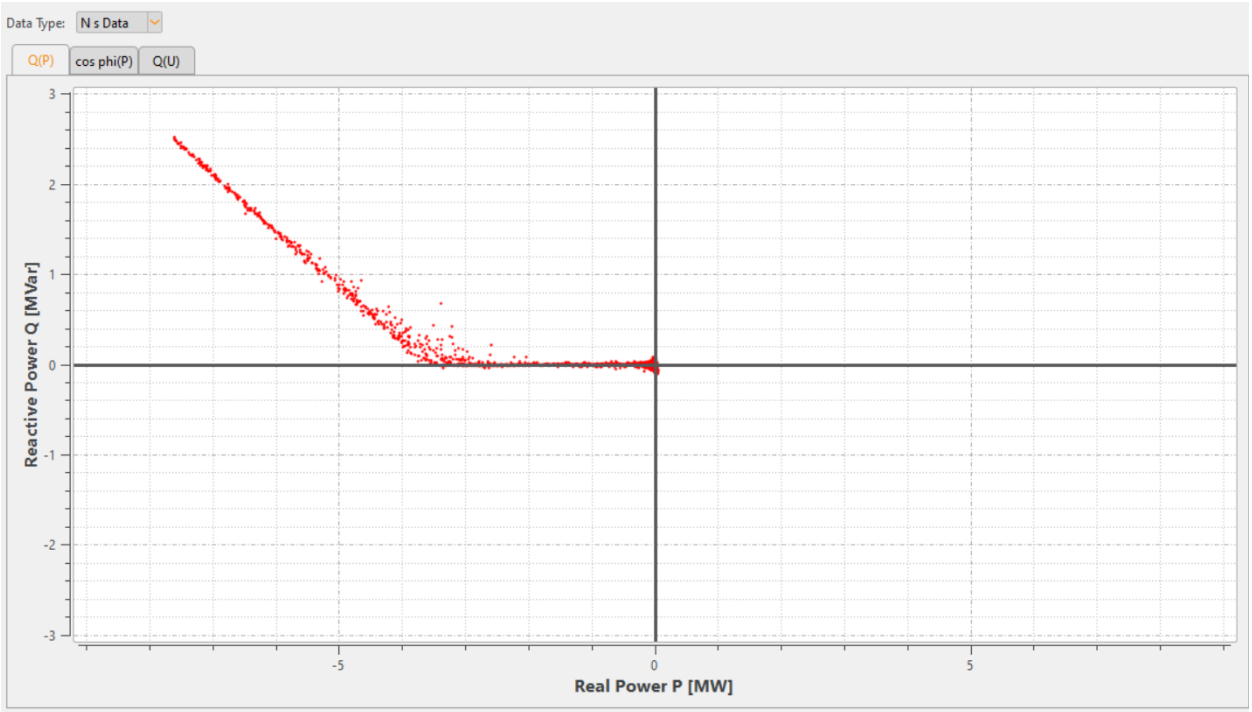


1.15 Q diagram for reactive and active power

Generation plants often have to set a specified reactive power for a certain feed-in capacity. This can be determined very easily from the measurement data using the three graphs provided in the Q diagram. The Q diagram shows the following measurement data.

- Q(P): Displacement reactive power Qv as a function of active power P
- Cos phi(P): Cosine of the phase angle Phi as a function of active power P
- Q(U): Displacement reactive power Qv as a function of voltage U

In the measurement data, you can select whether the evaluation should be created using the n-second measurement interval or the n-minute interval.



Example: Displacement reactive power Qv as a function of the active power fed in by a wind turbine

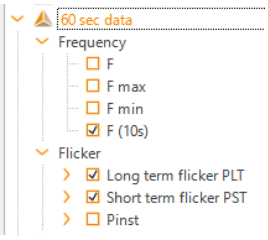
1.16 Timing diagrams of long-term data

In the menu point "Cyclic data" all permanently recorded measuring data are listed. More than 3800 different measured values (voltages, harmonics, inter-harmonics, currents, powers and energy) are recorded in each measurement.

Data class	Description
200 ms	Data with highest time resolution, data is only recorded and displayed if selected in device setup.
3 s	Contains measured values of the ripple control signal levels. The recording of further measured values can be activated via the device setup.
N sec data	Main interval of the measurement (N = 1 … 1800 Seconds, 600 sec for measurements according to IEC61000-4-30 Class A).
N min data	Power and energy values in power interval (N = 10 / 15 / 30 minutes)

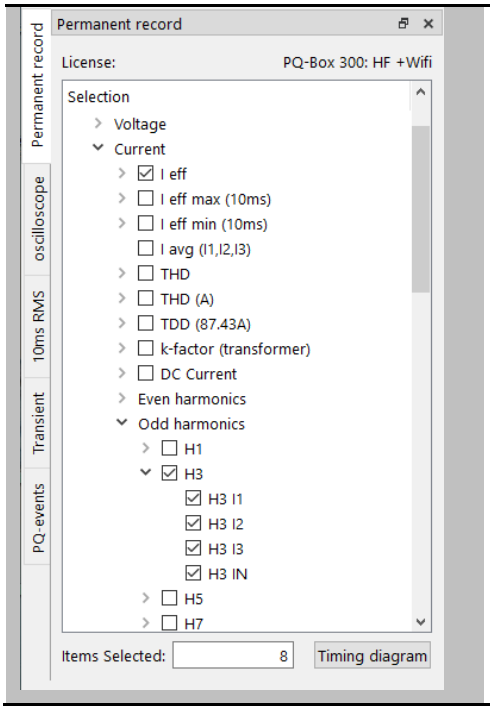
The main interval (right image: e.g. “60 sec data”) also always contains the following data regardless of the set measurement interval:

- Frequency (10 sec)
- Short-term flicker (10 min)
- Long-term flicker (2 h)



Any measured values can be displayed together in a level-time diagram. For example, a relationship can be formed between the voltage fluctuations, the resulting flicker levels and the cause in the network by means of associated current changes.

Selection of cyclic data to be displayed as level-time diagram



Create level-time diagram

- Select measured values or measured value groups from the measured value tree.
- By pressing the "Timing diagram" button, a new diagram is created.
- The selection of the measured variables is reseted automatically.
- The measurement data are displayed exactly in the order in which they were selected.

After confirming the selection, the measurement data is automatically grouped and displayed. The "Details" card shows the min, max and average value of the selected measurement or the displayed range for each variable.

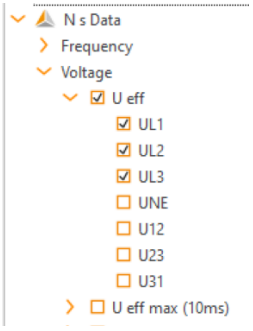
By left-clicking on the icons below the graphical window, individual channels can be shown or hidden. For navigation through the diagram area, the following icons are available in the header line.

Zoom: Press and hold the left mouse button and drag a window from left to right to zoom into the selected area. If the window is dragged in the opposite direction, the zoom is reset.

Timing diagram

A grayed-out area in the overview window below shows the zoomed time range.

In a 4-wire network, WinPQ mobil selects all wire-neutral voltages. The phase-to-phase voltages are automatically selected in the 3-wire network. However, all values are always present in every measurement. By opening the measured values menu, you can reach the other values as well as the neutral conductor-earth voltage Une.

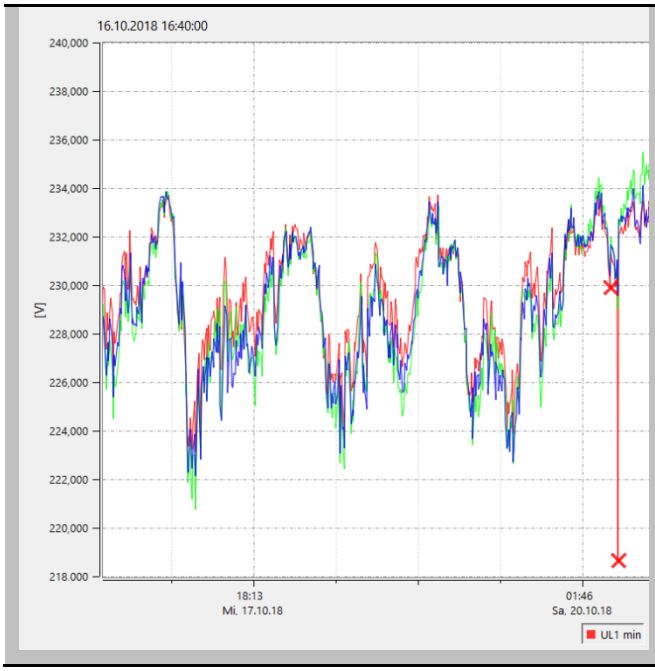
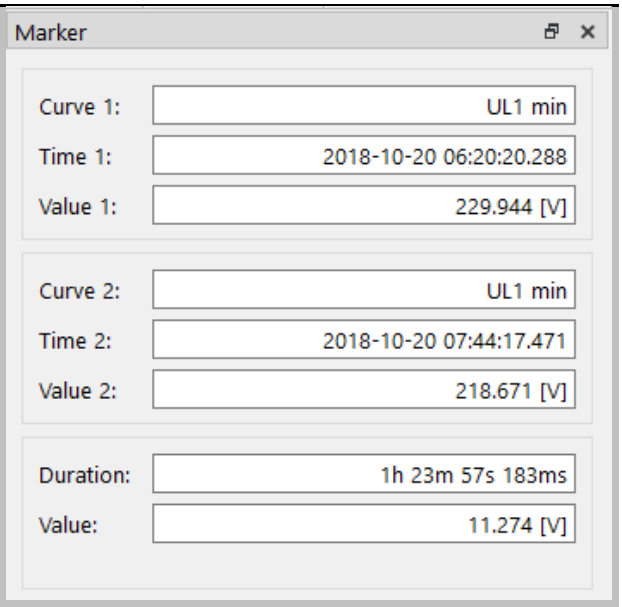


1.16.1 Set markers

Two markers can be set in the plot using the right mouse button. The nearest curve is selected, and the marker adapts its colour. Alternativ ist da auch mit einer gedrückten Taste und linker Maustaste möglich:

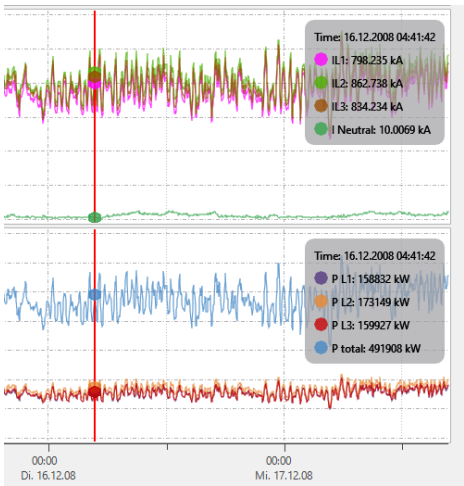
- **Marker No. 1** shift + left click
- **Marker No. 2** ctrl + left click

The distance between both markers is calculated as an absolute value. The time distance is always calculated, the value difference is only calculated for identical units.

Markers in timing diagram	**Marker view with time- an value difference**
	

Even with long set measuring intervals (e.g. 10min) the exact time information in milliseconds is displayed in the marker for the extreme values (10ms).

1.16.2 Vertical Marker



The vertical marker is the ideal tool for comparing the data of several measured variables in different units. In the right-hand area, the legends in the corresponding diagram show the values at exactly the same point in time.

The marker follows the mouse pointer and can be fixed by left-clicking with the mouse. Another left-click releases the fixation, and it follows the mouse pointer again.

1.16.3 Plot line type options

Five types of representations are offered for the plot lines.

Connects each measuring point directly. (Basic setting for all diagrams)

Connects each measuring point directly and plots a marker for each point.

Data points without connection line.

This step display is particularly suitable for average values, e.g. 15-minute power values. Here, the average value over the measurement period is displayed as a straight line.

The "Step display inverted" offers the possibility to clearly display mains interruptions in the level-time diagram.

1.16.4 Further functions in the context menu (right mouse button):

With a right mouse click in the display area, the following functions can be selected:

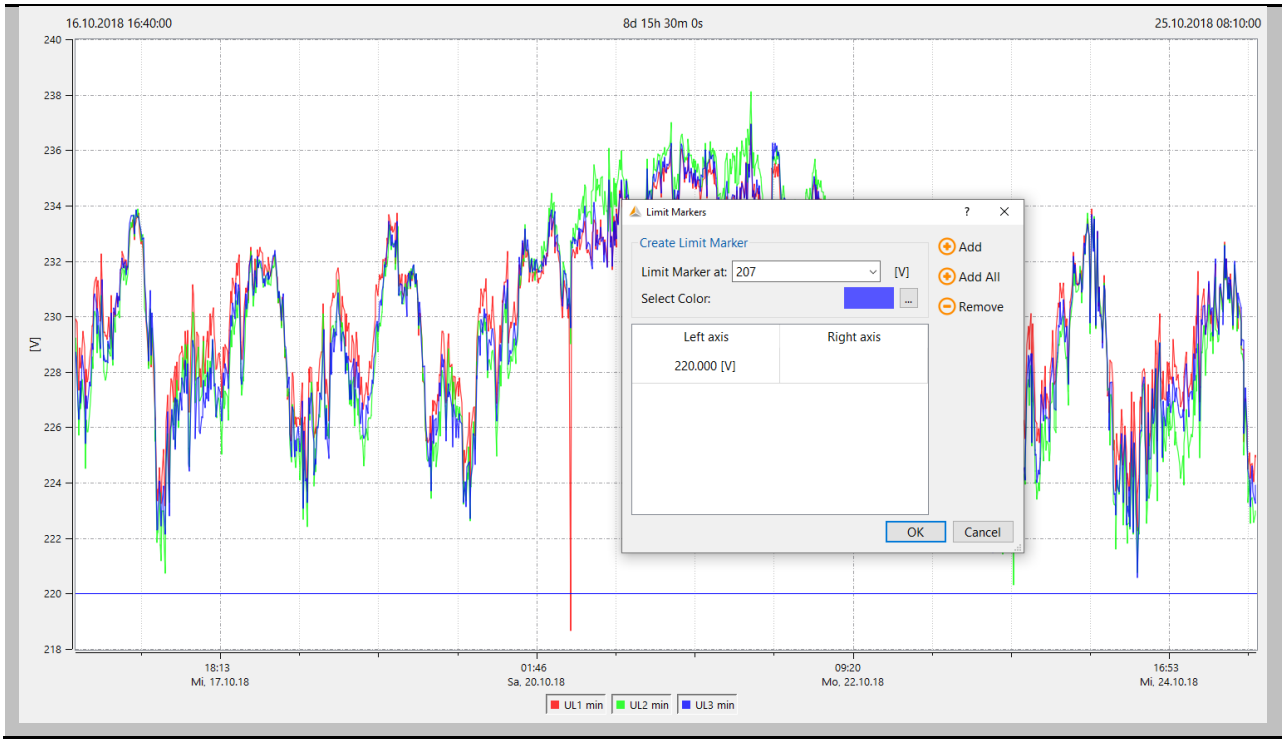
- **Delete markers** = remove all markers
- **Vertical marker =** activate or deactivate the vertical marker
- **Show flagging** = Measured data which were recorded during a power failure or power interruption are marked (flagged). Here the marking can be shown and hidden.
- **Scaling left** = scale left axis manually
- **Scaling right** = scale right axis manually
- **Logarithmic scale**
- **Divide axis** = SW automatically separates measured values with their own scale reasonably so that no measured values overlap.
- **Autoscale** = Software scales the window automatically
- **Limit markers** = Set value and colour of a limit line.
- **Show all** = the entire measurement period is displayed
- **Show day** = set time scaling to 1 day

- **Show week** = set time scaling to 7 days
- **Show 2 weeks** = set time scaling to 14 days
- **Show 4 weeks** = set time scaling to 1 month
- **Insert comment** = With this function a comment can be inserted into the graphic. This also appears in the printout.
- **Print** = current graphic is sent to the set printer or saved as a PDF document.
- **Copy image** = The graphic representation is copied to the clipbord. Afterwards, the illustration can be transferred to an MS-WORD™ document, for example.

1.16.5 Limit marker line

In the menu item "Limit markers" it is possible to define several limit lines. The colour, the value, as well as the associated Y-axis of the limit value line are set.

Example: Limit line for voltage; 207V (-10% Un)



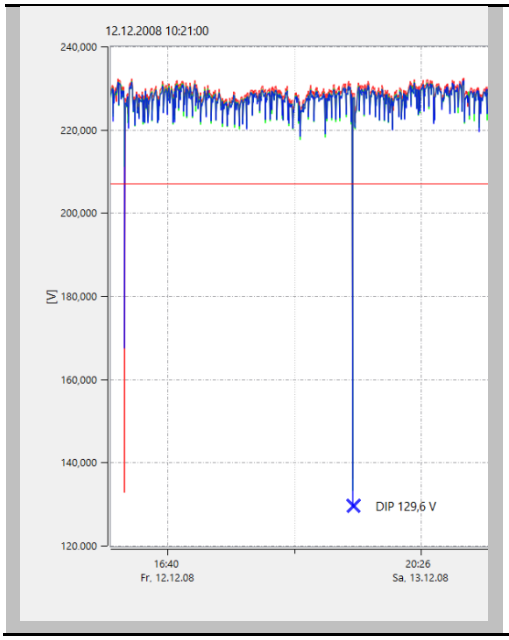
Display limit values

If a limit line for a harmonic, the voltage or the unbalance is to be displayed, the software automatically suggests the associated limit value of the set standard.
The limit value is automatically offered as a % value or absolute value, depending on the representation of the harmonics.

1.16.6 Insert comment

With the function "Insert comment" it is possible to put as many texts as you like into the graphic.

Comments in graphical visualization



Change comments

- It is possible to move the comment via drag-and-drop with the left mouse button.
- Delete the comment by selecting it with the left mouse button and "Remove" key on the keyboard.
- Edit a comment by double-clicking with the left mouse button.

1.16.7 Oscilloscopic records

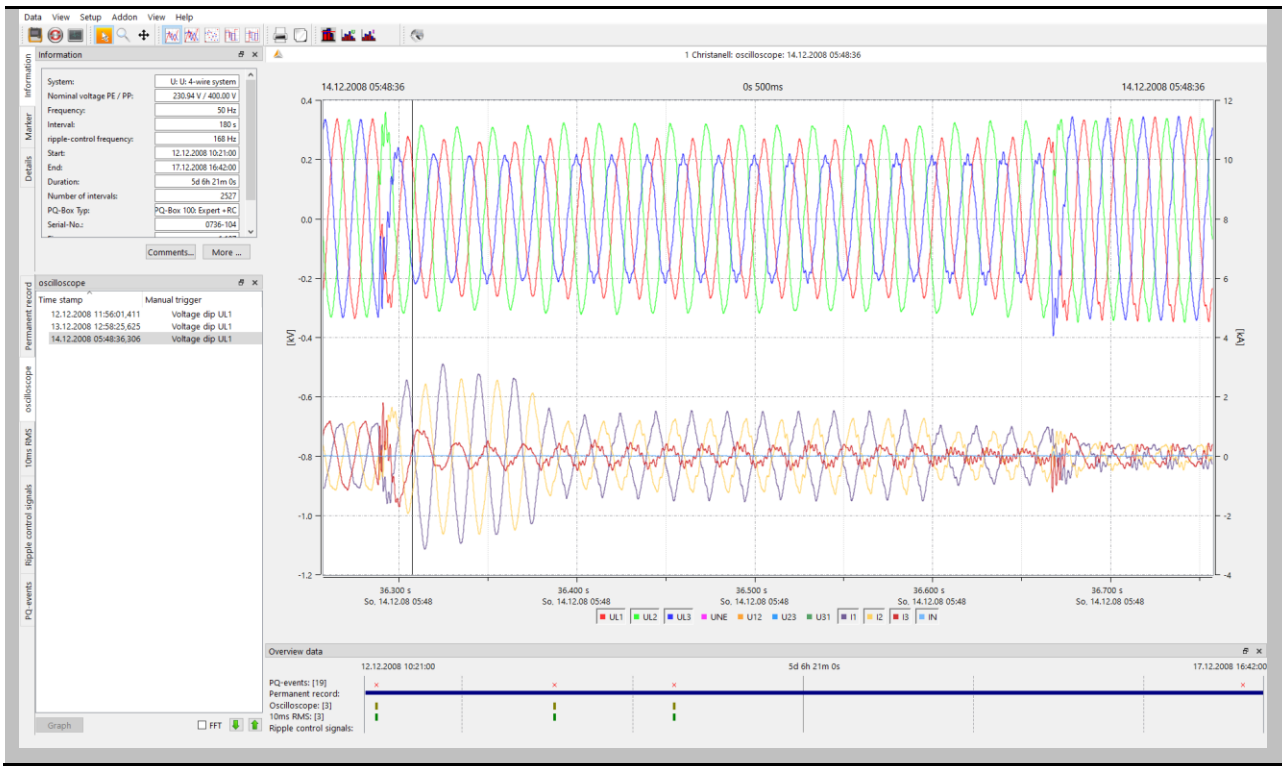
Using the "Oscilloscope" card, all oscilloscope recorders triggered manually, as well as via trigger settings, are listed. These can be sorted according to the time or the trigger condition.

Via a left click on the line the corresponding oscilloscope image is displayed.

In each disturbance record the following measured values are recorded:

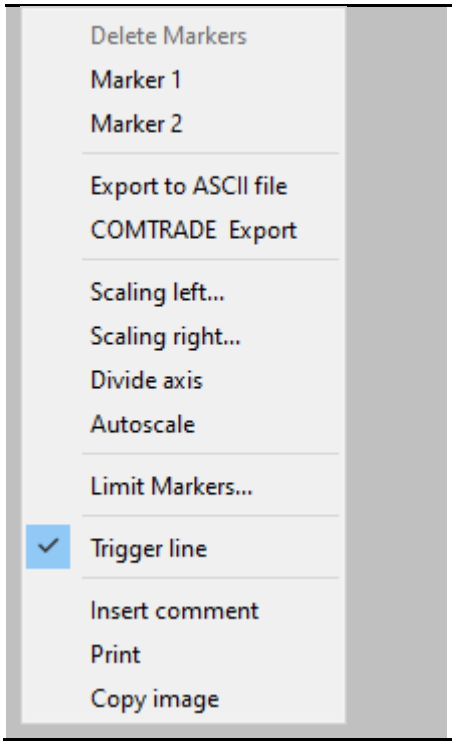
- All voltages „Line-to-line“ (U12, U23, U31)
- All voltages „Lint-to-earth“ (UL1, UL2, UL3, UNE)
- All currents (I1, I2, I3, IN)

Visualization of an oscilloscopic record



These two keys can be used to scroll through the triggered images. The software remembers the settings of the previous image and shows all further images in the same display (e.g. only the voltage channels without current).

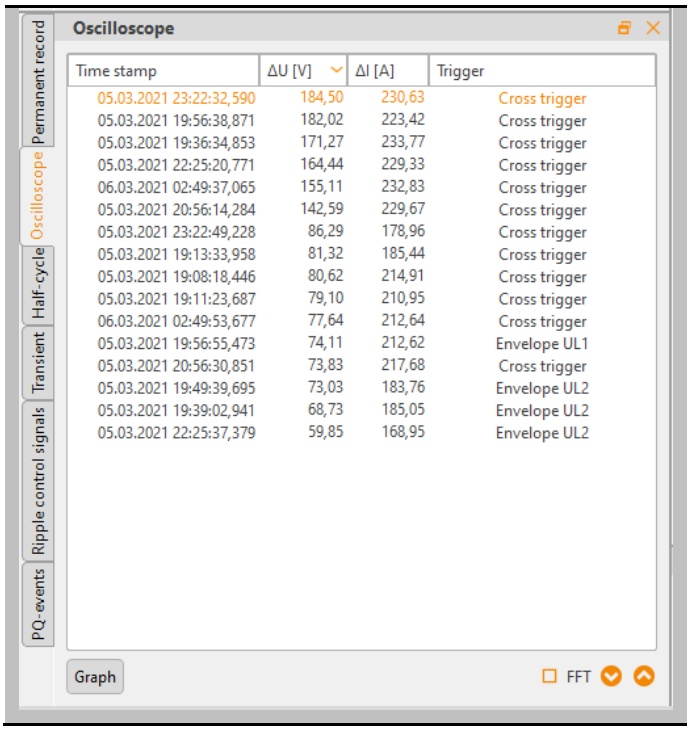
Right-click menu



- **Export to ASCII file**
  Export the data of the current fault record as a CSV file.
- **COMTRADE export**
  Export of the data of the current fault record as COMTRADE file.
- **Scaling left/right**
  Adjust scaling manually.
- **Divide axis**
  Display voltage and current in separate diagrams.
- **Trigger line**
  Suppress trigger line.
- **Print**
  Export current record as PDF.
- **Copy image**
  Copy to clipboard

Filter disturbance records:
By clicking on the column headings in the overview, all oscilloscopic records can be sorted by time, strongest voltage change ΔU [V], strongest current change ΔI [A] and trigger reason.
The changes of voltage and current are calculated from the difference of neighboring sample points and displayed as magnitude.

Record overview with filter option



Time stamp	ΔU [V]	ΔI [A]	Trigger
05.03.2021 23:22:32,590	184,50	230,63	Cross trigger
05.03.2021 19:56:38,871	182,02	223,42	Cross trigger
05.03.2021 19:36:34,853	171,27	233,77	Cross trigger
05.03.2021 22:25:20,771	164,44	229,33	Cross trigger
06.03.2021 02:49:37,065	155,11	232,83	Cross trigger
05.03.2021 20:56:14,284	142,59	229,67	Cross trigger
05.03.2021 23:22:49,228	86,29	178,96	Cross trigger
05.03.2021 19:13:33,958	81,32	185,44	Cross trigger
05.03.2021 19:08:18,446	80,62	214,91	Cross trigger
05.03.2021 19:11:23,687	79,10	210,95	Cross trigger
06.03.2021 02:49:53,677	77,64	212,64	Cross trigger
05.03.2021 19:56:55,473	74,11	212,62	Envelope UL1
05.03.2021 20:56:30,851	73,83	217,68	Cross trigger
05.03.2021 19:49:39,695	73,03	183,76	Envelope UL2
05.03.2021 19:39:02,941	68,73	185,05	Envelope UL2
05.03.2021 22:25:37,379	59,85	168,95	Envelope UL2

FFT Analyse

☑ FFT

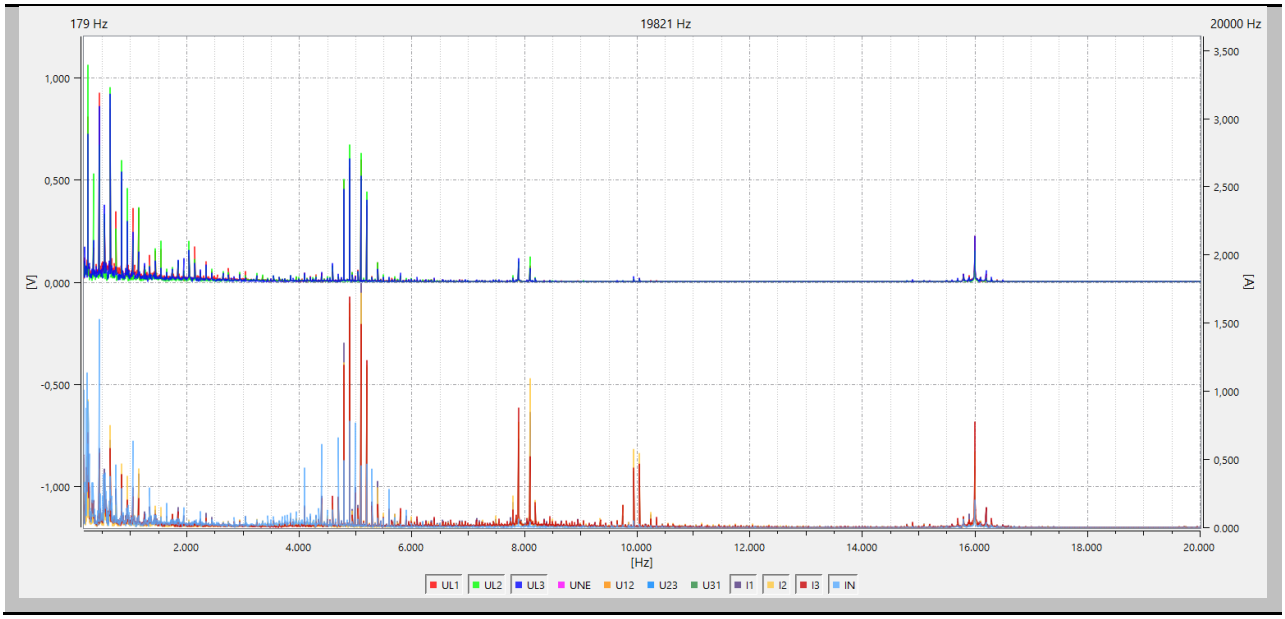
The calculation of the FFT spectrum is possible by activating the field "FFT" of each triggered oscilloscope image.

