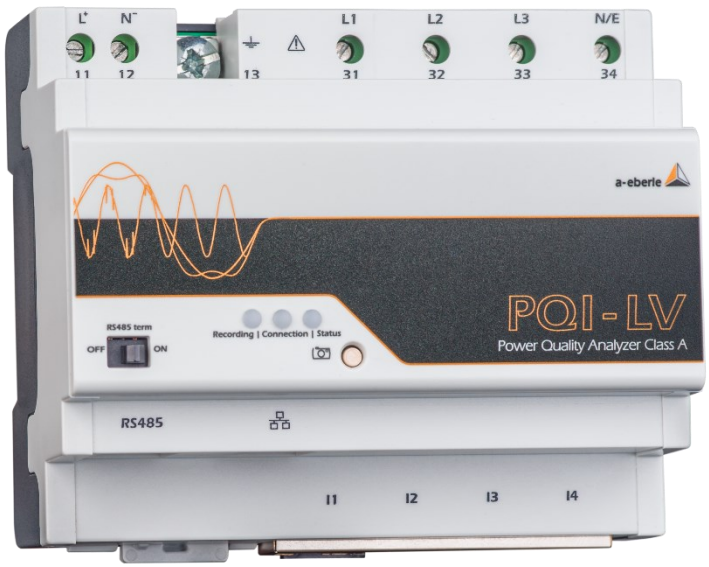
a-eberle

User Manual

Power Quality Network Analyser

Model PQI-LV

Power-Quality Evaluation Software WinPQ *lite*



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Model PQI-LV

Note:

Please note that this user manual may not always contain the latest information concerning the device. If, for example, you have changed the firmware of the device to a higher version via the Internet, this description will no longer be completely accurate.

In this case, contact us directly or use the latest version of the operating instructions available from our Internet site (www.a-eberle.de).

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Table of Contents

1. User prompt

The user manual contains all important information for installation, commissioning and operation. Read the user manual completely and do not use the product until you have understood it.

1.1 Target group

These operating instructions are intended for trained and qualified staff as well as trained and tested operators. The contents of these operating instructions must be made accessible to the persons responsible for installing and operating the system.

1.2 Warnings

▶ **Structure of the warnings**

⚠ SIGNAL WORD	**Type and source of danger!** Consequences of non-observance ➲ Action to avoid the danger.

▶ **Types of warnings**

Warnings differ according to the type of danger as follows:

⚠ DANGER!	Warns of an imminent danger which, if not avoided, will result in death or serious injury.
⚠ WARNING!	Warns of a potentially dangerous situation that can result in death or serious injuries when not avoided.
⚠ CAUTION!	Warns of a potentially dangerous situation that can result in serious or minor injuries when not avoided.
NOTICE!	Warns of a potentially dangerous situation that if not avoided could result in material or environmental damage.

1.3 Tips

Notes on appropriate use of the device.

1.4 Other symbols

Instructions

Structure of the instructions:

➲ Guidance for an action.

↳ Indication of an outcome, if necessary.

Lists

Structure of unnumbered lists:

- List level 1
  - List level 2

Structure of numbered lists:

1) List level 1
2) List level 1
   1. List level 2
   2. List level 2

1.5 Applicable documentation

For the safe and correct use of the product, observe the additional documentation that is delivered with the system as well as the relevant standards and laws.

1.6 Keeping

Keep the user manual, including the supplied documentation, readily accessible near the system.

2. Scope of Delivery/Order Codes

2.1 Scope of Delivery

- PQI-LV
- Security documentation
- WinPQ Lite Software www.a-eberle.de/pqi-lv-software-en

2.2 Order Codes

Characteristic	Code
Power Quality Interface and fault recorder ● 4 voltage converters 100V /400V/690V 10MOhm (CAT IV 300V) ● 4 switchable inputs for low voltage current transformers ○ Current clamp ○ Rogowski coils ● In accordance with DIN EN-50160 and IEC 61000-4-30 (Class A) ● WinPQ lite software for *PQI-LV* ● Webserver	*PQI-LV*
Supply voltage ● AC 90 V…110 V…264 V or DC 110 V…220 V…430 V ● DC 12 V...60 V...150 V	 H1 H2
Option IEC61000-4-7 (40.96 kHz sampling) ● 10.24 kHz sampling; without 2 kHz to 20 kHz measurement ● Frequency measurement of voltage and current from 2 kHz to 20 kHz 40.96 kHz sampling oscilloscope recorder	 B0 B1
Option Fault recording ● Without fault recording ● With fault recording Oscillograph with voltage and current, sampling rate: 40,96kHz / 10,24kHz and TRMS recorder with powerful triggering	 S0 S1
Option communication protocol ● Modbus RTU & TCP ● IEC 60870-5-104 (RJ45) ● IEC61850 (RJ45) ● Modbus Master for I-Sense feeder measurement and recording	 P0 P1 P2 P3
Option Data format ● Without PQDIF export function according to IEEE1159-3 ● With PQDIF export function according to IEEE1159-3 Data transfer via feature P2 - IEC61850 / MMS	 F0 F1

Software WinPQ lite	Code
Software WinPQ lite For parameterising PQI-LV, as well as reading PQI-LV measurement data and online data as a single-user licence **– free of charge**	

WinPQ database	Code
Software WinPQ For parameterization, archiving and evaluation of PQI-D, PQI-DA, PQI-LV and PQI-DE measurement data with the following basic functions: ● 32-bit/64-bit Windows program interface ● Database for saving the measured values per measuring point Data access via TCP/IP network ● Visualization option for all measured variables retrievable from a PQI-D, PQI-DA, PQI-LV and PQI-DE as a function of time and as a statistical variable ● Automatic reporting according to EN50160; IEC61000-2-2 / 2-4; IEEE519 ● Automatic export functions (Comtrade , PQDif, ASCII, PDF) and fault report transmission ● One additional workstation license for one Windows user is included in the price	**WinPQ**
Licences ● as single-user license for 2 PQ measuring instruments (PQI-D, PQI-DA, PQI-LV, PQI-DE) ● as single-user license for 2 to 10 PQ measuring instruments (PQI-D, PQI-DA, PQI-LV, PQI-DE) ● as single-user license for > 10 PQ measuring instruments (PQI-D, PQI-DA, PQI-LV, PQI-DE) ● as single-user license for > 100 PQ measuring instruments (PQI-D, PQI-DA, PQI-LV, PQI-DE	 L0 L1 L2 L3
User manuals ● German ● English ● French	 A1 A2 A3

PQI-LV - accessories	Code
Rogowski Coil 1...1000 A; 330 mV / 1000 A; 10 Hz...5 kHz; 3m connection cable one piece	111.7087.06

3. Safety instructions

- Follow the user manuals.
- Keep the user manual with the device.
- Ensure that the device is operated only in a perfect condition.
- Never open the device.
- Ensure that only qualified personnel operate the device.
- Connect the device only as specified.
- Ensure that the device is operated only in the original condition.
- Connect the device only with recommended accessories.
- Ensure that the device is not operated outside the design limits.

  (see chapter 5)
- Ensure that the original accessories are not operated outside the design limits.
- Do not use the device in environments where explosive gases, dust or fumes occur.

3.1 Meaning of the symbols used on the device

Nature and source of the danger! Read the safety instructions inside the manual!

Functional earth

USB-interface

TCP-IP interface

CE marking guarantees compliance with the European directives and regulations regarding Electromagnetic Compatibility (EMC)

Alternating voltage (AC)

Direct voltage (DC)

4. Intended use

The product is used for the measurement and evaluation of voltage and current signals in the power grid only. If the instrument is used in a manner not specified by the manufacturer, the protection provided by the instrument may be severely impaired.

The instrument is intended for use in the low voltage range in CAT IV (300 V) up to a maximum of 690 V (conductor-conductor). Other voltage levels such as medium or high voltages must be connected to the instrument via voltage transformers.

5. Technical Data

5.1 PQI-LV Description

The PQI-LV power quality analyser and fault recorder for low-voltage grids is the central component of a system that can be used to solve all measurement tasks in electrical low-voltage grids. The PQI-LV can be used both as a power quality interface in accordance with power quality standards and as a measuring device for all physically defined measured values in three-phase grids.

The component is particularly suitable for monitoring and recording special supply qualities or quality agreements between the energy supplier and custom-er and making them available for evaluation. In addition, the measuring device offers the option of recording up to 16 feeders via I-Sense technology, pro-cessing them and transferring them to the higher-level WinPQ and WebPQ software solution!

In addition to the option of standard evaluations in accordance with EN50160, the PQI-LV also has a highspeed disturbance recorder with a recording rate of 40.96 kHz / 10.24 kHz and a 10 ms RMS value recorder via an additional licence S1. This enables a detailed analysis of grid faults.

Modern voltage quality measuring instruments operate according to the IEC 62586 standard, which describes the complete product characteristic of a Power Quality Analyser. This standard defines not only the purpose of use and the EMC environment, the environmental conditions, but also the exact measurement methods (IEC 61000-4-30) to create a comparable basis for the user.

According to IEC 62586, the PQI-LV is a device PQI-A-FI-H and has therefore been fully certified in external laboratories.

The PQI-LV meets all demands of the IEC 61000-4-30 Ed.3 (2015) standard for an A-Class device.

The measuring device and the development are subject to strict security requirements within the scope of the requirements in *KRITIS*. In relation to these, an active patch management, encrypted communication standards as well as a User Rights Management (*URM*) via *RADIUS* are available in the device! This also includes signed firmware updates, security logging and active protection against brute force attacks. All this contributes to a secure operation in your IT environment!

Parameter IEC61000-4-30	Class
Power frequency	A
Magnitude of the Supply Voltage	A
Flicker	A
Supply voltage dips and swells	A
Voltage interruptions	A
Supply voltage unbalance	A
Voltage harmonics	A
Voltage Interharmonic	A
Mains signalling voltage	A
Underdevation and overdeviation	A
Measurement aggregation intervals	A
Time-clock uncertainty	A
Flagging	A
Transient influence quantities	A

The PQI-LV has been developed for measurements performed in public grids, as well as for recording PQ data in industrial environments, up to 690 V (C-C) measurement voltage:

- Din rail device
- No moving parts (fans, hard drives)
- CAT IV

5.2 Technical Data

- Webserver for basic configuration on the device
- 1 GB internal memory
- Input channel bandwidth 20 kHz
- 4 voltage inputs, final value of measurement range: 480 V L-N, accuracy < 0.1%
- 4 switchable current inputs for Rogowski coils and current clamps
- Simultaneous processing of sampled and calculated voltages and currents
- Oscilloscopic voltage and current recorder sampling rate : 40.96 kHz / 10.24 kHz
- Half cycle recorder:
  - power frequency, r.m.s. of voltages and currents, voltage and current phasors
  - power recording rate : ~10ms (50 Hz) / ~8.33ms (60 Hz)
- Powerful recorder triggering
- Online streaming of voltages and currents at 40.96 kHz sampling rate.
- IEC 61000-4-30 Class A Measurement data processing
- Recording of the voltage quality faults in accordance with DIN EN 50160; IEC61000-2-2; -2-12;-2-4.
- Phase of voltage and current harmonics n=2...50
- Spectral analysis 2 kHz…20 kHz,(90 frequency bands, BW = 200 Hz) of voltages and currents according (IEC 61000-4-7)
- EDGE function - 32 freely configurable monitoring states for monitoring and triggering all measured variables - Output via protocol for controlling on site
- Complex analysis software WinPQ lite (sold as a package)

Option WinPQ – Database Software

- Analysis of the data on a database using the WinPQ software package.
- Permanent communication with many devices, in parallel.

5.3 Technical Data

5.3.1 Dimensions / Weight

Dimensions / Weight	
L x B x H	130 x 90 x 58 mm
Weight	298g

5.3.2 Power supply

Feature	H1	H2
AC Nominal range [V]	100...240	-
AC Operating range [V]	90...264	-
DC Nominal range [V]	150...340	24...110
DC Operating range [V]	120...430	12...150
Power consumption	≤ 5 W < 7 VA	≤ 7 W
Frequency Nominal	50...60 Hz	DC
Frequency Operating	40...70 Hz	DC
External fuse characteristics	6A B	6A B
Energy storage	2 sec	2 sec

5.3.3 Voltage Inputs

Voltage inputs	
Channels	U_1 , U_2 , U_3 , $U_{N/E/4}$
Electrical safety DIN EN 61010	300V CAT IV 600V CAT III
Input reference	PE
Impedance -> PE	10 MΩ || 25pF
Nominal input voltage U_{nom}	230 VAC
Measuring range end value	0...480 V_{AC} L-E
Overload capacity, permanent	600V_{AC}
Maximum crest factor @ U_{nom}	3
Bandwidth	DC...20 kHz
Rated mains frequency f_n	50 Hz / 60 Hz
Frequency range of the fundamen-	f_n ± 15 %

Voltage inputs	
tal	42.5...50...57.5 Hz 51.0...60...69.0 Hz
Accuracy	
Fundamental frequency, r.m.s. U_1 ≤ 150% U_{nom} 0°C ≤ T_A ≤ +45°C: -25°C ≤ T_A ≤ +55°C:	 ±0.1% v. U_{nom} ±0.2% of U_{nom}
Fundamental frequency, phase U_1 ≥ 10% U_{nom} :	 ±0.02°
Harmonics n = 2...50, r.m.s. U_h ≥ 1% U_{nom} : U_h < 1% U_{nom} :	 ±5.0% v. U_h ±0.05% of U_{nom}
Harmonics n = 2...50, phase U_h ≥ 1% U_{nom} :	 ±0.5°
Interharmonics n = 1...49, r.m.s. U_{ih} ≥ 1% U_{nom} : U_{ih} < 1% U_{nom} :	 ±5.0% v. U_h ±0.05% of U_{nom}
Mains frequency	±1 mHz @ 10 %...200 % U_n
Flickermeter DIN EN 61000-4-15:2011	Class F1
Dip residual voltage	±0.2 % U_n @ 10 %...100 % U_n
Dip duration	±20 ms @ 10 %...100 % U_n
Swell residual voltage	±0.2 % U_n @ 100 %...150 % U_n
Swell duration	±20 ms @ 100 %...150 % U_n
Interruption duration	±20 ms @ 1 %...100 % U_n
Voltage unbalance	±0.15 % @ 1 %...5 % measured value
Ripple control voltage (< 3kHz)	±5% of the measured value @ Us = 3%...15% U_n ±0.15 % U_n @ Us = 1 %...3 % U_n

5.3.4 Current Inputs

Current sensor inputs (switchable)	
Full Scale Range (FSR)	$0.35V_{AC}$ @ 50Hz
Input impedance	2MΩ
Input type	symmetrical
External sensors (switchable)	Rogowski coil, mini current clamp potential-free
Differential overload capacity, permanent	$10V_{AC}$
Common mode area	±15V
Measuring bandwidth	25Hz...20kHz
Fundamental frequency, r.m.s. $I_1 \geq$ 10% FSR: $I_1 <$ 10% FSR:	 ±0.2% of I_1 ±0.02% of FSR
Fundamental frequency, phase $I_1 \geq$ 10% FSR:	 ±0.2°
Harmonics n = 2...50, r.m.s. $I_h \geq$ 1% FSR: $I_h <$ 1% FSR:	 ±5.0% of I_h ±0.05% of FSR
Harmonics n = 2...50, phase $I_h \geq$ 1% FSR:	 ±1.0°
Interharmonics n = 1...49, r.m.s. $I_{ih} \geq$ 1% FSR: $I_{ih} <$ 1% FSR:	 ±5.0% of I_{ih} ±0.05% of FSR

5.3.5 Electrical safety – environmental parameter

Environmental parameters	Storage and transport	Operation
Ambient temperature : Limit range of operation	IEC 60721-3-1 / 1K5 -40 ... +70°C IEC 60721-3-2 / 2K4 -40 ... +70°C	IEC 61010 -25 ... +45°C
Ambient temperature : Rated range of operation H1 Rated range of operation H2	---	IEC DIN EN 61010 -25 ... +45°C -25 ... +50°C
Relative humidity: 24h average No condensation or ice	5...95 %	5...95 %
Solar radiations	---	700 W/m^2
Vibration, earth tremors	IEC 60721-3-1 / 1M1 IEC 60721-3-2 / 2M1	IEC 60721-3-3 / 3M1

5.3.6 Electrical safety

Electrical safety	
– IEC 61010-1 – IEC 61010-2-030	
Protection class	1
Pollution degree	2
Overvoltage category mains supply option : H1 H2	 300 V / CAT II 150 V / CAT III
Measurement category	300 V / CAT IV 600 V / CAT III
Altitude	≤ 2000m
IP protection class in installed condition	IP20

Electromagnetic Compatibility
Immunity – IEC 61000-6-5, Environment H
Emissions – CISPR22 (EN 55022) , Class A

5.3.7 Storage of measured values

Storage of measured values	
Internal memory	1024 MB

5.3.8 Communication protocols

Communication Protocols
● MODBUS RTU ● MODBUS TCP
● IEC60870-5-104 (Option P1) ● IEC61850 (Option P2)

5.3.9 Time synchronization interface

Time synchronization protocols (Receive / Slave)
● NTP

5.3.10 Other interfaces

Interfaces	
Ethernet	RJ45 (10/100 Mb)
RS485	RJ45

NOTICE!

Property damage due to unauthorized IT access via network interface!

- ➲ IT security guidelines for the place and purpose of use must be observed!
- ➲ IT security settings of the device must be observed!

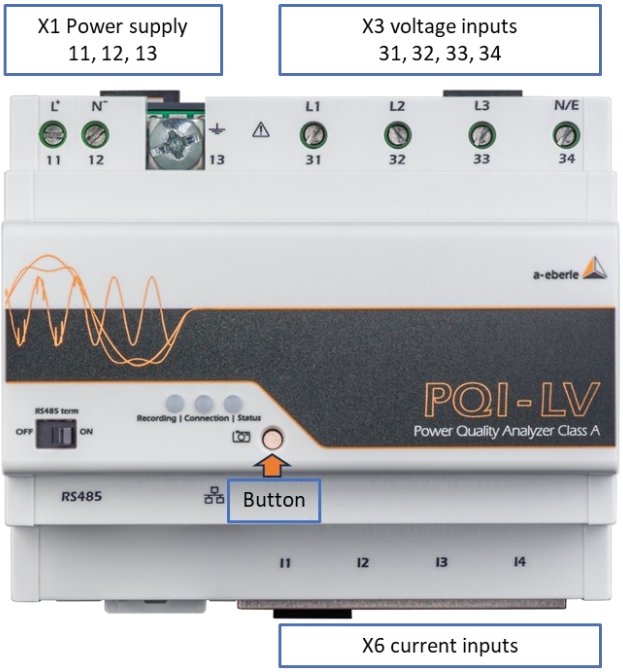
LAN-interface

- ➲ Even when disconnected, all COM and LAN connecting cables must not fall below the insulation distance to dangerous parts.
- ➲ It must not be possible to disconnect individual wires from the clamp.
- ➲ Pull the plugs only directly on the housing, never on the cable.
- ➲ Make sure that the connection cable is fixed or strain relieved.

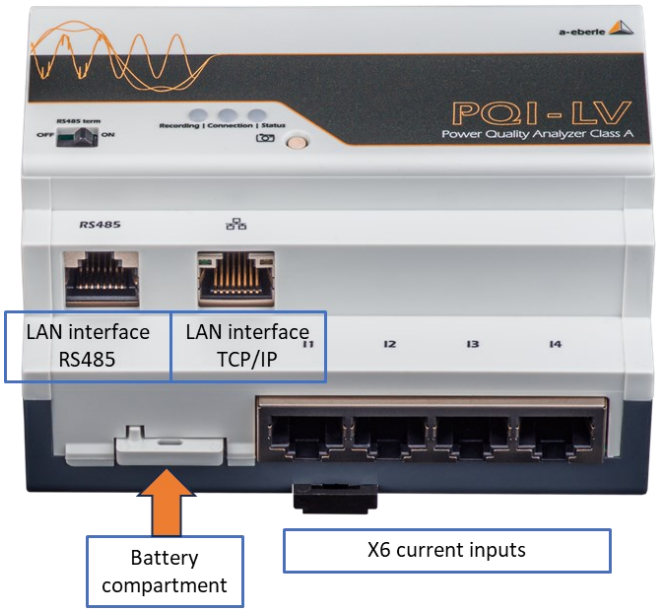
5.5 Mechanical design

The PQI-LV can be mounted on a DIN rail. The connection to the COM interface is via an RJ45 patch cable. All other connections are designed as screw terminals.

An RJ45 connection is available for the TCP/IP interface.



Front view PQI-LV



Side view of PQI-LV

5.5.1 Battery

The battery is only needed for the real-time clock in the device so that the device can keep the time even without a power supply. In a buffered system, a battery is therefore not necessary if external time synchronization is available

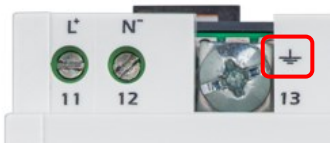
- The battery has a lifespan of >5 years
- Changing the battery does not affect the operation of the device when it is connected to the power supply, as the device is supplied with power internally.
- Pull the battery out of the casing and insert a new battery.
- Battery type: Li button cell CR1632
- Follow the disposal guidelines of the respective country and those in the operating instructions.

5.6 Terminal strip number PQI-LV

Terminal strip no.	Designation		Function	Terminal no.	Cable cross section mm²	Stripped length in mm
X1	Auxiliary voltage	U_H	L (+)	11	0,75 – 1,5	6
			N (-)	12	0,75 – 1,5	6
X1	Ground	GND	E	13	1,5 – 2,5	8
X3	Phase voltage	U1	L1	31	0,75 – 1,5	6
	Phase voltage	U2	L2	32	0,75 – 1,5	6
	Phase voltage	U3	L3	33	0,75 – 1,5	6
	Neutral point voltage	U4	N	34	0,75 – 1,5	6
X6	Phase current L1	I1	I1	RJ45 AWG 23		
	Phase current L2	I2	I2	RJ45 AWG 23		
	Phase current L3	I3	I3	RJ45 AWG 23		
	Neutral conductor / sum current	I4	I4	RJ45 AWG 23		

5.7 Protection ground

The device is provided with a functional earth, which also serves as reference potential for the voltage inputs.



The functional earth is marked with ⏚ and terminal X1 / 13 on the measuring instrument.

Connect the grounding cable to terminal X1 / 13 on the meter and tighten the screw. Use an eyelet terminal for the connection and make sure it is tight!

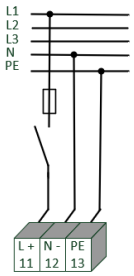
⚠ DANGER! **Danger to life due to electric shock!**

Incorrect connection of this measuring instrument can lead to death, serious injury or fire hazard!

- ➲ The functional earth must always be connected to PE potential.
- ➲ The functional earth must not carry a dangerous voltage under any circumstances

5.8 Supply voltage connection

The PQI-LV is available with two different supply voltage characteristics. Please take the correct supply voltage from the type plate before connection.



Example of a 230 V AC connection with feature H1:

After connecting and switching on the power supply, the status LED flashes red during initial start-up (initial start-up not complete). If a restart occurs after initial start-up is complete, the LED changes to green.

⚠ DANGER! **Danger to life due to electric shock!**

Serious personal injury or death may result from:

- Touching bare or stripped wires that are energised.
- Touching dangerous inputs on the device.

- ➲ Make sure that the device is connected in a de-energized state.
- ➲ Ensure that all connecting cables are fixed and strain relief is provided.
- ➲ All cable requirements of the terminal blocks must be observed. (e.g., stripping length of the cables)

Notice!	**Material damage due to non-observance of the connection conditions or impermissible overvoltage!**

Failure to comply with the connection conditions or exceeding the permissible voltage range may damage or destroy your device.

Before applying the supply voltage to the device, the following points must be observed:

- ➲ Voltage and frequency must correspond to the specifications on the type plate! Observe the limit values as described in the technical data (see chapter 5)!
- ➲ Observe features of the device (H1 / H2)
- ➲ In the building installation, the supply voltage must be provided by a listed miniature circuit breaker and fuse that meets the requirements of IEC 60947-1 and IEC 60947-3!
- ➲ The miniature circuit breaker
  - be easily accessible to the user and installed close to the device.
  - Label for the respective device.
- ➲ Do not take the supply voltage at the voltage transformers.
- ➲ Provide a fuse for the neutral conductor if the neutral connection of the source is not earthed.

5.9 Mains connection for PQI-LV

The mains connection of the PQI-LVs depends on the type of mains in which the measurement is to be made.

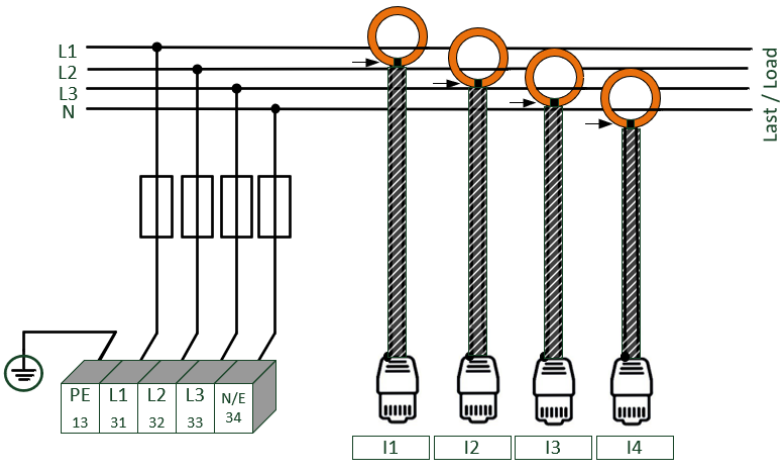
The PQI-LV is designed for direct measurement in low voltage (3-phase / 4-wire connection) for low voltage networks (TN, TT and IT networks) or for residential and industrial applications. A special form of low voltage measurement is measurement in the 4-wire / 1 phase connection with which three independent voltage circuits and current circuits can be measured at the same earthing conditions (see chapter 5.9.3).

The current is measured via sensor transformers with voltage output, which are connected via RJ45 with EMC protection. Either Rogowski coils or current transformers with mV outputs can be used. Switching between these two different types of current sensors is carried out in the measuring device via parameters.

⚠ WARNING!	**Personal injury and damage to property due to non-observance of the safety regulations**

- ➲ Before making any connections, please read this manual thoroughly and follow the safety measures described here.

5.9.1 3-phase / 4-wire connection



Example: Connection of a PQI-LV in a three-phase - four-wire system

- **Voltage connections**
  - The voltage connections must be made as shown in the circuit diagram above
  - If no N conductor connection is available, connect connections E and N together.
  - Make sure that the switching mode (4-wire) is set
- **Current connections**

The PQI-LV has sensor inputs with feature C46. The sensor inputs are designed as EMC-compliant RJ45 sockets for RJ45 plugs and can be operated either with Rogowski coils or classic current transformers with mV signal output. A parameter in the WebServer can be used to switch between integrated signal (Rogowski coil) or linear input signal (current transformer). The current transformer ratio is factory-set to nominal current (e.g., 350mV / kA). This must be adapted to the current transformer used. The appropriate transformers can be obtained from A.Eberle. The connection of transformers from other manufacturers is possible, provided that the described connection conditions (input range, impedance) are observed.

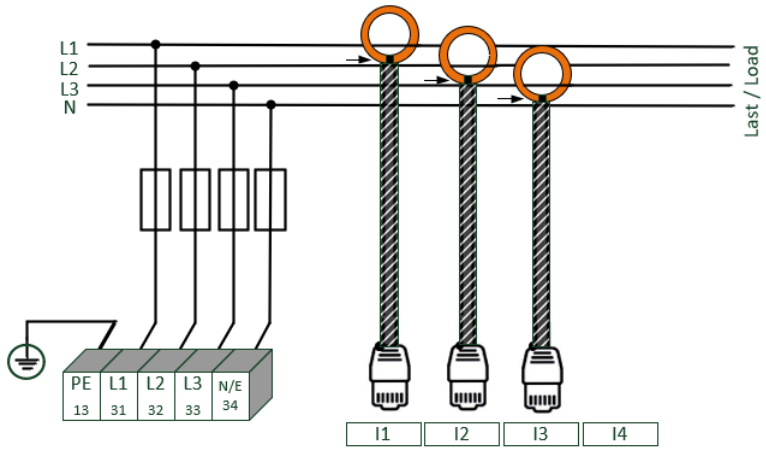
⚠DANGER! **Danger to life due to electric shock!**

Attention dangerous contact voltage!

Flashover and high short-circuit currents possible in CAT III and CAT IV!

- ➲ Ensure that the PE conductor (earthing) is connected to the PQI-LV.
- ➲ Before starting work, check that no voltage is present!
- ➲ Provide protective equipment for CAT II, CAT III or CAT IV.
- ➲ High-load fuses >10 kA or >50 kA must be used in accordance with the CAT.
- ➲ Short-circuit current transformers before starting work.
- ➲ Ensure that all connecting cables are fixed and strain relieved.
- ➲ All cable requirements of the terminal blocks must be observed. (e.g., stripping length of the cables)

5.9.2 4-wire connection without neutral current



PQI-LV without neutral conductor of current transformer in 4 conductor connection

- **Voltage connections**
  - If no N conductor is available, connect E and N together.
  - Ensure that switching (4-wire) is selected
- **Current connections**

With feature C46, the PQI-LV has switchable sensor inputs. The sensor inputs are designed as EMC-compliant RJ45 sockets for RJ45 plugs and can be operated either with Rogowski coils or classic current transformers with mV signal output. Parameters in the WebServer can be used to switch between integrated signal (Rogowski coil) or linear input signal (current transformer). The current transformer ratio is factory-set to nominal current (e.g., 350mV / kA). This must be adapted to the current transformer used. The appropriate transformers can be obtained from A.Eberle. The connection of transformers from other manufacturers is possible, provided that the described connection conditions (input range, impedance) are observed.

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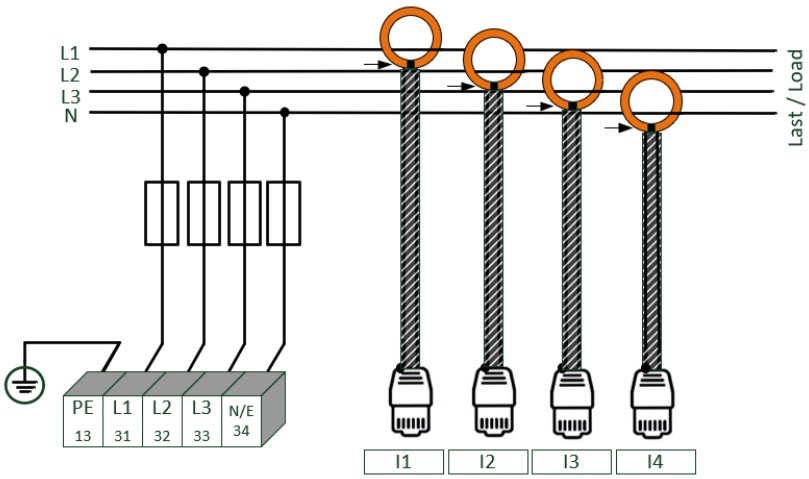
- ➲ Short-circuit current transformers before starting work.
- ➲ Ensure that all connecting cables are fixed and strain relieved.
- ➲ All cable requirements of the terminal blocks must be observed. (e.g., stripping length of the ca-

bles)

5.9.3 4-wire / 1-phase



PQI-LV in 4-wire connection -1-phase

In the 4-conductor system, 1-phase circuit type, no conductor-conductor events and three-phase system events are evaluated. Voltages with the same earth potential and any currents can be recorded.

DANGER! **Danger to life due to electric shock!**

Attention dangerous contact voltage!

Flashover and high short-circuit currents possible in CAT III and CAT IV!

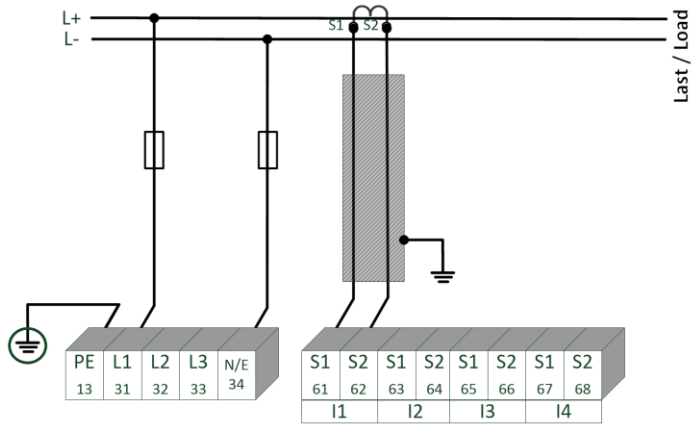
- Ensure that the PE conductor (earthing) is connected to the PQI-LV.
- Before starting work, check that no voltage is present!
- Provide protective equipment for CAT II, CAT III or CAT IV.
- High-load fuses >10 kA or >50 kA must be used in accordance with the CAT.
- Short-circuit current transformers before starting work.
- Ensure that all connecting cables are fixed and strain relieved.
- All cable requirements of the terminal blocks must be observed. (e.g., stripping length of the cables)

5.9.5 DC mains connection

Using hall sensor clamps for current measurement, it is generally possible to use the PQI-LV also in DC systems under the following conditions.

For DC voltage measurement, a difference must be made between symmetrically earthed and solidly earthed systems.

- For IT systems with high-impedance centre grounding, the device is designed for measurements up to ± 600 V, with more than ± 300 V an overvoltage protection is required to comply with the CAT III 600 V.
- For TN-S system, the device is designed for measurement up to 600 V.



Example of PQI-LV connection with current transformer with small signal output DC mains

Depending on the feature, the device is suitable for direct acting current transformers (e.g., open-loop Hall-effect current transformers) with an analogue output voltage of up to ± 350 mV. The measurable bandwidth on the device is DC...20 kHz. Shielding of the signal lines is recommended but not necessary.

DANGER! **Danger to life due to electric shock!**

Attention dangerous contact voltage!

Flashover and high short-circuit currents possible in CAT III and CAT IV!

- ➲ Ensure that the PE conductor (earthing) is connected to the PQI-LV.
- ➲ Before starting work, check that no voltage is present!
- ➲ Provide protective equipment for CAT II, CAT III or CAT IV.
- ➲ High-load fuses >10 kA or >50 kA must be used in accordance with the CAT.
- ➲ Short-circuit current transformers before starting work.
- ➲ Ensure that all connecting cables are fixed and strain relieved.
- ➲ All cable requirements of the terminal blocks must be observed. (e.g., stripping length of the cables)

⚠ WARNING!	**Personal injury and damage to property due to non-observance of the safety regulations**

The current small signal measuring inputs are symmetrical and not galvanically isolated from earth! The inputs offer no protective separation function about electrical safety!

- ➲ The protection functions must be completely provided in the external converters.
- ➲ The converter outputs must be balanced and potential-free!

5.10 RS485 Interface

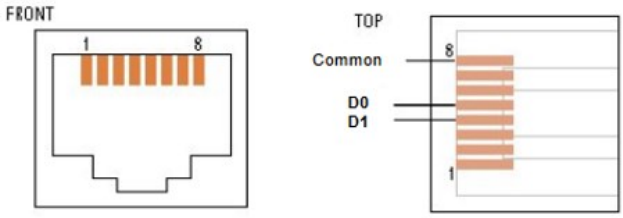
The PQI-LV has one serial interface which can be used as RS485. The functions are determined by the parameterization via the WinPQ Lite software.

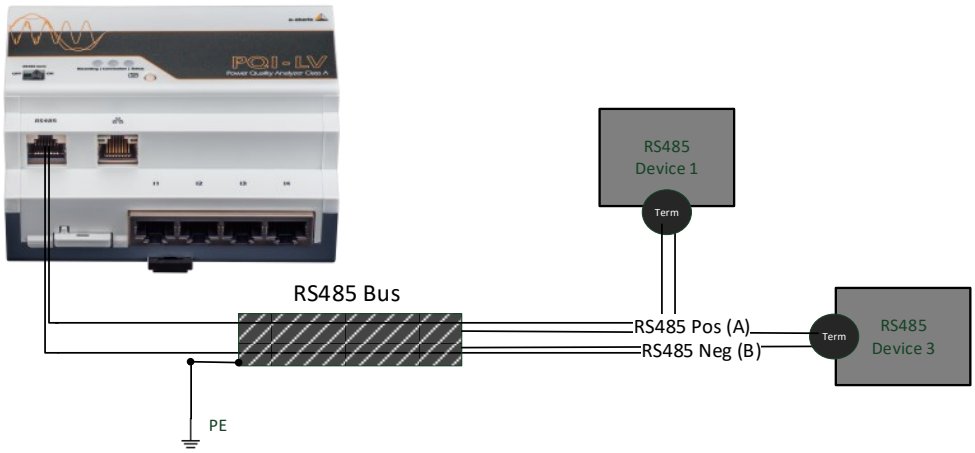
▶ **The following functions are available:**

- Modbus on COM1 over RS485)

5.10.1 Connection and Termination

Pin assignment RJ45 - Modbus	
Pin 4	RS485 Pos (A)
Pin 5	RS485 Neg (B)
Pin 8	Common





Wiring example PQI-LV RS485

Use a twisted shielded cable for the RS485 interface. The shields of all cables must be connected to a voltage-free ground as close as possible to the device!

Please make sure that the maximum cable length of 1200 m for RS485 and 15 m for RS232 is not exceeded!

▶ **Termination RS485**

The first and last station on the bus must be terminated. A dip switch is provided on the PQI-LV for this purpose. The dip switch is located on the front of the device, directly above the RS485 interface.

- Dip switch to ON:
  Bus termination is switched on
- Dip switch set to Off:
  Bus termination is switched off

5.10.1.1 Connection of PQI-LV as Master in a bus

The measuring device can also function as Modbus RTU master in a bus. Notes on parameterization and operation can be found in 13.1.3 and 13.1.4. When setting up the bus, the following notes should be observed:

- **RS-485**
  - Max. 32 participants allowed (Gateway plus 31 RTU-Slaves)
  - Connect wire RS-485A, RS-485B and GND (see chapter 5.10.1)
  - 1 terminating resistor (120…150 Ohm) each at the beginning and end of the backbone
  - Ground the shield of the cable on one side only (to PE)!
  - Maximum length of the backbone: approx. 700m (at low baud rates also up to 1200m)

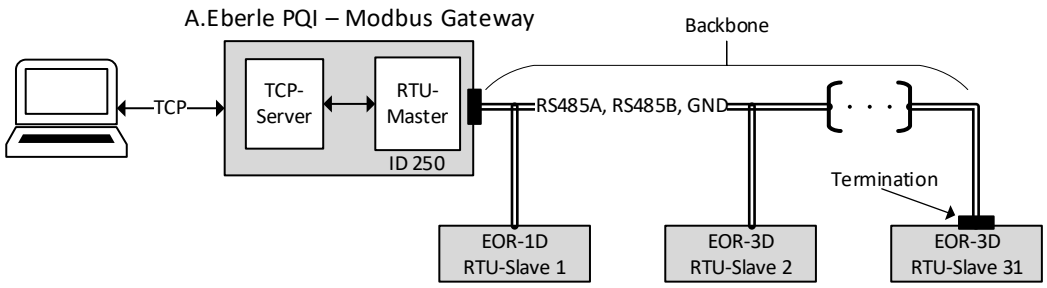


Figure 1: Exemplary connection of a RS485 bus with Modbus gateway

5.11 Measurement / Functions

PQI-LV complies with the automatic event detection and measurement standards, which are:

Standard	Description
EN50160	European power quality standard
IEC61000-2-2	EMC standards in low voltage grids
IEC61000-2-12	EMC standards in medium voltage grids
IEC61000-3-6/7	EMC standards in high voltage grids
IEC61000-2-4 (Class 1, 2, 3)	Industrial EMC standards
IEC61000-3-2/3	Limits for harmonic current emissions
NRS048/IEEE519	International power quality standards
IEC61000-4-30 Class A ed. 3	Methods of measuring power quality
IEC61000-4-7	EMC standards up to 18,69 kHz
IEC61000-4-15	Flicker measurement

5.11.1 Continuous Recording:

Five fixed and two variable measurement time intervals are available for continuous recording. All measured values can be freely activated or deactivated in the data classes. More detailed information about the available measurands per data class can be found in the technical datasheet.

- 10/12 periods (200ms)
- 1 sec
- n*sec (can be set from 2 seconds to 60 seconds)
- 150/180 periods (3 sec.)
- n*min (can be set from 1 minute to 60 minutes)
- 10 min
- 2 h

5.11.2 PQ Events

trigger quantity	lower	upper
voltage dip (T/2)	✓	
voltage swell (T/2)		✓
voltage interruption (T/2)	✓	
voltage rapid voltage change (T/2)	sliding average filter mean +/- threshold	
voltage change (10min)	✓	✓
voltage unbalance (10min)		✓
mains signalling voltage (150/180T)		✓
voltage harmonics (10min)		✓
voltage THD (10min)		✓
voltage short term flicker PST (10min)		✓
voltage long term flicker PLT (10min)		✓
power frequency (10s)	✓	✓

5.11.3 Recorder triggering

trigger quantity	lower	upper	step
r.m.s. phase voltages (T/2)	✓	✓	✓
r.m.s. phase-phase voltages (T/2)	✓	✓	✓
r.m.s. residual/neutral-ground voltage (T/2)		✓	✓
Positive sequence voltage (T/2)	✓	✓	
Negative sequence voltage (T/2)		✓	
Zero sequence voltage (T/2)		✓	
Phase voltage phase (T/2)			✓
phase voltages wave shapes (wave shape filter)	+/- threshold		
phase-phase voltages wave shapes (wave shape filter)			
residual/neutral-ground voltage wave shape (wave shape filter)			
r.m.s. phase currents (T/2)	✓	✓	✓
r.m.s. total / neutral current (T/2)		✓	✓
Power frequency (T/2)	✓	✓	✓
Command	external		

5.11.4 Memory management

The PQI-LV is equipped with one gigabyte of internal memory and intelligent memory management. This ensures that the oldest data records are always overwritten by the most current data according to the First in First out principle (FIFO).

By default, the measuring device is divided into two memory areas:

- Continuous measurement data with 50% of the total memory
- Fault record and events and other asynchronous measurement data

In the standard parameterization with approx. 800 measured variables in the 10 min data class, the device can continuously and seamlessly record all 800 measured variables such as current, voltage, harmonics and power over 140 weeks.

Memory allocation

The memory distribution of the PQI-LV uses the internal 1 GB memory in a circular ring buffer for all measurement data.

The circular buffer is divided as follows:

- 512 MB circular memory for long-term measurement data
- 320 MB circular memory for disturbance records (oscilloscope images; TRMS values)
- 16 MB circular memory for log files and power quality events

In addition, a maximum of 512 files can be saved in each circular memory area.

It is possible to change the memory allocation using parameters. Please contact the support of A.Eberle.

6. Operation of the PQI-LV

6.1 Getting started

When the PQI-LV power analyser is started for the first time, the device indicates that the initial commissioning has yet to be carried out by means of the flashing red status LED. For this purpose, the device has a web server that can be accessed via the default IP address in the subnet 255.255.0.0 using a browser such as Firefox, Chrome or Microsoft Edge. This requires a connection

The connected parameterization PC must have a fixed IP address in the same subnet to access the web server. If you have any questions about changing the IP address of your PC, please contact your IT department.

After the first login, the operator is guided through the initial commissioning of the measuring device. This three-step wizard must be run once after the PQ measuring device has been fully connected. The wizard guides you through the commissioning process with direct explanations.

The three steps are:

- Step 1: Configuration of the communication settings (IP address / DHCP) to access the device remotely.
- Step 2: Configuration of the users who are required for login at the web server.
- Step 3: Configuration of the power quality parameters and settings for the measuring point, such as transformer parameters and standard templates.

Once all connections have been made, we recommend running the wizard to avoid incorrect measurement data being recorded due to the absence of measurement voltages or currents or the failure to enter parameters.

The measurement data is only recorded when the entire wizard has been completed and the PQI-LV has performed a restart.