The accessible spectrum depends on the PQ-Box type.

Model	Available spectre
PQ-Box 50	**DC to 10 kHz**
PQ-Box 100	**DC to 5 kHz**
PQ-Box 150	**DC to 10 kHz**
PQ-Box 200	**DC to 20 kHz**
PQ-Box 300	**DC to 20 kHz**

The marker fields show the selected frequency and amplitude in the spectrum in the FFT analysis.

Voltage and current in FFT Analysis up to 20.000 Hz



1.16.8 Half-period TRMS Records

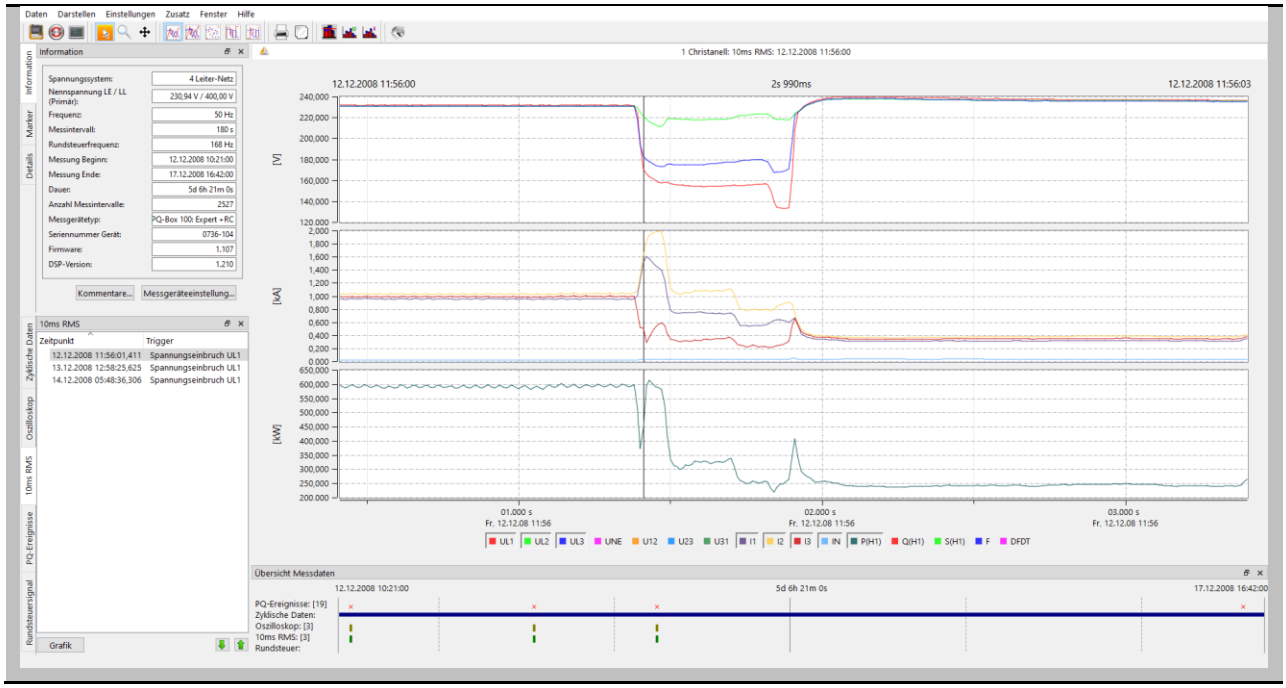
The "1/2 periode RMS" card lists all RMS recordings that were recorded manually or via trigger settings. These can be sorted according to the time or the trigger condition.

Via a left click on the line the corresponding oscilloscope image is displayed.

In each disturbance record the following measured values are recorded:

- All voltages „Line-to-lie“ (U12, U23, U31)
- All voltages „Line-to-neutral“ (UL1, UL2, UL3, UNE)
- All currents (I1, I2, I3, IN)
- Power (P, Q, S)
- Frequency and frequency changes (F, DFDT)

Visualization of a 10ms TRMS record



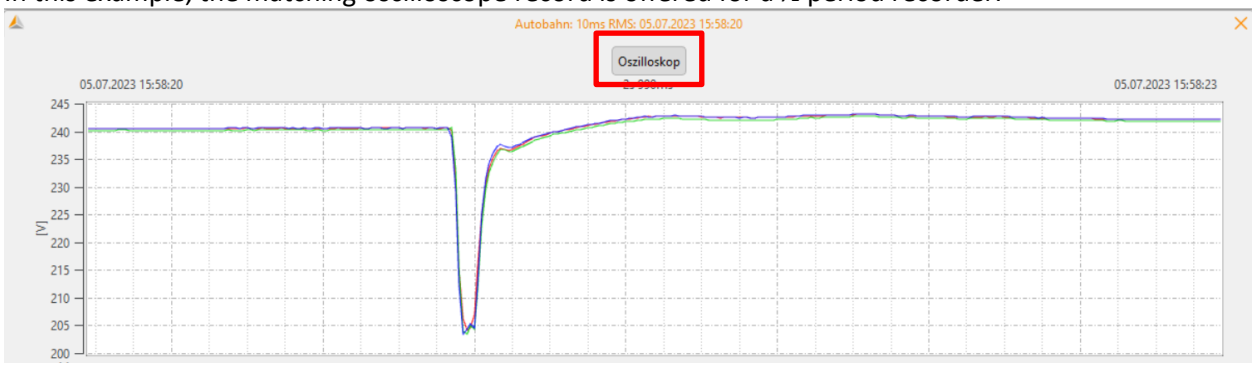
These two buttons can be used to scroll through the triggered images. The software remembers the settings of the previous image and shows all further images in the same display (e.g. only the voltage channels without current).

Filter disturbance records:
By clicking on the column headings in the overview, all TRMS records can be sorted by time, highest voltage Umax [V], lowest voltage Umin [V], highest current Imax [A] and trigger reason.

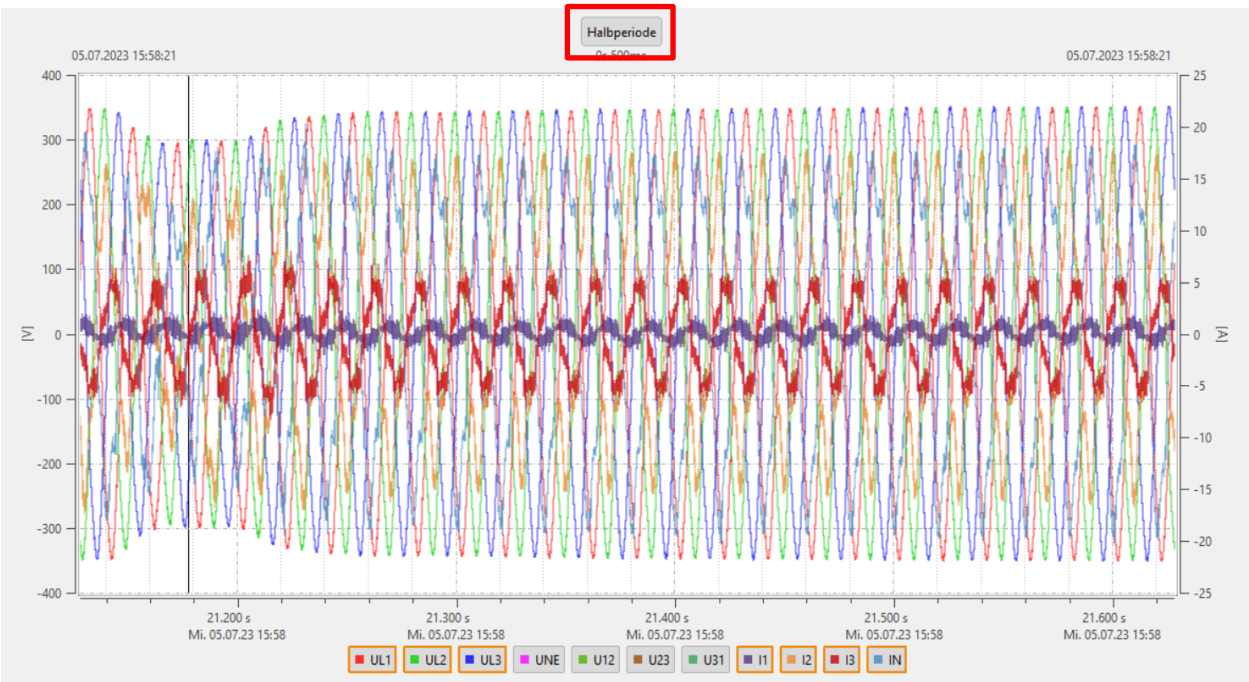
1.16.9 Switching directly to recorder for this event

If you open a fault record from an oscilloscope image, ½ period recorder or transient record, the software searches for records at the same time.

In this example, the matching oscilloscope record is offered for a ½ period recorder.



Change in the software directly to the appropriate disturbance record for the same event.



1.16.10 Transient recorder (only PQ-Box 200, PQ-Box 300)

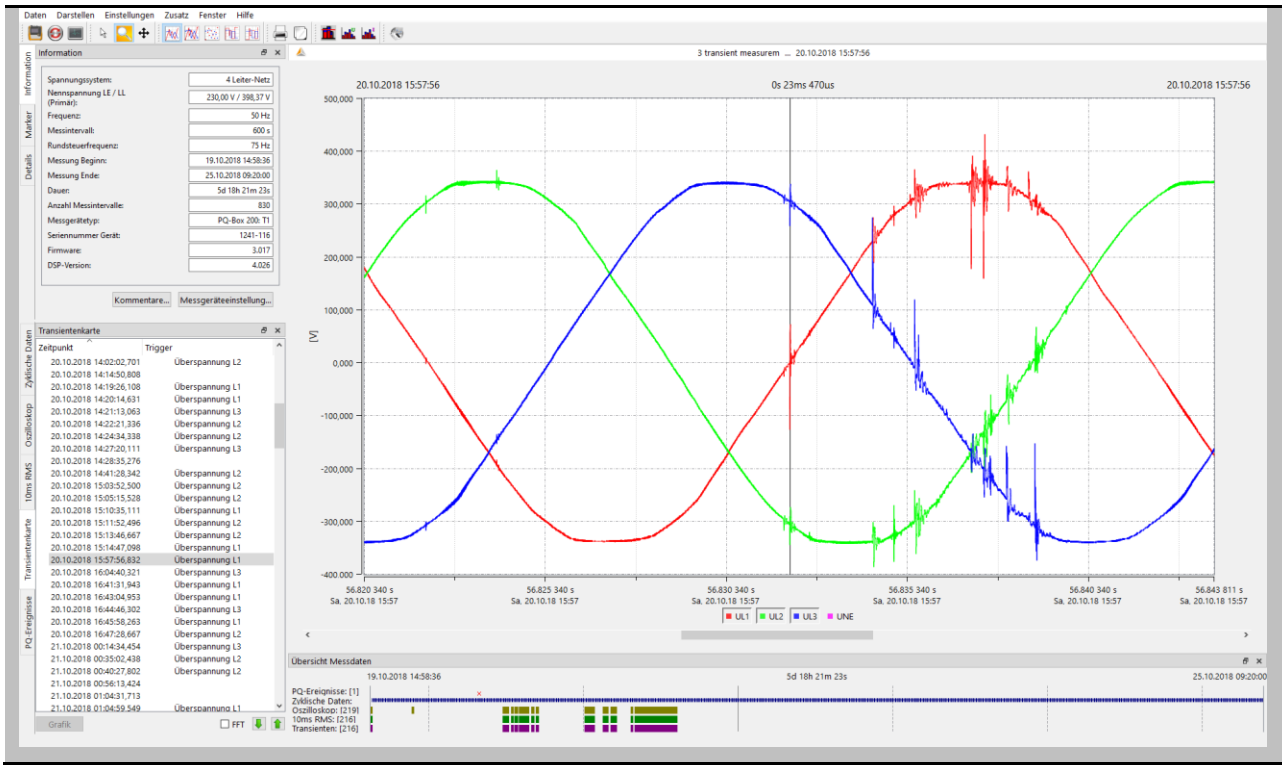
The "Transient recorder" tab lists all transient signals triggered manually and via trigger settings. These records can be sorted according to the time or the trigger condition.

Via a left click on the line the corresponding oscilloscope image is displayed.

In each disturbance record the following measured values are recorded:

- All voltages „Line-to-earth“ (UL1, UL2, UL3, UNE)

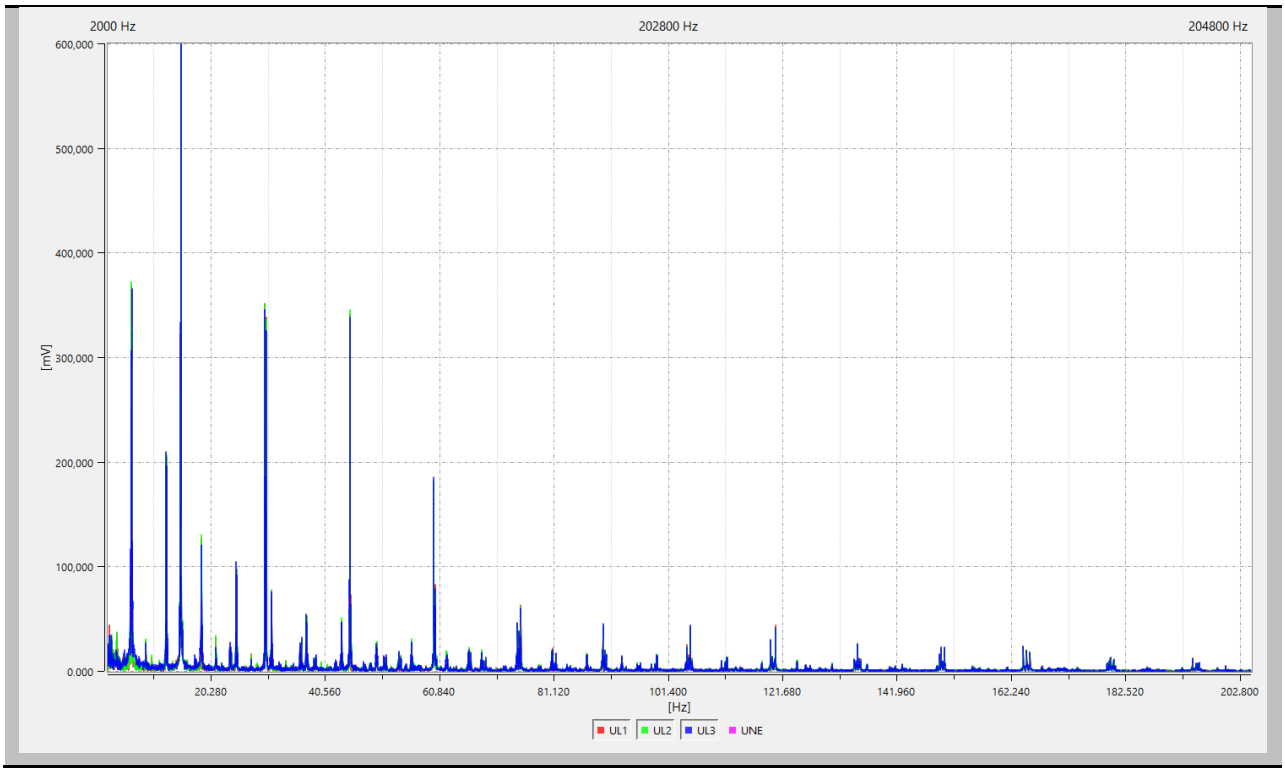
Visualization of a transient record



In the transient recorder the measured values are displayed as voltage against ground potential. When measuring in the medium voltage via a transformer, the secondary values are shown here.

FFT of transient recorder:
Using the FFT function of the transient recorder, it is possible to perform evaluations of the voltage amplitudes in a frequency spectrum up to a maximum of half the sampling frequency.

Example PQ-Box 300 – Spectre up to 204,8 kHz



Filter disturbance records:
By clicking on the column headings in the overview, all oscilloscopic records can be sorted by time, strongest voltage change ΔU [V] and trigger reason.
The change rate of voltage is calculated from the difference of neighboring sample points and displayed as magnitude.

1.16.11 Ripple control signal recorder

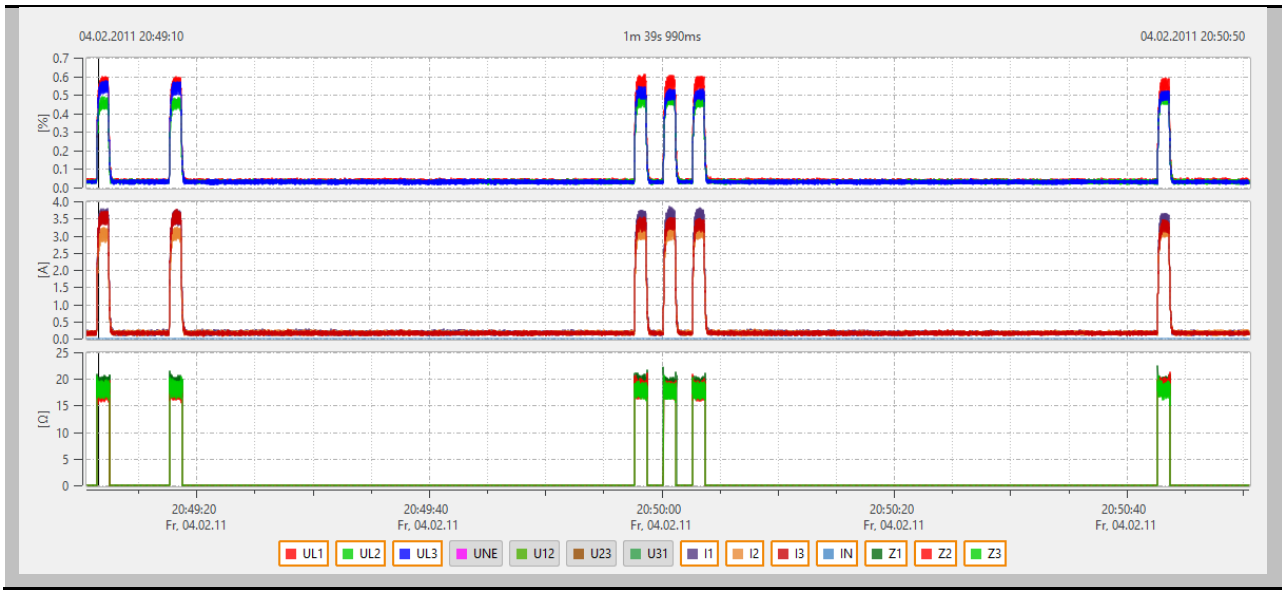
With the "R1 - Ripple control signal analysis" option, the PQ-Box can trigger specifically on a ripple control signal. The telegram is recorded with a resolution of 10ms over the set recording duration. The maximum recorder length is 210 seconds.

The following measured values are recorded with each disturbance value recording:

- All voltages „Line-to-line“ (U12, U23, U31)
- All voltages „Line-to-earth“ (UL1, UL2, UL3, UNE)
- All currents (I1, I2, I3, IN)
- Phase angle between voltage and current of this frequency
- Impedance (calculated)

In the example below, the ripple control frequency 180Hz was recorded over a duration of 1 minute and 40 seconds.

Ripple control telegram – Recording of voltage and current as 10ms effective values

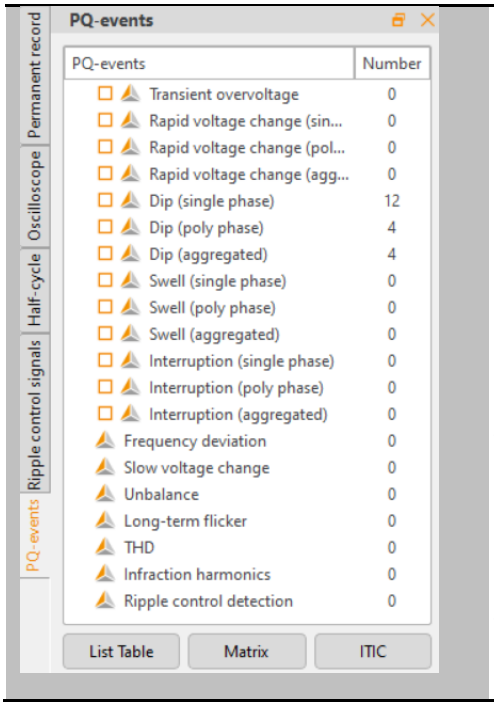


Filter disturbance records:
By clicking on the column headings in the overview, all Ripple Control records can be sorted by time, highest voltage Umax [V], highest current Imax [A] and trigger reason.

1.16.12 PQ Events

Using the "PQ events" card, all violations of the set limit values are displayed.

PQ-Events menu and evaluation options



PQ events which the PQ box records during the measurement.

PQ events which the software determines based on the selected standard template. The number of violations can change depending on the selected limit value file.

- **List table**
  Detailed table view of all PQ-Events with time stamp and extreme values.
- **Matrix**
  Automatic classification of voltage events into groups according to depth and duration.
- **ITIC**
  Visualization of PQ-Event in ITIC graph.

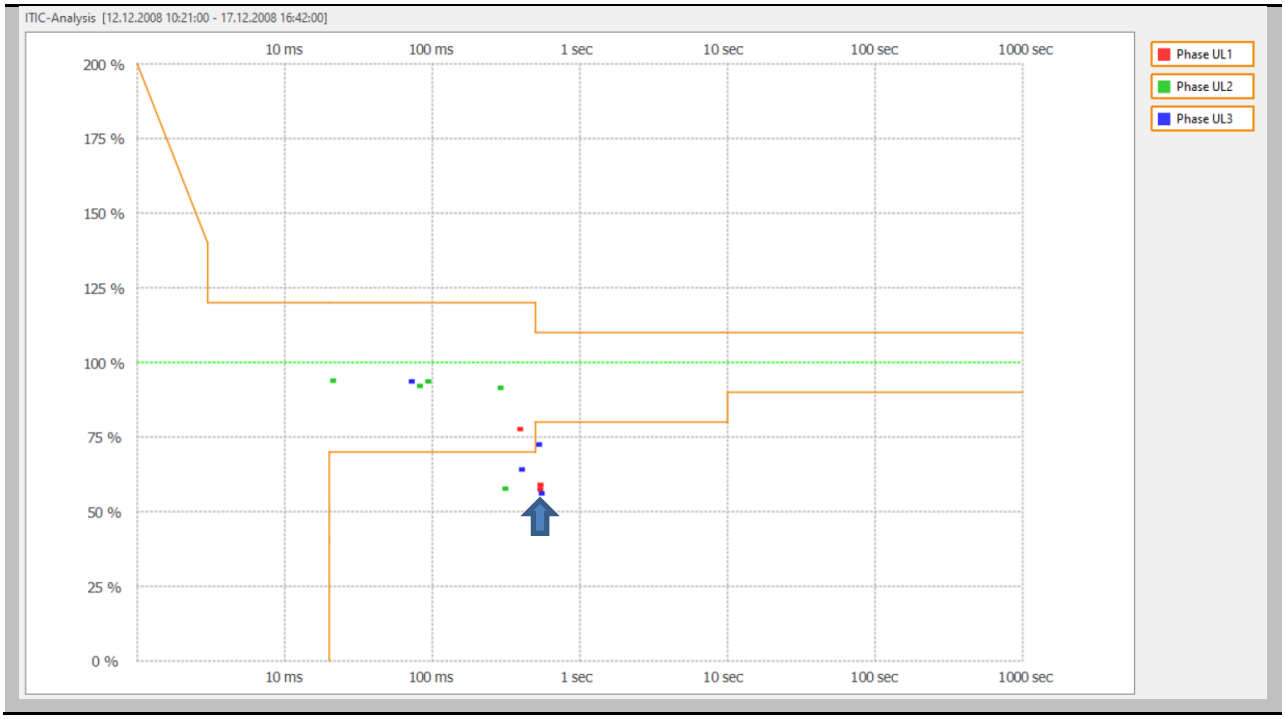
Table view of PQ Events

	Event	Start Time	Max. Value [V]	End Time	Duration
1	Dip UL1	12.12.2008 11:56:01,411	132.796	12.12.2008 11:56:01,930	0s 519ms
2	Dip UL3	12.12.2008 11:56:01,411	167.448	12.12.2008 11:56:01,921	0s 510ms
3	Dip UL2	12.12.2008 11:56:01,440	211.248	12.12.2008 11:56:01,720	0s 279ms
4	Dip UL3	13.12.2008 12:58:25,615	129.643	13.12.2008 12:58:26,148	0s 531ms
5	Dip UL1	13.12.2008 12:58:25,625	136.184	13.12.2008 12:58:26,148	0s 521ms
6	Dip UL2	13.12.2008 12:58:25,667	212.729	13.12.2008 12:58:25,746	0s 79ms
7	Dip UL2	13.12.2008 12:58:25,845	133.259	13.12.2008 12:58:26,148	0s 301ms
8	Dip UL3	14.12.2008 05:48:36,296	148.153	14.12.2008 05:48:36,687	0s 390ms
9	Dip UL1	14.12.2008 05:48:36,306	179.344	14.12.2008 05:48:36,687	0s 380ms
10	Dip UL2	14.12.2008 05:48:36,367	216.811	14.12.2008 05:48:36,387	0s 20ms
11	Dip UL2	17.12.2008 13:49:05,214	216.258	17.12.2008 13:49:05,305	0s 90ms
12	Dip UL3	17.12.2008 13:49:05,236	216.240	17.12.2008 13:49:05,305	0s 69ms

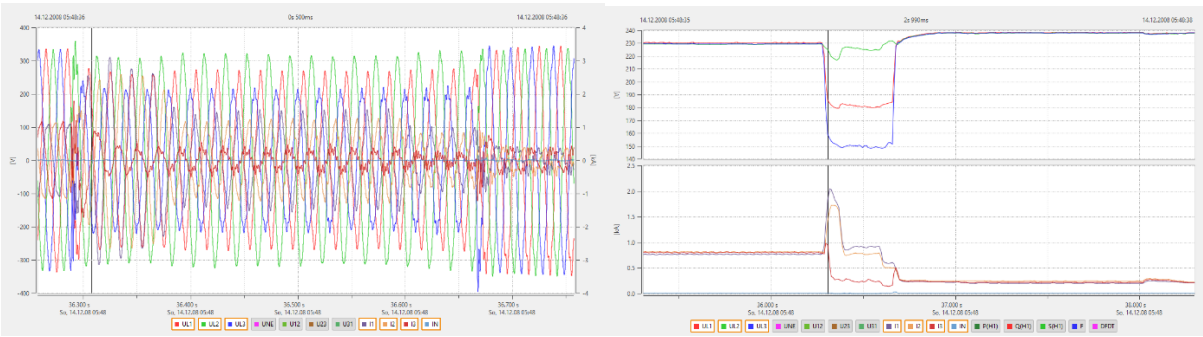
By left-clicking in the header, the tabular display can be sorted by maximum value or duration.

When displaying all voltage events as ITIC visualization, all deviations from the nominal voltage are displayed graphically as duration and amplitude.

ITIC Visualization of PQ Events



If there is a suitable fault record behind a PQ event in the ITIC graphic, you can open it directly by clicking on the event.



In addition to the ITIC graphic, the "PQ events" card contains an event table “UNIPEDE statistics” for all voltage dips and overvoltages.

Classification of PQ Events into EN-Matrix

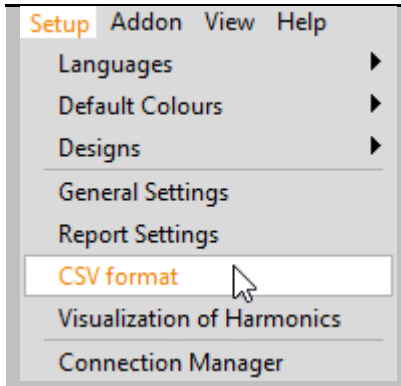
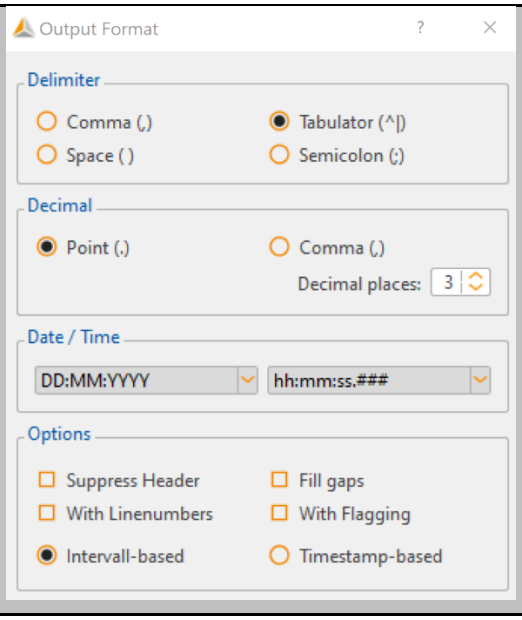
Residual voltage U [%]	Duration t [ms]					
	10 ≤ t < 200	200 ≤ t < 500	500 ≤ t < ...	1000 ≤ t < ...	5000 ≤ t < ...	t ≥ 60000
90 > u ≥ 80	0	0	0	0	0	0
80 > u ≥ 70	0	1	1	0	0	0
70 > u ≥ 40	0	2	3	0	0	0
40 > u ≥ 5	0	0	0	0	0	0
5 > u	0	0	0	0	0	0

Swell voltage U [%]	Duration t [ms]			
	10 ≤ t < 500	500 ≤ t < 5000	5000 ≤ t < 60000	t ≥ 60000
u ≥ 120	0	0	0	0
120 > u ≥ 110	0	0	0	0

Via WinPQ mobil/Settings/General this matrix can be switched to other network standards. (Netcode, NRS-048, GB-China)

1.16.13 Data export as CSV

Basic parameters for the measurement data export can be defined under "Settings/Export". The separation of the decimal point is to be specified as a point in English Windows versions.

Menu of export setup	Change export setup
	

Options:

- **Suppress header:** Do not show information such as designation of measuring job, device number and measuring interval in the header of CSV file.
- **Fill gaps:** In case of interruptions of the measuring job, the gaps are filled with 0. All time intervals are continuous with constant interval.
- **With Flagging:** Export flagging of measured values according to IEC61000-4-30.
- **With Line numbers:**
- **Interval-based:** Extreme values of voltage and current are exported with the time stamp of the respective interval.
- **Timestamp-based:** Extreme values of voltage and current are exported with exact timestamp.

All interval data of a measurement can now be exported via "Data/Export to CSV" in order to import them e. g. in MS Excel.

Load Load a previously saved selection of measured quantities.

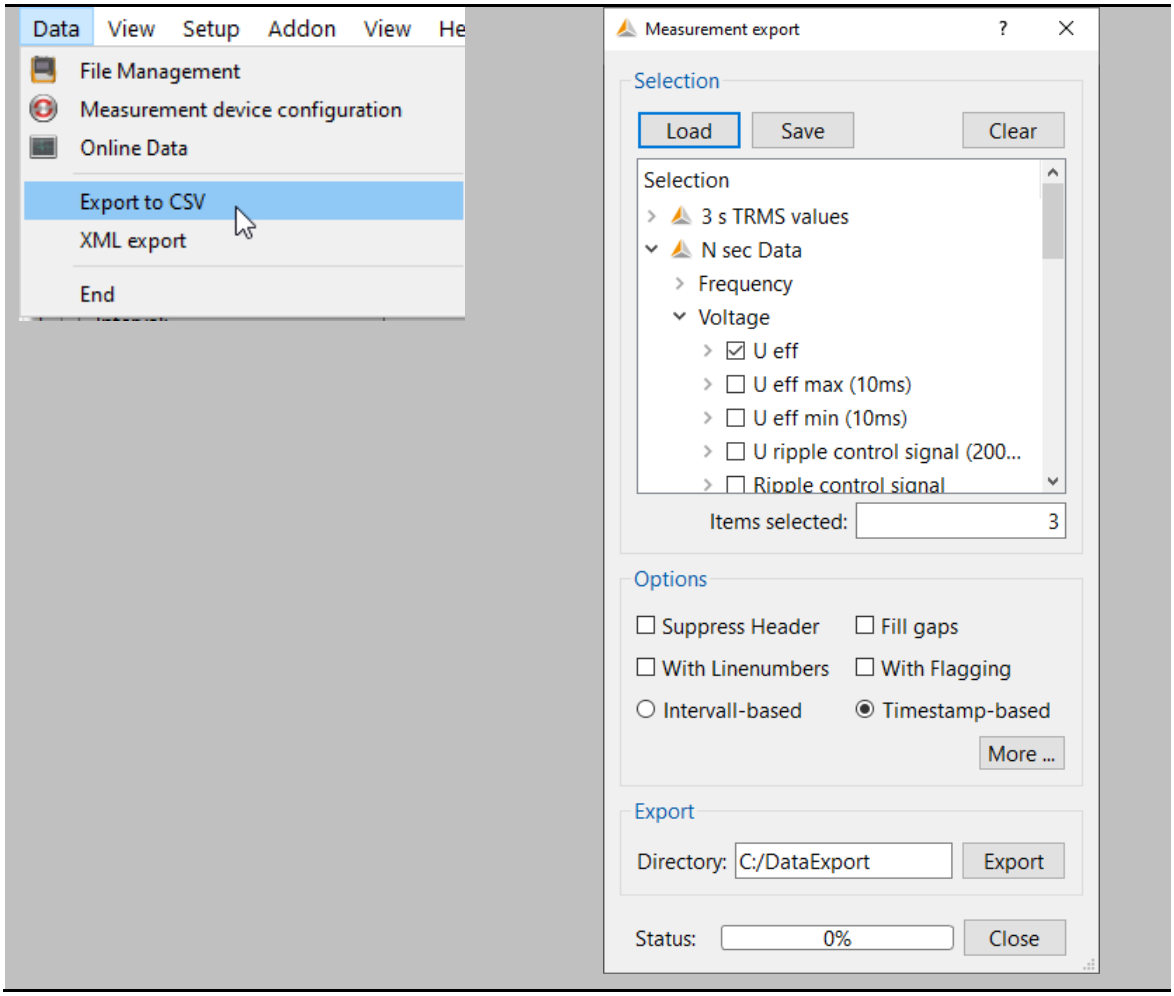
Save Save the current selection as a template.

Clear Deactivate all selection fields.

More… Edit output format.

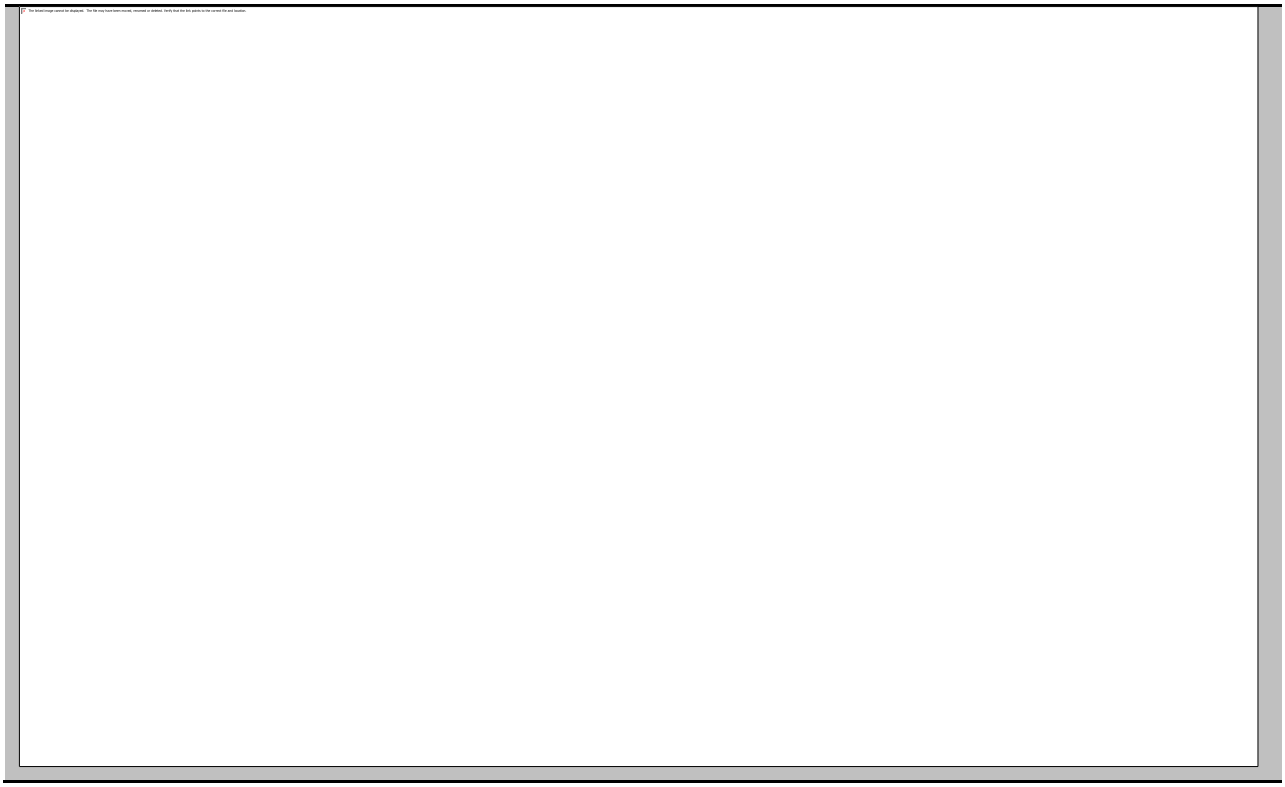
Export Save data in the destination directory.

Export of measurement data in CSV Format **Select data and edit output format**



When saving the measurement data, you can choose between the two data formats “CSV” and “ASCII.” This makes it very easy to import the files into MS Excel using drag-and-drop.

Example CSV Dataexport in Excel

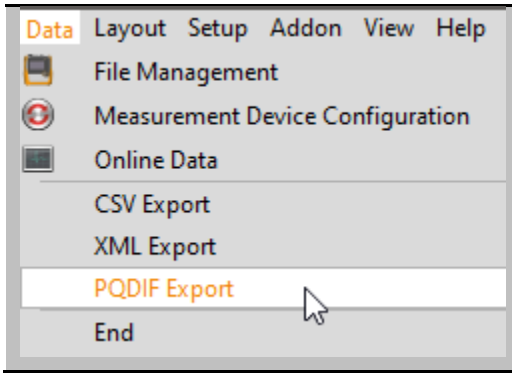


The order of the selected measurement data in the selection menu automatically also determines the order of the columns in the export file.

In the CSV export, the minimum and maximum values of the RMS values are displayed with the exact time stamps. This function can be switched off in the basic settings for the data export of the measurement data.

1.16.14 Data Export as PQDIF

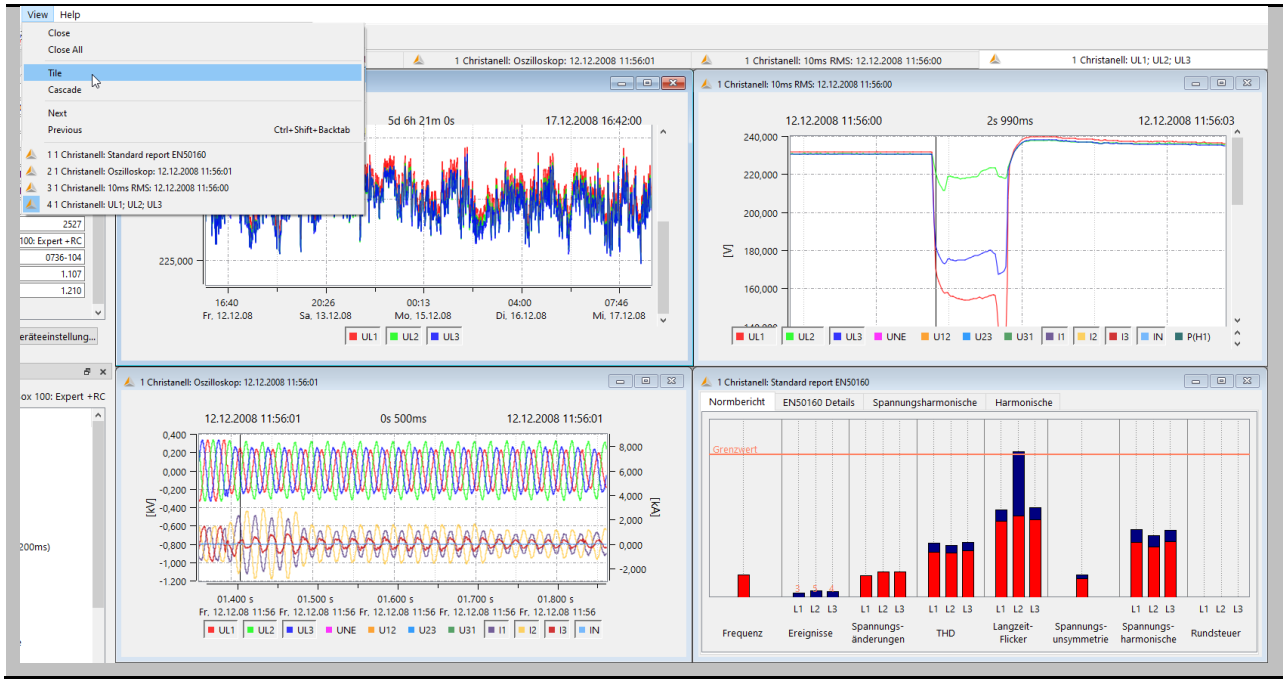
All measurement data can be exportet into PQDIF (Power Quality Data Interchange Format according to IEEE 1159.3) Format via the menu **Data** -> **PQDIF Export**.

Export of measurement data as PQDIF	Export Values
	• 10s Frequency • 10 min Data of Voltage, Current, Power, Energy (incl. harmonics and supraharmonics up to 9 kHz) • 15 min Power and Energy • 2h Flicker

1.16.15 Additional functions

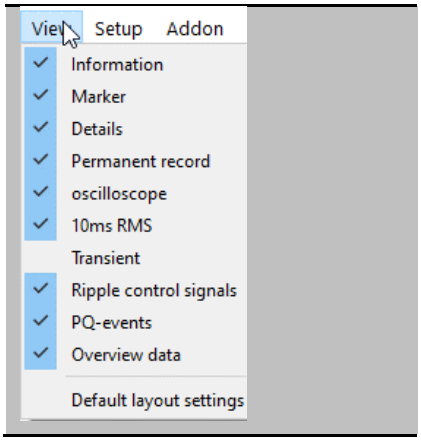
Via the menu „View/Tile“ it is possible to display all opened measurement windows in one screen.

Multiple open windows in one view



The tabs „Information” or „Overview data“ can be disabled in order to generate more space for the evaluation graph. It is possible to reactivate them via the "View" tab.

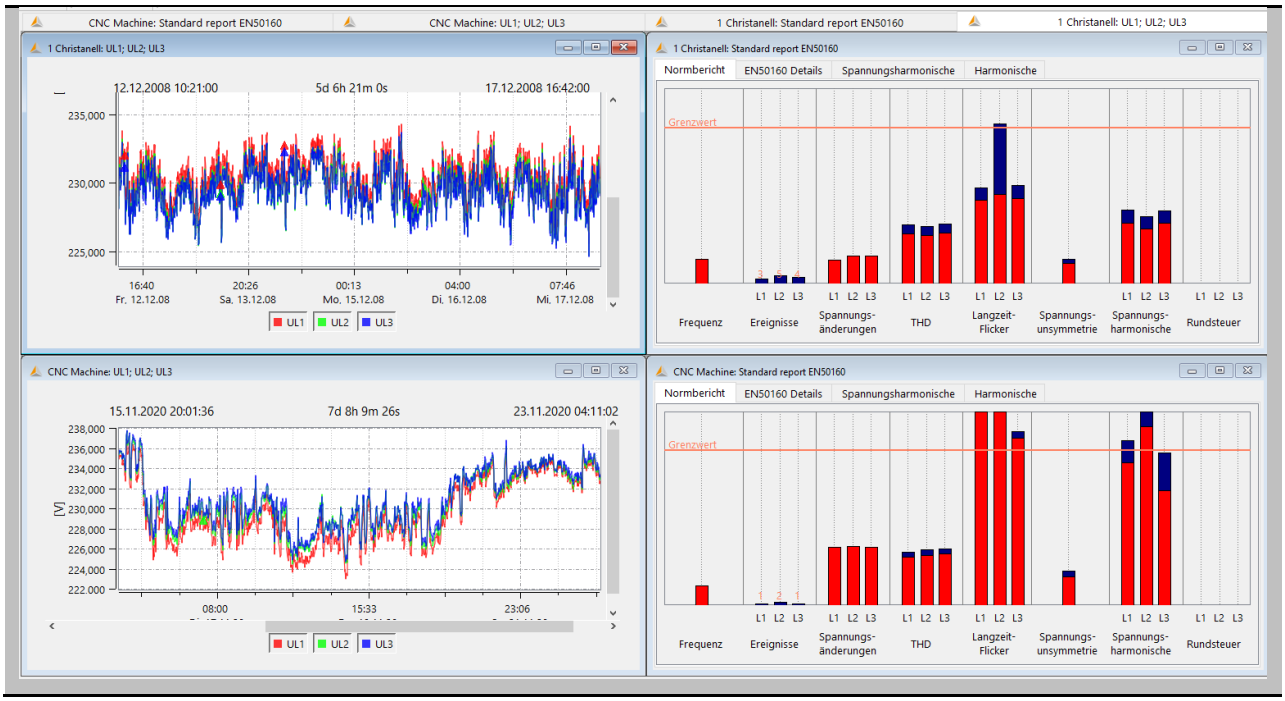
How to show and hide tabs



1.16.16 Compare two different measurement files

It is possible to open an additional measurement during an evaluation. Timing diagrams and norm evaluations can be displayed in one screen and compared to each other.

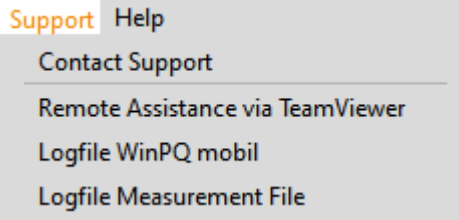
Two different measurements shown side by side
(2 x EN50160 Report, 2 x Timing diagram)

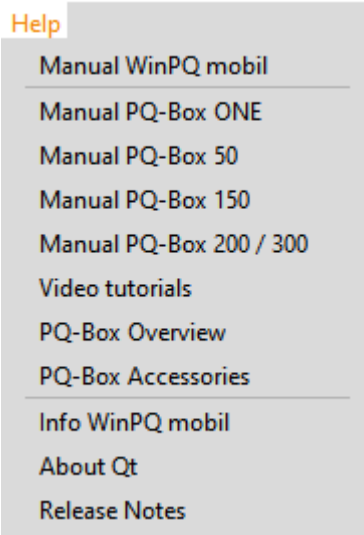


Tip: Several instances of the WinPQ mobil software can be opened on one computer at the same time. This makes it possible to display and compare two measurements on separate screens.

1.17 Menu ‘support’ and menu ‘Help’

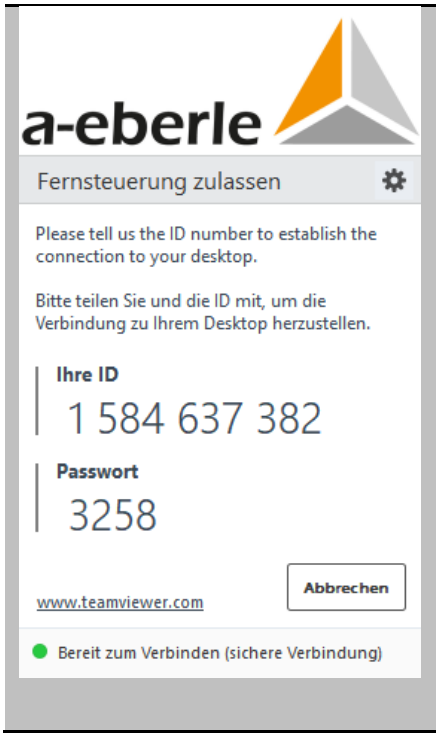
The “Support” menu offers support for problems with the software and the PQ-Boxes. In the “Help” menu of the WinPQ mobil software, you can access the current operating instructions for the PQ-Boxes and the software as well as other documents and video tutorials.





The function “Remote Assistance via TeamViewer“ allows to create a remote desktop connection to the A.Eberle support team in a fast and easy way.

Quicksupport via TeamViewer

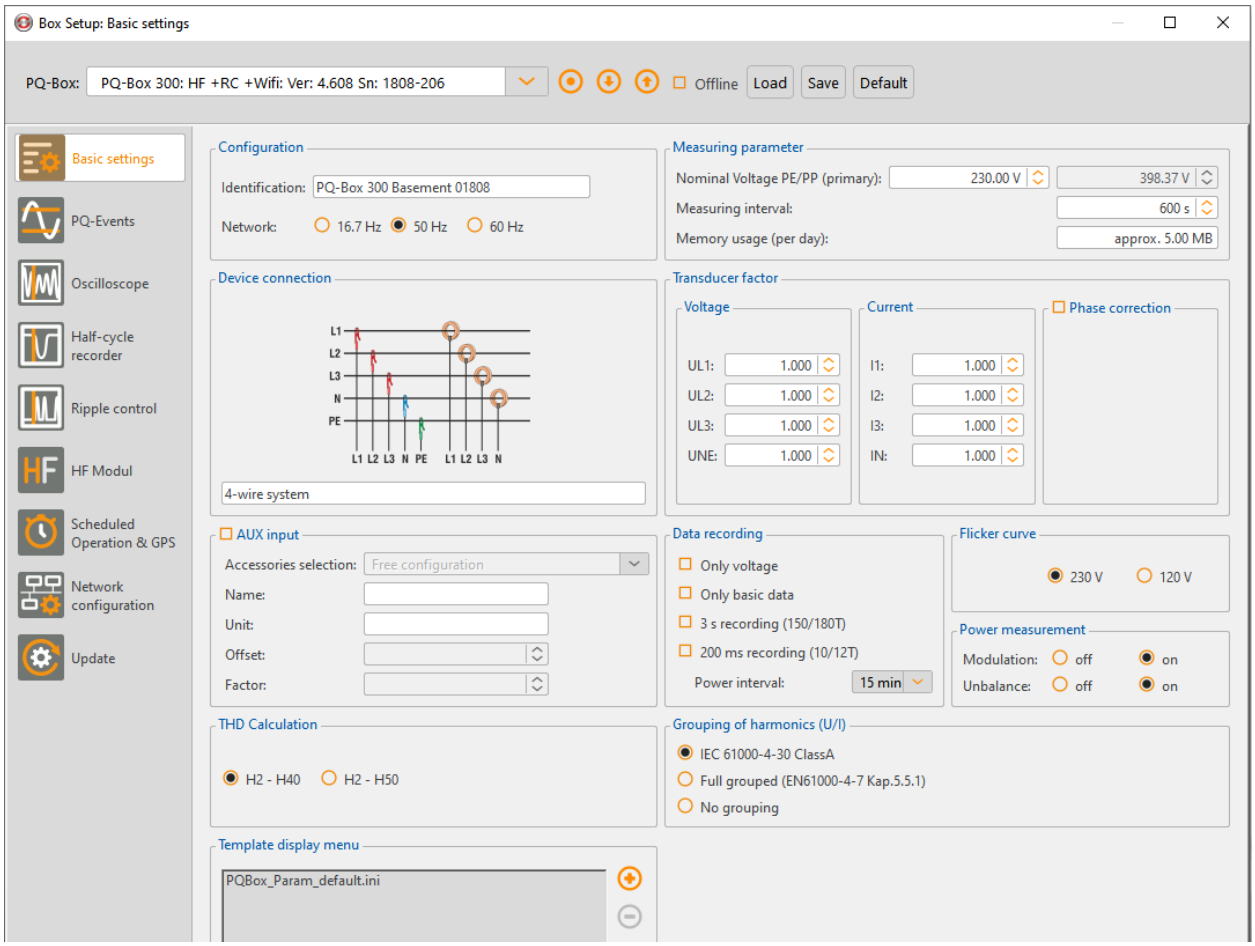


2. Parameters and standard limits of PQ-Box

By using this icon in the header of the start window of the WinPQ mobil software it is possible to change device parameters, trigger conditions and limit values of the PQ box.

After opening the parameterization window, the correct PQ box can be selected in the "PQBox" selection field, if more than one device is connected.

After selection of the measuring device, the parameters of the connected PQ box are downloaded and displayed automatically.



Start window with basic settings of the PQ-Box

The following buttons are available for interaction with the measuring device:

Start a measurement directly after parameterization has been completed.

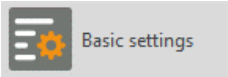
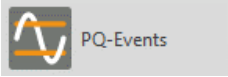
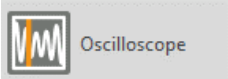
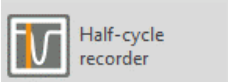
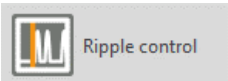
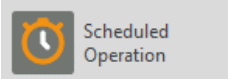
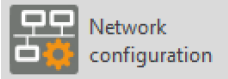
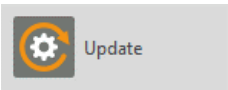
Download parameterization from thedevice.

Send parameterization or template to the device.

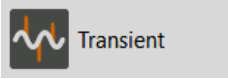
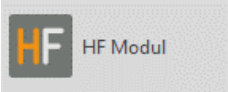
Templates are managed using the buttons in the upper right corner:

Load	Load a standard template or your own parameterization template.
Save	Save the parameterization as your own template.
Basic settings	Reset the entire parameterization mask incl. limit values and trigger settings to basic settings.

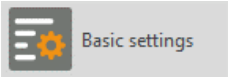
The parameter menu is divided into several subcategories and is displayed depending on the PQ-Box model. Fields that are hidden or disabled are not supported by the connected PQ-Box. The following cards are displayed for each PQ-Box:

	General settings such as measuring interval, transformer factors and network type.
	Settings of limit values for PQ standard evaluation, PQ events and harmonics.
	Parameterization and trigger thresholds of the oscilloscope recorder.
	Parameterization and trigger thresholds of the 10ms RMS recorder.
	Ripple control frequency settings.
	Time synchronization and scheduled measurement jobs.
	Settings IP address, network configuration PQ-Box
	Firmware update and license extension.

The following parameter groups are only available for the PQ-Box 200 or PQ-Box 300 models.

	Parameterization of Transient Recorder (PQ-Box 200 with Option T1 only).
	Parameterization of HF-Measuring card for recording of supraharmonic voltages (PQ-Box 300 only).

2.1 Setup – Basic settings



In the Basic settings menu, settings such as grid type, nominal voltage and transformation ratio of current and voltage transformers are made.

System settings: connection for voltage and current measurement:

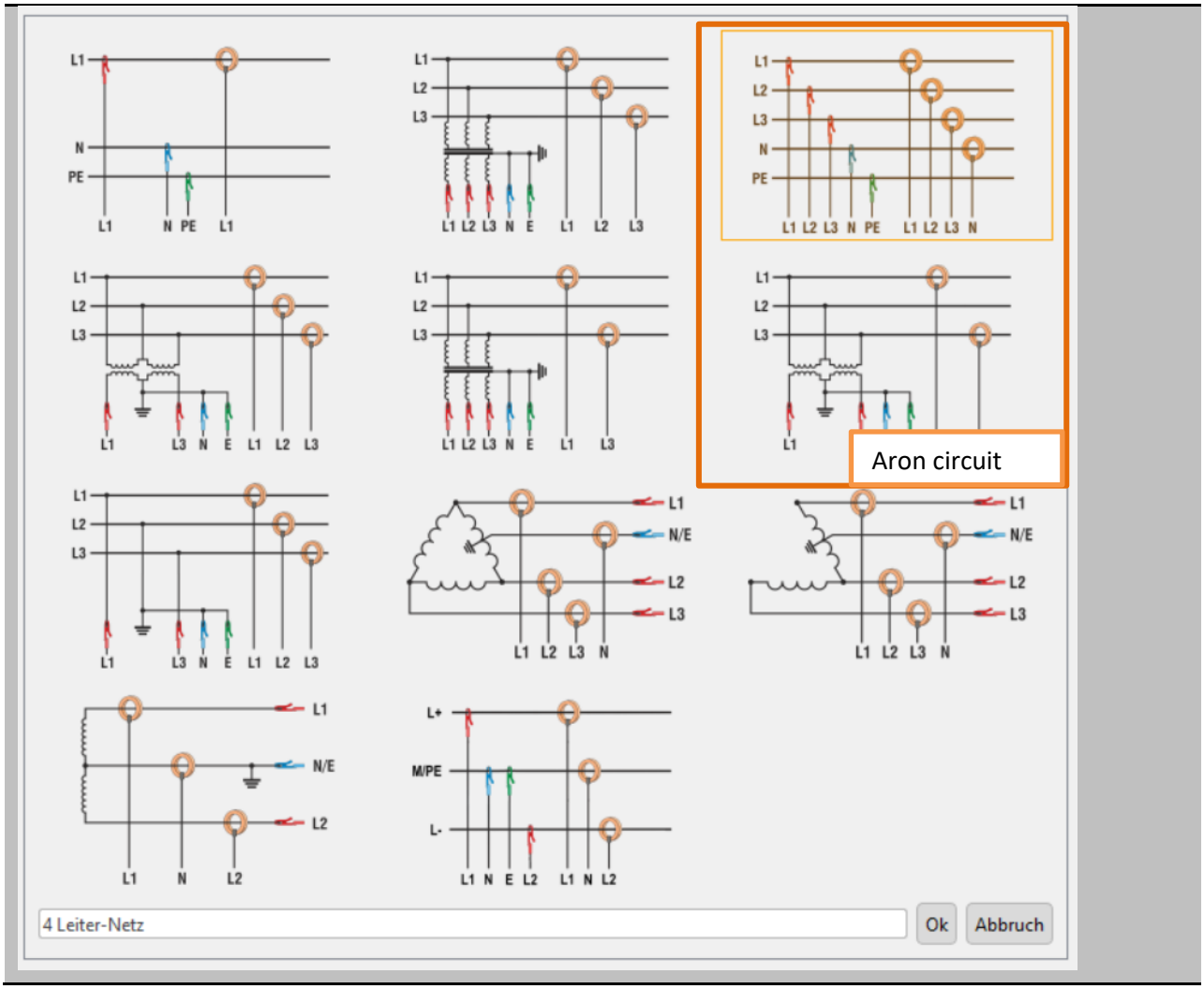
- 1 Wire system (Phase L1)
- 3 Wire system (isolated grid, no neutral)
- 4 Wire system (L1, L2, L3, N und ground)
- V-circuit (This function is activated if the voltage transformers in the medium or high voltage network are connected in V-circuit. The voltage lead U2 is connected to earth)
- Delta high leg
- Split phase
- DC 2-wire

By setting 3-wire or 4-wire system, the device distinguishes the type of network to be measured. In an isolated 3-wire network, all evaluations of the EN50160 standard are calculated based on the phase-to-phase voltages.