6.2 Initial Setup - Operation of the Assistant

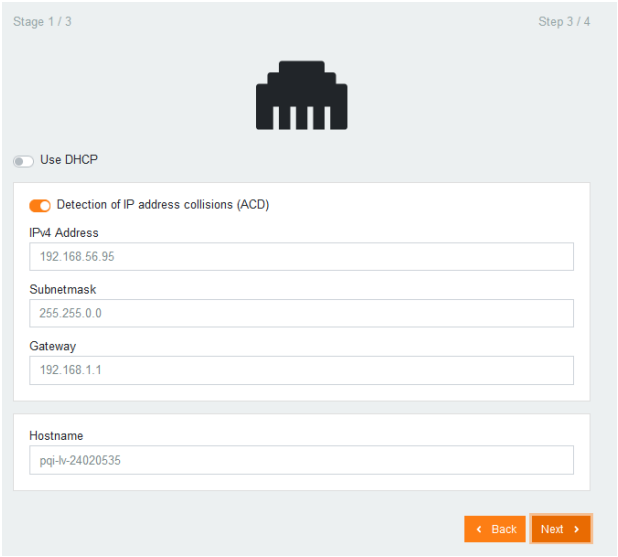
The setup wizard guides you through the initial parameterization of your measuring instrument. This wizard must be completed in full to adapt the measuring instrument to the individual requirements at the measuring

The guided wizard is divided into three stages. If you want to change the selected settings in an active stage, you can navigate back to the previous pages by clicking the “Back” button. If you want to change settings you made in a previous stage, you can restart the wizard from the beginning (see Section 6.2.4).

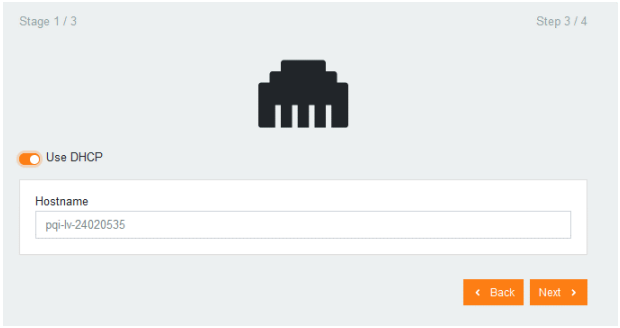
The multi-stage concept allows you to interrupt the wizard after the network settings and/or user creation and, if necessary, to have it finished by another group of people after installation via the network.

6.2.1 Step 1 – Communication settings / IP address configuration

After the operating language has been set, the settings for configuring the network can be made.



Network settings with DHCP disabled



Network settings with DHCP enabled

Two operating modes are available for communication via TCP / IP.

- **Operation with fixed IP address**
  - **IP address**: Enter a fixed IP address as specified by the IT/OT administrator.
  - **Subnet mask:** Enter the subnet mask

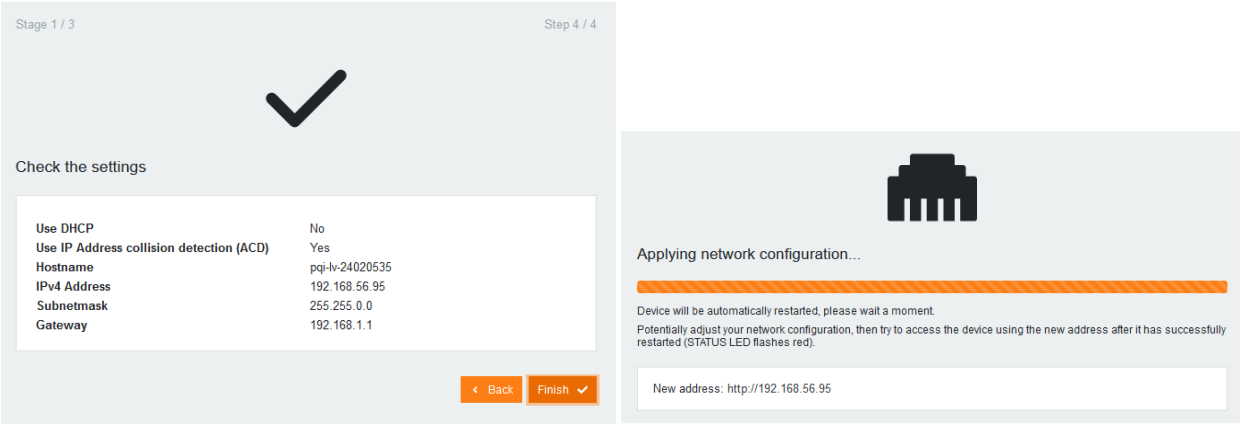
- **Gateway**: Enter the gateway via which the device can be reached
- **IP address collision detection (ACD):** With this function, the device checks at start-up whether the parameterized IP address is already available in the network. For more information, see section 7.5.2
- **Host name:** The measuring device can be addressed directly in DNS-enabled networks using the host name by default, each device is given a name consisting of the device type and the unique serial number

▶ **Operation on a DHCP server**

- **DHCP deactivated:** The measuring device is used with a fixed IP address to be assigned in the next step
- **DHCP activated:** The measuring device receives its IP address via a DHCP server available in the network.

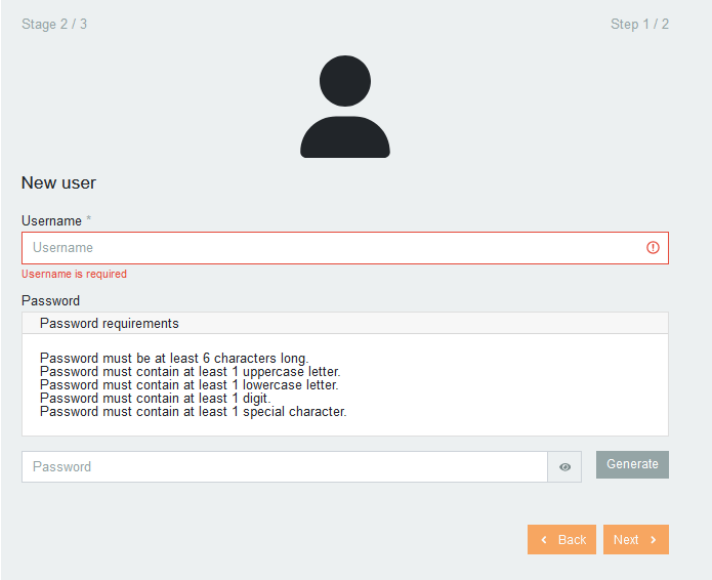
The IP address, subnet mask and gateway are hidden when DHCP is active

After completing the settings, a summary of the settings is displayed If this is confirmed with “Finish”, the device is restarted and can then be accessed via the new settings Please ensure on your PC that the device can still be accessed via the connected PC after the settings have been accepted.



6.2.2 Level 2 - User configuration

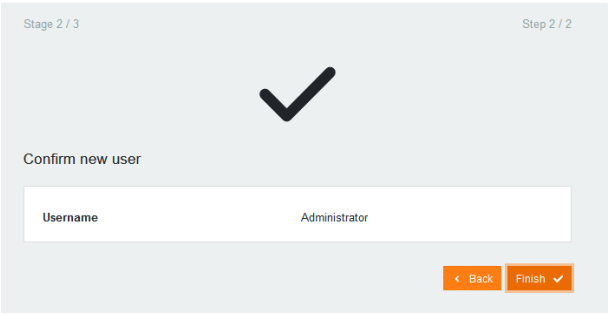
In the second stage, the administrative user is created for the web server of the measuring device, which is required to complete the wizard.

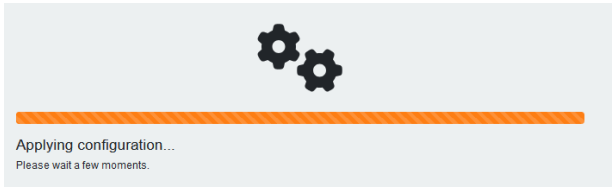


The username must be at least 6 characters long and the password policy must be observed when entering the password

The password policy can also be edited using the WinPQ lite software (section 9.2)

After completing the settings, a summary of the settings is displayed If this is confirmed with “Finish”, this user is created in the device and the device can still only be accessed by entering the user and the selected password





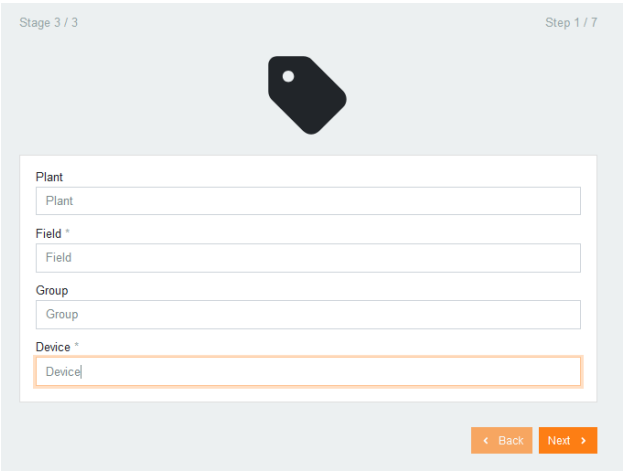
6.2.3 Level 3 - Measuring point configuration

In the third step, the settings for configuring the power quality parameters and settings for the measuring point, such as the transformer parameters and standard templates, are made. The following steps are necessary in step three:

- **registration**

Before the parameters for the measuring point can be set, it is necessary to log in with the administrative user defined in step two.

- **Device identification**



For clear identification of the measuring point, a meaningful designation of the measuring point should be made. These designations are also used for all reports.

The devices are also hierarchically displayed in the database software according to group, company name, name of the measuring field and the device name.

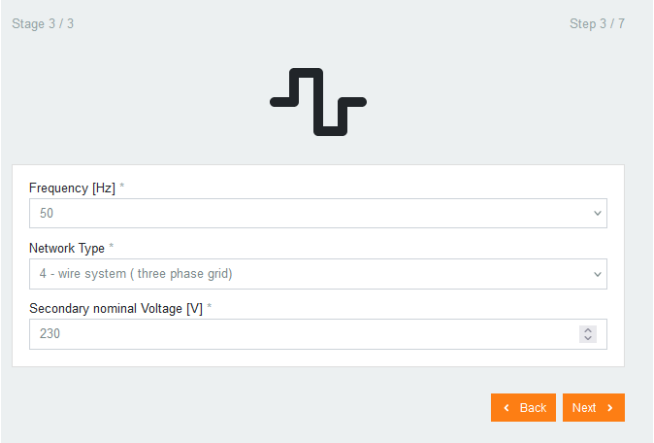
- **Power Quality Norm**

Select the power quality standard

- low-voltage grid / TN system
  => EN50160-NS
- low-voltage grid / IT system
  => EN50160-NS-IT

These settings are used to determine the recording parameters and the basic settings for the limit values. These can then be customized as required

Net type & Net frequency



Basic settings for the PQI-LV grid connection

Further information on the grid connection can be found in chapter 6.2

- **Network type:**

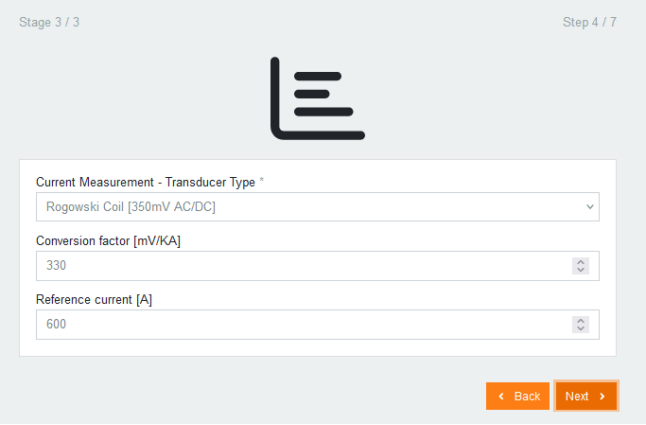
  Entering the network configuration “4-conductor network” or “4 x 1-conductor network” determines how power quality events are recorded.

  - In a 4-conductor network, all power quality events are calculated from the phase-earth voltages and assessed as network events.
  - In a 4x1-conductor network, all power quality events are determined from the phase-earth voltages and evaluated as independent phase events.
- **Frequency**: Set to 50Hz or 60Hz grid frequency

The network configuration cannot be edited when the PQ standard EN50160-NS-IT and EN50160-MS/HS are selected.

- **Secondary nominal voltage [V]:** Setting the reference voltage in the low voltage – TN system as conductor / ground voltage in volts and in the low voltage – IT system as conductor / conductor voltage in volts

Current measurement



- **transducer type**

Both Rogowski coils and magnetic current transformers with an mV output or mini current clamps with an output signal of up to 350mV can be connected to the PQI-LV as a small-signal current transformer.

- **Current transformer factor [mV/kA**

Enter the transformer factor of the small-signal transformer in [mV/kA]. The Rogowski coil with article number 111.7087.06 is already correctly preset at 330mv/kA

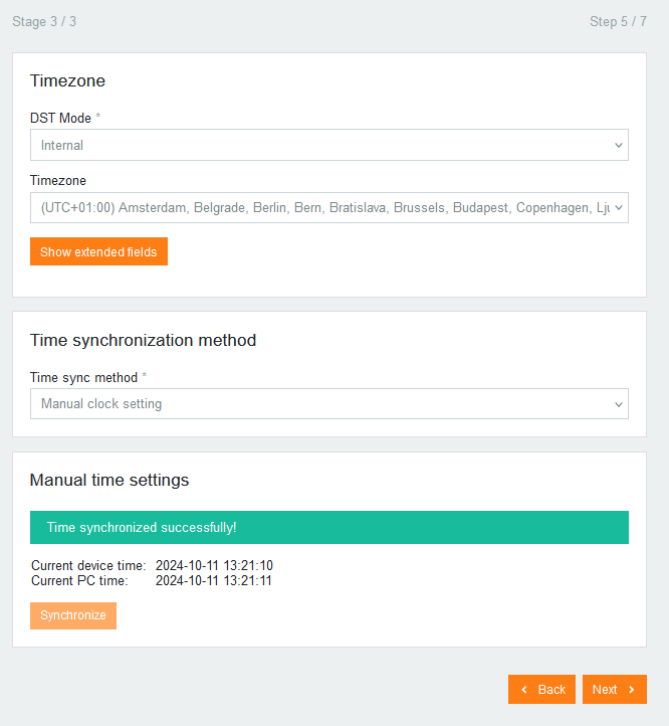
- **System current:**

Setting the nominal current of the system

Time settings

The device has several synchronization options for the time setting. In general, central synchronization is recommended for permanently installed measuring devices according to IEC61000-4-30 (NTP or DCF77.

The device is set to UTC+1 with automatic wintertime changeover in the factory. The time zone and summer/wintertime changeover are to be adapted to local conditions.



- **DST – Mode**

Information on whether the switchover between summer and winter time is carried out in the selected time zone (dependent on time zone)

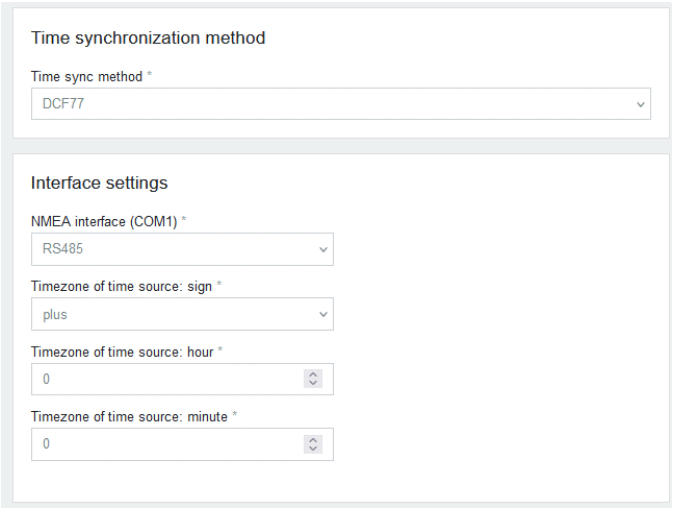
- **Time zone:**

Setting the time zone in which the device is located. Recording is done internally in UTC. However, the measurement data is displayed in local time.

- **Method of time synchronisation:**
  - Manuell
  - DCF77
  - NTP

In **manual mode**, the local time of the parameterization PC can be transferred to the device by clicking the “Synchronize” button.

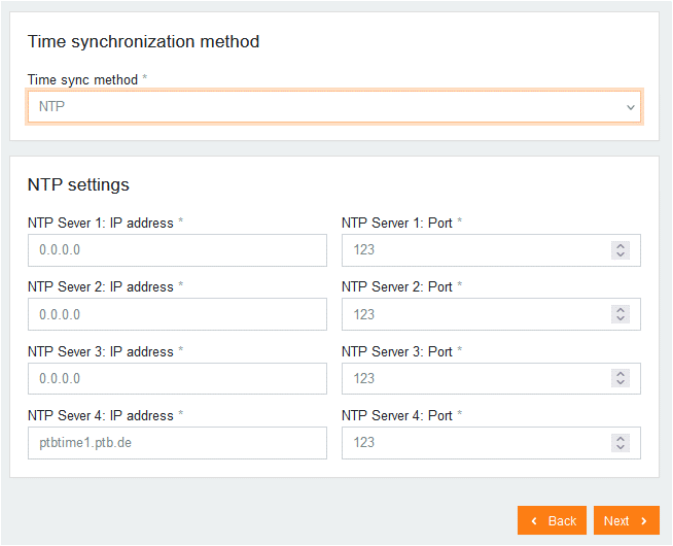
According to IEC61000-4-30, an external synchronization source such as NTP / DCF77 / GPS is required. The settings are described in section 7.4.8.



DCF77

In this mode, synchronization is done via a DCF clock.

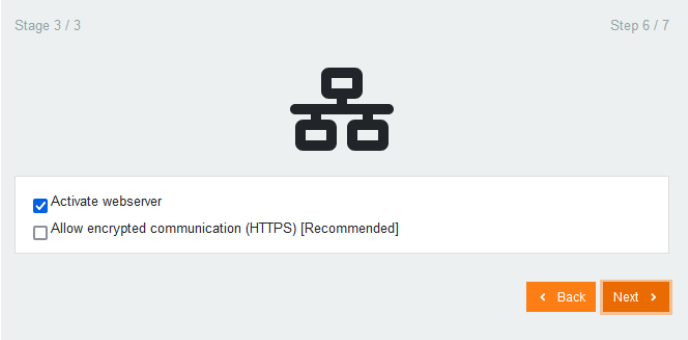
For this purpose, this clock is connected to the RS485 interface at COM 1 of the device.



NTP

In this mode, synchronization is done via a network accessible NTP server. Up to four NTP servers can be entered, with the NTP server with the best accuracy being used for synchronization.

Please note that port 123 must be accessible from the device to the NTP server

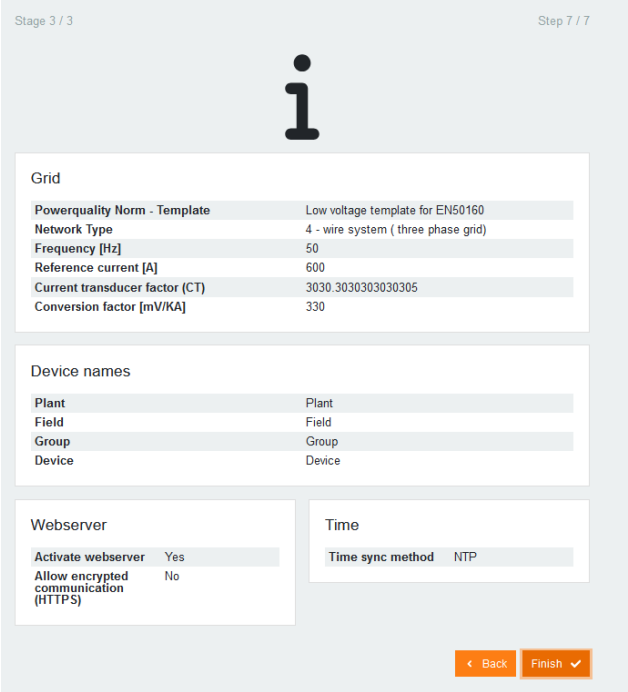


Webserver active

For individual reasons, it may be useful to completely switch off the web server on the device after initial operation. To do this, you can deactivate the web server. It is also possible to switch off the HTTPS encryption. To do this, deactivate the “Allow encrypted communication (HTTPS)” checkbox

When the web server is deactivated, communication with the device is only possible via the WinPQ lite software. The web server can then only be activated via the WinPQ lite software!

Summary Page



- **Finish**

At this point, all settings for the device can be accepted or the setup wizard can be cancelled.

If the wizard is cancelled, it will appear every time the device is restarted because the necessary basic settings have not been made.

Click “Finish” to confirm.

- the device is restarted
- the device deletes all old measurement data in the device memory
- many parameters are reset to the factory settings.
- the measurement technology is started after the restart and the recording is started

6.2.4 Reset commissioning wizard

If, for example, you no longer know the IP address as a user or you want to start the wizard from the beginning, you can reset the device to its initial state by pressing the button for 7 seconds.

This will reset all settings that have already been made within the guided wizard. The users already created will also be deleted by this reset.

Resetting procedure

- The device is switched on and the commissioning wizard is not yet complete.
- Press and hold the button on the front panel for 7 seconds
- After the button has been released, the device triggers a restart
- Now you can start up the device again. The device can be reached again via the address http://192.168.56.95 in the subnet 255.255.0.0

The complete reset of the device is described in chapter 6.5.

6.3 Button functions

The PQI-LV has only one button as a control element, which has different functions depending on the operating mode.

6.3.1 Functions during the startup

Duration of button press	Behaviour
7sec	Resetting the startup wizard (see section 6.2.4)

6.3.2 Functions during operation

Duration of button press	Behaviour
Short, <1sec	Manual trigger to initiate a fault record (S1 license required)
7sec	Activation/deactivation of the web server for on-site parameterization.
20sec	Restart of the PQI (soft reset)

6.4 LED

The three LEDs show the current operating modes of the measuring device.

6.4.1 States during the startup wizard

During the setting up, the device has several states that are indicated by means of LEDs.

▶ **IP address configuration not completed**

Status LED	**Red flashing**
Connection LED	Red flashing: Miscellaneous Red/Yellow flashing: Link up and connection established
Recording LED	Off

In this mode, the device can be accessed via http://192.168.56.95 with subnet mask 255.255.0.0.

▶ **User and measuring point configuration not completed**

Status LED	Red flashing
Connection LED	Green: Connection established Off: Link up and no connection Red: Link down
Recording LED	Off

6.4.2 Conditions in stationary operation

During operation, the displays of the three LEDs are to be considered isolated from each other.

▶ **Status LED**

Colour	**Description**
Green	Normal operating mode without failure
Orange	Boot mode
Rot	Device malfunction

▶ **Connection LED**

If several pieces of information are visualized at the connection LED at the same time, the worst information is displayed according to the “red > orange > green” scheme.

Colour	**Description**
Green	Active network connection via TCP/IP
Orange	If the NTP time synchronization method is selected, synchronization with the NTP server is not possible.
Off	Link up without active connection
Red	Link down

▶ **Recording LED**

Colour	Description
Grün	Recording in progress
Orange	Recording of a fault record or presence of a PQ event
Rot	Recording stopped

6.5 Reset device to factory settings

If the device status is unknown, the device can be reset to factory settings on site.

REMARK! **Property damage due to data loss!**

Resetting to factory settings deletes all measurement data and any additional software licenses. To avoid this, the following points must be observed:

➲ Ensure that license keys are stored securely.

➲ Ensure that the measurement data from the device is backed up.

To reset the device, the following procedure is necessary:

- Disconnect the power supply voltage of the device and wait until the LEDs go out.
- Press the button on the front panel and restore the power supply.
- The button must be pressed and held until all three LEDs flash yellow quickly. At that moment, the button can be released.
- The device starts to boot from the internal recovery image. The status LED flashes red and green altern
- When the LED is only flashing green, the update has been completed.
- The device should automatically restart within the next 60 seconds. If this does not happen, disconnect the power supply briefly.

Afterwards, the device can be put back into operation. To do this, the device must be accessible again via the address http://192.168.56.95 in the subnet 255.255.0.0.

6.6 Webserver

The PQI-LV has a web server that provides initial diagnostic functions on site.

For on-site use, it is possible to press and hold the PQI-LV button for 7 seconds. This activates the web server for on-site work. After a configurable period of inactivity, the web server is automatically deactivated again.

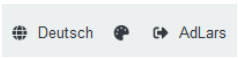
The web server can be permanently activated via the parameterization with the WinPQlite.

After entering the IP address of the device, the login page appears first

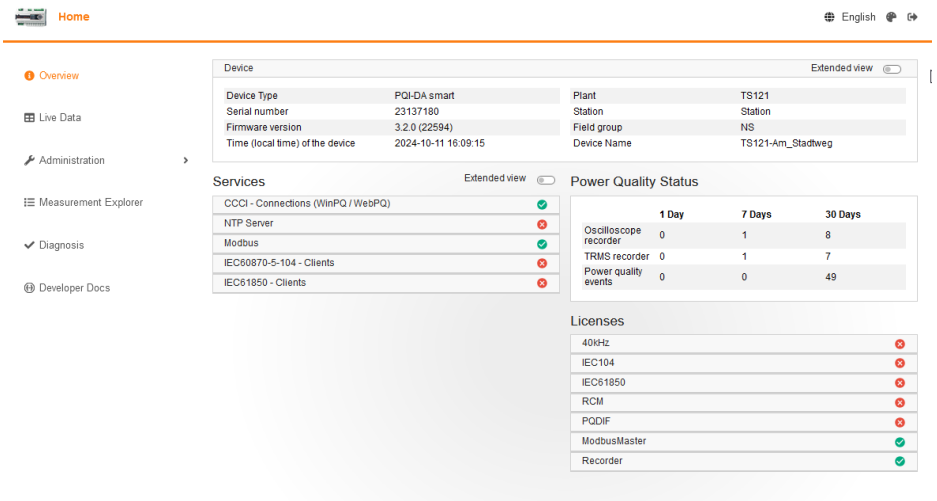
6.6.1 Overview

After logging in, the web server's overview page is displayed. This page contains relevant meta information about the measuring device. In addition, individual settings for the design and language can be made. These can be selected individually in the top bar.

- Clicking on the symbol  will switch the design directly between light and dark mode
- Clicking on the symbol  will open a drop-down menu with the available languages



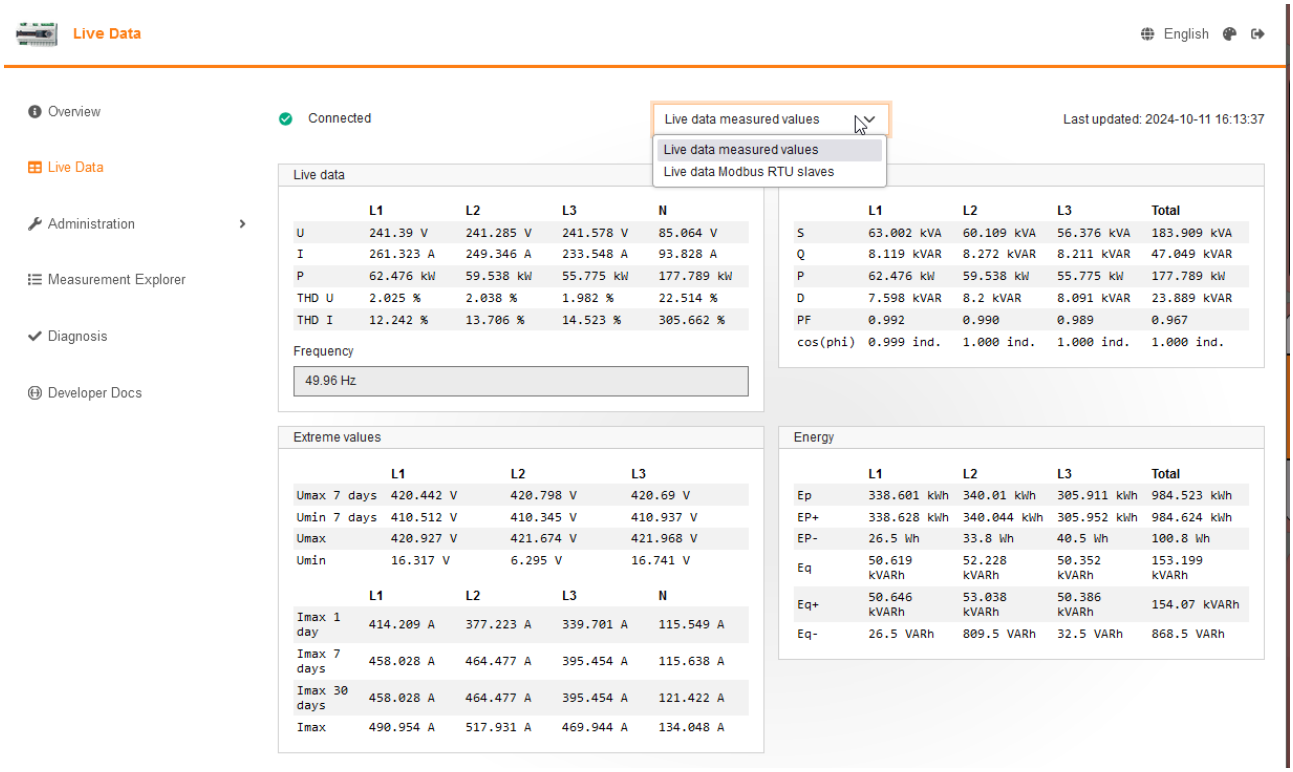
On this page, administrative users can also view the active services and network connections of the device.



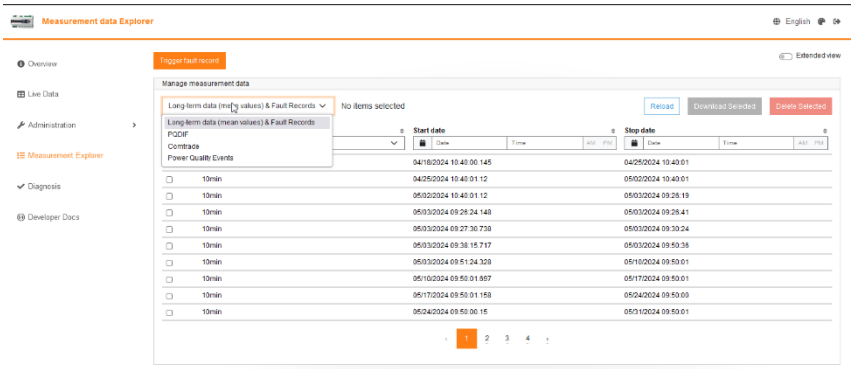
The calibration certificate can be downloaded from the device as a PDF in the extended view

6.6.2 Live data

The live data displays the 1-second effective values of selected base quantities, the drag indicators and the statistics. However, other views can also be selected. “Live display of Modbus RTU slaves”



6.6.3 Measurement Explorer



The measurement Explorer can be used to display, download and delete the recording files of the measuring device. Selective filtering allows you to quickly select the files you are looking for.

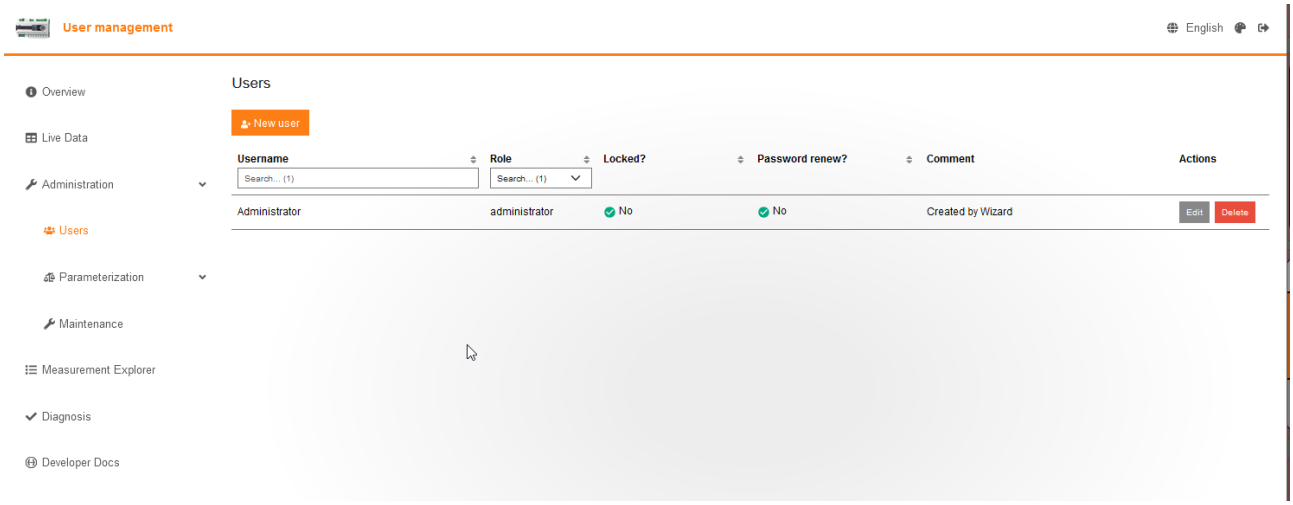
Four different file types can be selected from the drop-down menu:

- **Long-term data:** Recording files from fault recordings and synchronous data classes. These files can be evaluated retrospectively using the WinPQlite and WinPQ software packages.
- **Power quality events:** files containing meta information about PQ events. These files can be evaluated retrospectively using the software packages WinPQlite and WinPQ.
- **PQDIF:** Recording files in PQDIF format, provided that a valid license F1 is present on the device and PQDIF files are recorded (see chapter 15.2)
- **COMTRADE:** Recording files in PQDIF format, provided that a valid license F1 is available on the device and PQDIF files are recorded (see chapter 15.1).

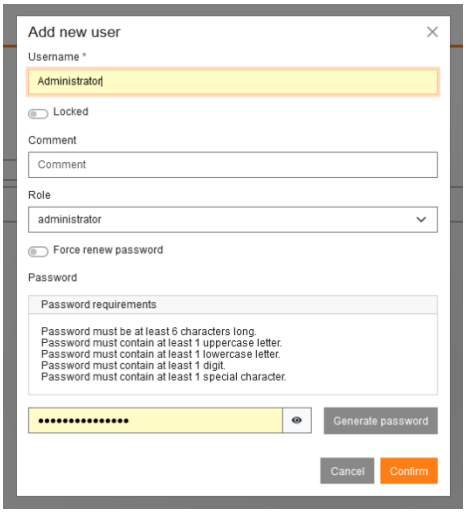
With the help of the **REST API** provided by the device, it is also possible to download these files via automatic access using scripts; see chapter 14 for more information.

6.6.4 User administration

In the user administration, further users can be added, users can be blocked, users can be deleted, and passwords can be changed.



By clicking on “New user”, a new user can be added via the open modal.



By clicking on “**Delete**”, the user is deleted.

By clicking on “**Edit**”, an existing user can be edited.

The password policy is to be set using the WinPQ lite software (chapter 9.2).

7. WinPQ lite Software

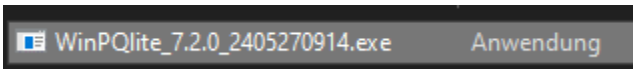
The free evaluation software WinPQ lite (downloadable from www.a-eberle.de/pqi-lv-software-en) was developed exclusively for the PQI-LV, PQI-DA smart and PQI-DE network analyzers and includes the following functions:

- Parameterization of the PQI-LV, PQI-DA smart and PQI-DE power quality analyser
- Online analysis of measurement data
- Reading measurement data from the measuring device
- Evaluating offline measurement data
- Firmware update for PQI-LV, PQI-DA smart and PQI-DE

The powerful **database and evaluation software WinPQ** which is available at an extra charge supports all mobile and permanently installed Network Analysers supplied by A. Eberle in one system. Measuring data from different devices can be compared to each other. There is a fully automated and permanent connection to all permanently installed devices. Detailed Power-Quality reports and sequence of events recording are automatically created by the system and can be sent via e-mail. There are separate operating and commissioning instructions for the WinPQ software.

7.1 Installing the evaluation software

Please download the software from the website www.a-eberle.de/pqi-lv-software-en and check the checksums for security reasons! The installation can be started with administrative rights by double-clicking on the *WinPQ lite_7.2.0_Datum.exe* contained in the zip file.



The installation corresponds to the usual Windows standard, including the uninstallation of the program system via the "Add or Remove Programs" control panel. The installation location of the programs (target directory) can be freely selected during installation.

The start icon 

is automatically created on the desktop of the PC.

Uninstalling the software via the control panel

The components are removed from the PC using Windows **Control panel**.

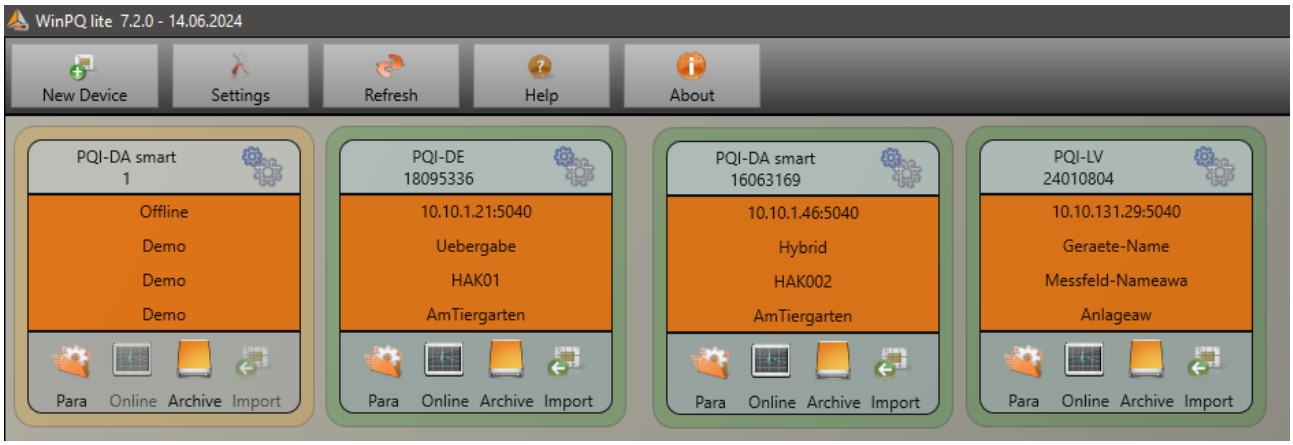
Via **Software**, **WinPQ lite** entry, use the **Remove** button to delete the evaluation software.

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

Software Update

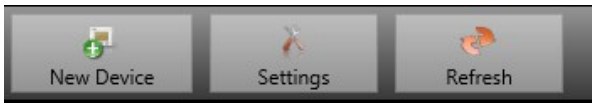
The evaluation software as well as all updates and current device firmware can be found free of charge on our website at the product group "Power Quality / Software WinPQ lite". www.a-eberle.de

Please also install the current device firmware on your measuring device to ensure that you can use any new functions.



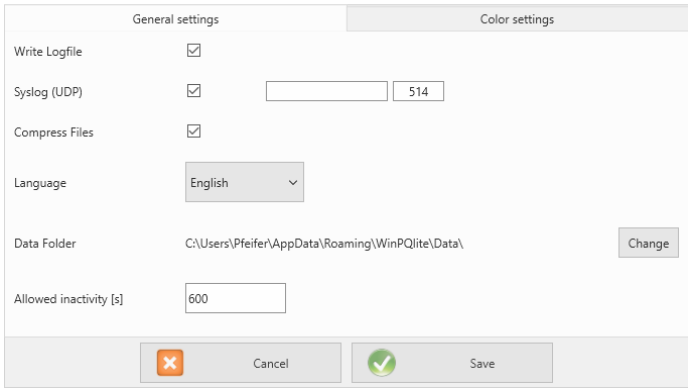
Start screen for WinPQ lite, example with three PQI devices and one offline tile

7.2 Basic setting for Software



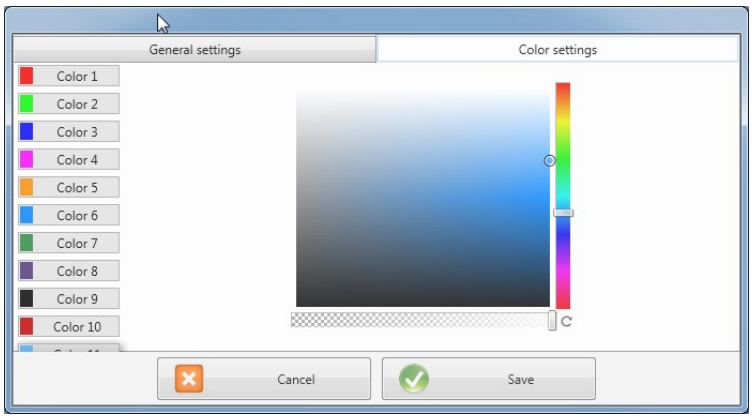
The following changes are possible under the menu item "Options":

General Settings



- **Write Logfile:** software messages are logged in a file.
- **Syslog (UDP):** the logbook messages are also transmitted via syslog protocol via the network.
- **Compress files:** if this option is activated the WinPQlite is zipping the .xml-files of parameterization before sending them to the device. This leads into a faster communication and parameterization.
- **Language:** software language setting (SW must be restarted after a change)
- **Data folder:** Folder in which all measurement data are stored. This can be individually adapted to your own folder structure, for example to store the measurement data of the PQI-LVs on *D:\measurement data*\.
- **Allowed Inactivity:** if this time of inactivity will be reached, the WinPQlite closes open connections with the device. The default-value of allowed inactivity are 10min=600s.

Colour Settings

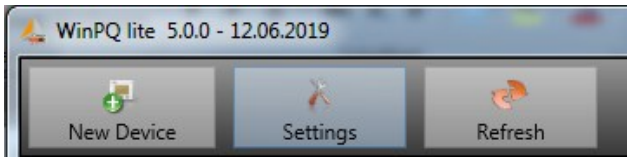


Individual colours can be used to display the measurement data.

The colours are used in the order of the clicked measurement data.

7.3 Setting up a new PQI-LV

Via the function “**New device**” an assistant is called up which creates the measuring devices as a tile on the WinPQ lite Desktop and completes the commissioning of the device.



For a fully secure connection, the "IT Security Guide PQI-LV for Administrators" must also be observed in addition to these operating instructions!

7.3.1 Creating a device tile

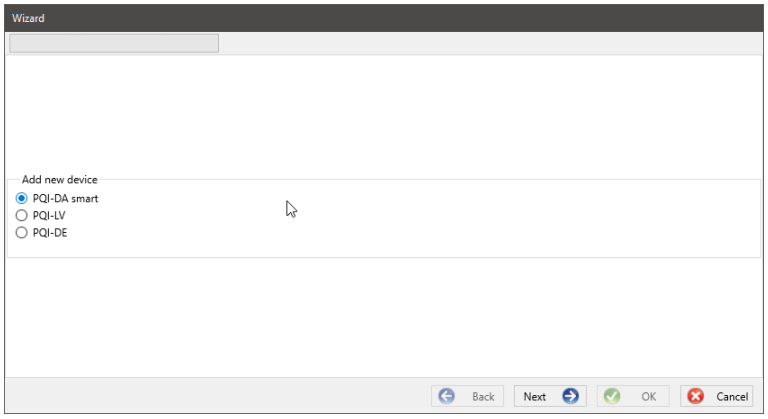
Since the A.Eberle devices with firmware version 2.0 or higher have several modes due to the increased IT security requirements, it is necessary to differentiate when adding encoders to the WinPQ lite software.

Under the following conditions, a device can be created in the WinPQ lite software without further actions:

- A device with a firmware version lower than V2.0 is present.
- A device with firmware V2.0 and switched on compatibility mode is present.
- There is a device with firmware V2.0 and already setup user administration.

If none of the above requirements are fulfilled, the measuring instrument is not yet completely set up. The instructions in chapter 6.2 must be followed to completely setup the device.