In a 4-wire network (grounded network), all power quality parameters are calculated based on the phase-to-neutral voltages.

In the 1-wire measurement only measured values of the phase L1, N and PE are recorded. This setting is also suitable for DC networks.

11 connection configurations are available for the PQ-Box.



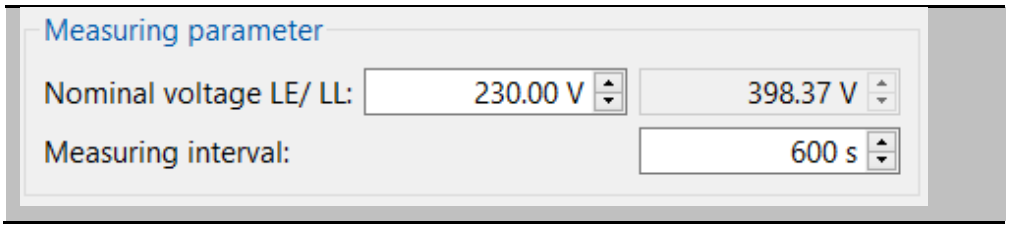
Aron circuit
If the current transformers in the medium or high voltage network are in Aron circuit, this configuration is used. The current of phase L2 is not connected and calculated by the PQ-Box.

It is possible to label a measurement job with a text (maximum 32 characters) before a measurement. After transferring the measurement data to the PC, this text can be found under "Comment 2".

In the 3-wire system, the contractually agreed line-to-line voltage is specified as the nominal voltage, e.g. 20400V. In the 4-conductor network, the line-to-neutral voltage is specified, e.g. 230V.

The measuring interval of the PQ-Box can be set freely in the range from one second to 1800 seconds. The basic setting is 10 minutes, as this is a fixed interval in the EN 50160, IEC61000-2-2 and other standards.

Setting of nominal voltage and measuring interval

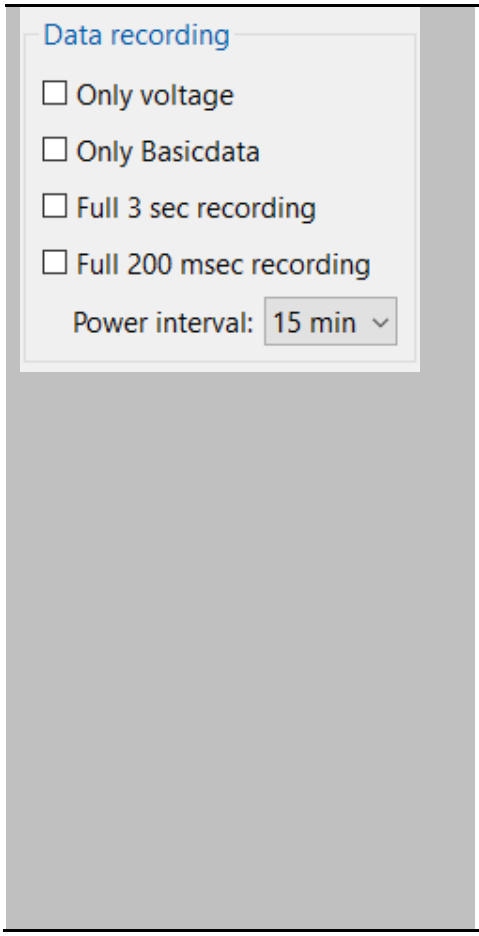


The PQ box references all trigger thresholds or PQ events to the set nominal voltage. This cannot be changed subsequently!

2.1.1 Measured value recording of PQ-Box

The generated data size during a measurement can be influenced very strongly at this point.

Options of the measured value recording



- **Only voltage**
  In this setting no currents and powers are recorded.
  The amount of data is reduced to approx. 40%.

- **Only Basicdata**
  Basic measurement data contains only basic measurement quantities. Harmonics / interharmonics / phase difference / phase angle are missing. All recorders are active.

- **3Sek/200ms intervals**
  Parallel to the free data class (1s to 30 min), the data classes 3-seconds and/or 200ms can be activated. Measured values of the following categories are recorded additionally:
  3 sec: Voltage, Current
  200 ms: Frequency, Voltage, Current

- **Power interval**
  All power values are recorded in addition to the freely adjustable interval with 10, 15, or 30 minute intervals. These intervals always start synchronously with the full hours.

Attention:
The 200ms and 3s data classes are only suitable for short measurement periods and produce a very large amount of data. If selected, the free interval will be automatically limited to 60 sec minimum.

Guide values of the size of the generated measurement data:

- The free measuring interval generates in **10 minute** setup generates a data amount of approx. **15 MByte per week.**
- The free measuring interval generates in **1 second** setup generates a data amount of approx. **30 MByte in 1 hour.**
- The **200ms interval** generates a data amount of approx. **80 MByte in 1 hour.**
- Das **3 Sek interval** generates a data amount of approx. **5 MByte in 1 hour.**

The measurement data of the triggered fault records and PQ events are also added. However, these are limited to a maximum data size of 2 GB in the default setting.

☐ Only Basicdata

Basic measurement data includes the following measured variables:

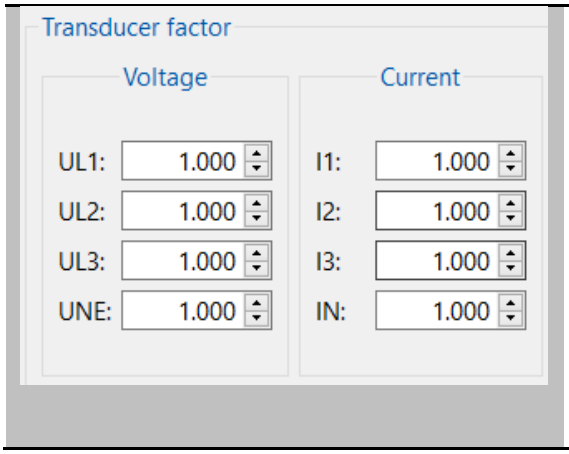
Status, Events, Flagging
Frequency values (mean, extreme)
Voltage values (mean, extreme)
Flicker
Current values (mean, extreme)
Power values (mean, extreme)
Ripple signal voltage
THC, K-Factor, Phase angle, symmetrical components
Distortion power, Power factor
Voltage deviation, Symmetry, PWHD
PWHD, PHC current
cos Phi, sin Phi, tan Phi, power values fundamental
Reactive power fundamental
10/15/30-minutes interval
Power values (mean, extreme)
Distortion power, Power factor
cos Phi, sin Phi, tan Phi, power values fundamental
Reactive power fundamental

The “Basic measurement data” setting only generates approx. 25% of the measurement data of the basic setting. For example, all harmonics are missing in the recording.

2.1.2 Transducer factor of VTs and CTs

In the transformer settings, the transformation ratio of the current and voltage transformers to which the power analyzer is connected is entered.

Setting-up the transducer conversion factor



Example:

Voltage:

primary = 20.000 V; secondary = 100 V;

factor UL1, UL2, UL3, UNE = 200

Current:

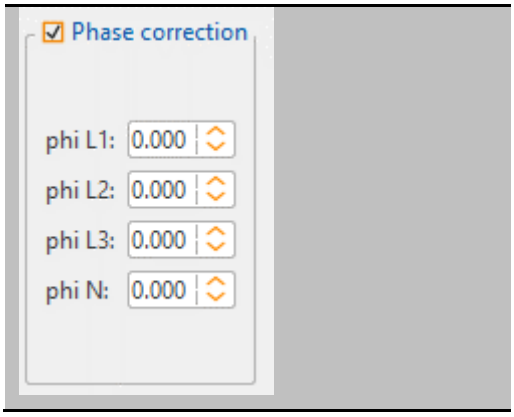
primary = 100 A; secondary = 5 A

Factor I1, I2, I3, IN = 20

The CT ratio factors can be corrected after the measurement with the help of the "Data converter". All current values, harmonics, powers and energies are converted.

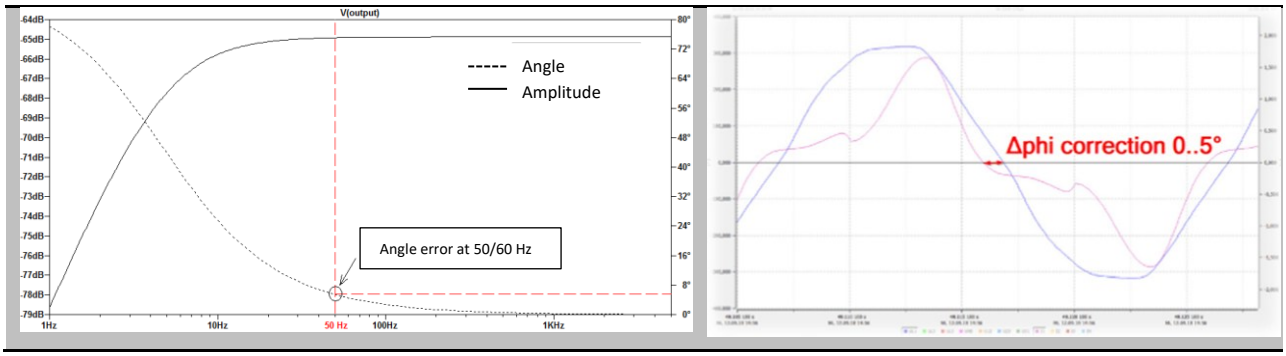
With the function "Phase correction current clamps" it is possible to correct the phase angle error of a current clamp or an external current transformer. This function is only available for current clamps with magnetic core. Rogowski coils typically do not have a phase error and therefore do not need to be corrected.

Phase correction of current clamps



To correct the phase error, the phase error of the corresponding current transformer at the nominal frequency of the network (50/60 Hz) is entered in the field of the respective phase. The following figure shows the typical characteristic of the phase error over the frequency of the measured signal. The phase error for these current transformers is always positive (capacitive). In the WinPQ mobil software it can therefore be corrected in a range between 0 and +5°. Example: 1.000 means a phase angle correction of an error of +1°.

Typical characteristic of the phase error of current transformers



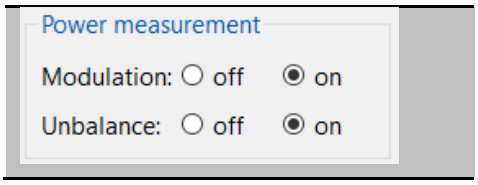
Attention:

DC current measurement is only possible with deactivated "Phase correction" function.

2.1.3 Power calculation setup

The power calculation in the device firmware can be performed in different configurations. The different types of reactive power can be switched on or off as required. This has an influence on the calculation of the collective total power and the apparent power.

Setup of power calculation



Power calculation with calculation of the unbalance reactive power and the modulation reactive power is the factory setting of the device.

This setting has an influence on the power measurement values in the device display, the online measurement data and the recorded measurement data.

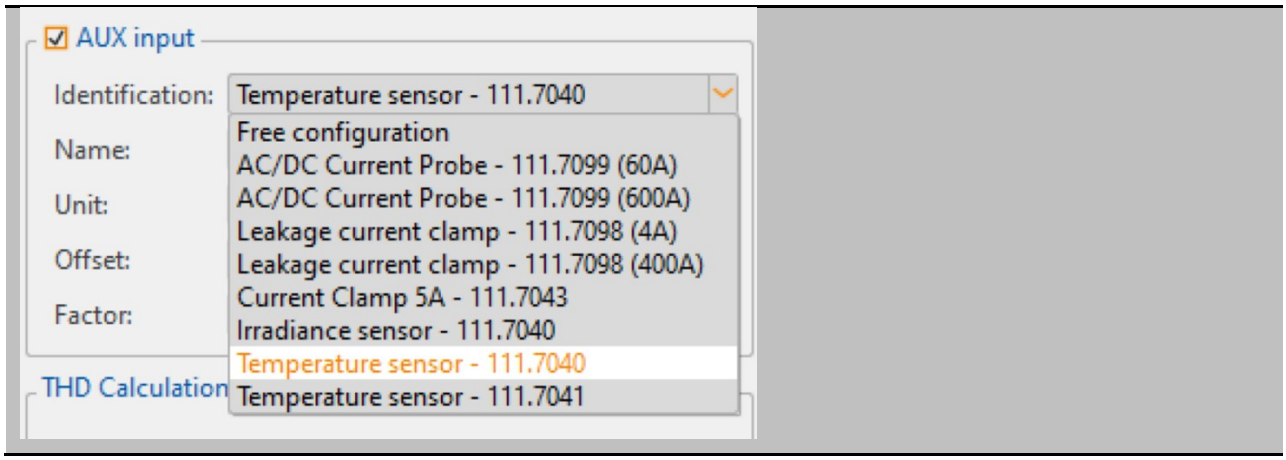
For further information on reactive power calculation, we recommend the following info letter, which can be downloaded from our homepage (www.a-eberle.de).

- Definition and measurement of power measurement quantities according to DIN 40110-2 and IEEE 1459 standard

2.1.4 AUX Input

The models PQ-Box 200 and PQ-Box 300 are equipped with an AUX input, which can be switched on and off via the menu shown below. If the AUX input is active, it appears in the trigger conditions of the oscilloscope recorder and RMS recorder.

Selection menu of all sensors from the accessories catalogue



For all other sensors, the designation is set to "Free configuration". Here is the default setting of the PQ-Box: 1 (unit) = 1 mV.

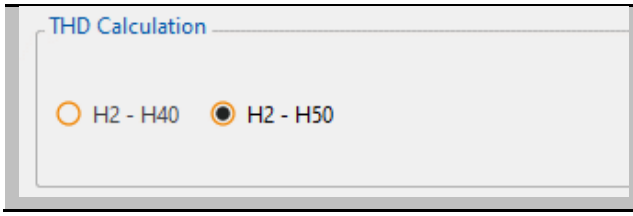
Example: An insolation sensor produces an output signal of 100mV at 1000 W/sqm. So corresponds to 1mV=10W/sqm. In this example, the conversion factor would be the factor 10 and the unit W/qm.

2.1.5 THD Calculation and grouping of harmonics

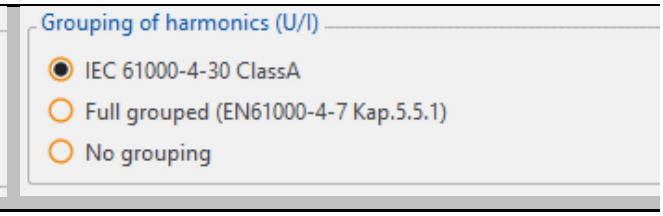
The calculation of the THD values of the voltages and currents can be set in the device setup.

- H2 to H40 (Measurement according to EN50160)
- H2 to H50 (Measurement according to IEC61000-x-x)

THD calculation setup



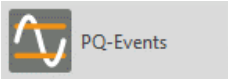
Grouping of harmonics setup



The calculation method for the harmonic groupings can be set depending on the application (voltage quality measurement or device testing).

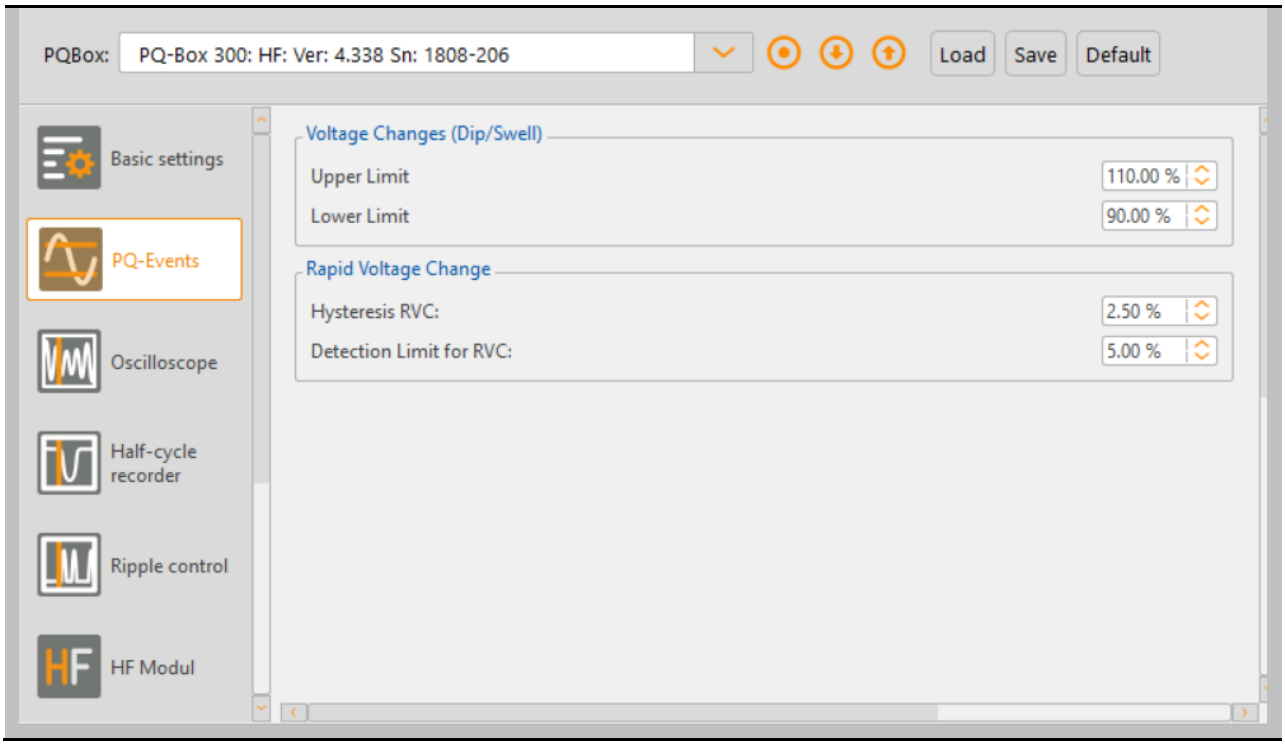
- IEC61000-4-30 Class A for EN50160 measurements
- Full grouped (IEC61000-4-7 Chapter 5.5.1) for device testing according to IEC 61000-3-X
  - Full harmonic group calculation (2nd harm. = 75Hz to 125Hz).
  - Full inter-harmonic group calculation. (2nd interharm. = 55Hz to 95Hz)
- No grouping, single spectral lines without sidebands are stored.

2.2 Setup – PQ Events



In this menu the limit values for the event recording of the PQ box are defined.

Window for changing the thresholds for PQ event recording



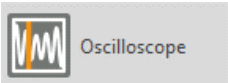
The limit values for PQ events can be set independently of the statistical evaluation of the measurement data. If one of the limit values is violated, this event is saved as a PQ event and later displayed in the software as a list or ITIC diagram.

The settings of the PQ event limits cannot be changed after the recording.

Hint:

In older software versions before WinPQ mobil V6.0, all limit values for the standard evaluation were defined in this menu. These can now be defined in the software via **Setup** -> **Report Settings** after the measurement recording.

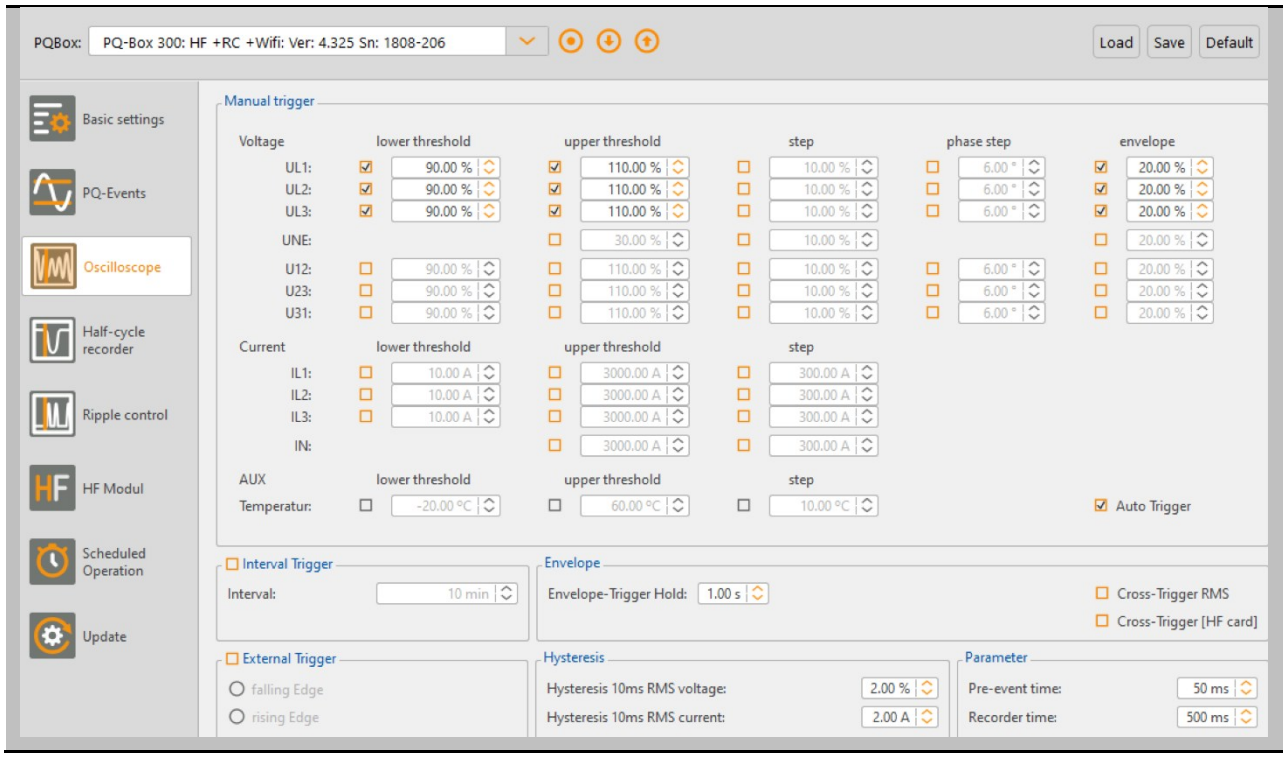
2.3 Trigger settings of Oscilloscope Recorder



Trigger conditions for oscilloscope recorders can be set in the "Oscilloscope" menu item.

In the default setting, an effective value threshold of +10% and -10% of the nominal voltage is set. If a field is greyed out and not marked, this trigger criterion is not active. All trigger conditions can be operated in parallel and are linked as logic “or”.

Oscilloscope recorder settings window



The **recording length** is the total recording time for the oscilloscope record in milliseconds. The "prehistory" is defined as the time recorded before the event occurred. The length of the oscilloscope record, as well as the prehistory can be freely changed from 20ms to 4 000ms

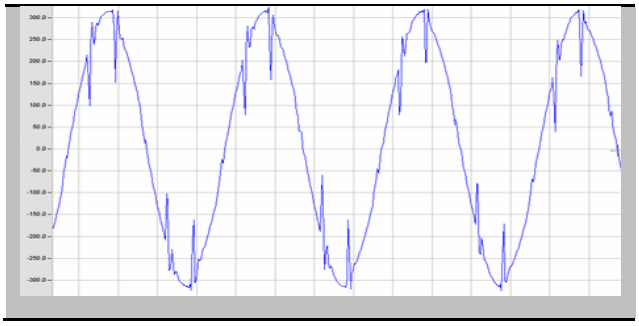
When the **Interval Trigger** is activated, an oscilloscope record is recorded periodically depending on the set interval duration. The FFT function integrated in the software can be used to evaluate the harmonic distortion via the calculated spectrum.

2.3.1 Explanation of trigger conditions

If the trigger thresholds are given in %, the value refers to the nominal voltage that has been setup into the basic settings (e. g. 23000 V in 3 wire grid or 230 V in 4 wire grid).

lower threshold [%]	Starts a recording when the value falls below the set trigger threshold. Trigger basis are the 10ms effective values.
upper threshold [%]	Starts a recording when the set trigger threshold is exceeded. Trigger basis are the 10ms effective values.
step [%]	Starts a recording at an RMS value jump in the set height. Trigger basis are the 10ms effective values.
phase step [°]	Starts a recording at a phase shift. Trigger basis is a shift of the sine zero crossings in degrees.
envelope [%]	Starts a recording in case of a sinusoidal violation. The encoder detects a violation of the sine wave at the sampling level. (e.g. commutation notches).

Example: Commutation notches causing the envelope trigger to start a recording.



Dead-time of envelope trigger:

The dead time envelope trigger can very quickly produce a very large number of oscilloscope images. To reduce the amount of data you can set a fixed time interval between the individual recordings.

Example: Dead-time = 5 seconds

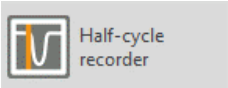
At the end of an oscilloscope recording the trigger condition "envelope trigger" is deactivated for 5 seconds. All other trigger settings continue to work without a dead-time.

Hysteresis: In the IEC61000-4-30 standard a hysteresis is provided for events.

Example: Limit for a voltage dip = 90% - Hysteresis = 2%

A network breakdown begins with the 90% limit line being exceeded and is ended when the network voltage reaches 92% (+2%) again.

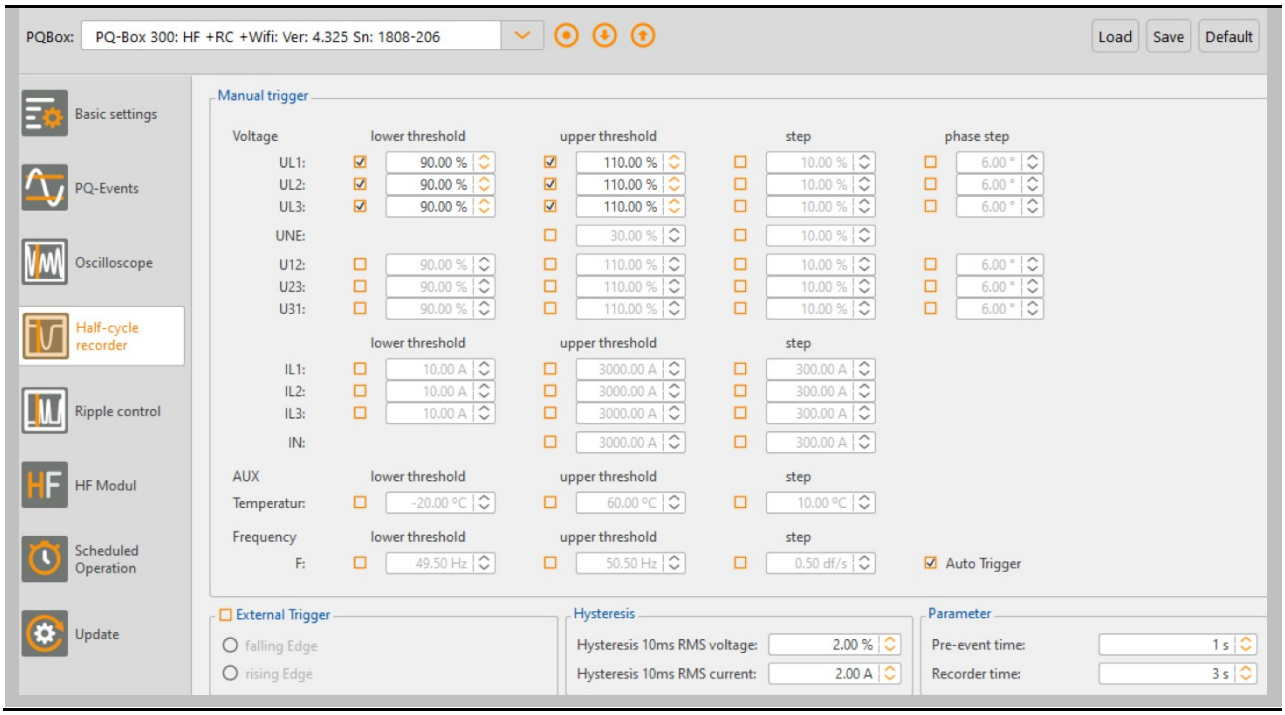
2.4 Trigger settings of half-period recorder



Trigger conditions for half-period recorders can be set in the "10ms RMS recorder" menu item.