7.3.1.1 Wizard Step 1 - Device Selection



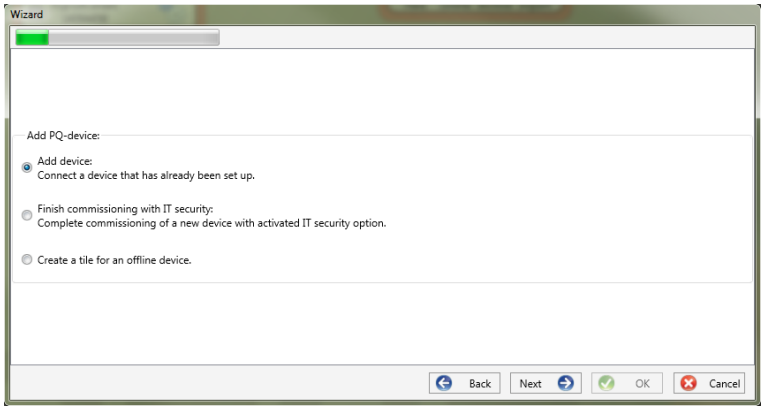
Device selection:

- PQI-LV

- PQI-DA smart

- PQI-DE

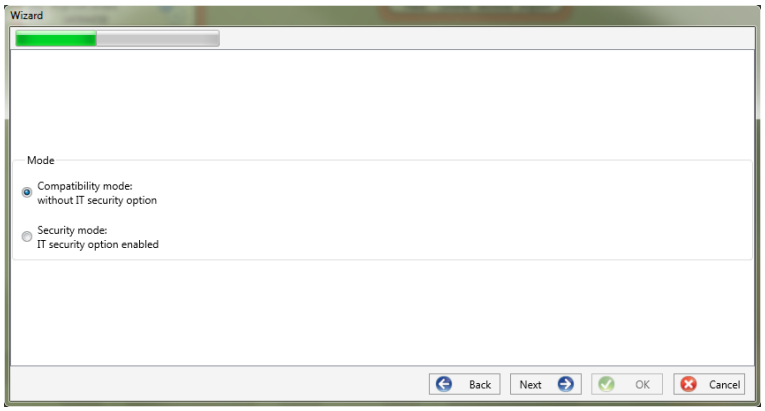
7.3.1.2 Wizard Step 2 - Device Setup



Selection for a device according to the requirements listed above is

"Connect device that's already been set up."

7.3.1.3 Wizard Step 3 - Device Mode



Selection of the procedure for finishing the devices - Security settings:

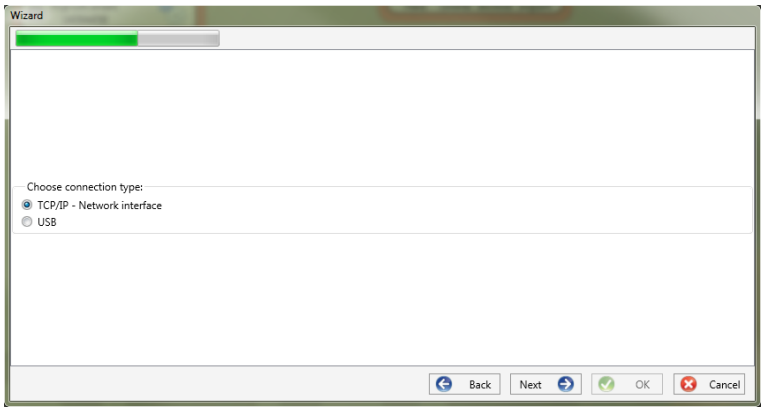
- Compatibility mode

The TCP/IP communication to the device is unencrypted.

- Security mode

The TCP/IP communication device is encrypted using the SSH protocol.

7.3.1.4 Wizard Step 4 - Device Connection

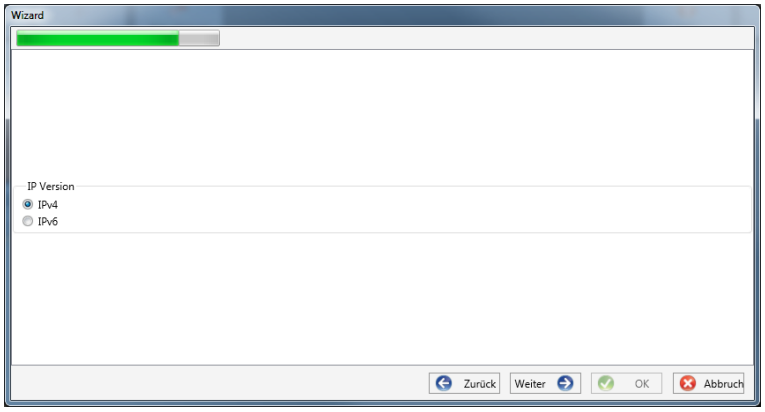


Selection of connection

The device can be connected via USB or TCP / IP (network) communication.

If the USB interface is used, it must be selected in the following step.

7.3.1.5 Wizard Step 5 - IP Version

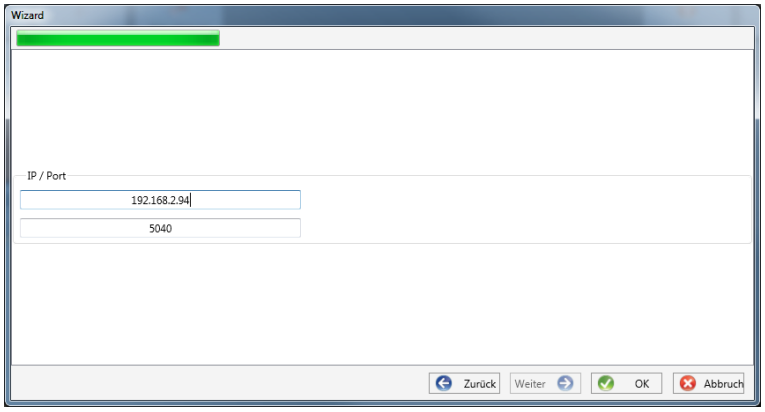


Selection of IP version

A distinction can be made between IPv4 and IPv6. IPv6 is currently only supported via gateways.

The default connection is IPv4.

7.3.1.6 Wizard Step 6 - IP Address



IP address of the measuring instrument:

Enter the IPv4 address and the connection port of the encoder.

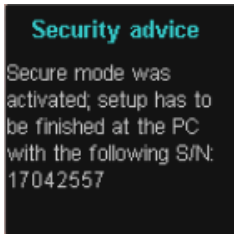
The default port after completion of the wizard in 6.3 depends on the selected mode:

- Security mode: Port 22
- Compatibility mode: Port 5040

Click "OK" to accept the values and create a tile for this device on the software interface. Any number of devices can be created.

7.3.2 Completing the device Wizard in Secure Mode

If the setup of the meter was performed in "Secure Mode" as described in 6.2, the meter will display the following screen after restarting until the setup is complete:

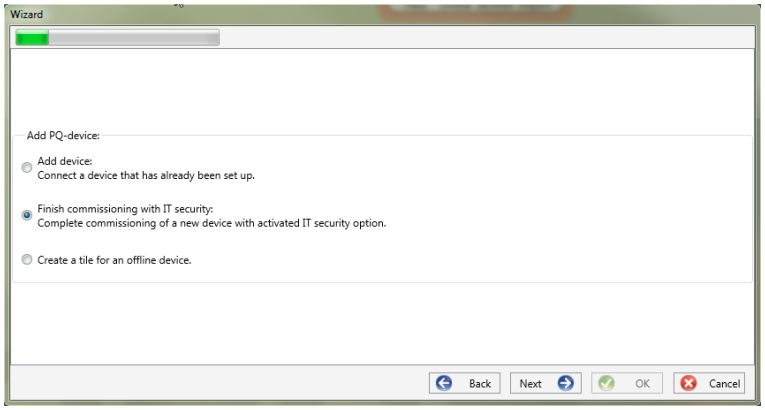


At the end of commissioning in security mode, a user database is created on the device in which all information on users, their roles and the associated rights are stored.

To create individual users for the device in this database, it is necessary to execute the commissioning assistant via the "New device" button.

The device is selected as described in Section 7.3.1.1.

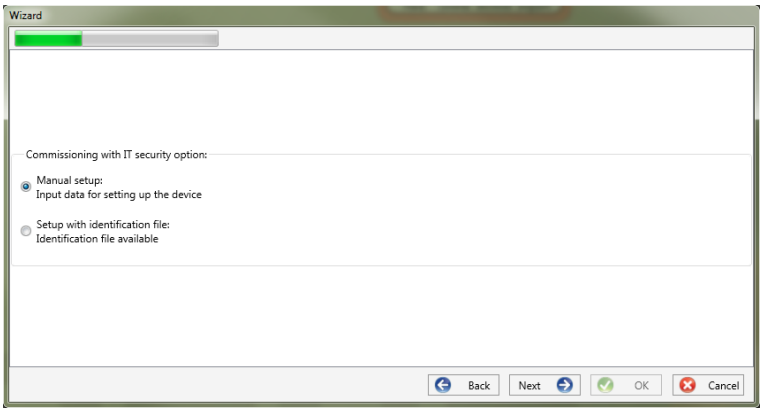
7.3.2.1 Security Wizard - Completion



Selection to complete all security settings:

"Completion of commissioning with IT security".

7.3.2.2 Security Wizard - Procedure Selection



Selection of the procedure for completing the devices - Security settings:

- Manual setup (see chapter 7.3.2.3)

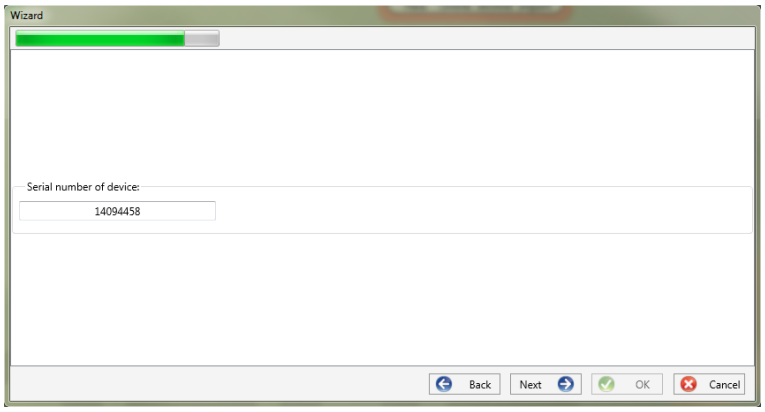
Manual entry of all data such as IP address / serial number of the device

- Identification file (see chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**)

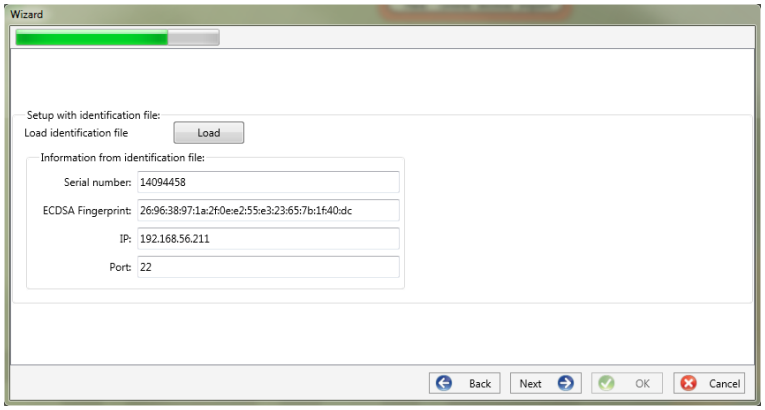
Use of an identification file made

available by the device

7.3.2.3 Security Wizard – Manual



For setup, the serial number of the instrument must be known and entered in the field to establish the first connection via an encrypted connection to the device.

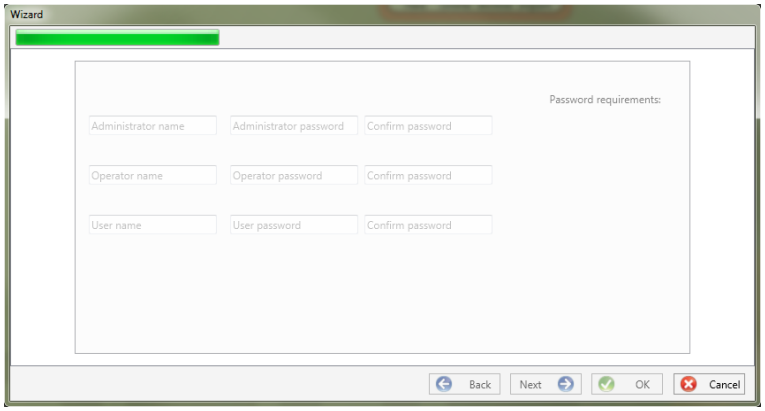


After the file has been selected, all information required for the connection is automatically entered.

In any case, the ECDSA fingerprint must be compared with the fingerprint on the measuring device before clicking **Next** to uniquely verify the identification!

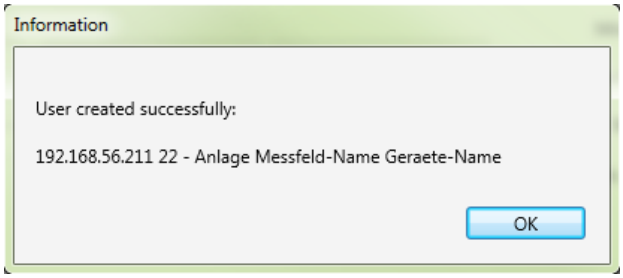
Click **Next** to download the password guidelines from the meter.

7.3.2.4 Security Wizard - User Setup



For each of the three roles defined (administrator, operator, user), the device requires a user who must be entered together with a password.

Depending on the password policy, a password that complies with the company's IT policy is required.



If all users have been successfully created and transferred to the meter, the following message appears

"User successfully created!"

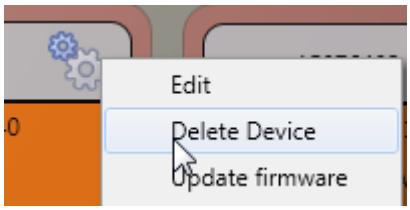
Commissioning in high-security mode is now complete.

The detailed description of rights and roles with specification of rights is listed in the security documentation.

In addition to the three standard users per role, further users can be created in the measuring instrument. The settings are described in chapter 9.

7.3.3 Deleting a device tile

Device tiles can be deleted via the **Setup general** device menu.

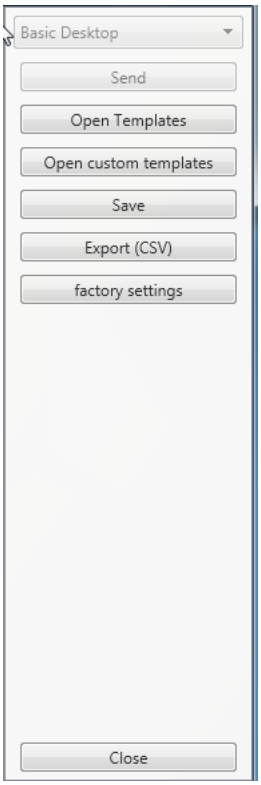


7.4 Device setup

The PQI-LV's parameter setup can be accessed via **Para** button on the device panel. Parameters can be set in basic or expert view, which is also referred to as the classic view in the following sections. These views can be switched by choosing the corresponding selection field in the right main menu of the parameterization window.

The **main menu** (see chapter7.4.1) is displayed in the right area of the parameterization window. The **parameters menu** with selectable parameter groups is shown in the left window area (see chapter 7.4.2).

7.4.1 Main Menu: Views and functions

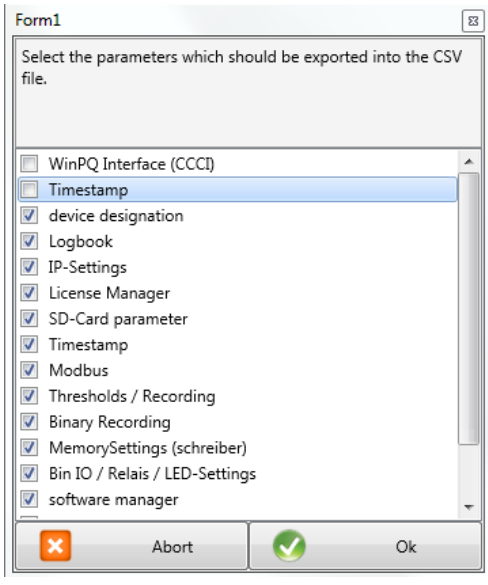


The **basic view** allows application-driven parameterization of the device; the **classic expert view** shows the parameter structure of the device in list form and is described in chapter 7.5. The service view should only be used for parameterizations in cooperation with the A. Eberle service team. Incorrect parameterizations can lead to malfunctions!

Via **Send** button, the previously defined parameters are sent to the device. The buttons **open templates** or **open custom templates** can be used to load different standard templates or custom parameter sets.

- Low voltage network according to EN50160 and trigger settings
- Medium voltage network according to EN50160 and trigger settings
- High voltage network according to EN50160 and trigger settings
- IEEE519 for different voltage levels

Via **save** button, settings are saved to an XML file. The **Factory settings** option resets all settings on the device except for the network, connection and license settings to the factory settings.



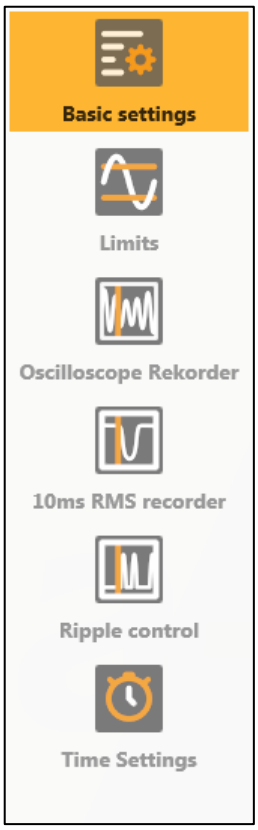
Selection dialog for exporting the desired data

36		
37	Frequency	50
38	Frequency ripple signal voltage [Hz]	168
39	Flicker bulb	1
40	Normalized voltage L-L-Sp. [percent from UNOM]	100
41	hysteresis 1/2-Perioden-voltage [percent from UC bzw. UC/	1
42	tolerance band fast voltage change RVC, dd [percent from U	1
43	|dmax|-threshold fast voltage change RVC [% from UC bzw.	6
44	threshold voltage dip (Dip) [percent from UC bzw. UC/1.73]	90
45	threshold voltage swell (threshold) [percent from UC bzw. U	110
46	threshold voltages interruption [percent from UC bzw. UC/1.	5
47	lower threshold 10s- network frequency /Hz	49,5
48	higher threshold 10s-Total network frequency /Hz	50,5
49	lower threshold 10min-voltage [percent from UC bzw. UC/1.	90
50	higher threshold 10min- voltage [percent from UC bzw. UC/1	110
51	threshold 10min-THD [percent]	8
52	threshold 10min-voltages unbalance [percent]	2
53	threshold short time flicker PST	1
54	threshold long time flicker PLT	1
55	threshold 3 Sec -ripple signal voltages [percent from UC bzw.	9
56	Trigger-threshold 200ms-ripple signal voltage recorder [perc	1
57	limit table 10min-voltages harmonic (H2) [percent]	2
58	threshold 10min-voltages harmonic (H3) [percent]	5
59	threshold 10min-voltages harmonic (H4) [percent]	1
60	threshold 10min-voltages harmonic (H5) [percent]	6
61	threshold 10min-voltages harmonic (H6) [percent]	0,5
62	threshold 10min-voltages harmonic (H7) [percent]	5
63	threshold 10min-voltages harmonic (H8) [percent]	0,5
64	threshold 10min-voltages harmonic (H9) [percent]	1,5
65	threshold 10min-voltages harmonic (H10) [percent]	0,5
66	threshold 10min-voltages harmonic (H11) [percent]	3,5

Example of a CSV file in Excel

After resetting the PQI-LV to factory settings, the assistant must be executed again! All measurement data will be deleted from the device after the wizard has been executed! **Close** closes the parameterization last. Changes that are not saved will be lost!

7.4.2 Parameter Menu: Device parameters and settings

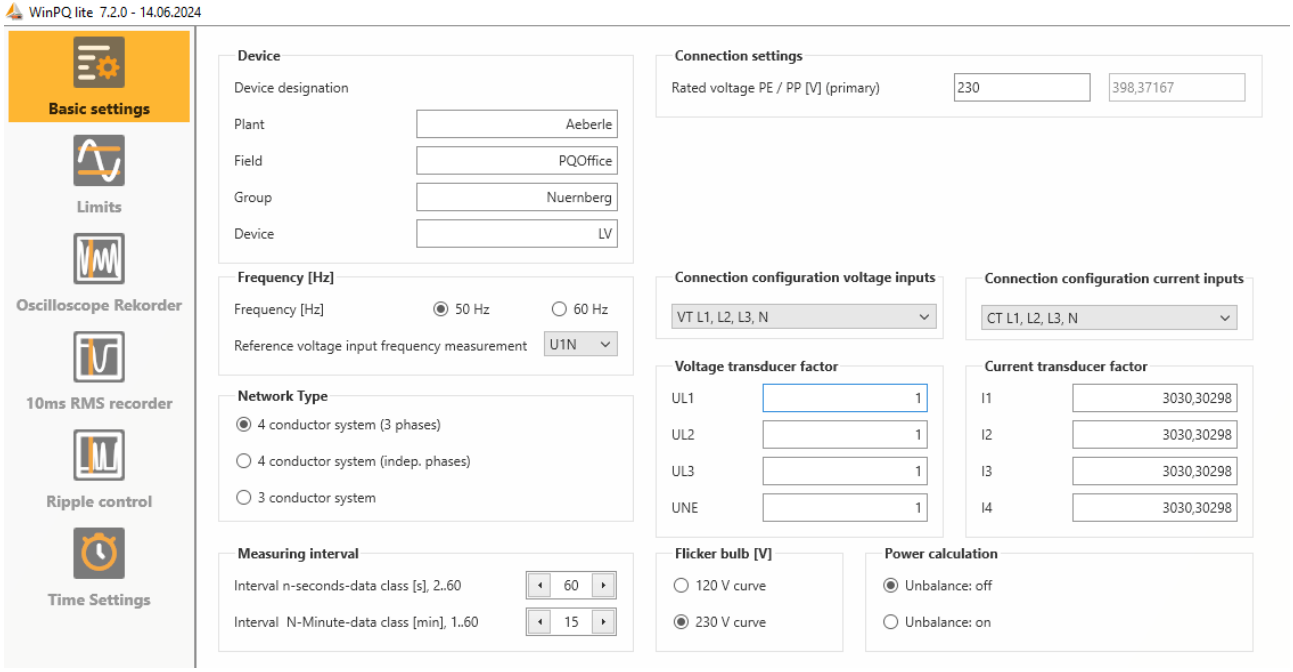


The device parameters and settings are divided into functional groups and can be selected in the left window area (see fig. left). These are explained in more detail in the following chapters. The different parameters are partly dependent on each other as well as on the loaded or selected template when the device has been commissioned.