In the default setting, an effective value threshold of +10% and -10% of the nominal voltage is set. If a field is greyed out and not marked, this trigger criterion is not active. All trigger conditions can be operated in parallel and are linked as logic “or”.

Half-period recorder settings window



Explanation of the trigger condition Frequency trigger:

The RMS recorder can be started when a frequency threshold (Hz) is undershot or overshot, and when a frequency gradient (Hz/s) is exceeded.

The **recording length** is the total recording time for the oscilloscope record in seconds. The prehistory is defined as the time recorded before the event occurred.

The length of the recording, as well as the **prehistory** can be freely changed from 1 second to 600 seconds.

2.5 Automatic Trigger

The automatic trigger function for the oscilloscope recorder and half period recorder can be separated enabled or disabled.

If enabled, the PQ-Box changes independently for all enabled trigger thresholds, in case of a too sensitive threshold. This prevents the recording of unnecessarily large amounts of data.

The "automatic trigger" acts for each threshold selectively and can increases all these limits (e.g. the upper and lower threshold, the step, the phase shift or the wave shape trigger)

Should a power failure occur, which leads to a continuous violation of the lower trigger threshold, the limit is automatically reset to a pre-set value.

Implementation of the automatic trigger:

Three timers act to decrease the sensitivity of the affected trigger level. The trigger levels for the upper threshold, lower threshold, step, phase shift and wave shape triggers are each adjusted independently.

- **Expansion threshold:**

This timer acts to decrease the trigger sensitivity based on an exponential function. The larger the difference between the actual trigger condition and the setting, the larger decrease in sensitivity is applied.

- **Hold threshold**

If a new trigger condition occurs that is just slightly higher than the last trigger level, that new trigger level is used as the threshold for the next 600 seconds (the 'hold threshold').

- **Approximation threshold**

At the end of the ‘hold threshold’, the 'approximation threshold' timer adjusts exponentially the threshold back to the setting value.

Using the automatic trigger function the user can ensure that the highest interference will be recorded always.

Hint:

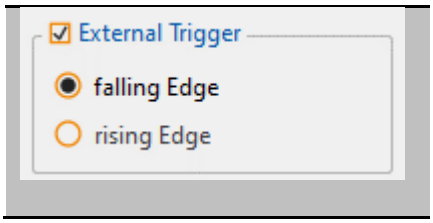
For short measurement tasks or with custom trigger thresholds, please turn the automatic trigger function always off.

Do you want to capture measurement data over a long period (> 5 days) and you do not know the exact conditions of the network? Then the auto-trigger function helps when the thresholds are set too low to not fill immediately the device memory.

2.6 Trigger via binary input (only PQ-Box 200/PQ-Box 300)

Oscilloscope recorders and half-period RMS recorders can be triggered via a binary input on the PQ-Box 200 and PQ-Box 300 models. For models where this function is not available, the function is deactivated in the parameterization interface.

Setup of external trigger



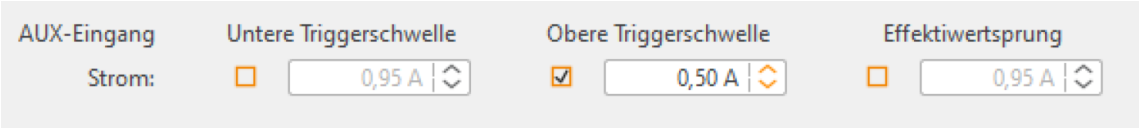
A digital input for an external trigger signal is available via two 4 mm sockets. This input starts the oscilloscope and/or half-period RMS recorder.

AC and DC signals up to 250 V can be used. A trigger can be activated by a rising or falling edge. The threshold value is 10 V.

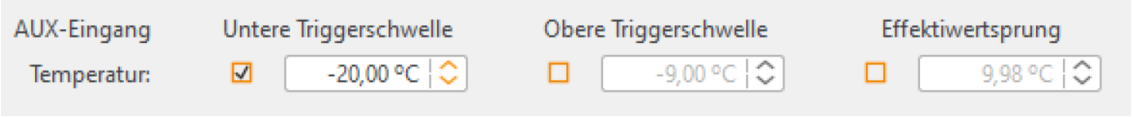
2.7 Trigger by AUX input (only PQ-Box 200/PQ-Box 300)

Wurde der AUX-Eingang aktiv geschaltet in den Grundeinstellungen (siehe 2.1.4) so erscheint dieser Kanal auch in der Auswahl der Triggerbedigungen für den Oszilloskoprekorder und ½ Perioden RMS Schrieb. Der Name des AUX-Einganges sowie die Einheit werden an dieser Stelle der Triggerbedingungen angezeigt.

Example 1: Trigger when a residual current of 0.5A is exceeded



Example 2: Trigger on falling below a temperature of -20°C

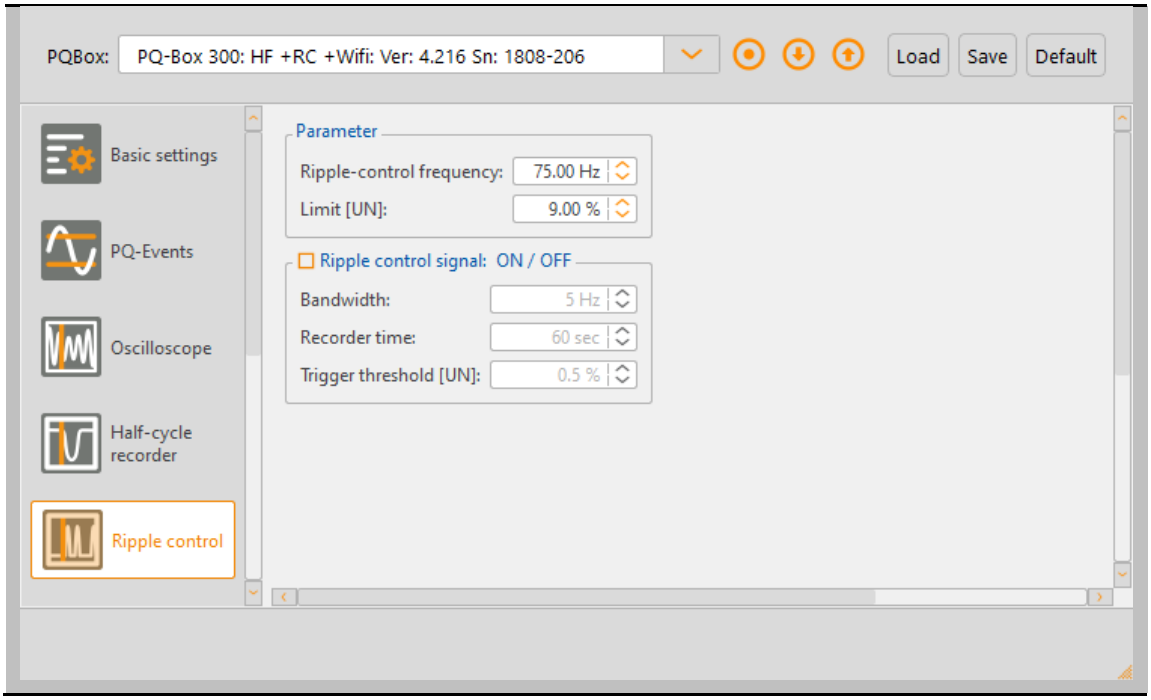


2.8 Ripple control signal analysis

Rundsteuer Parameterization of ripple control recorder.

The ripple control frequency setting is available on every PQ-Box model. The ripple control recorder can only be activated if the PQ-Box has license R1.

Setup of ripple control frequency



In the ripple control signal frequency field any frequency can be entered in the range from 100 Hz to 3,750 Hz. This frequency now will be permanently recorded as a maximum value of 200ms interval in the cyclic data.

If the frequency is set smaller than 100Hz, the 3 sec. recordings for this signal stop.

Option ripple signal recorder (R1):

If the option “ripple signal recorder” activated in the PQ-Box, it is possible to start a high speed recorder that monitors this frequency.

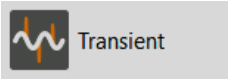
You can setup the frequency of the signal, the bandwidth of the filter, the recorder time length and the trigger threshold voltage. The maximum recorder length is 210 seconds.

PQ-Box with licensed/active optional “Ripple Signal Recorder” can be identified by the LCD display (6th Screen) showing “+S” after the PQ-Box 150 type.

Attention

The ripple control recorder can generate large amounts of data and should only be switched on when a specific disturbance in the signal course is being searched for.

2.9 Transient board setup (only PQ-Box 200 with Option T1)



Parameterization of transient board

In the Transient board section, the following parameters are set for recording:

Voltage Trigger

Trigger threshold for the triggering of the transient recording.

For the trigger threshold only the amplitude of the transient is considered, the amplitude of the fundamental can be neglected. The trigger threshold must always be entered as a secondary value!

Sample Rate

The sampling rate can be set between 200kHz and 4MHz. The recording time depends on the sampling rate and is defined as follows:

- **4MHz = 16ms**
- **200kHz = 320ms**

Pre-history is always 50 % of total recorder length.

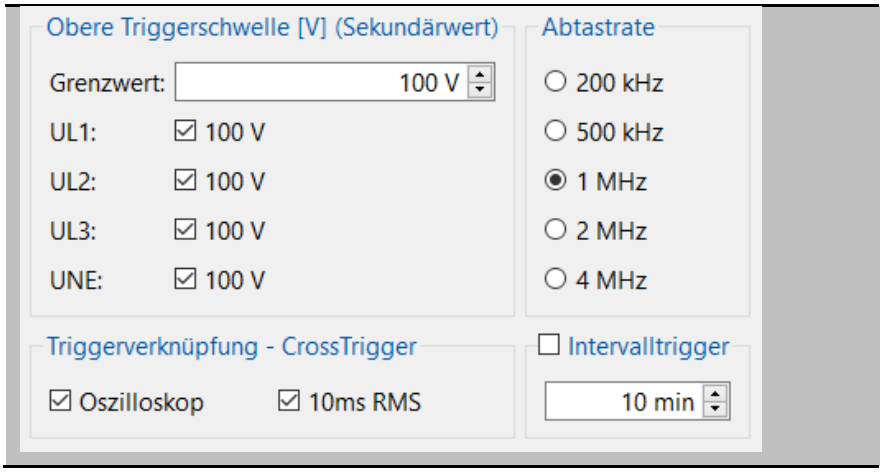
Transfer Trigger

With this function the oscilloscope recorder and/or the RMS recorder can be started simultaneously with the transient recording.

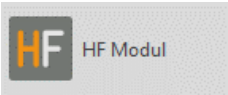
Interval Trigger

The interval trigger automatically starts recording in the set interval. The cross trigger is not activated for records that have been trigger by interval trigger.

Settings of transient board



2.10 High Frequency module (PQ-Box 300 only)



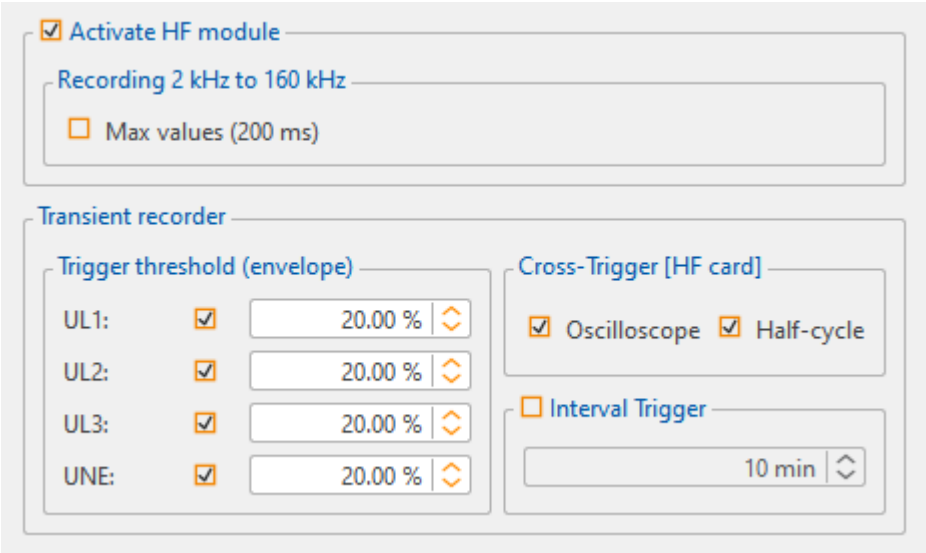
The PQ-Box 300 can be parameterized for the recording of supraharmonic voltages.

Following settings are possible:

Activate HF module This setting can be used to switch the detection of the frequencies 9 kHz to 160 kHz on and off. The PQ-Box records the entire frequency range with 200 Hz frequency bands.

200ms Maximalwerte For supraharmonics, as with almost all other measured variables, the average value is formed over the set measurement interval. In addition, the 200ms maximum values for recording can be switched on and off here.

Cross-Trigger If the trigger threshold is exceeded, the oscilloscope or half-cycle recorder can optionally be triggered and recorded.



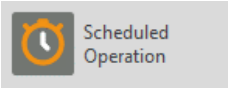
The PQ-Box records all supraharmonic voltages, as well as the harmonic voltages, depending on the set network type (see chapter **Error! Reference source not found.**):

L-N: 1-wire, 4-wire, split-phase, DC 2-wire

L-L: 3-wire, V-circuit, Delta High-Leg, Open Delta, Delta grounded

N-E: is calculated for 3-wire configuration

2.11 Scheduled Operation



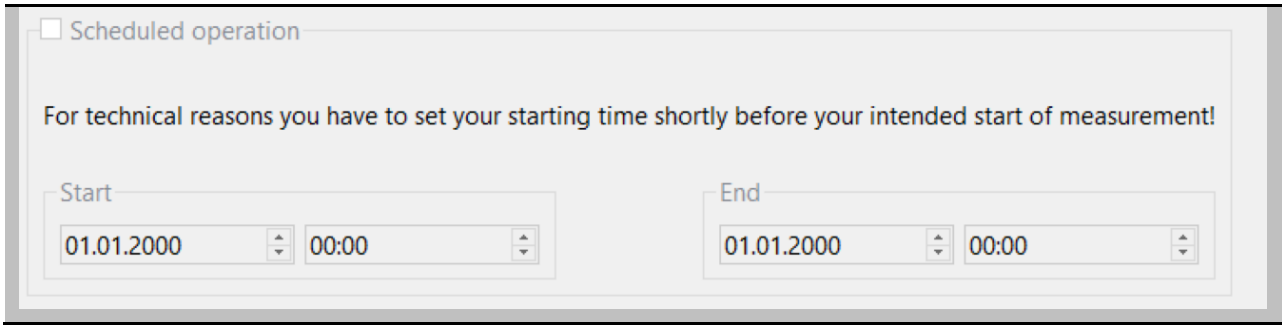
Time synchronization and scheduled measurement jobs.

Programming the PQ box via a time job

It is possible to start and stop the PQ box via a preset time schedule.

Example:

The PQ Box is scheduled to start autonomously at 10 a.m. on Oct. 24, 2020, and stop on Oct. 31, 2020



If the start button on the PQ box is pressed before the measuring job, the box starts recording immediately.

If the stop button on the PQ box is pressed before the end of the measuring job, the measurement is stopped immediately.

2.12 Network configuration PQ-Box

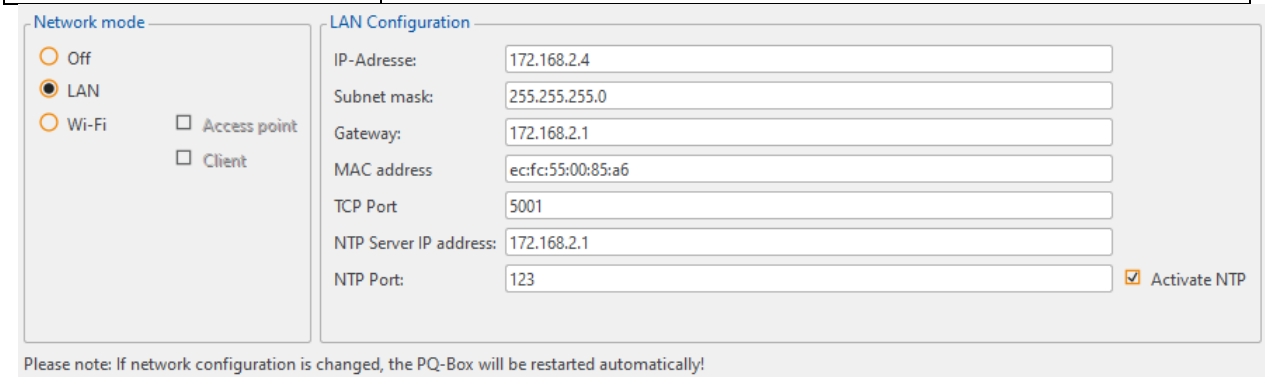
Parameterization of the network configuration of a PQ-Box.

Four options can be selected as a network mode :

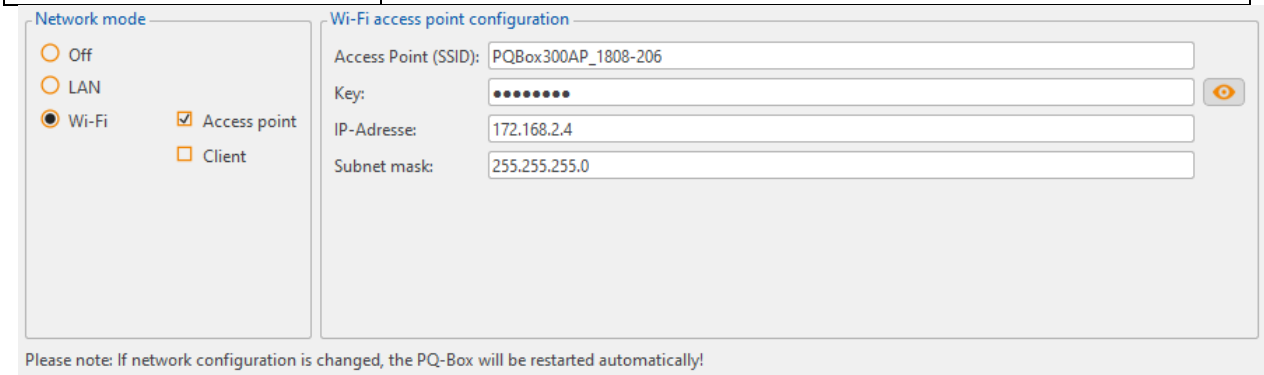
Off	Network interface of the PQ-Box is deactivated
LAN	Communicating via ethernet (for PQ-Box 150, 200, 300 only)
Wi-Fi Access Point	PQ-Box broadcasts its own Wi-Fi network. The SSID can be found on the label
Wi-Fi Cient	Connect the PQ-Box as a client to an existing Wi-Fi network

Each mode can be configured individually as described in the following.

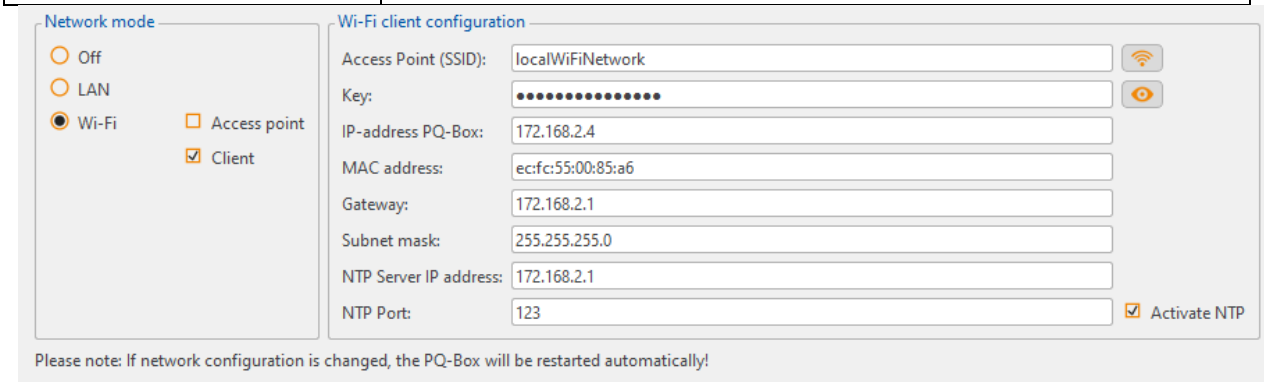
Mode: LAN	
IP address	IP address of the PQ-Box. Default: 172.168.2.4
Subnet mask	Defines the range of the subnet. Default: 255.255.255.0
Gateway	Gateway for communicating with other (sub)nets
MAC address	Unique MAC address of the PQ-Box
TCP Port	Default: 5001
NTP Server IP address	For using the Network Time Protokoll: IP address of the NTP server
NTP Port	Default: 123



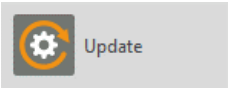
Modus: Wi-Fi Access Point	
Access Point (SSID)	Name of the Wi-Fi network
Key	Default: last 8 characters of the serial number including dash
IP address	IP address of the PQ-Box. Default: 172.168.2.4
Subnet mask	Defines the range of the subnet. Default: 255.255.255.0



Mode: Wi-Fi client	
Access Point (SSID)	Name of the Wi-Fi network
Key	Password of the local Wi-Fi network
IP address	IP address of the PQ-Box. Default: 172.168.2.4
MAC address	Unique MAC address of the PQ-Box
Gateway	Gateway for communicating with other (sub)nets
Subnet mask	Defines the range of the subnet. Default: 255.255.255.0
NTP Server IP address	For using the Network Time Protokoll: IP address of the NTP server
NTP Port	Default: 123



2.13 Firmware Update



Update of device firmware and licence upgrade

In the "Update" menu section, the firmware of the power analyzer can be updated, or the device can be upgraded with additional functions via a license code.

Firmware Update PQ-Box

A firmware update can be transferred to the measuring device via the USB interface as well as the TCP or WLAN interface.

Step-by-step instruction:

Step 1 Plug-in the power supply.

Step 2 Stop running measurement.

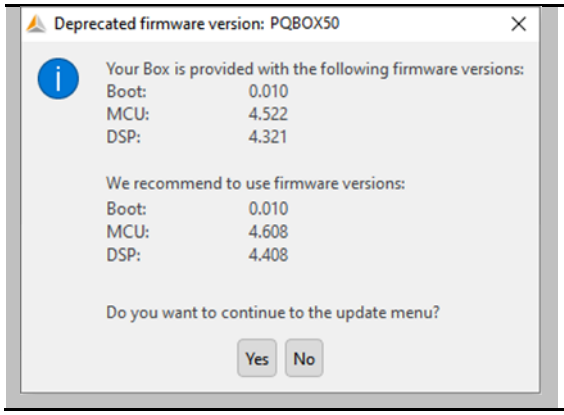
Step 3 Connect the PQ-Box to the PC via USB or WLAN/TCP network and start WinPQ mobil software.

Step 4 Confirm message "We recommend an update" with **Yes**.

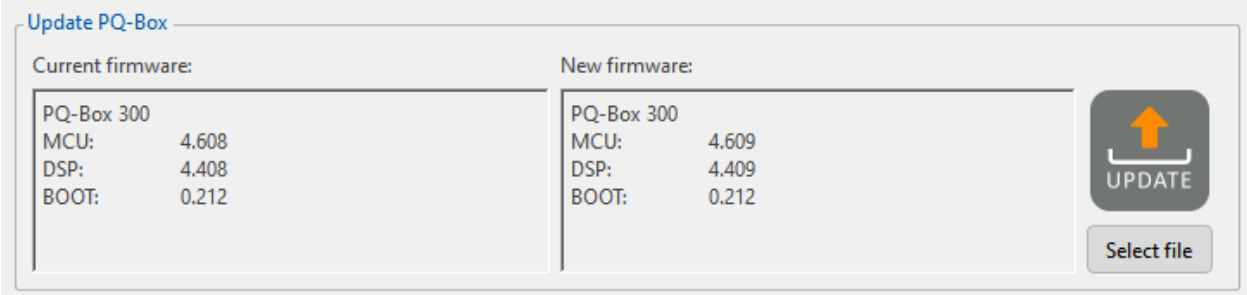
Start the Firmware Update.

Step 6 PQ-Box reboots automatically after the update is finished.

Update notification

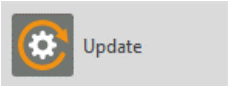


The software verifies the firmware status when connecting to the PQ-Box. If a newer firmware is available, the following message appears. By clicking Yes, WinPQ mobil automatically opens the update menu.

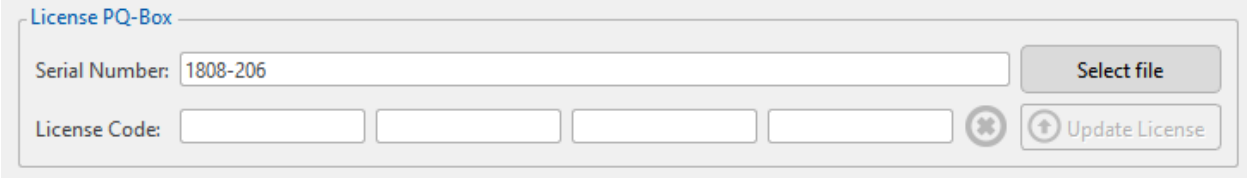


WinPQ mobil automatically selects the current Firmware. Click on “UPDATE” to start the process.

2.14 Lizence upgrade PQ-Box



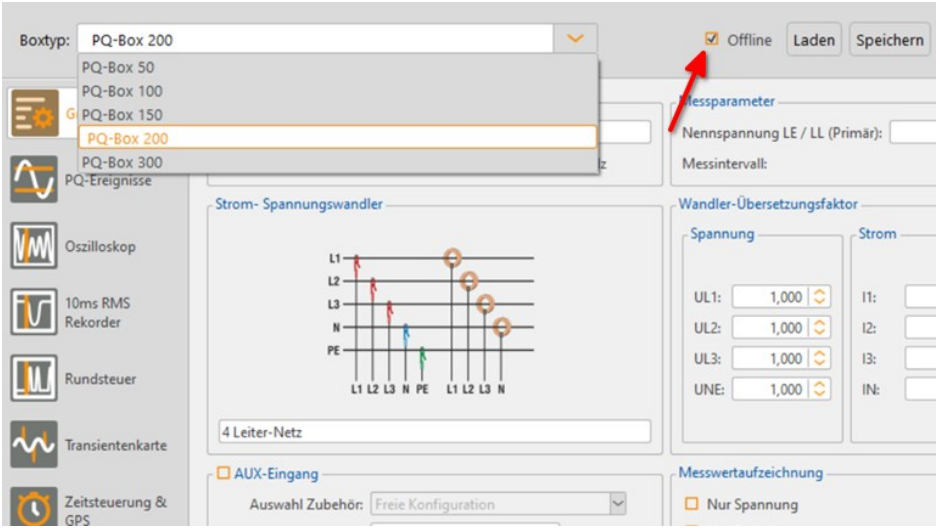
Update of device firmware and licence upgrade



The serial number of the selected measuring device appears automatically in the interface shown above. The purchased license code can be entered below and activated for the device by clicking on “Update license”. The console below logs the process and shows the progress and result of the update.

2.1 Offline-Parametrierung einer PQ-Box

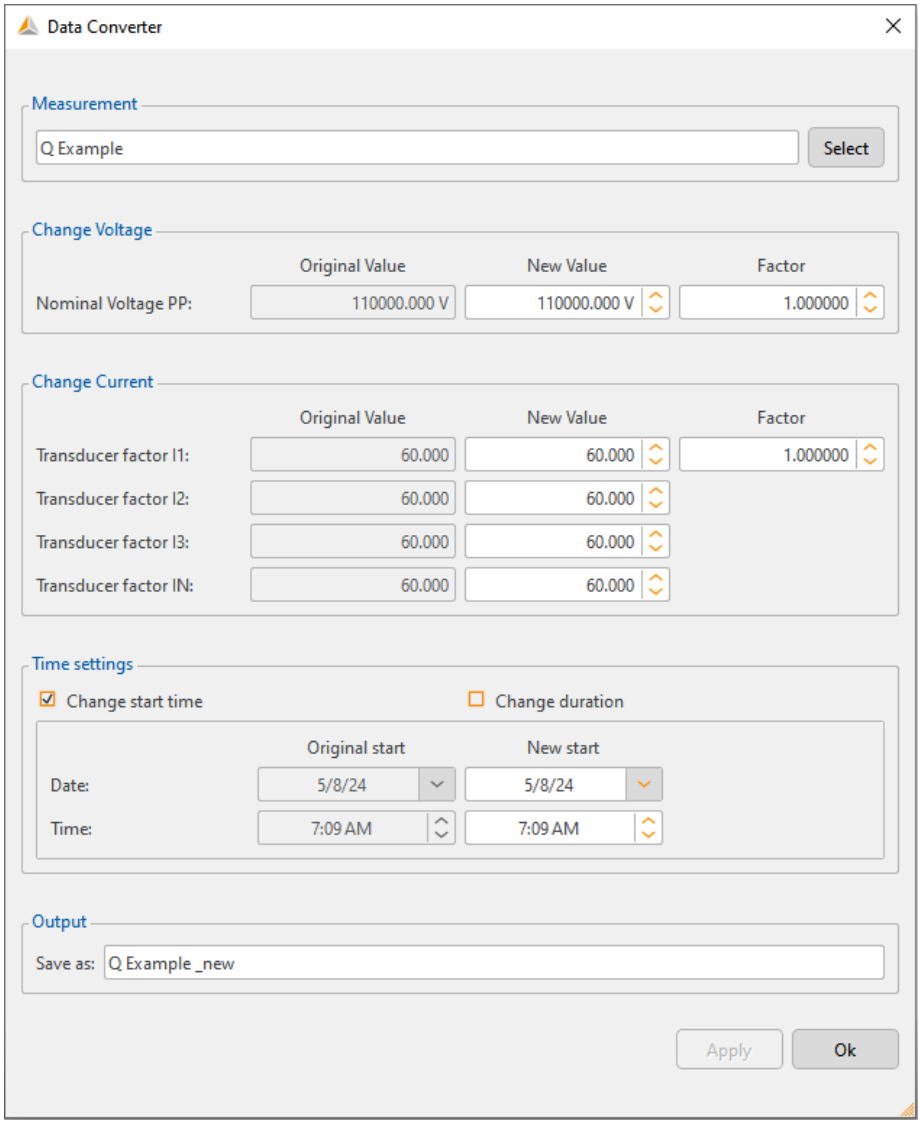
If you want to parameterize a template file for a PQ-Box without having a device connected, switch on the “Offline” function and select the desired PQ-Box variant.



3. Edit measurement data

3.1 Data converter

With the tool "Data converter" it is possible to make corrections of an existing measurement file. If an incorrect nominal voltage or an incorrect current transformer factor was specified during parameterization of a PQ box, this can be subsequently changed here.



It is also possible to change the time stamp of the measurement file as well as the duration.

Step 1 Open the measurement file to be changed via “Select” button.

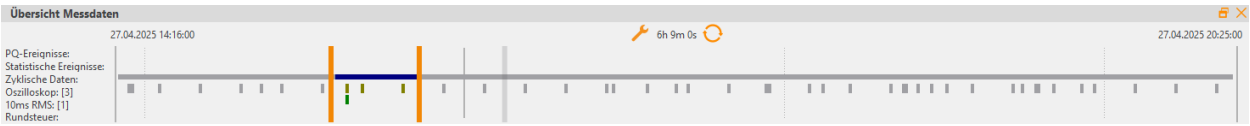
Step 2 Enter the correct voltage value or current transformer factor. At ‘Time settings’ the start time or the duration can be edited.

Step 3 With Apply, the measurement data is now converted and saved as a copy of the original file.

The corrected measurement file is now saved as a copy of the original file with the extension "_new" in the original directory. If everything is correct, the original file can now be deleted. An edited file can be edited again at any time**.**

In the “Measurement data overview” window, the start and end of the recording can be set using the two orange lines on the left and right edges.

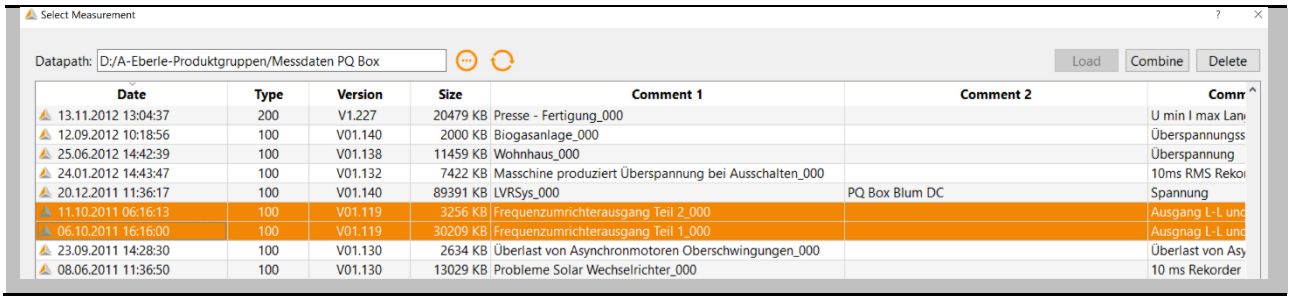
Hold down the left mouse button and drag the lines to the desired position and click on the symbol to open the data converter with automatically filled fields for the new start and end of the recording.



3.2 Combining partial measurements into a total measurement

From WinPQ mobil version 5 on, it is possible to connect partial measurements directly in the measurement data administration.

Connection of single measurements



Date	Type	Version	Size	Comment 1	Comment 2	Comm
13.11.2012 13:04:37	200	V1.227	20479 KB	Presse - Fertigung_000		U min I max Lan
12.09.2012 10:18:56	100	V01.140	2000 KB	Biogasanlage_000		Überspannungss
25.06.2012 14:42:39	100	V01.138	11459 KB	Wohnhaus_000		Überspannung
24.01.2012 14:43:47	100	V01.132	7422 KB	Masschine produziert Überspannung bei Ausschalten_000		10ms RMS Reko
20.12.2011 11:36:17	100	V01.140	89391 KB	LVRSys_000	PQ Box Blum DC	Spannung
11.10.2011 06:16:13	100	V01.119	3256 KB	Frequenzumrichterausgang Teil 2_000		Ausgang L-L und
06.10.2011 16:16:00	100	V01.119	30209 KB	Frequenzumrichterausgang Teil 1_000		Ausgnag L-L und
23.09.2011 14:28:30	100	V01.130	2634 KB	Überlast von Asynchronmotoren Oberschwingungen_000		Überlast von Asy
08.06.2011 11:36:50	100	V01.130	13029 KB	Probleme Solar Wechselrichter_000		10 ms Rekorder

If multiple measurements are selected, several partial measurements can be combined into a new measurement file using the **Combine** button.

4. Online-Analysis

Open online analysis.

PQBox Select a PQ-Box from device list.

Start online data stream.

Stop online data stream.

Using the online analysis function, RMS values, oscilloscope images, harmonics, interharmonics, and power flow direction of the harmonics are displayed online on the screen of a PC or laptop. The displayed data is refreshed in one-second intervals.

Online measurement is possible during a running measurement, before a started measurement and after a finished measurement.

The presented online windows depend on the measuring device type and the licence. The following table gives an overview of the functions.

Online function	PQ-Box 50	PQ-Box 100	PQ-Box 150	PQ-Box 200	PQ-Box 300
Oszilloskope	**light**	**basic+**	**basic+**	✓	✓
HF Oszilloskope	-	-	-	-	✓
FFT Spektrum	**expert**	**expert**	**expert**	✓	✓
Harmonics	**light**	**light**	**light**	✓	✓
Inter-harmonics	**light**	**light**	**light**	✓	✓
2- 9 kHz Voltage harmonics	-	-	**expert**	✓	✓
2- 9 kHz Current harmonics	-	-	**expert**	✓	✓
9- 160 kHz Voltage harmonics	-	-	-	-	✓
9- 20 kHz Current harmonics	-	-	-	✓	✓
Direction of harmonics	**expert**	**expert**	**expert**	✓	✓
Timing chart	**light**	**basic+**	**basic+**	✓	✓
Power Harmonics	**expert**	**expert**	**expert**	✓	✓
Details	**light**	**basic+**	**basic+**	✓	✓

U/I Phase	**light**	**basic+**	**basic+**	✓	✓
Power	**light**	**basic+**	**basic+**	✓	✓
PQ-Box Status	**light**	**basic+**	**basic+**	✓	✓

4.1 Oscilloscope

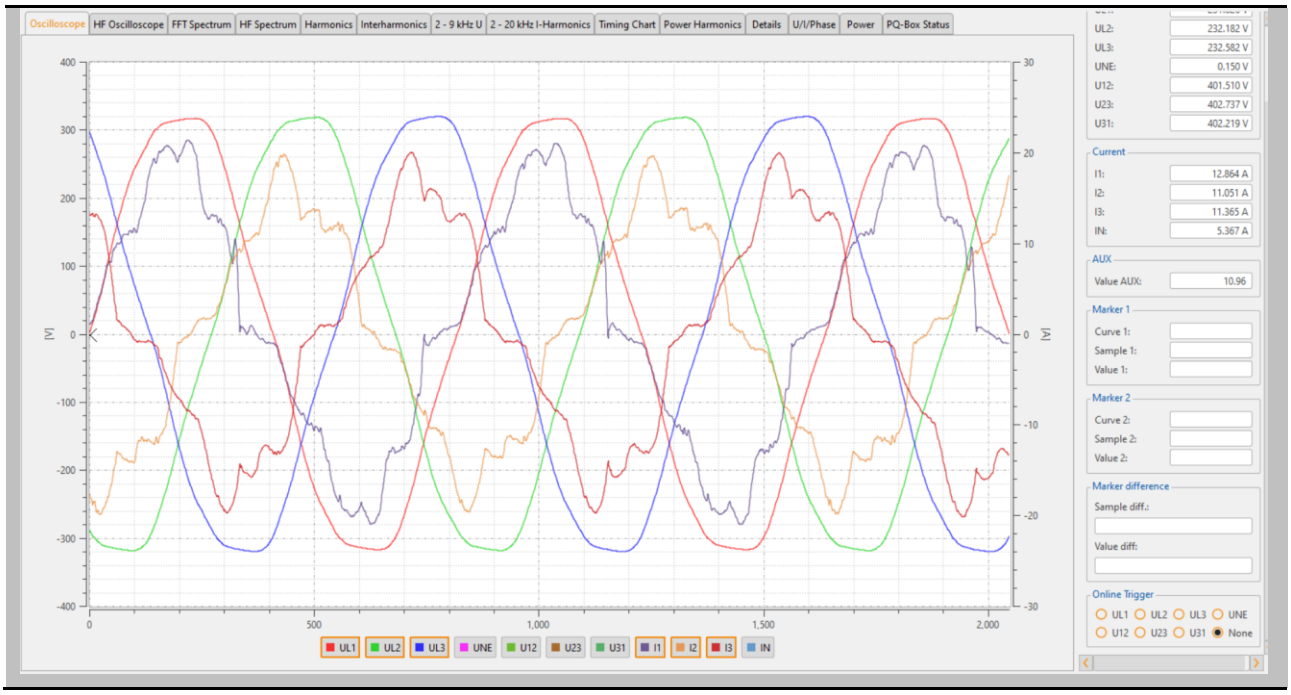
Online oscilloscope images of all voltage and current channels are displayed on the screen via the "Oscilloscope" card. The sampling rate depends on the PQ-Box model used:

Model	Sampling frequency
PQ-Box ONE	**20 kHz**
PQ-Box 50	**20 kHz**
PQ-Box 150	**20 kHz**
PQ-Box 200	**40 kHz**
PQ-Box 300	**40 kHz**

The following channels are displayed and can be activated or deactivated via the legend:

- all voltages „line-to-line“ (U12, U23, U31)
- all voltages „line-to-ground“ (UL1, UL2, UL3, UNE)
- all currents (I1, I2, I3, IN)

Oszilloscope screen



Sampling rate

The length of the time window can be changed via the selection field **Sample** in the upper right corner.

Overview

The column on the right contains important online RMS values and marker information.

If you want to synchronize the oscilloscope waveform to a channel, select a measurement input of the PQ Box.

In this example, the PQ Box automatically synchronizes the displayed oscilloscope image to the zero crossing of the voltage UL1.

4.2 HF-Oszilloskop (only PQ-Box 300)

Via the "HF Oscilloscope" card, online oscilloscope images of all voltage channels are transmitted with a sampling rate of 409.60 kHz.

The following channels are displayed:

- all voltages „line-to-ground“ (UL1, UL2, UL3, UNE)

HF Oszilloscope card

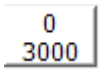
The voltage channels can be activated or deactivated via left click into the legend.

4.3 FFT Spectrum

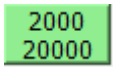
With the measurement function "FFT Spectrum" all harmonics and interharmonics of all currents and voltages can be analyzed online in detailed resolution.

Model	Spectrum
PQ-Box ONE	**DC to 10 kHz**
PQ-Box 50	**DC to 10 kHz**
PQ-Box 150	**DC to 10 kHz**
PQ-Box 200	**DC to 20 kHz**
PQ-Box 300	**DC to 20 kHz**

There is the possibility to choose between the following FFT calculation methods in the online software:

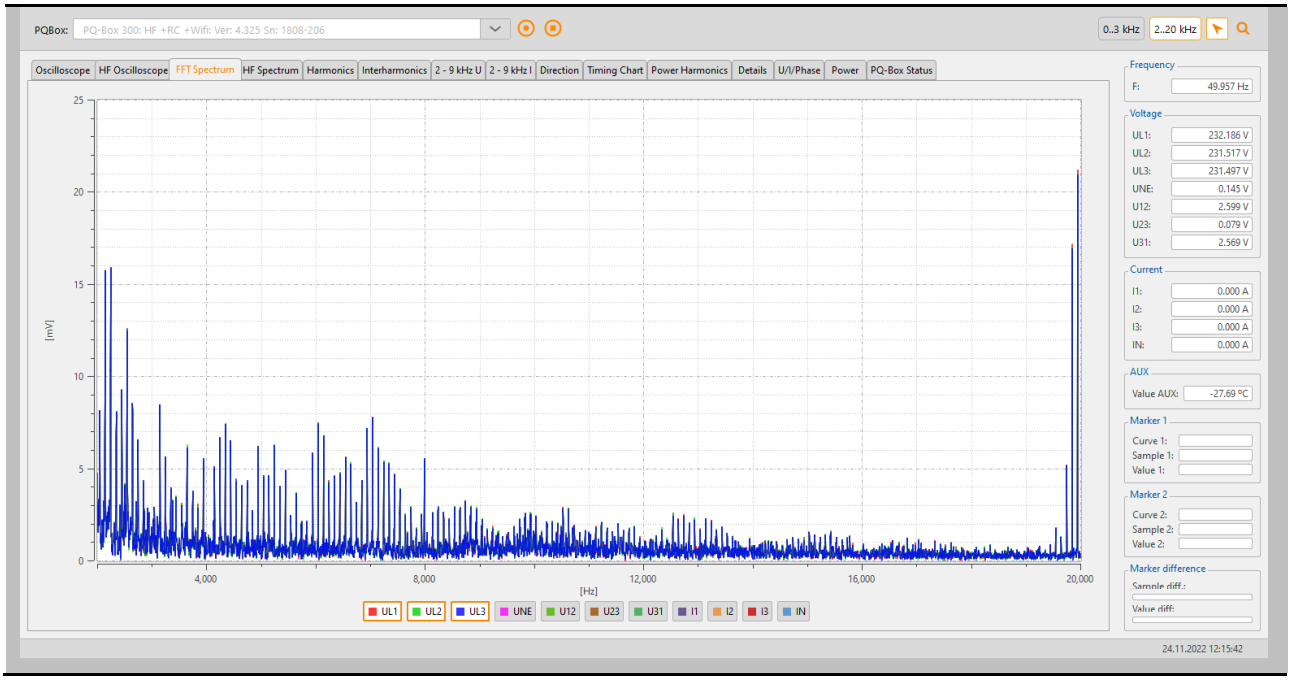


Calculation method IEC 61000-4-30 Class A (grid synchronous).



Calculation method IEC 61000 – 4 – 7

FFT Spectrum card



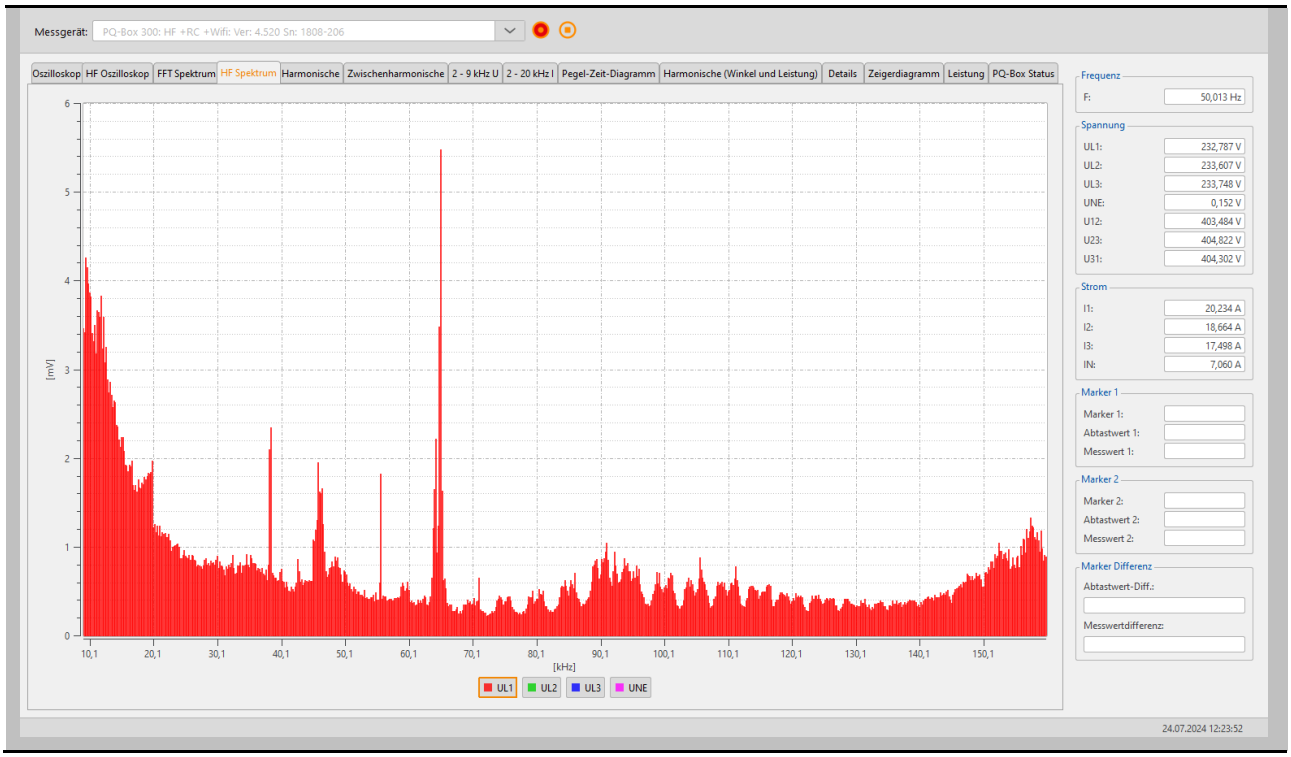
The following functions are available in the "right click" menu:

Print	Current screen image is sent to the printer.
Copy image	The spectrum is copied to the Windows clipboard.
With DC	DC component can be shown and hidden in the graphic.
Divide axis	Separates the screen into two areas for voltages and currents.
Maximum value logging	With the help of this function it is possible to record the maximum values of the spectral lines of the online FFT (dashed line). This makes it possible to determine online whether increased harmonic levels in the range up to 20 kHz occur at the measuring point.

4.4 HF Spectrum (only PQ-Box 300)

The "HF spectrum" window displays all voltage supraharmonics up to a 160 kHz as online measured values.

HF Spectrum view



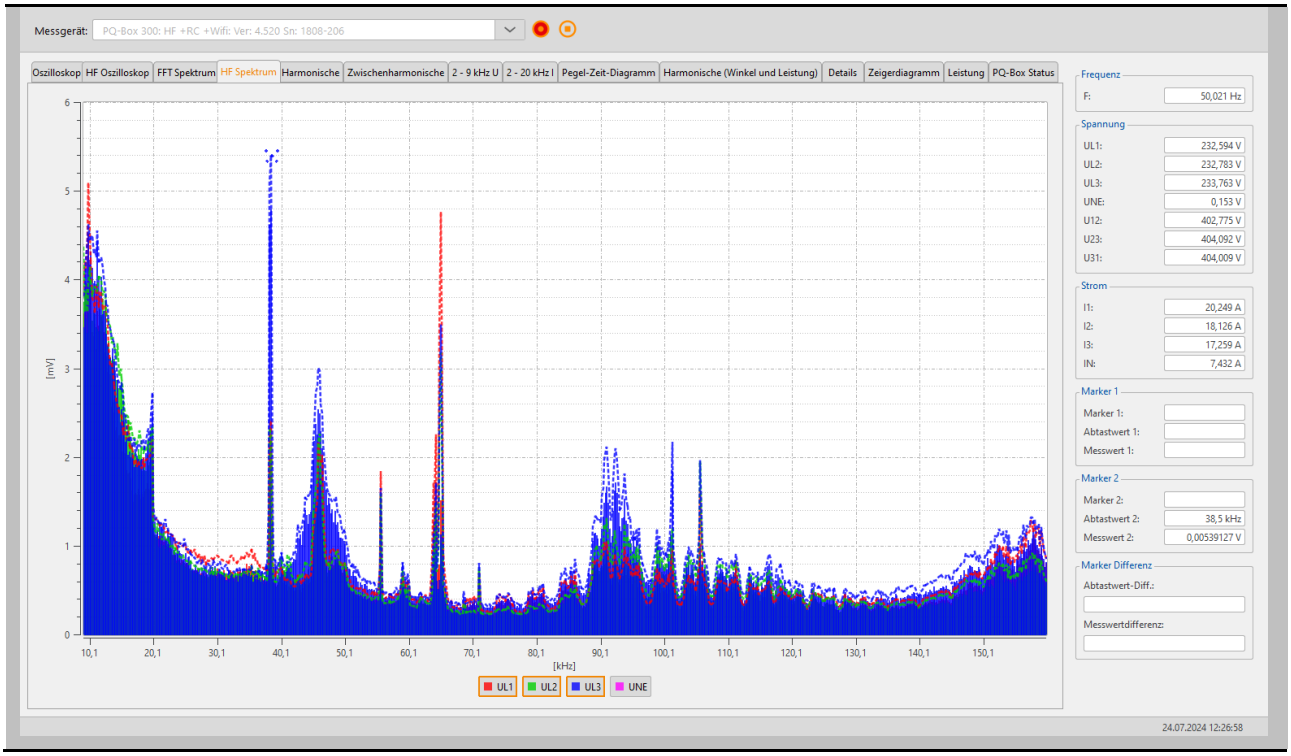
The following functions are available in the "right click" menu:

Limit curve Supraharmonics	Display of the limit line from 9kHz to 150kHz. These limit values can be changed in the main menu "Settings”.

Recording maximum values over a period of time

The “Record maximum values” function can be activated via the right mouse button menu. All maximum values are now recorded over the period from when the function was activated. These are displayed in an envelope curve over all displayed phases.

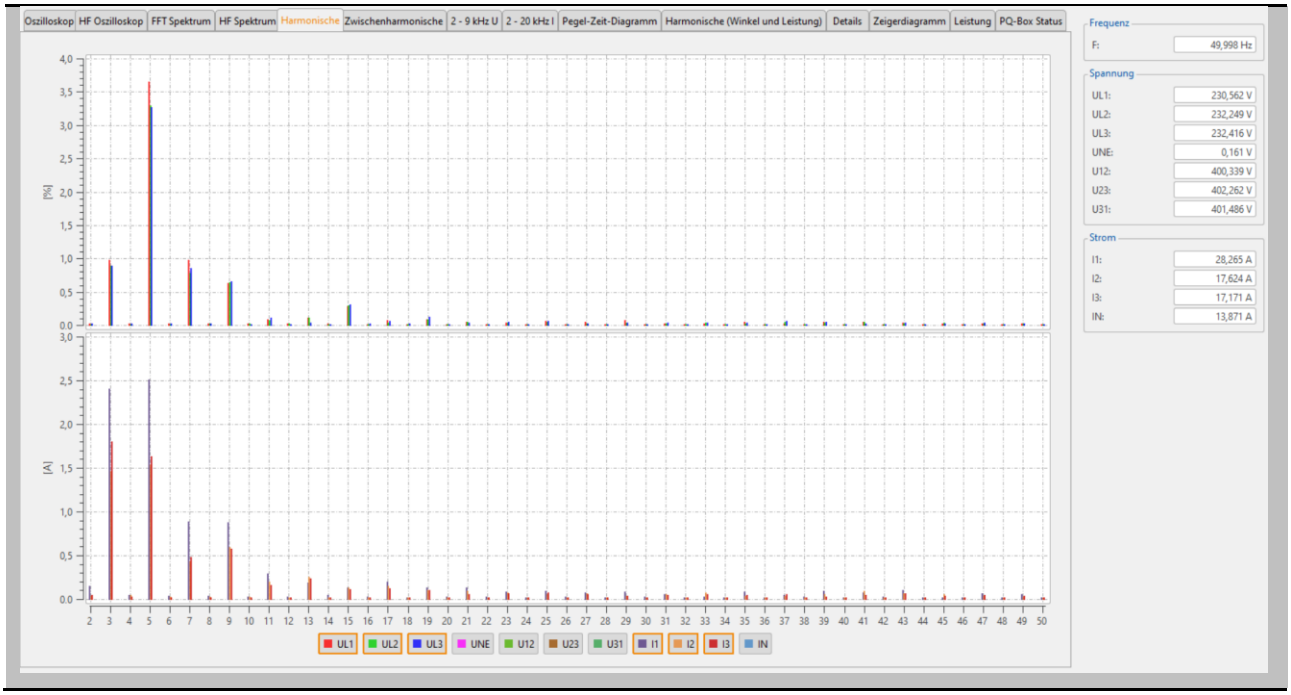
Marker 2 (right mouse button menu) shows an interference level of 38.5 kHz



4.5 Harmonics

All current and voltage harmonics (2nd to 50th) are displayed online via the "Harmonics" card. The measurement data is calculated by the meter according to IEC61000-4-30 class A and transferred to the PC.

Harmonics card



The following functions are available in the "right click" menu:

Print Current screen image is sent to the printer.

Copy image The spectrum is copied to the Windows clipboard.

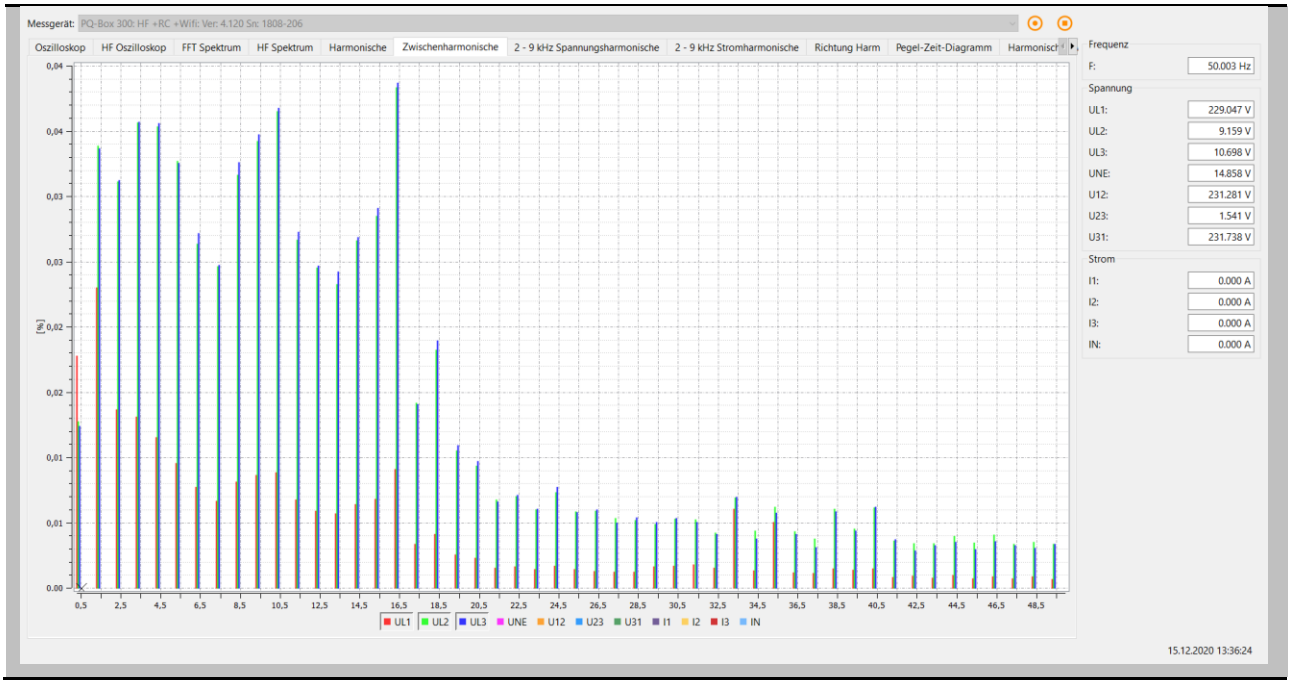
Divide axis Separates the screen into two areas for voltages and currents.

Limit curve Visualize limit value with the help of a horizontal line.