Further explanations of the various setting values can be found in the next chapter 7.5.

7.4.3 Basic Settings

All main settings can be found into the basic settings window.



To provide a clear overview, all parameters are bundled into functional groups.

7.4.3.1 PQI-LV

All device identifiers can be entered here for a clear assignment of the PQI-LV. These identifiers are used for presentation in the WinPQ lite interface, when copying data to an SD card (folder name) and for unique assignment into the WinPQ database.

7.4.3.2 Connection Settings

- **Nominal voltage (conductor-earth) in volts is defined here (primary).**

The PQI-LV refers all trigger thresholds or PQ events to the set nominal voltage. The nominal voltage in the 3-wire network is the agreed conductor-conductor voltage,
e.g., 20,400 V. In 4-wire network, the conductor-ground voltage is specified, e.g., 230 V.

7.4.3.3 Frequency

Selection of the grid frequency and selection of the reference voltage input for frequency measurement

7.4.3.4 Network Type

- **Selection of the network type:**

If a 3-conductor system has been selected, all evaluations of standard EN50160 are calculated based on the conductor-conductor voltages. In 4 conductor system, all power quality parameters are determined from the conductor-ground voltages. Choosing 4 conductor system with independent phases, the power values of the individual phases are calculated separately.

7.4.3.5 Connection configuration of voltage and current inputs

Selection of the connection configuration and the voltage transformer factors. Enter the ratio of the current and voltage transformers to which the power analyser is connected in the transformer settings.

- **Rogowski-coils:**
  - Conversion factor of the Rogowski coil: $CT = 85 * \frac{\mathrm{mV}}{\mathrm{kA}}$
  - internal conversion factor: $kni = \frac{1}{CT} = 11761{,}71 \frac{\mathrm{A}}{\mathrm{V}}$
- **AC-Mini current transducers:**
  - Since a mini current clamp is usually connected in the secondary circuit of a current transformer, the internal conversion factor **kni** depends on both the transformer ratio of the current transformer and the ratio of the mini current clamp.

Secondary rated current of the current transformer: $I_{W,sek} = 5A$

Primary rated current of the current transformer: $I_{W,pr} = 200A$

- Conversion factor of the current clamp: $CT = 100 \frac{\mathrm{mV}}{\mathrm{A}}$
- internal conversion factor: $kni = \frac{I_{W,pr}}{I_{W,sek} * CT} = \frac{200A}{5A * 100 \frac{mV}{A}} = 400 \frac{\mathrm{A}}{\mathrm{V}}$

The conversion factors must be entered identically on all four phases.

7.4.3.6 Measuring interval

Configuration of the two adjustable recording intervals N-seconds and N-minutes. In addition to the class A measurement intervals, numerous values can be recorded by the PQI-LV at freely adjustable intervals. For example, this can be used for the measurement of maximum power in the 15 min interval. The intervals are always synchronic to full hours.

7.4.3.7 Flicker-Curve-Lamp model

Select the lamp model for a 120 V or 230 V flicker curve. In 120 V systems (e.g., America), a different flicker curve is specified than in a 230 V system (e.g., Europe).

7.4.3.8 Power calculation

Selection of the power calculation with or without unbalance.

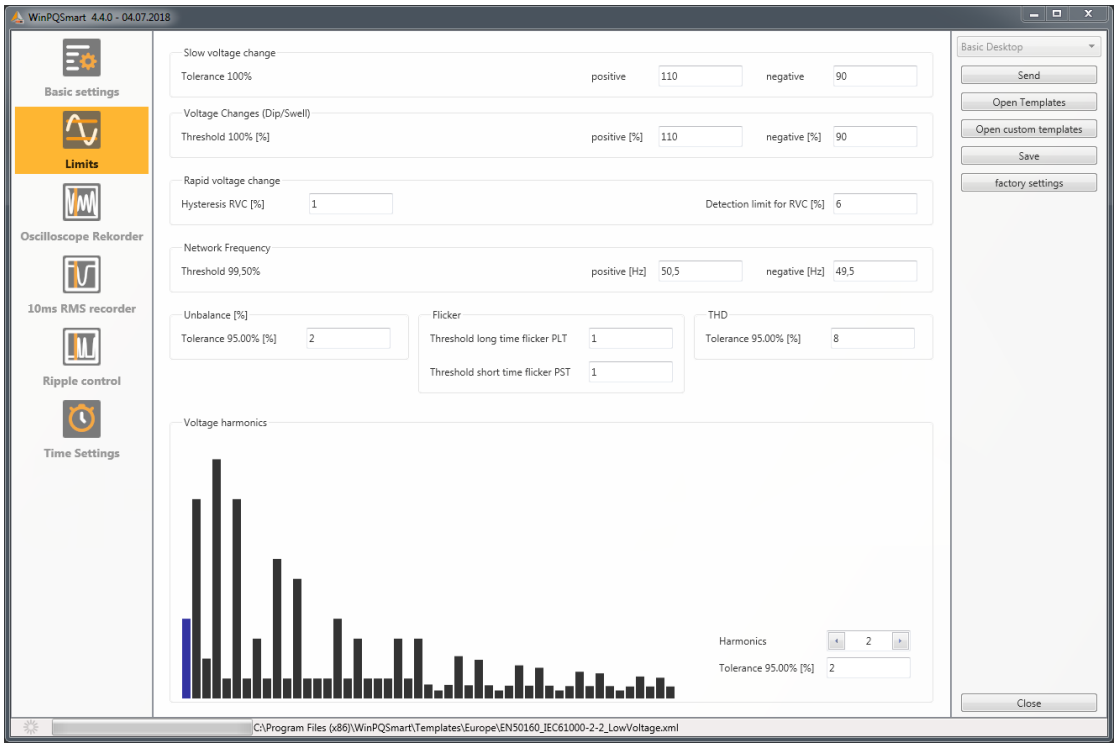
The various types of reactive power can be switched on or off as required. This has an influence on the calculation of the collective reactive power as well as the apparent power.

- **Unbalance: On**
  Power calculation according to DIN40110 Part 2 - with calculation of the unbalance reactive power and the modulation reactive power is the default setting of the device. This Adjustment is strongly recommended for measurements on the transformer stations.
- **Unbalance: Off**
  Power unbalance is not considered in the calculation of reactive power.

This setting has an influence on the measured power values of reactive and apparent power in the display, the online measured data and the recorded measured data as well as in process controlling.

7.4.4 Limits

In this menu, all limit values of the currently set standard or loaded standard template are preselected. The compatibility levels can be changed by the user. This setting has a direct influence on the standard reports! It is recommended to work with standard templates!



For a clearer overview, all parameters are organized in functional groups. The various (physical) quantities and their calculation methods are defined and described in chapter 16.

- **Voltage changes**

Limits for slow voltage changes and fast voltage changes (for details see the respective standard).

- **Frequency**

Upper and lower limit value of the permitted frequency deviation in relation to the set grid frequency.

- **Unbalance**

Limit value for unbalance.

- **Flicker**

Limits of long and short-term flicker.

- **THD**

Limits of the Total Harmonic Distortion.

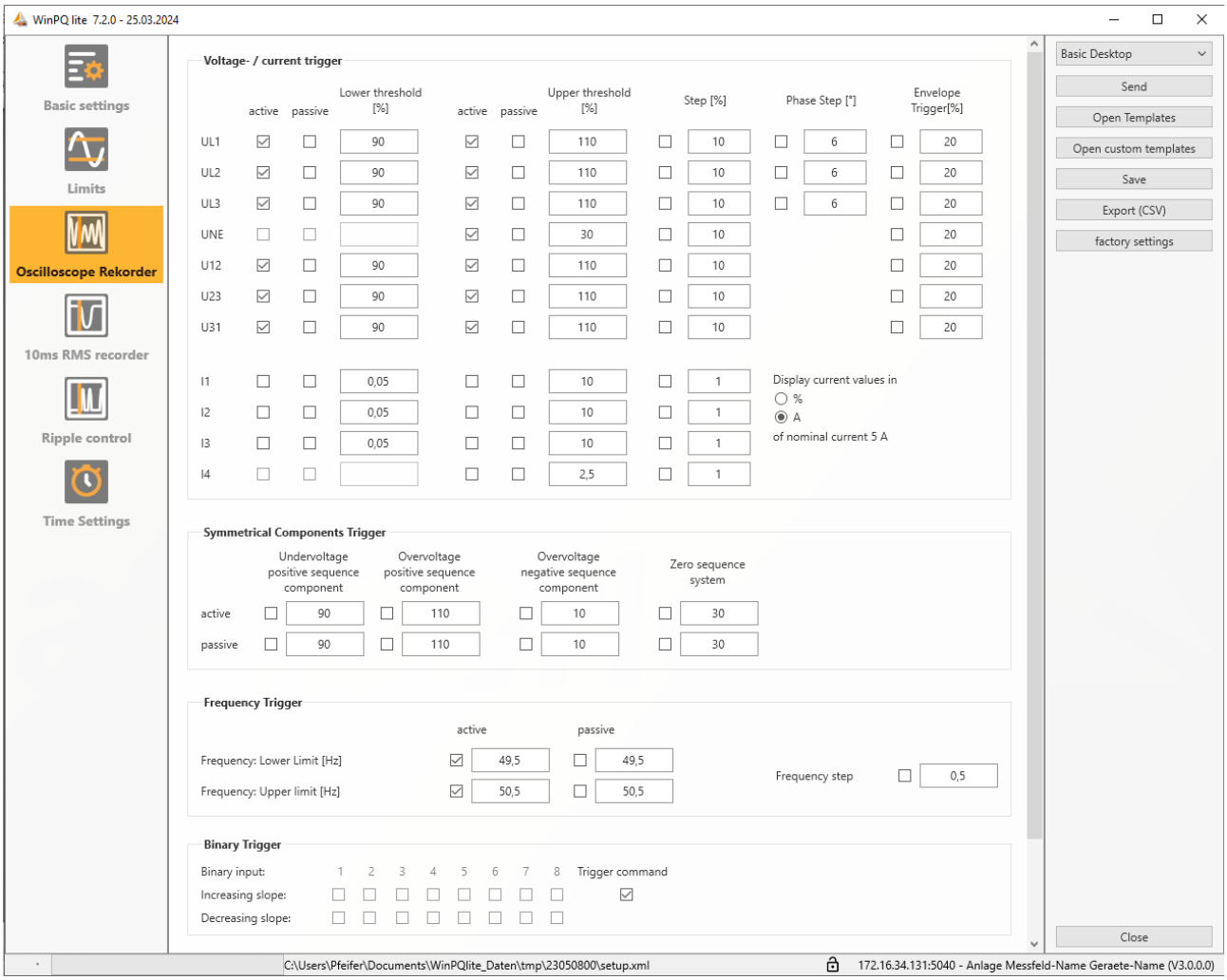
- **Voltage harmonics**

Limits of voltage harmonics with direct selection.

7.4.5 Oscilloscope Recorder – Feature S1

The parameterization of the recorders is only possible if the fault recording is activated on the device with feature S1. To activate the license, see chapter 11.

The trigger conditions and thresholds, i.e., trigger criteria for oscilloscope recorder, as well as other settings of the oscilloscope recorder can be set in this menu. In default configuration, an effective value threshold of +10% and -10% of the nominal voltage is defined.



For a clearer overview, all parameters are organized in functional groups. If a field is greyed out and/or not selected, this trigger criterion is not active or cannot be activated. The parameters of the current trigger can be displayed either absolute or as percentage value of the nominal current (setting in the basic configuration).

The trigger thresholds of the oscilloscope and RMS recorder are not completely independent. All common parameters are automatically adjusted in both recorders.

7.4.5.1 Voltage and current trigger

In general, the trigger thresholds refer to the nominal voltage, e.g., 230 V or 20,400 V, which has been set in the basic settings.
If the voltage/current value (10ms RMS value) falls below the lower trigger threshold or exceeds the upper trigger threshold, a recording is started as well as in case of RMS value jump or phase jump.

The envelope trigger starts a recording in case of a so-called sinus violation. Thereby the device detects a violation of sampling points with respect to the configured envelopes of the sinusoidal curve (e.g., commutation dips). In practice, a setting in the range of 10 to 25% (of the nominal voltage) is usually recommended.

7.4.5.2 Symmetrical Components Trigger

A record is started in case of the specified symmetrical component thresholds are violated.

7.4.5.3 Frequency Trigger

Starts the recorder when the values fall below or exceed the set mains frequency (basic settings). The frequency jump parameter triggers the ROCOF (Rate of Change of Frequency). For internal processing and determination of the ROCOF, filters are used which can be optimised for each application in the field. To design these filter coefficients, please contact product support, who will be happy to provide you with the white paper and package for recording the ROCOF. The standard parameters are suitable for detecting ROCOF>0.2Hz/s with a duration of at least 0.25s.

7.4.5.4 Recorder length and Pre-event time

The recorder length specifies the total time frame of the oscilloscope recorder in milliseconds. Pre-event time is defined as the time that passed before a (trigger) event occurred and is also recorded.

The PQI-LV's fault recorders provide a minimum recording length and a maximum recording length. Thereby, the minimum recording length is extended up to the maximum recording length, depending on the trigger condition. This function offers the possibility to reduce data due to short events as well as to record very long events ensuring an effective use of data storage!

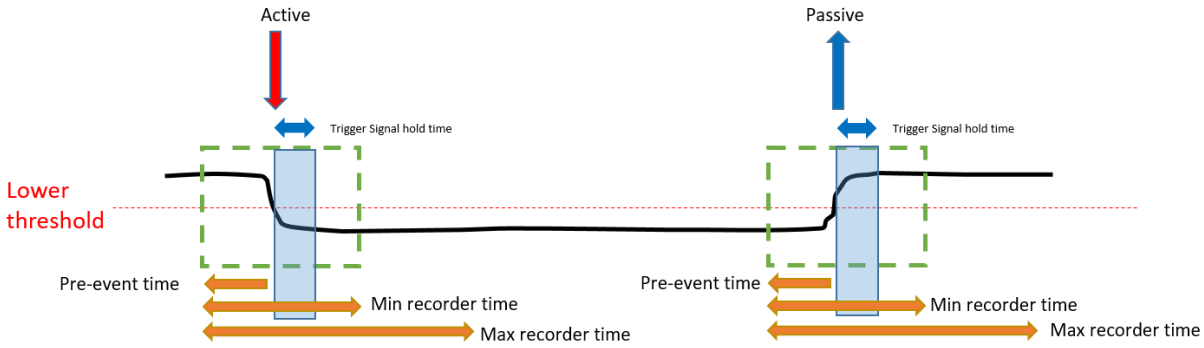
7.4.5.5 Active / passive trigger:

Active triggering occurs, if e.g., the voltage drops from desired to undesired state.

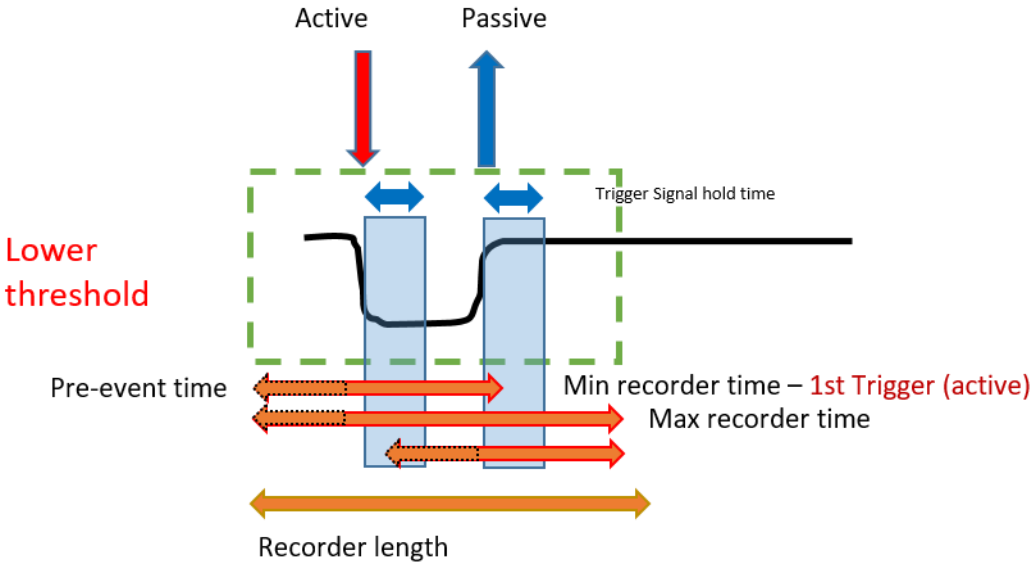
Passive triggering allows triggering the transition from undesired to desired state e.g., after voltage interruptions.

This feature offers the possibility to record very long earth faults with an enormous data reduction, since both the beginning and the end of the event can be recorded entirely, without the obligation to record the whole event!

- **Example 1: Single fault with activated " active " and " passive " trigger**

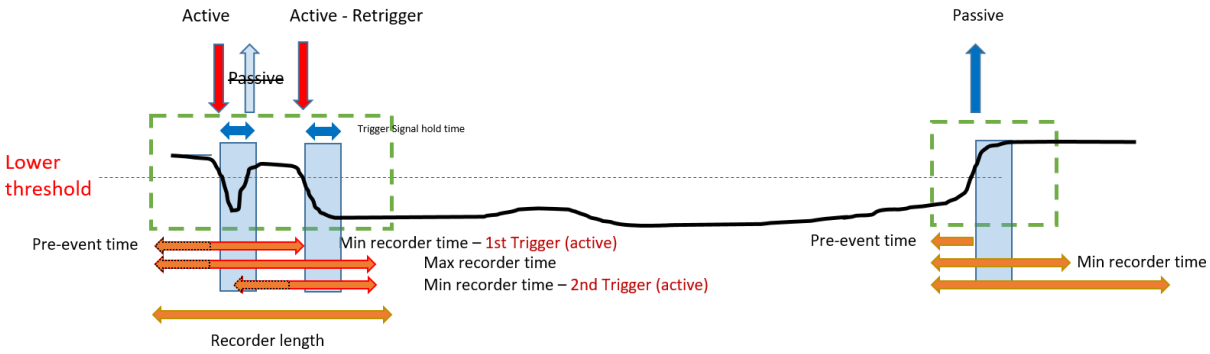


- **Example 2: Single fault with activated «active» and «passive» trigger & retrigger**



If another trigger criterion occurs during the minimum recording length after the trigger signal holding time, the Record is extended by the minimum length up to the maximum length

- **Example 3: double fault with activated «active» and «passive» trigger, retrigger combined with trigger signal hold time & max time**

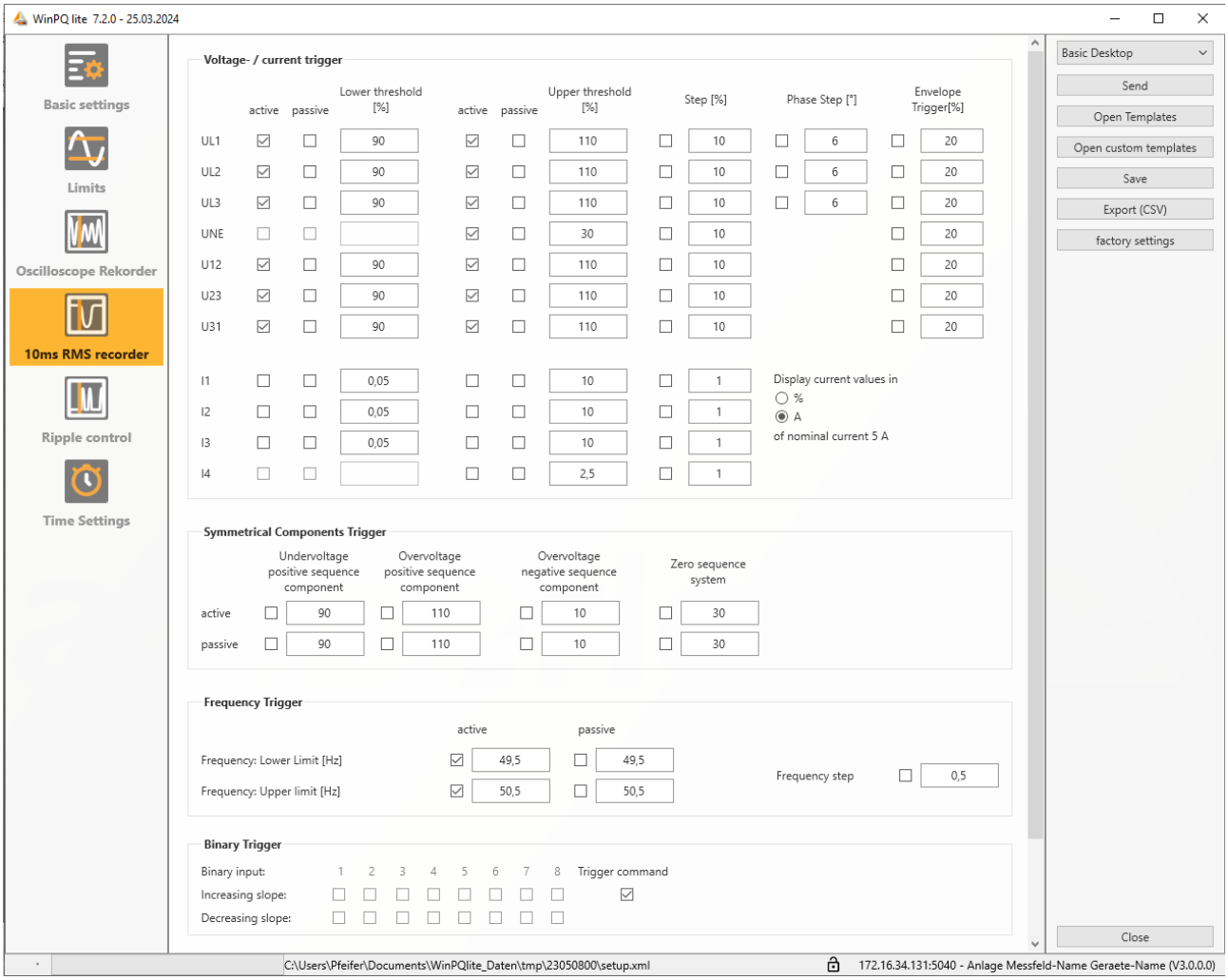


Passive Trigger is not evaluated during “trigger signal hold time”, which can be set up inside Expert mode

7.4.6 RMS Recorder – Feature S1

The parameterization of the recorders is only possible if the fault recording is activated on the device with feature S1. To activate the license, see chapter 11.