4.6 Interharmonics

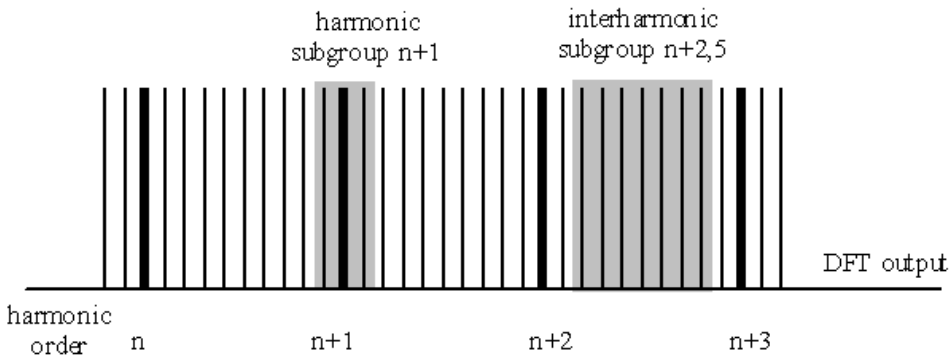
All current and voltage inter-harmonics up to 2,500 Hz are displayed online via the "Inter-harmonics" card. The measurement data is calculated by the measuring instrument according to IEC61000-4-30 Class A using the grouping method and transferred to the PC.

Interharmonics card



Explanation of the grouping procedure according to IEC:

Subgroups are formed to evaluate the interharmonics in the network. All interharmonics between two harmonics are combined to a harmonic subgroup. Example for 50Hz: Interharmonic H2 contains the frequencies 110 Hz to 140 Hz.

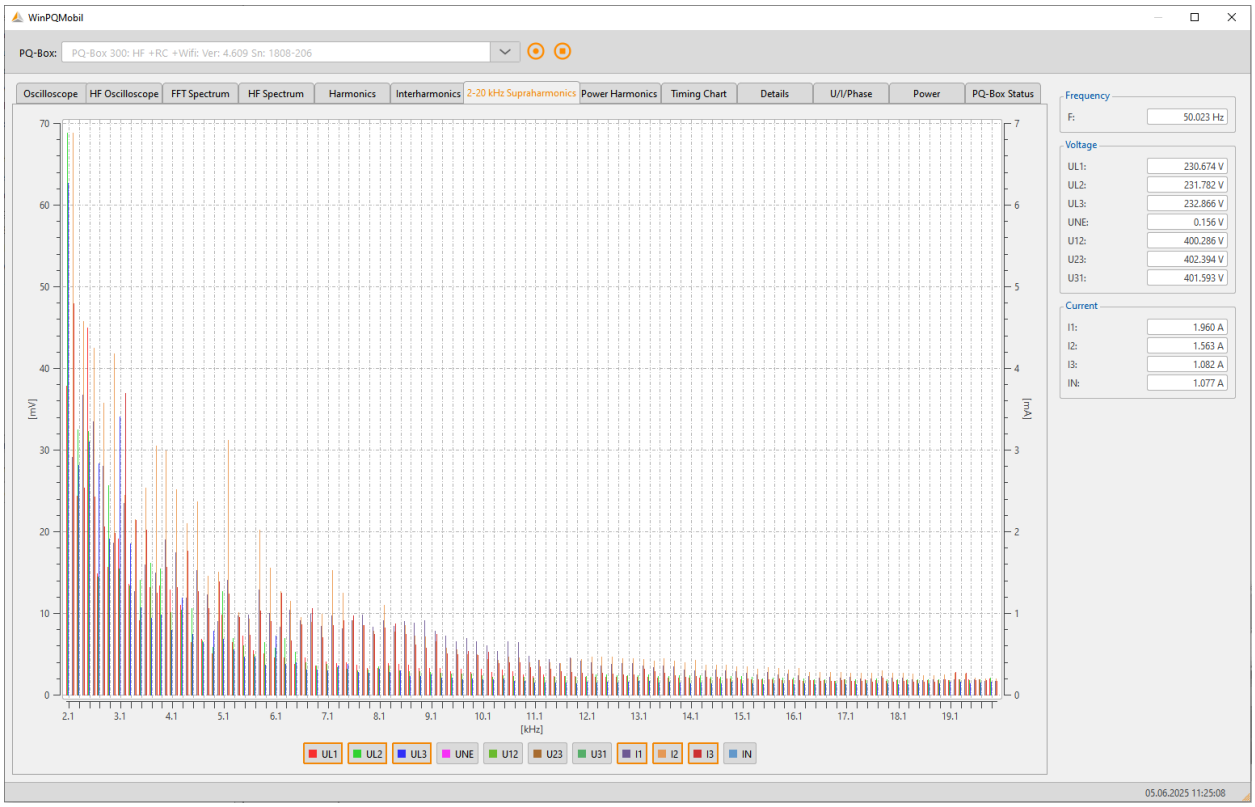


4.7 Supraharmonics 2-9 kHz / 2-20 kHz

Via the card "2 to 9kHz" all current and voltage harmonics are displayed in 200Hz groups. Evaluation is done according to IEC61000-4-7.

It is always the center frequency of the respective frequency band that is displayed.
Example: All frequencies from 8.805Hz to 9.000Hz are in the band 8.9kHz

- PQ-Box 50 Expert - Voltage and current harmonics 2kHz to 9kHz
- PQ-Box 150 Expert - Voltage and current harmonics 2kHz to 9kHz
- PQ-Box 200 - Voltage and current harmonics 2kHz to 20kHz
- PQ-Box 300 - Voltage and current harmonics 2kHz to 20kHz



4.8 Timing Chart

In the "Online timing diagram" voltages, currents, powers and frequency can be observed over an adjustable period of time (1 to 60 minutes).

All measured variables of the PQ-Box can be accessed via the selection window on the left-hand side. The measured values in the online level-time diagram are filled as long as you are in the online data. You can switch between all online windows at will.

Via the right mouse button menu, the scales can be adjusted or the image can be copied to the clipboard.

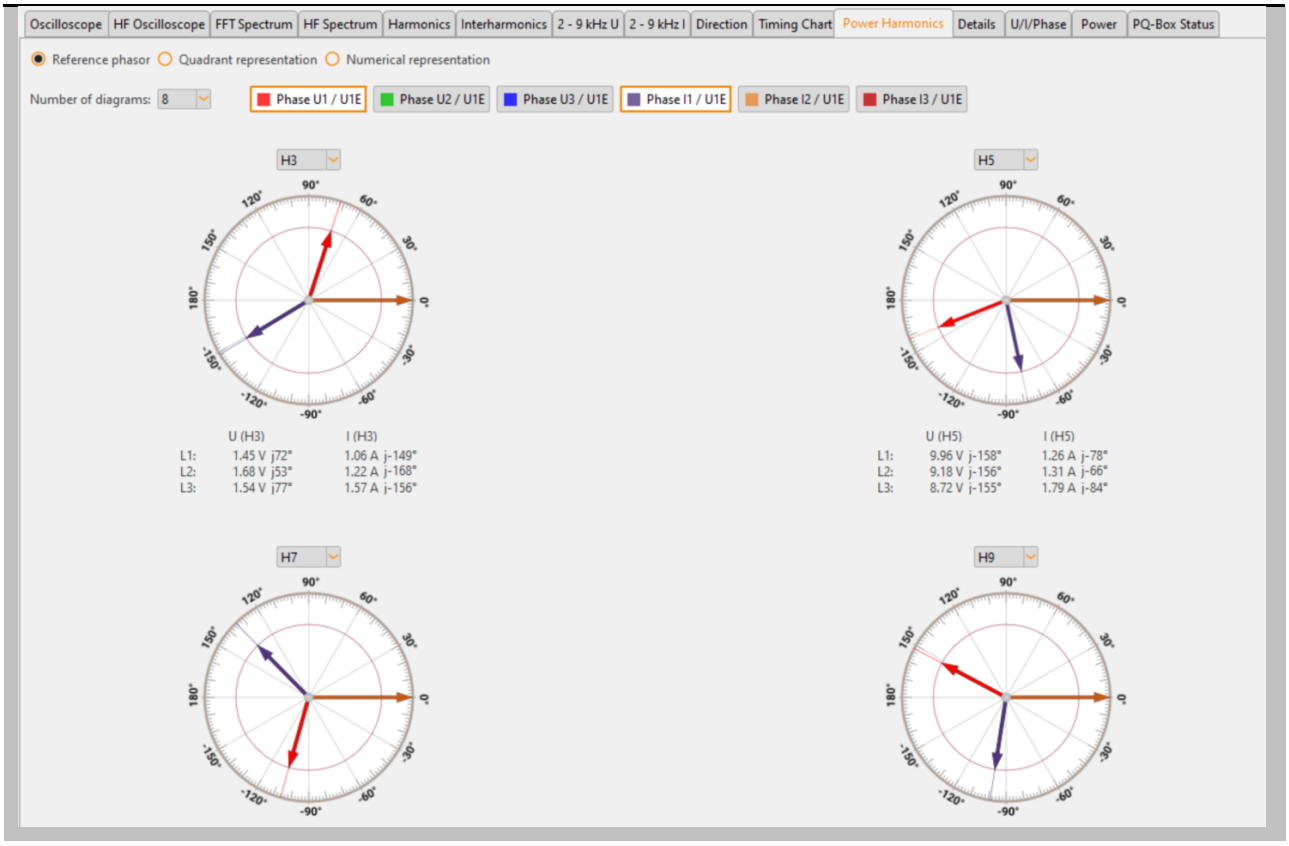
Timing Chart

With the "Clear display" function, the measurement data in the image is deleted and a new recording begins.

4.9 Power Harmonics

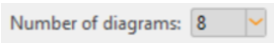
The following charts listing the phase angles and power measurements of the harmonics of 2nd to 40th order.

Reference phasor



The picture above shows the angle of the voltage harmonics and current harmonics with respect to the fundamental voltage.

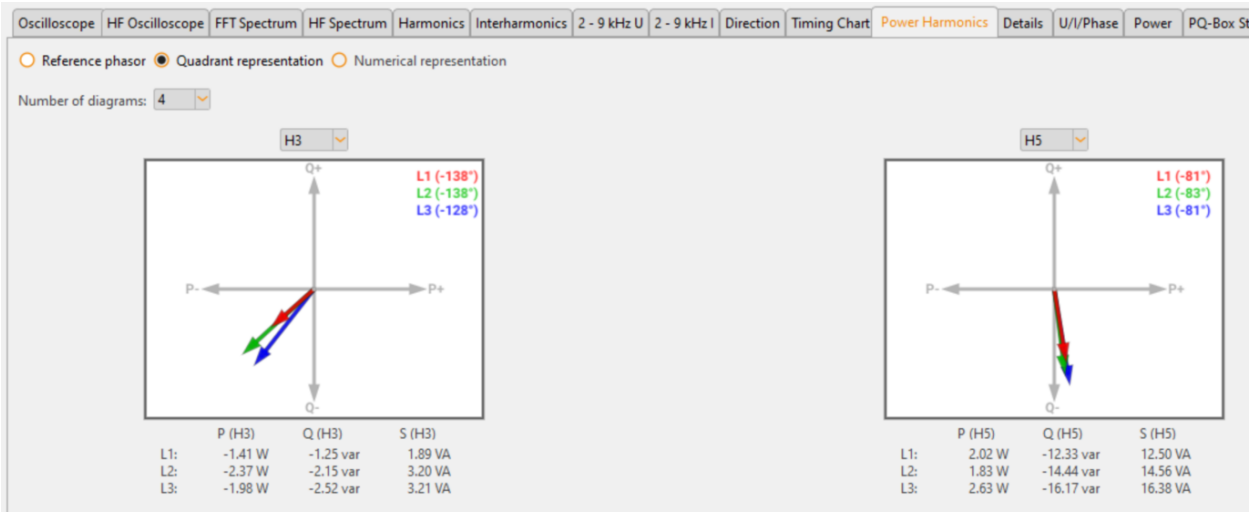
The number of harmonics that you want to display in parallel can be set.



Quadrant representation

In the following diagrams, the phase angle phi of the respective harmonic is used to show the direction of flow of the active power and quadrants 1 to 4.

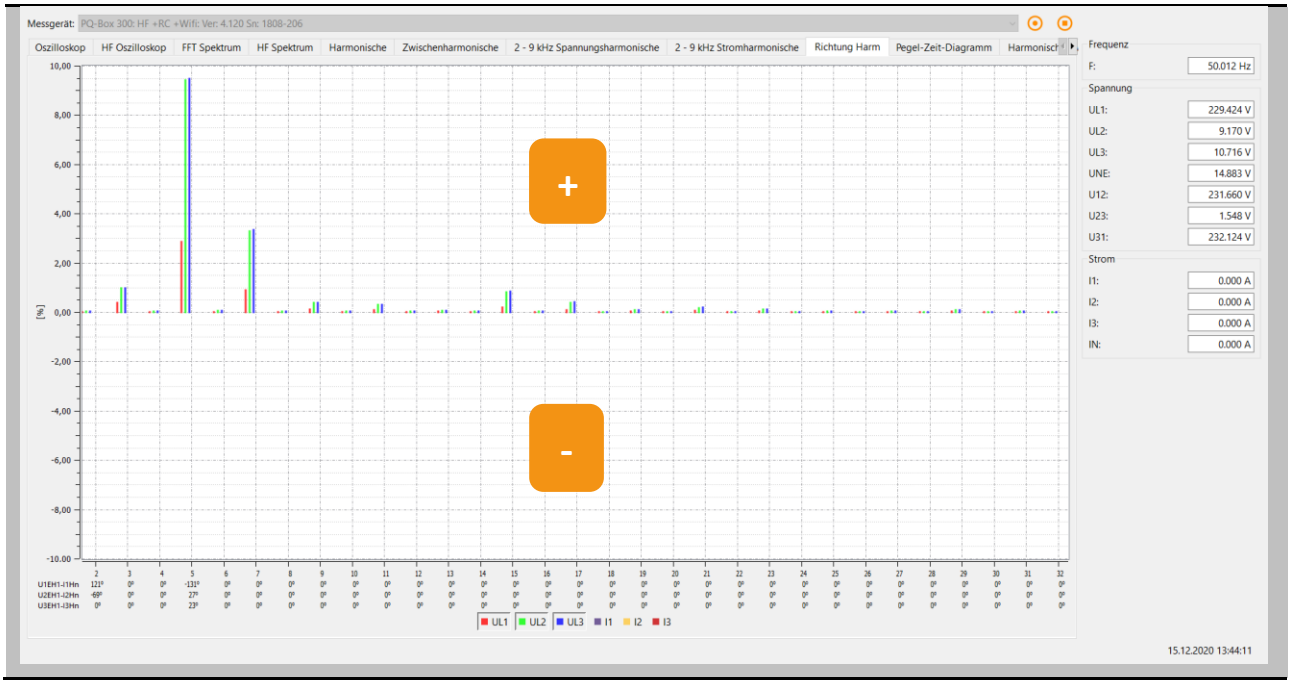
Formula for the 2nd harmonic: $P_2 = U_2 \cdot I_2 \cdot \cos \varphi_2$



This representation shows the power flow of the active power of the selected harmonic.

Direction of harmonics

The "Harmonic direction" map shows the power flow direction of the harmonics at the measuring point. A reading in the positive scale (+) means a power flow directed from the network to the consumer. If the measured value is in the negative scale (-), there is a power flow direction from the consumer to the mains..



Phase angle of the current harmonics:

The measured values in the lower part of the graph show the angle of the current harmonics (2nd to 32nd harmonic) in relation to the respective fundamental of the voltage.

Numerical representation

Oscilloscope | HF Oscilloscope | FFT Spectrum | HF Spectrum | Harmonics | Interharmonics | 2 - 9 kHz U | 2 - 9 kHz I | Direction | Timing Chart | Power Harmonics | Details | U/I/Phase | Power | PQ-Box Status

○ Reference phasor ○ Quadrant representation ◉ Numerical representation

Voltage phase angle [°]

L1	66	73	123	-160	-154	-95	-143	149	76	101	74	-20	118	136	-176	107	-138	-66	-117	171	-90	119	142	-107	-171	-24	-121	59	-168	-172	141	-130	170
L2	139	56	102	-156	-24	-106	-94	143	160	65	59	95	68	143	-1	78	16	-33	131	-172	-136	143	-167	-161	104	-120	84	61	119	121	34	-128	0
L3	-155	78	69	-156	-14	-93	-142	145	1	14	9	-21	-177	145	-8	113	-142	-44	-167	119	36	139	126	-148	-137	-84	-170	95	-145	173	-91	-110	0

Current phase angle [°]

L1	-70	-150	171	-79	111	134	-72	-105	112	131	65	-129	-104	-124	-50	157	-127	-24	-177	63	93	-143	81	-6	5	126	-52	168	-77	36	-167	-117	172
L2	-49	-165	-165	-74	-13	150	-70	-118	-88	131	-141	-168	124	-117	-16	134	119	-9	-11	-42	-91	-151	152	-61	0	167	-158	-167	-177	126	0	112	85
L3	-73	-154	-87	-84	-63	160	-94	-116	-64	108	54	-154	-134	-101	16	142	170	-23	-109	105	91	-168	162	-57	-53	81	166	-164	-92	-120	14	119	0

Harmonic phase angle [°]

L1	135	-137	-48	-81	94	131	-71	-106	-36	-30	8	110	-139	-99	-126	-50	-10	-42	60	108	177	-98	61	-101	-176	-149	-69	-109	-91	151	-52	-13	-2
L2	-173	-139	-94	-82	-11	104	-24	-100	-112	-67	-160	-97	-56	-100	14	-56	-103	-23	142	-130	-45	-66	41	-99	104	73	-117	-132	-64	-4	34	120	-85
L3	-82	-128	156	-72	49	107	-48	-99	65	-94	-45	132	-43	-114	-24	-29	49	-21	-58	14	-55	-53	-37	-90	-84	-165	24	-102	-53	-68	-105	131	0

Harmonic real power [W]

L1	-0	-1	0	2	-0	-0	0	-0	0	0	0	-0	-0	-0	-0	0	0	0	0	-0	-0	-0	0	-0	-0	-0	0	-0	-0	-0	0	0	0
L2	-0	-2	-0	2	0	-0	0	-0	-0	0	-0	-0	0	-0	0	0	-0	0	-0	-0	0	0	0	-0	-0	0	-0	-0	0	0	0	-0	0
L3	0	-2	-0	5	0	-0	0	-0	0	-0	0	-0	0	-0	0	0	0	0	0	0	0	0	0	-0	0	-0	0	-0	0	0	-0	-0	0

Harmonic reactive power [Var]

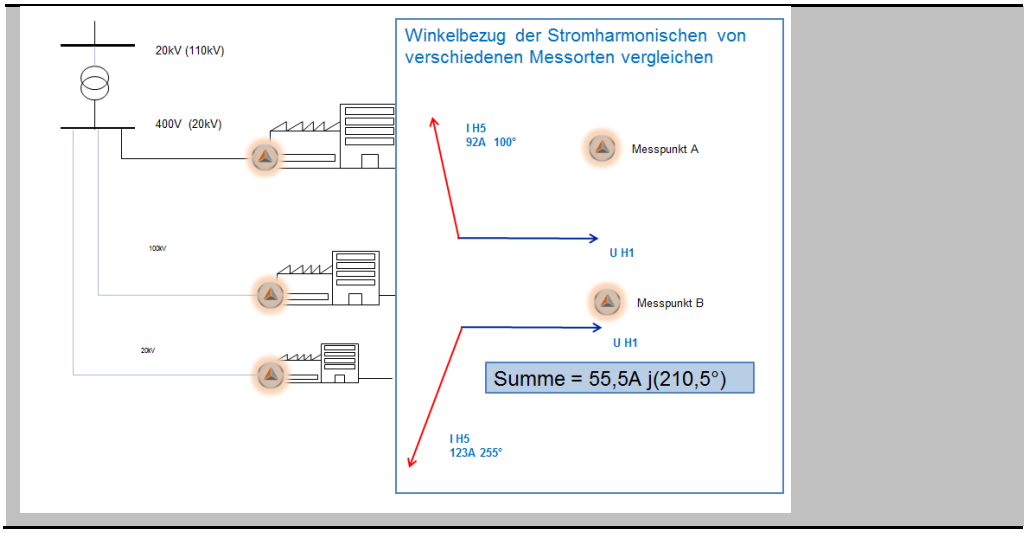
L1	0	-1	-0	-12	0	1	-0	-0	-0	-0	0	0	-0	-0	-0	-0	-0	-0	0	0	0	-0	0	-0	-0	-0	-0	-0	-0	0	-0	-0	-0

- Phase angle of the voltage harmonic related to fundamental of the voltage
- Phase angle of the current harmonic related to fundamental of the voltage
- Phase angle phi between voltage and current
- Active power of harmonics
- Reactive power of harmonics
- Apparent power of harmonics

Example:

At a connection point with several consumers, it is to be evaluated whether for example the 5th current harmonics add up favorably or unfavorably at the connection point. In our example the 5th current harmonic of consumer A is 92 A and consumer B is 123 A. With the indication of the current angle it is possible to calculate the sum current in a complex way. In the example the result is 55.5 A.

Example direction of harmonics

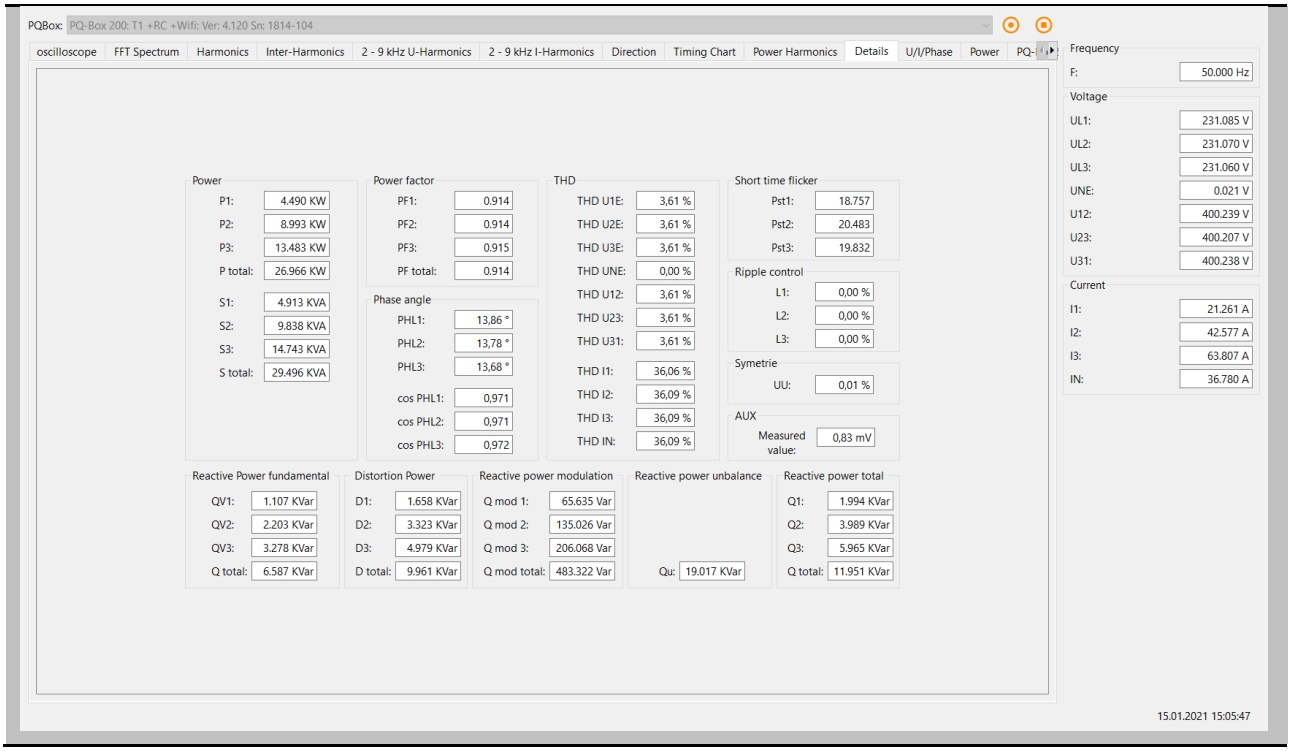


4.10 Details

Via the "Details" card, the active, reactive and apparent powers of the single phases and also three-phase values are displayed online.

Furthermore, the power factor, the cos phi and the phase angles of the fundamental oscillation of the network are displayed.

Details of the measurement



Explanation of the power measurement values in the online data:

- **P** – Active power
- **S** – Apparent power
- **Q** – Total reactive power

The total reactive power consists of the following components:

- **QV** – Displacement reactive power (inductive + or capacitive -)
- **D** - Distortion reactive power / reactive power of harmonics
- **Q mod** – Modulation reactive power
- **Qu** – Asymmetric reactive power
- **Qh** – Displacement reactive power of harmonics (can be disregarded in practice)

$$Q = \sqrt[2]{QV^2 + D^2 + Q_{mod}^2 + Q_u^2 + Q_h^2}$$

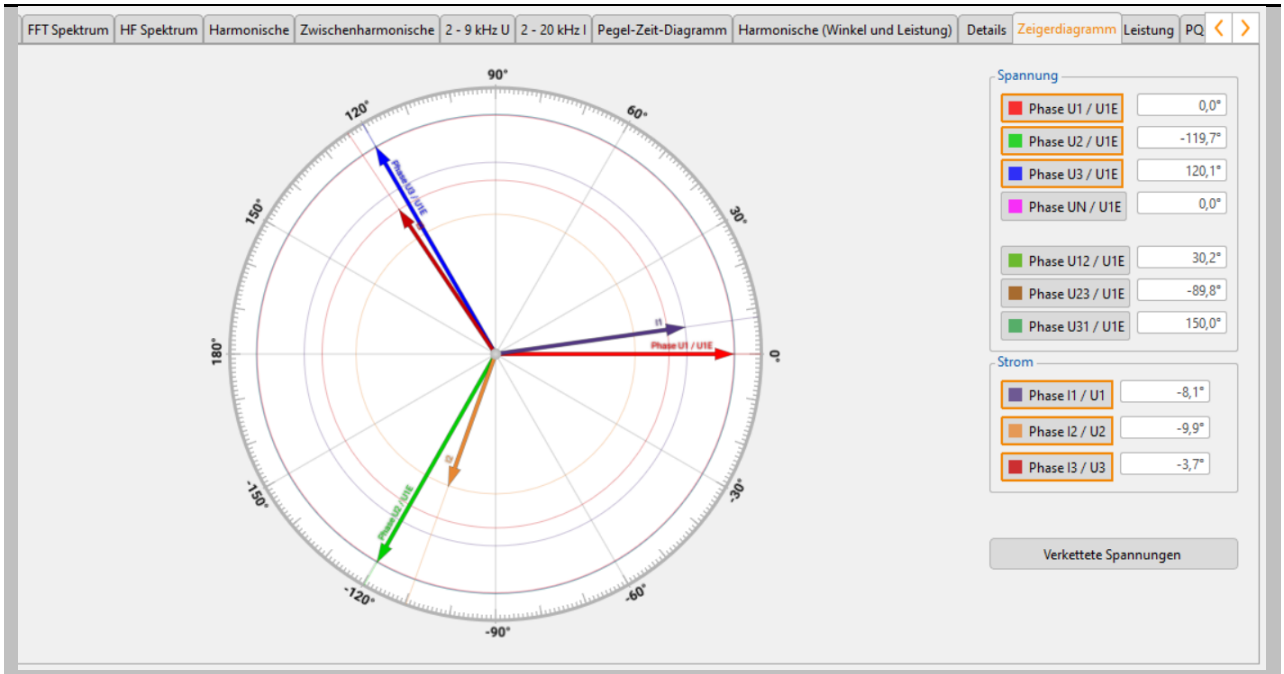
For further information on reactive power calculation, we recommend our info letter "Definition and measurement of power measurement quantities according to the DIN 40110-2 and IEEE 1459 standards with the PQ boxes". This can be downloaded from our homepage:

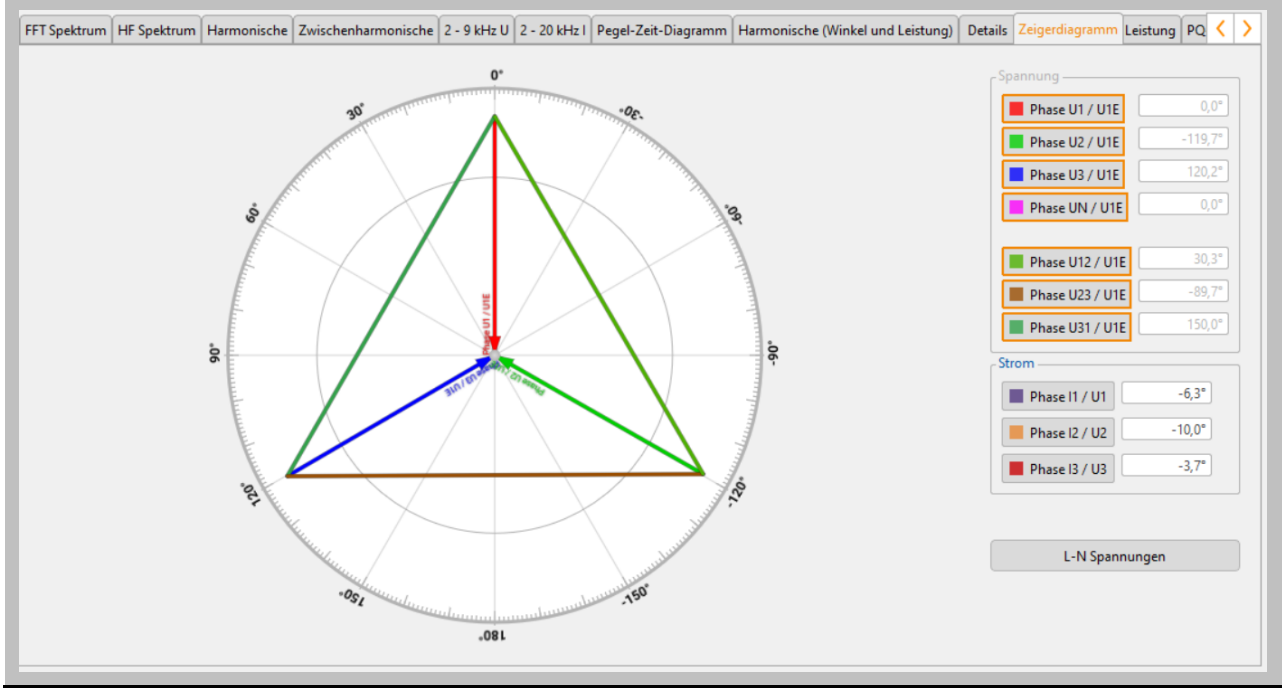
https://www.a-eberle.de/en/downloads/information-letters-publications-calculating-tools/information-letters

4.11 Phasor diagram

With the function pointer diagram all voltages and currents are displayed graphically with magnitude and phase angle. The display can be switched between phase to earth and phase to phase values.

Phasor diagram



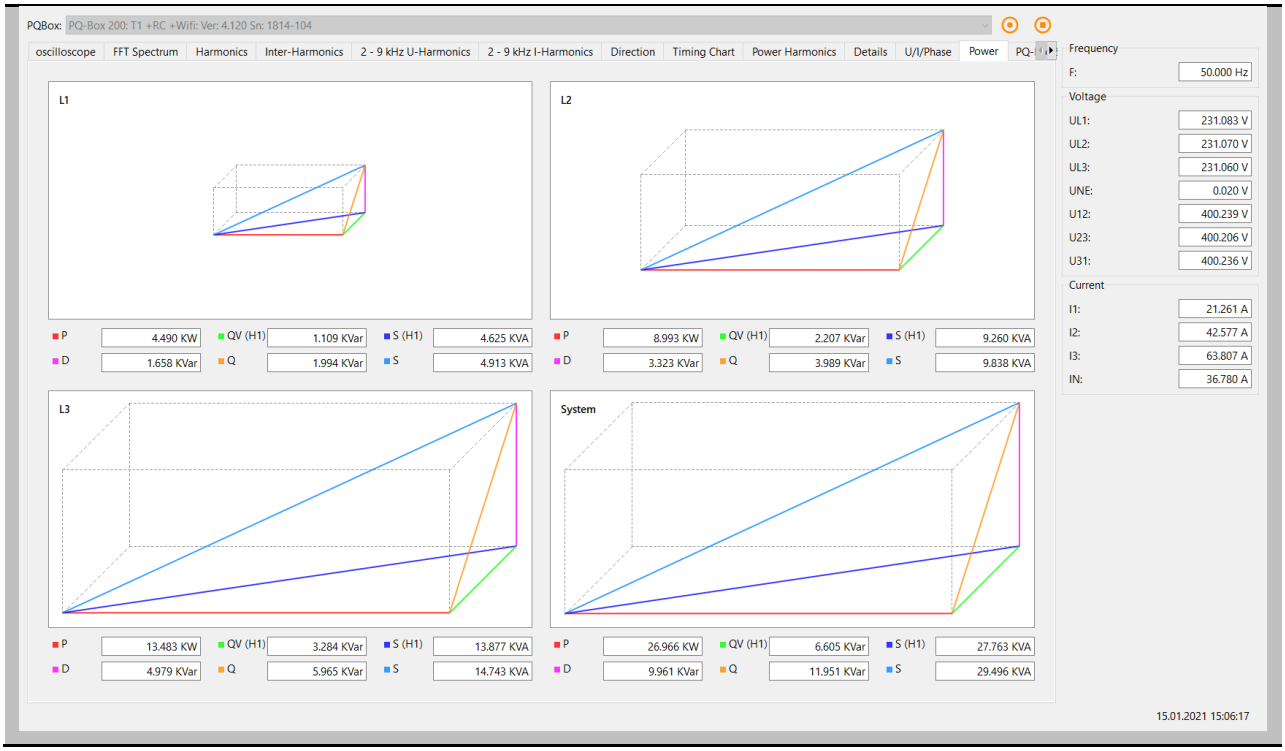


4.12 Power 3D

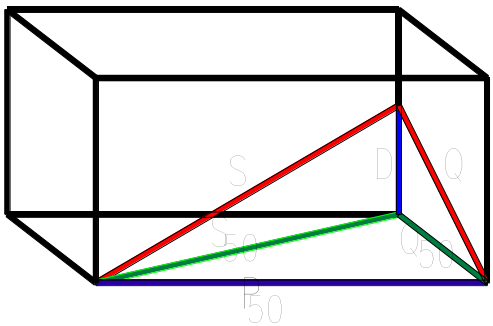
On the map "Power 3D" all power values are displayed in a three-dimensional graphic.

A power triangle is displayed for each phase, as well as for the total network power.

Power triange of all lines and the total system



The graph shows the individual power values once for the total RMS value and once for the fundamental vibration values.

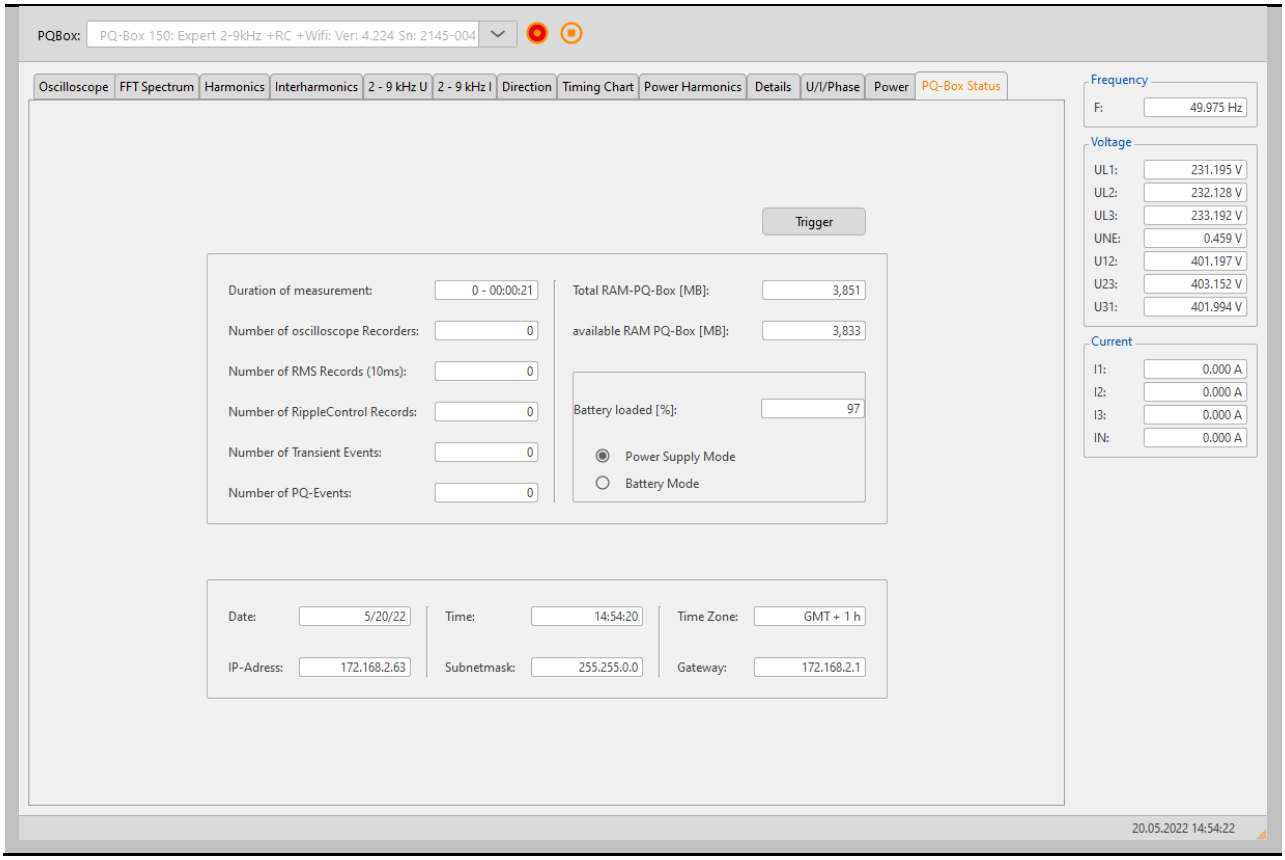


4.13 Online Status

In "PQ Box Status", the status of the meter can be requested via a remote connection.

- Duration of the measurement in "days - hours, minutes, seconds".
- Number of disturbance records
- Available memory
- Date and time
- Trigger via Software

Status of the selected PQ box



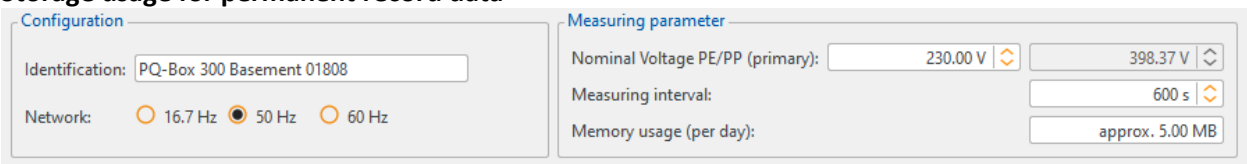
5. Measurement Data

5.1 Measured quantities

PQ-Box permanent record data

The interval corresponds to the freely selectable measuring interval of 1 sec up to 1800 sec (30 min).

Storage usage for permanent record data



For a rough estimate, WinPQ mobile displays the expected size of the measurement data under the adjustable measurement interval. This can also vary depending on the PQ-Box and its version (e.g. Basic, Light, etc.).

Events and fault records must also be added to this data volume. The amount of data is highly dependent on the occurrence of these events and the trigger settings of the measuring device.

5.2 PQ-Box Measurement Procedure / Formulas

Signal sampling:

The voltage and current inputs are filtered with an anti-aliasing filter and digitized with a 24-bit converter.

The sampling rate is at the nominal frequency

- PQ-Box 200 40.96 k samples/s for voltage and current per channel
- PQ-Box 300 409.6 k samples/s for voltage and 40.96 k samples/s for current per channel

The aggregation of the measurements is based on IEC61000-4-30 for Class A devices.

▶ RMS values of the voltages and currents, min. / max. values

U TRMS / I TRMS

The interval value of the voltage or current is the mean of the true RMS values (TRMS) of the length of the selected interval.

U min / max; I min / max

Per measurement period, the highest and lowest ½ periode value (10ms/50Hz) voltage or current RMS value is saved in addition to the average.

▶ Ripple control signal

U Ripple Control / U Ripple control max (200 ms)

One additional frequency between 100 Hz and 3.750 Hz can be set in the PQ-Box setup. This frequency is displayed as a middle and 200 ms maximum value within a measurement interval.

Phase angle voltage / current

Angle between the phases of the fundamental oscillation L1, L2, L3.
Phase L1 is the reference value and is specified as 0 °.

DC Voltage / Current

The DC component is displayed here as a percentage of the fundamental. When measuring in DC networks, the measured value Ueff can be used to display the DC voltage.

Flicker levels Pst / Plt / Pinst

The **Short-term flicker levels P_{st}** (10 min) and **Long tern flicker levels P_{lt}** (2 h) are calculated for the star and delta voltages. P_{st} and P_{lt} are defined in EN 61000-4-15: 2010.

- **The measuring interval of the Pst is set to 10 minutes fix and is independently from the free intervall.**

Long-term flicker P_{lt} is being calculated from 12 P_{st} values. Formula for P_{lt} calculation:

$$P_{lt} = \sqrt[3]{\frac{1}{12}\sum_{i=1}^{12} P_{st,i}^3}$$

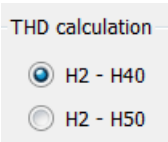
Pinst (instantaneous flicker) – the 1 sec intervall of the flickermeter

The Flickermeter can be changed in the setup fort he following constellations:

230V/50Hz; 230V/60Hz and 120V/50Hz; 120V/60Hz

THD – PWHD – K factor

All calculations are based on a 10/12 cycle averaging interval (50 Hz = 10 cycles / 60 Hz = 12 cycles), according to the formula of IEC61000-4-7 (exactly 2024 sample values will be used for calculation)



The THD calculation of voltage and current can be changed in the settings: 2 – 40th or 2 – 50th

THD voltage:

$$THD_u = \frac{\sqrt{\sum_{\nu=2}^{40} U_\nu^2}}{U_1}$$

THD current in %:

$$THD_i = \frac{\sqrt{\sum_{\nu=2}^{40} I_\nu^2}}{I_1}$$

THD(A) current in Ampere:

$$THC=\sqrt{\sum_{n=2}^{40} I_n^2}$$

PWHD - Partial Weighted Harmonic Distortion

The partial weighted THD calculates the 14th to 40th harmonics.

$$PWHD = \frac{\sqrt{\sum_{n=14}^{40} n \cdot C_n^2}}{C_1}$$

PHC - Partial Odd Harmonic Current

The PHC is calculated from the odd current harmonics n = 21..39.

$$PHC = \sqrt{\sum_{n=21,23}^{39} C_n^2}$$

K Factor

The values of the K-factors for phase currents are calculated from the corresponding RMS values C_n of the harmonics n = 1..40.

The K factor is a measure that indicates the ability of a transformer to withstand the current harmonics of a system.

Various transformer suppliers offer transformers with, for example, K factors K=4, K=13, K=20 and K=30.

Transformers are heated more by harmonic currents than 50 Hz currents.

A transformer with a higher K-factor withstands this better and is not heated as much as a transformer with a lower K factor.

The PQ-Box shows the K factor for the current. Only the K values that appear at maximum power are of interest. Just as with the THD of the currents in %, the value is not relevant at very low currents.

$$K = \frac{\sum_{n=1}^{40} (n \cdot C_n)^2}{\sum_{n=1}^{40} C_n^2}$$

UU Unbalance

The voltage asymmetries are calculated from the corresponding values of the modal components positive system, negative system and zero system. For EN50160 (events), only the voltage asymmetry is relevant and corresponds to the ratio of negative system to positive system. The value is output in [%].

Symmetric Components

The complex symmetrical components are calculated from the corresponding complex spectral components of the fundamental oscillations of the phase voltages and phase currents.

Phase voltage in a 4-wire system = Phase-to-Neutral voltage

Phase voltage in a 3-wire system = Phase-to-Ground voltage

Positive sequence:

$$\underline{U}_{1_PS} = \frac{1}{3} \cdot \left(\underline{U}_{1N-1} + \underline{a} \cdot \underline{U}_{2N-1} + \underline{a}^2 \cdot \underline{U}_{3N-1} \right)$$

$$\underline{I}_{1_PS} = \frac{1}{3} \cdot \left(\underline{I}_{1-1} + \underline{a} \cdot \underline{I}_{2-1} + \underline{a}^2 \cdot \underline{I}_{3-1} \right)$$

Negative sequence:

$$\underline{U}_{1_NS} = \frac{1}{3} \cdot \left(\underline{U}_{1N-1} + \underline{a}^2 \cdot \underline{U}_{2N-1} + \underline{a} \cdot \underline{U}_{3N-1} \right)$$

$$\underline{I}_{1_NS} = \frac{1}{3} \cdot \left(\underline{I}_{1N-1} + \underline{a}^2 \cdot \underline{I}_{2N-1} + \underline{a} \cdot \underline{I}_{3N-1} \right)$$

Zero sequence:

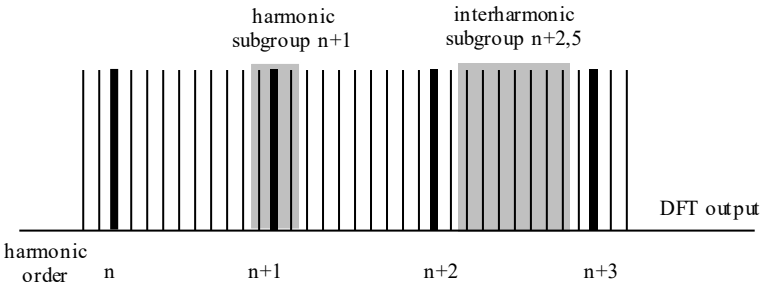
$$\underline{U}_{ZS} = \frac{1}{3} \cdot \left(\underline{U}_{1N-1} + \underline{U}_{2N-1} + \underline{U}_{3N-1} \right)$$

$$\underline{I}_{ZS} = \frac{1}{3} \cdot \left(\underline{I}_{1N-1} + \underline{I}_{2N-1} + \underline{I}_{3N-1} \right)$$

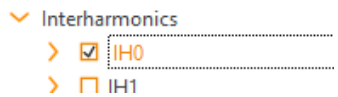
Harmonics / Inter-harmonics

The determination of the harmonics and inter-harmonics interval values displayed using the methods of the IEC61000-4-30 Class A standard based on 10/12 period values.

The PQ-Box 200 recognizes for all voltage and current channels, respectively, the harmonics up to the 50th ordinal. To evaluate the inter-harmonics, harmonic subgroups are created. 50 subgroups are recorded for all current and voltage channels.



Example:



"IH0“ is the first inter-harmonics group and evaluated the frequency range from 5 Hz to 45 Hz.

The harmonics for n=0...50 are calculated

Voltage harmonics (standardized, 10/12 periods):

$$\left|U_{n-10/12}\right| = \frac{\sqrt{\frac{1}{2} \cdot \sum_{k=n\cdot N-1}^{n\cdot N+1} \left|C_k\right|^2}}{U_{nom}}$$

Current harmonics:

$$\left|I_{n-10/12}\right| = \sqrt{\frac{1}{2} \cdot \sum_{k=n\cdot N-1}^{n\cdot N+1} \left|C_k\right|^2}$$

Frequency analysis 2 kHz to 9 kHz

In the frequency analysis 2 kHz to 9 kHz respectively 200 Hz frequency bands are summarized.

The specification of each frequency is the center frequency in this 200 Hz band.

$$Y_b = \sqrt{\sum_{f=b-95\,\mathrm{Hz}}^{b+100\,\mathrm{Hz}} Y_{C,f}^2}$$

Example: Frequency band 8.9 kHz corresponds to all 5 Hz spectral lines from 8.805Hz to 9.000Hz

Harmonic phase angle voltage / current

The phase angle of all voltage harmonics relates to the fundamental oscillation of the voltage of the same phase.
Example: Angle of voltage harmonics H5 phase L2 relates to the fundamental oscillation of the voltage of phase L2.

The phase angle of the current harmonics relates to the fundamental oscillation of the voltage of the same phase.
Example: Angle current harmonics H5 phase L2 relates to the fundamental oscillation of the voltage of phase L2.

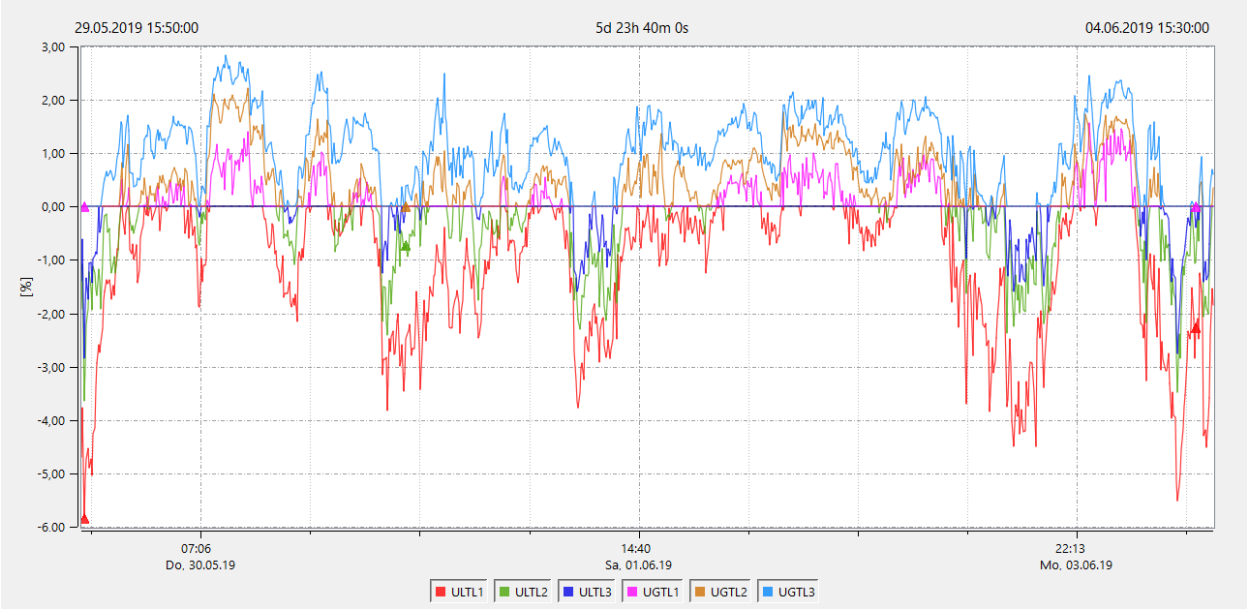
Divergence ULT / UGT

Representation of the voltage values in % of the nominal voltage.

ULT (lower threshold) – shows all measured values lower than the nominal voltage

UGT (greater threshold) – shows all measured values greater than the nominal voltage

It is usually useful to display both parameters together.



► Reactive power / Reactive energy

In the setup of the PQ-Box two variants of the power calculation are adjustable

a) Simplified power calculation

Reactive power without unbalanced reactive power calculation:

$$Q = \sqrt{Q_V{}^2 + D^2}$$

Q ∑ = Q L1+ Q L2 + Q L3

b) **Reactive power calculation according DIN40110 part 2**

Reactive power calculation with unbalanced power:

$$Q_{L-10/12} = Sgn(\varphi_{L-10/12}) \cdot \sqrt{S^2_{L-10/12} - P^2_{L-10/12}}$$

$$Q_{10/12} = Sgn(\varphi_{1-10/12}) \cdot \sqrt{S^2_{10/12} - P^2_{10/12}}$$

Reactive energy:

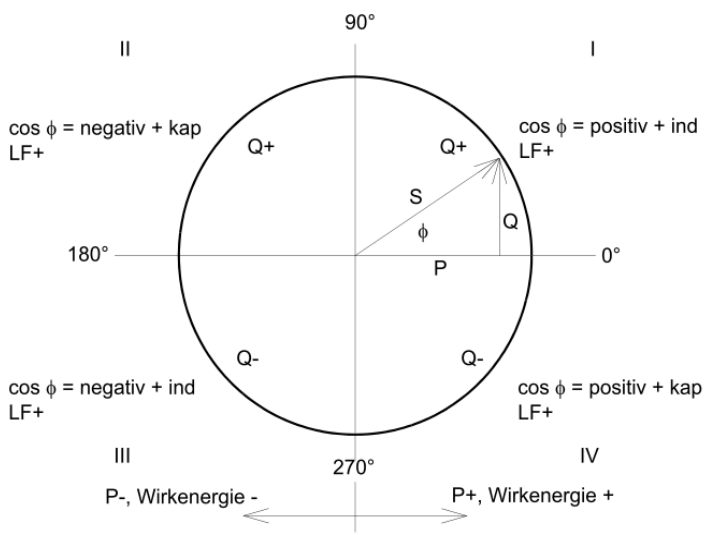
"Supply reactive energy" inductive reactive energies +EQ.

$$Q_S(n) = |Q_{L-10/12}(n)| \qquad für: Q_{L-10/12}(n) \geq 0$$

$$Q_S(n) = 0 \qquad für: Q_{L-10/12}(n) < 0$$

"Consumer reactive energy" capacitative reactive energies -EQ.

$$Q_S(n) = |Q_{L-10/12}(n)| \qquad für: Q_{L-10/12}(n) < 0$$

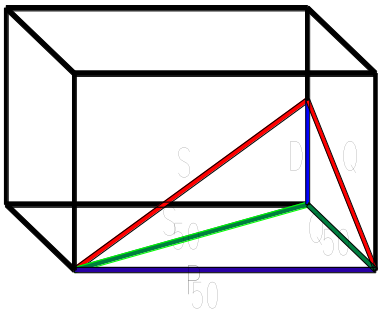


Distortion reactive power - D

The distortion reactive power - also called the harmonic reactive power - describes a specific form of reactive power that is caused in single phase and three-phase systems with non-linear loads such as rectifiers in power supplies. The current harmonics in combination with the line voltage result in reactive power components, which are called the distortion reactive power.

The distortion reactive powers are calculated from the voltage and the associated distortion currents:

$$D = U \cdot \sqrt{\sum_{\nu=2}^{\infty} I_{\nu}^{2}}$$



Power Factor PF

In electrical engineering the power factor or active power factor is calculated as the ratio of real power P to the apparent power S. The power factor can be between 0 and 1.

The ration is expressed in the following equation:

Power Factor PF: $\lambda = |P| / S$

The power factor contains the sign of the real power.

<u>Cos phi</u>

The PQ-Box calculates the cos phi in two versions:

a) Cos phi – standard (red)
b) Cos phi – calculated in the direction of the real power (blue)

On device display and in online measurement data, the standard cos phi (version a) is shown.

In the long-term measurement data both versions are available.

▶ Apparent Power - S

In the setup of the PQ Box variants of the power calculation are adjustable:

a) Simplified power calculation

$$S = \sqrt{P^2 + Q^2}$$

b) Power calculation according DIN40110 part 2

Conductor apparent power 4-wire system:

$$S_L = U_{LNrms} \cdot I_{Lrms}$$

Conductor apparent power 3-wire system:

$$S_L = U_{L0rms} \cdot I_{Lrms}$$

Collective apparent power in accordance with DIN40110:

$$S_\Sigma = U_\Sigma \cdot I_\Sigma \qquad U_\Sigma = \frac{1}{2} \cdot \sqrt{U_{12rms}^2 + U_{23rms}^2 + U_{31rms}^2 + U_{1Nrms}^2 + U_{2Nrms}^2 + U_{3Nrms}^2}$$

4-wire network:

$$I_\Sigma = \sqrt{I_{1rms}^2 + I_{2rms}^2 + I_{3rms}^2 + I_{Nrms}^2}$$

3-wire network, I1 + I2 + I3 ≠ 0 :

$$U_\Sigma = \frac{1}{2} \cdot \sqrt{U_{12rms}^2 + U_{23rms}^2 + U_{31rms}^2 + U_{1Erms}^2 + U_{2Erms}^2 + U_{3Erms}^2}$$

$$I_\Sigma = \sqrt{I_{1rms}^2 + I_{2rms}^2 + I_{3rms}^2 + I_{Erms}^2}$$

Geometric Fundamental Oscillations - Apparent Power:

$$\underline{S}_G = 3 \cdot [\underline{U}_{1_PS} \cdot \underline{I}_{1_PS}^* + \underline{U}_{1_NS} \cdot \underline{I}_{1_NS}^* + \underline{U}_{1_ZS} \cdot \underline{I}_{1_ZS}^*]$$

Active Power - P

The sign of the active power corresponds with the flow direction of the fundamental oscillation active energy (+: supply, - : consumer).

The values of the conductor - active power are calculated from the samples of a synchronization cycle.

$$P_{L-10/12} = \frac{\sum_{n=1}^{2048} p_L(n)}{2048}$$

(200 ms values) with conductor index L = {1, 2, 3, E}

The 10 min values are calculated as linear averages.

The collective effective power is defined for 4-wire and 3-wire systems as

$$P_{\Sigma} = P_1 + P_2 + P_3$$

Fundamental oscillation - active power (line):

$$P_G = \mathrm{Re}\{\underline{S}_G\}$$

$\underline{S}_G$ = Geometric fundamental oscillation apparent power

P min / max (1 sec)

The highest and lowest 1 sec effective value is recorded in addition to the mean value for each measurement interval for all power values.

Harmonic power measurement

The following measured power values are determined via the phase angle of the voltage and current harmonics and are available under the long-term measurement data:

- Harmonic Real Power
- Harmonic Apparent Power
- Harmonic Reactive Power
- Phi Harmonic

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