In this menu, the trigger conditions of the RMS recorder can be set. In the default settings, an effective value threshold of +10% and -10% of the nominal voltage is set.

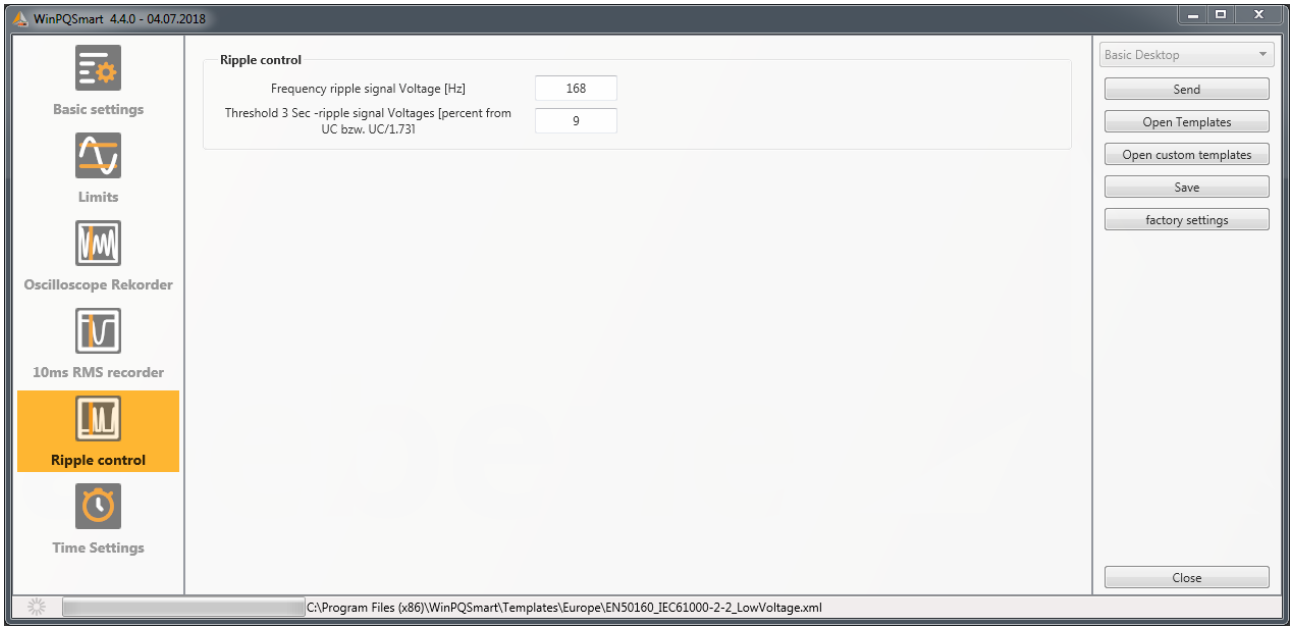


The settings in this menu are like the settings of oscilloscope recorder (see chapter 7.4.5) and are therefore not explained here again. If a field is greyed out and/or not selected, this trigger criterion is not active or cannot be activated.

The trigger thresholds of the oscilloscope and RMS recorder are not completely independent. All common parameters are automatically adjusted in both recorders.

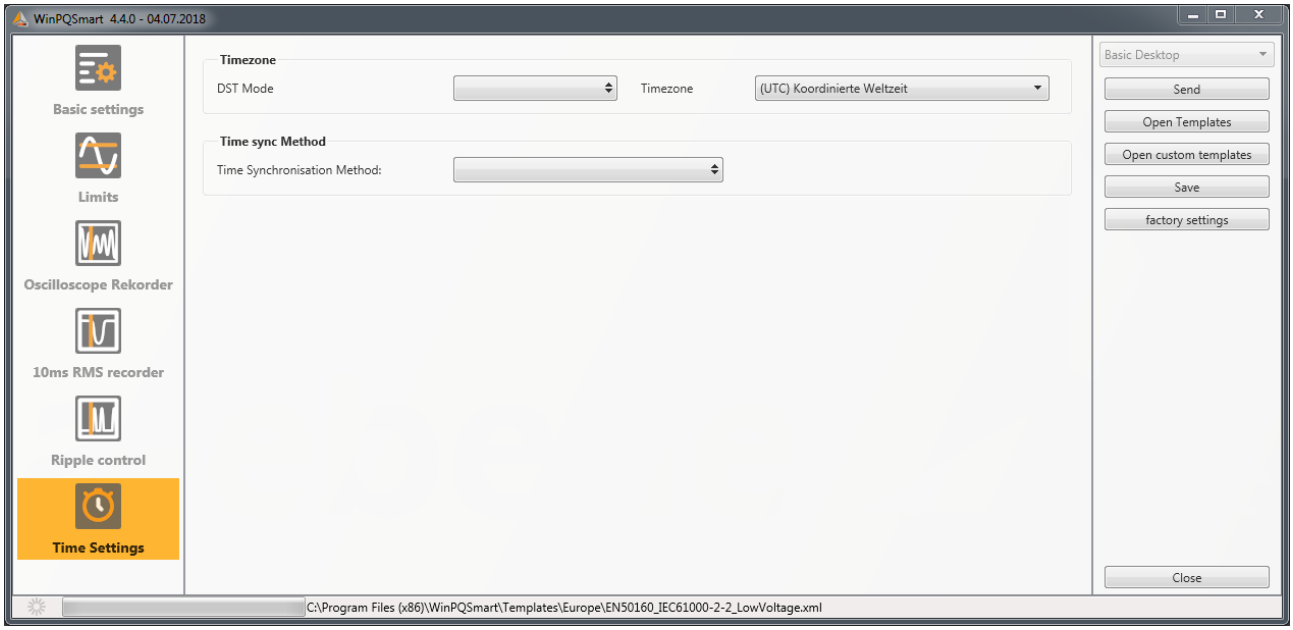
7.4.7 Ripple Control

In this menu, the parameters frequency ripple signal voltage [Hz] and threshold 3 sec ripple signal voltage [% of UC] can be set.



7.4.8 Time settings

In this window, the time settings of the device are parameterized. In the upper area, the time zone and the daylight-saving time (DST) can be set.



Below, the method of time synchronization can be selected.

For high-precision measurements, an independent clock such as GPS/DCF or NTP is recommended. (IEC61000-4-30: Class A - Measuring method!)

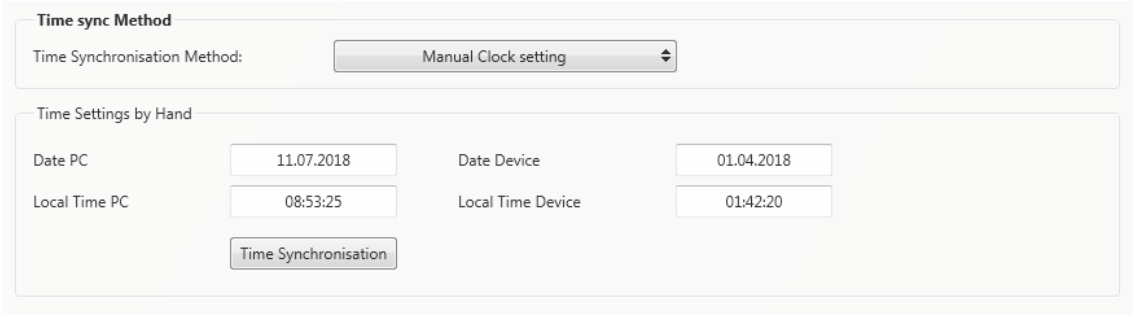
If the connection to the signal of a time synchronization method fails during the active measurement, the PQI-LV uses its internal oscillator, which has previously been synchronized to the pulse generator. If the connection to the pulse signal is subsequently re-established, the oscillator approaches the time of the pulse signal again in sub second steps (<1sec). This prevents time jumps in the recording. The possible time deviations, which are above 1 second, are hard set.

Depending on the selection, the corresponding settings are displayed. The necessary setup steps, e.g., connection of a GPS clock etc. are described in detail in chapter 5.3.2.

The following time sync methods can be selected:

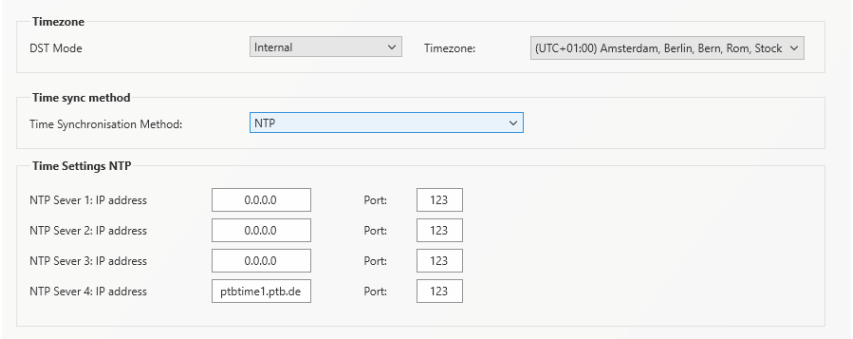
7.4.8.1 Manual Clock Setting

Manual synchronization of time and date with the local time of the computer. After synchronization, the function is locked in the current session. The parameterization interface must be restarted for a new execution. The local time of the encoder is not updated online, but only after the parameterization has been reloaded.



7.4.8.2 NTP

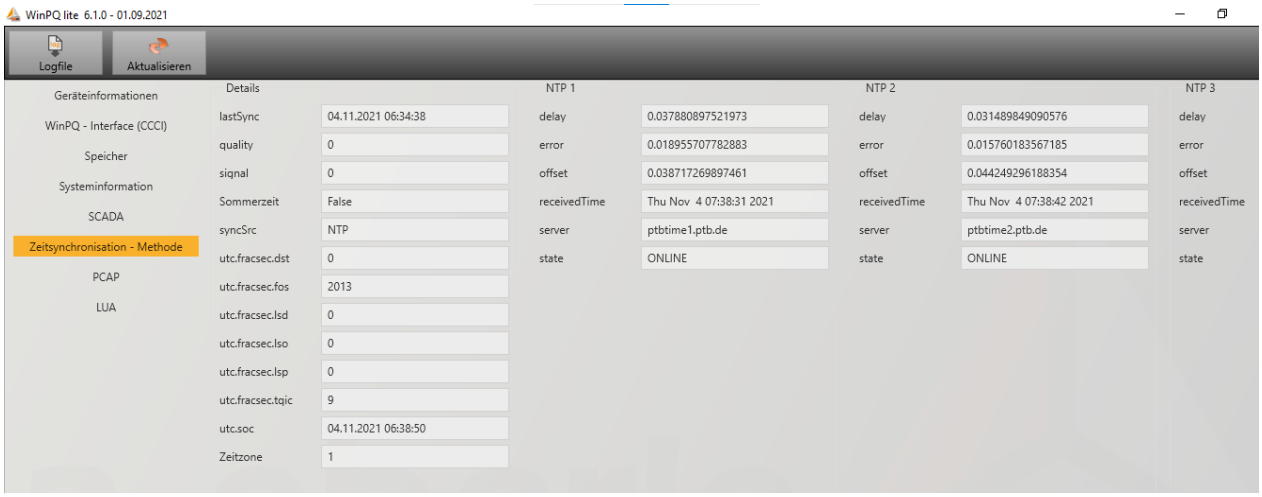
The PQI-LV supports up to four-time servers in one network. It automatically uses the best signal available. It is possible to insert the IPv4-address and the DNS hostname of the ntp server. To use DNS, it is necessary to insert the DNS server in the IP-settings of the device.



Incorrect time settings can lead to errors or problems during measurement data recording! Using NTP, a good signal quality should be assured (at least Stratum 8)!

The availability of the NTP server, the stratum and the quality of both NTP and the other time synchronization methods can be checked with the help of online diagnostics!

The connection to the server and the quality of the signal can be checked with the online diagnostic program (see chapter 8):

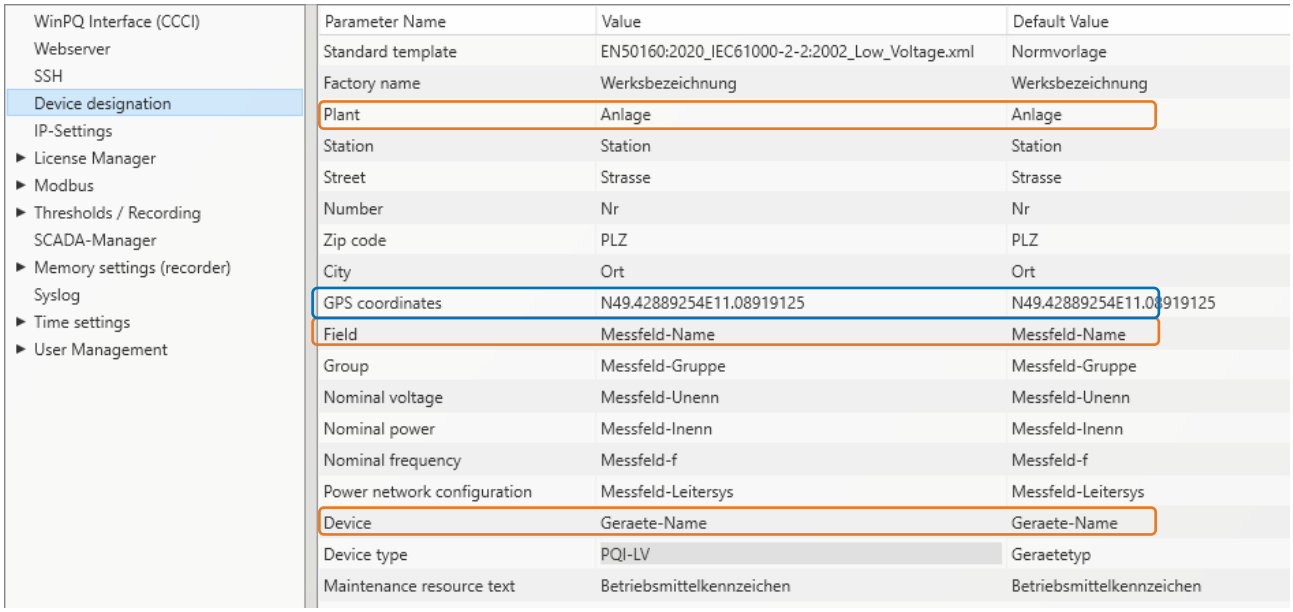


7.5 Device setup Expert View

For access to the advanced settings of the device, such as the parameterization of data recording or SCADA protocols, the **Expert View** provides a tabular representation of the device settings.

7.5.1 Device designations

The description of the device is defined in the "Device names" menu.



The orange marked fields describe the device tile as well as all fault records and measurement data in the archive.

The exact position of the measuring device can be entered in the "GPS" field using the geographical coordinates. To do this, proceed according to a certain pattern. The latitude is preceded by N (North) or S (South) depending on the hemisphere. For the longitude E (East) and W (West) are used analogously. As decimal separator the point is to be used, a comma is not taken over by the parameterization and leads to an incorrect entry!

Table 1: Examples to GPS coordinates

City	Latitude	Longitude	Entry
Berlin	52.5170365	13.3888599	N52.5170365E13.3888599
New York	40.7127281	-74.0060152	N40.7127281W74.0060152
Buenos Aires	-34.6042184	-58.3718455	S34.6042184E58.3718455
Canberra	-35.3075384	149.1245100	S35.3075384E149.1245100

7.5.2 TCP/IP settings

In the TCP/IP settings section, the network settings of the device can be done. If the DHCP client is not activated, the IP address, the subnet mask and the gateway can be set up manually. The device has Address Conflict Detection (ACD) according to RFC 5227 and RFC 2131, which means that the device queries the network for its parameterized IP address when it is restarted. If it receives a response to such an ARP request, the IP address is not set. If this function needs to be deactivated, the parameter “ACD (Address Conflict Detection): Number of packets” must be set to “0”.

If the IP address is parameterized with the WinPQlite to an IP address already existing in the network, the device does not take over this after the check. However, there is no feedback to the WinPQlite whether the parameterized IP address has been set successfully. In this case the device remains on the previous parameters.

The ACD is directly activated when the device is delivered from the factory. It is possible to deactivate the ACD in the commissioning wizard.

Furthermore, the device has the possibility to communicate via Domain Name Server (DNS). For this purpose, the host name of the device as well as the IP address of two DNS can be parameterized.

7.5.2.1 Wireguard VPN

Wireguard is a VPN solution for fast and secure device connectivity. A configuration file can be uploaded to the measuring device, which allows the device to communicate directly in the Wireguard VPN. This makes it possible to first secure insecure protocols such as IEC60870-5-104, IEC61850 or Modbus TCP in the VPN tunnel with end-to-end encryption. This makes it possible to communicate from the secure to the insecure area at high speed without interfering with the existing IT infrastructure.

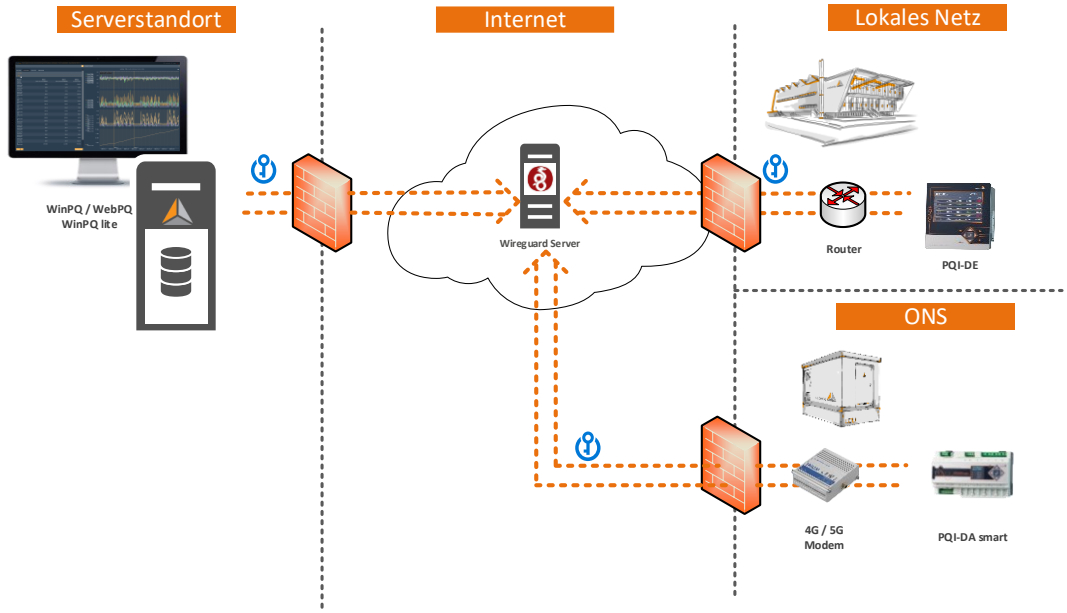
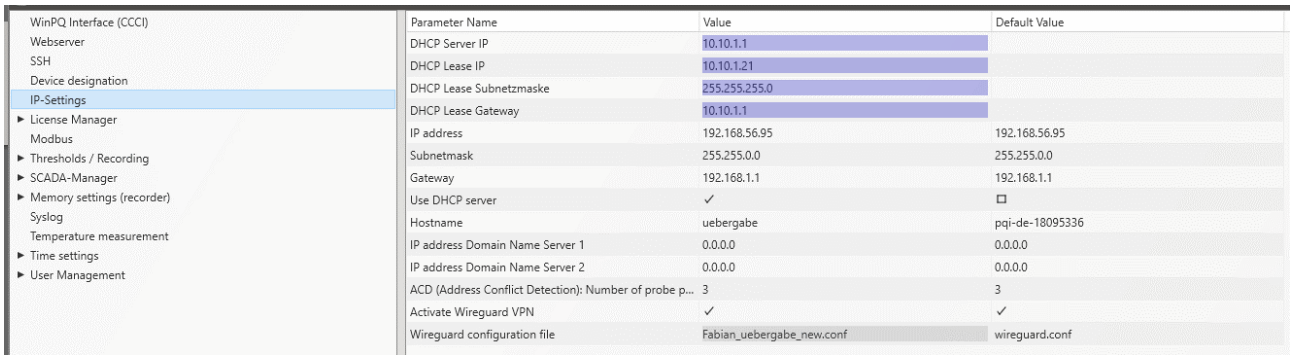


Figure 2: System sketch PQ application with Wireguard VPN (example)

To configure the measuring device itself, all you need to do is upload the configuration file in the parameterization and activate the “Wireguard VPN” service.



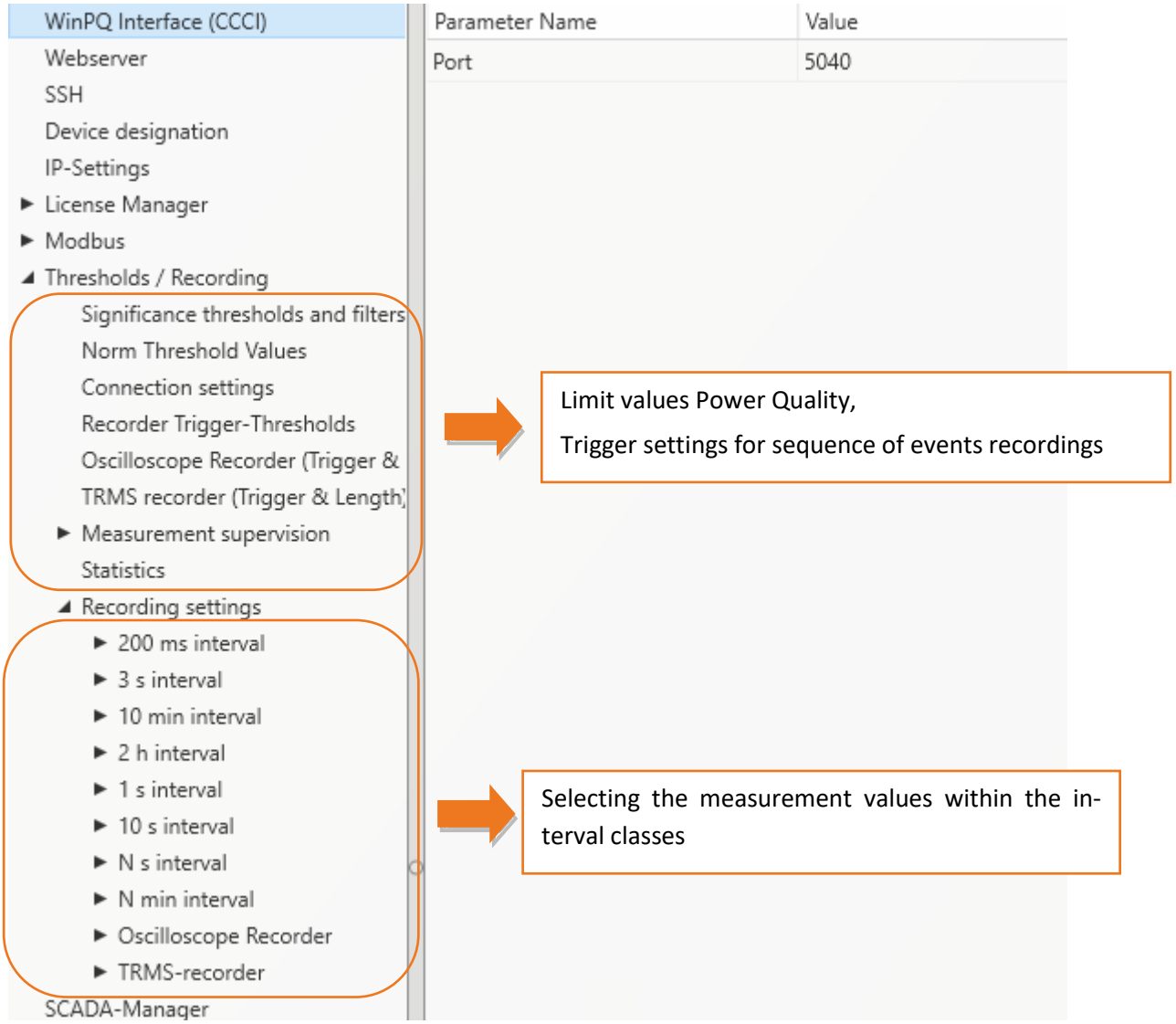
However, a central Wireguard server must be available in your own company for this.

The following restrictions apply to the configuration file:

- Exclusive use of IPv4
- Indication of the end point only as a static IP address; DNS resolution is not currently possible
- A maximum of two DNS servers can be stored
- Permitted IP: Either the specification of an entire subnet or up to four individual hosts.

7.5.3 Thresholds and Recording

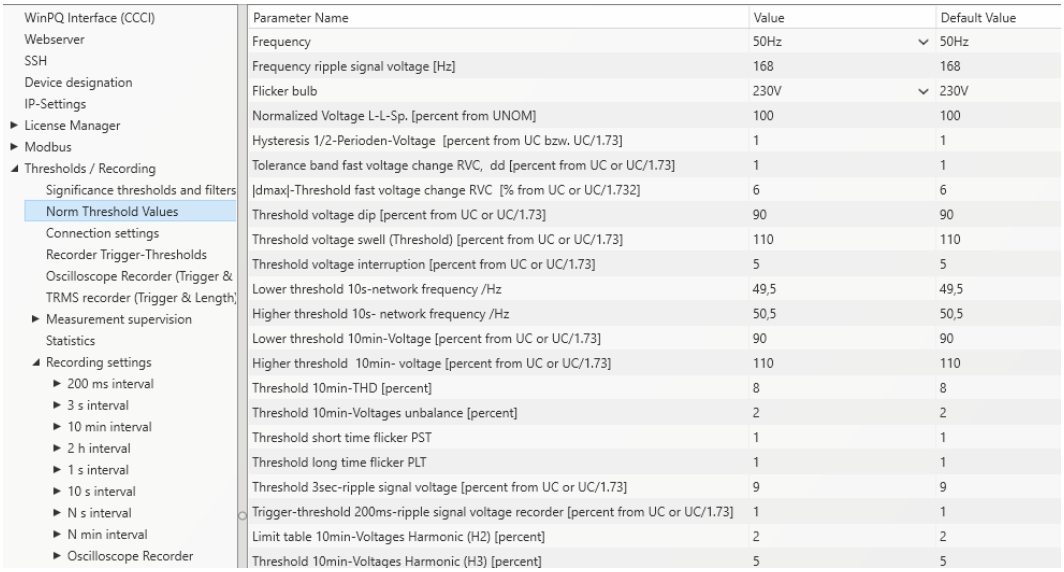
The menu tree "Thresholds and Recording" contains all parameters for Power Quality as well as all recording parameters.



7.5.3.1 Norm thresholds values

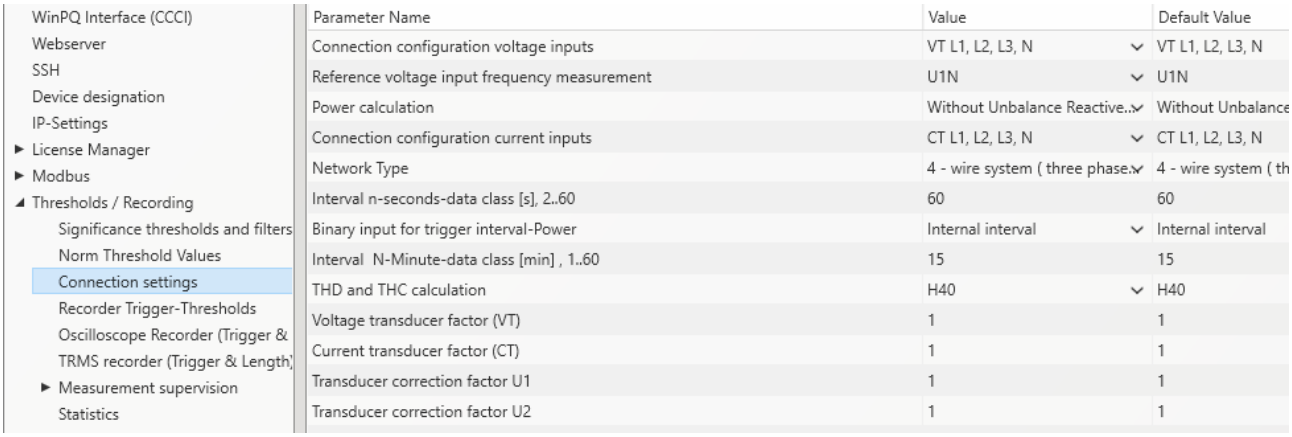
In **norm thresholds value** the limits for standard evaluations and for power quality events are set. The limits of EN 50160 for a low voltage system are stored in the default setting of delivery.

- Value: Value of PQI-LV – this value can be changed
- Default: Default setting



Parameter Name	Value	Default Value
Frequency	50Hz	50Hz
Frequency ripple signal voltage [Hz]	168	168
Flicker bulb	230V	230V
Normalized Voltage L-L-Sp. [percent from UNOM]	100	100
Hysteresis 1/2-Perioden-Voltage [percent from UC bzw. UC/1.73]	1	1
Tolerance band fast voltage change RVC, dd [percent from UC or UC/1.73]	1	1
|dmax|-Threshold fast voltage change RVC [% from UC or UC/1.732]	6	6
Threshold voltage dip [percent from UC or UC/1.73]	90	90
Threshold voltage swell (Threshold) [percent from UC or UC/1.73]	110	110
Threshold voltage interruption [percent from UC or UC/1.73]	5	5
Lower threshold 10s-network frequency /Hz	49,5	49,5
Higher threshold 10s- network frequency /Hz	50,5	50,5
Lower threshold 10min-Voltage [percent from UC or UC/1.73]	90	90
Higher threshold 10min- voltage [percent from UC or UC/1.73]	110	110
Threshold 10min-THD [percent]	8	8
Threshold 10min-Voltages unbalance [percent]	2	2
Threshold short time flicker PST	1	1
Threshold long time flicker PLT	1	1
Threshold 3sec-ripple signal voltage [percent from UC or UC/1.73]	9	9
Trigger-threshold 200ms-ripple signal voltage recorder [percent from UC or UC/1.73]	1	1
Limit table 10min-Voltages Harmonic (H2) [percent]	2	2
Threshold 10min-Voltages Harmonic (H3) [percent]	5	5

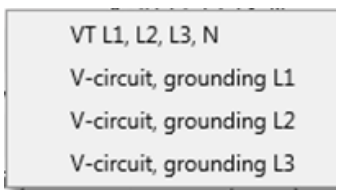
7.5.3.2 Connection settings



Parameter Name	Value	Default Value
Connection configuration voltage inputs	VT L1, L2, L3, N	VT L1, L2, L3, N
Reference voltage input frequency measurement	U1N	U1N
Power calculation	Without Unbalance Reactive..	Without Unbalance
Connection configuration current inputs	CT L1, L2, L3, N	CT L1, L2, L3, N
Network Type	4 - wire system (three phase..	4 - wire system (th
Interval n-seconds-data class [s], 2..60	60	60
Binary input for trigger interval-Power	Internal interval	Internal interval
Interval N-Minute-data class [min] , 1..60	15	15
THD and THC calculation	H40	H40
Voltage transducer factor (VT)	1	1
Current transducer factor (CT)	1	1
Transducer correction factor U1	1	1
Transducer correction factor U2	1	1

The following basic instrument settings can be made in this menu item:

- **Connection voltage inputs: 1, 2, 3, 4**



V-connection (two voltage transformers)

Grounding L2 = connect VT L1 and VT L3

L2 will be calculated from the device

- **Reference voltage:**

Determining the frequency measurement input channel: U1, U2, U3, Une, U12, U23, U31

- **Power calculation:**
  - Simplified power calculation - without calculation of unbalance power
  - According DIN40110-2; with calculation of the unbalance reactive power
- **Connection current inputs:**

CT L1, L2, L3, N
CT L2,L3
ct's L1, L3
ct's L1, L2

Aron connection of current (two CT´s)

CT L1, L3 = connect L1 and L3, current L2 will be calculated from the device

- **Network connection:**

4 - wire system (three phase grid)
4 - wire system (unique independent phases)
3 - wire system

- **Interval “n”-seconds data class:**

Free interval - 2 seconds to 60 seconds

- **Interval “n”-minutes data class:**

Free interval - 1 minute to 60 minutes (basic setting 15 minutes)

- **Calculation THD / THC:**

Calculation 2^{nd} to 40^{th} harmonic or 2^{nd} to 50^{th} harmonic

- **Voltage transducer factor (basic setting = 1)**

Example: VT 20,000 V / 100 V = factor 200

- **Current transducer factor (basic setting = 1)**

Example: CT 600 A / 5 A = factor 120

- **CT correction factor**

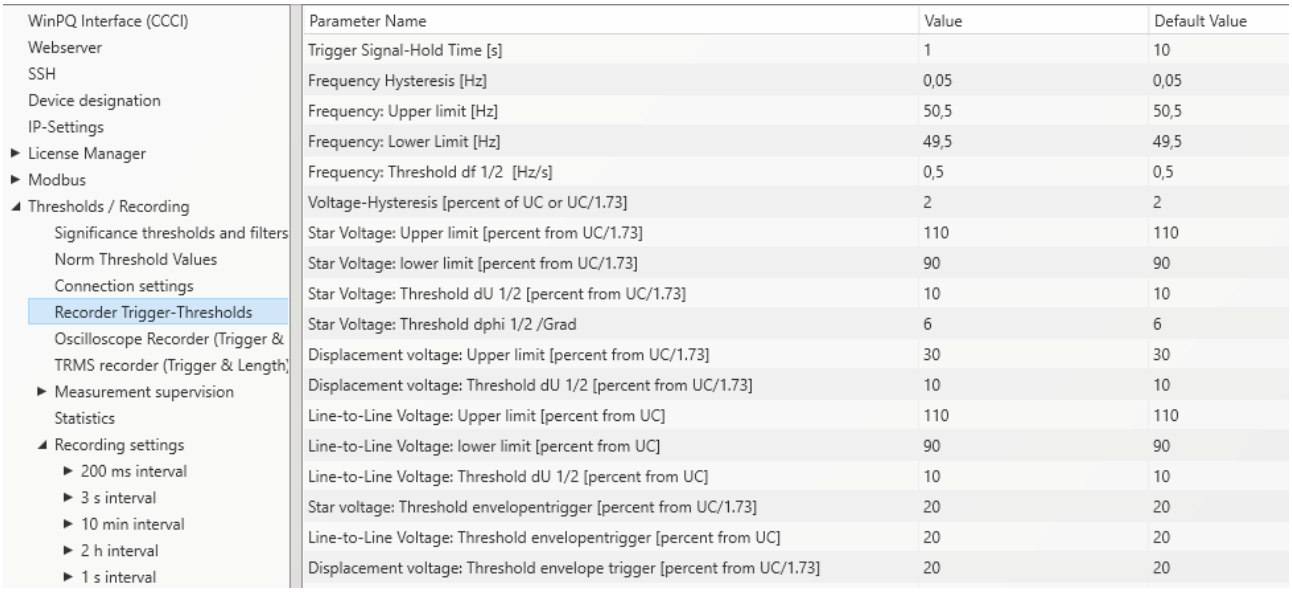
Additional to the current transducer factor it is possible to have a second CT correction factor. This factor will be multiplied with the current transducer factor. Possible values are from -2 to 2.

Using a current transformer correction factor of "-1", it is possible to change the power flow direction by software.

7.5.3.3 Trigger parameter for disturbance recorder

In this menu all limits for triggering of fault records can be changed. These thresholds are independent to the Power Quality thresholds.

Upper and lower trigger thresholds for frequency, voltage, current or unbalance can be set.



Parameter Name	Value	Default Value
Trigger Signal-Hold Time [s]	1	10
Frequency Hysteresis [Hz]	0,05	0,05
Frequency: Upper limit [Hz]	50,5	50,5
Frequency: Lower Limit [Hz]	49,5	49,5
Frequency: Threshold df 1/2 [Hz/s]	0,5	0,5
Voltage-Hysteresis [percent of UC or UC/1.73]	2	2
Star Voltage: Upper limit [percent from UC/1.73]	110	110
Star Voltage: lower limit [percent from UC/1.73]	90	90
Star Voltage: Threshold dU 1/2 [percent from UC/1.73]	10	10
Star Voltage: Threshold dphi 1/2 /Grad	6	6
Displacement voltage: Upper limit [percent from UC/1.73]	30	30
Displacement voltage: Threshold dU 1/2 [percent from UC/1.73]	10	10
Line-to-Line Voltage: Upper limit [percent from UC]	110	110
Line-to-Line Voltage: lower limit [percent from UC]	90	90
Line-to-Line Voltage: Threshold dU 1/2 [percent from UC]	10	10
Star voltage: Threshold envelopentrigger [percent from UC/1.73]	20	20
Line-to-Line Voltage: Threshold envelopentrigger [percent from UC]	20	20
Displacement voltage: Threshold envelope trigger [percent from UC/1.73]	20	20

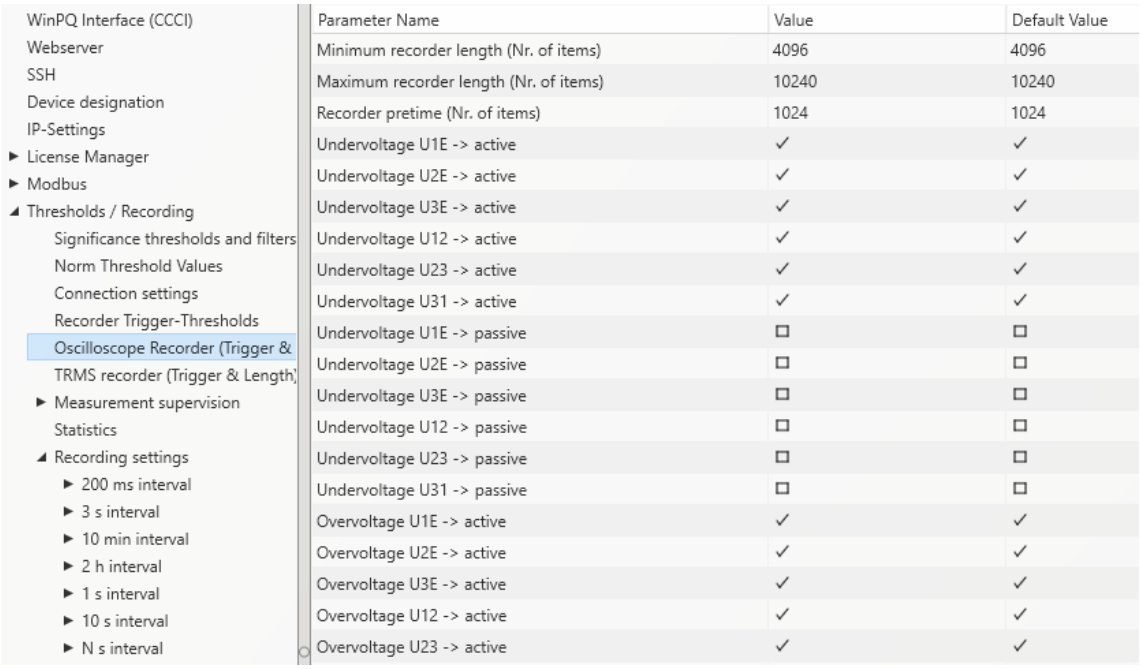
Example:

line-to-line voltage: lower limit [percent from UC]	90
line-to-line voltage: threshold dU 1/2 [percent from UC]	10

If one phase to phase voltage exceeds 110% or 90% of the nominal voltage, the oscilloscope and the ½ period RMS recorder will start recording.

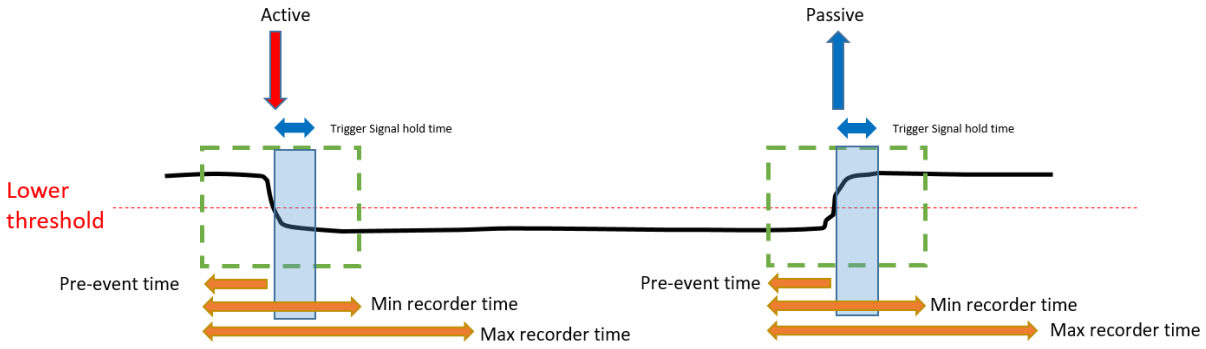
7.5.3.4 Oscilloscope recorder

The oscilloscope disturbance recorder is set up under the menu item "Limits/Recording -> Oscilloscope Recorder".



Parameter Name	Value	Default Value
Minimum recorder length (Nr. of items)	4096	4096
Maximum recorder length (Nr. of items)	10240	10240
Recorder pretime (Nr. of items)	1024	1024
Undervoltage U1E -> active	✓	✓
Undervoltage U2E -> active	✓	✓
Undervoltage U3E -> active	✓	✓
Undervoltage U12 -> active	✓	✓
Undervoltage U23 -> active	✓	✓
Undervoltage U31 -> active	✓	✓
Undervoltage U1E -> passive	☐	☐
Undervoltage U2E -> passive	☐	☐
Undervoltage U3E -> passive	☐	☐
Undervoltage U12 -> passive	☐	☐
Undervoltage U23 -> passive	☐	☐
Undervoltage U31 -> passive	☐	☐
Overvoltage U1E -> active	✓	✓
Overvoltage U2E -> active	✓	✓
Overvoltage U3E -> active	✓	✓
Overvoltage U12 -> active	✓	✓
Overvoltage U23 -> active	✓	✓

- **Minimum recorder length:** Setting of the standard fault recorder length
- **Maximum recorder length:** If another trigger criterion occurs during the minimum recording length after the trigger signal holding time, the Record is extended by the minimum length up to the maximum length.
- **Recorder pre time** is the time of the recorder file before the trigger threshold occurred.



- Active trigger = value exceeds or falls below threshold (start of the event)
- Passive trigger = value comes back to normal (end of the event)

- Sampling frequency of oscilloscope recorder can be changed from 10,240 Hz to 40,960 Hz

The maximum recorder length with 10.24 kHz is 16 seconds as well as with 40.96 kHz is 4 seconds (40,960Hz is only available with option B1)

Example recorder length: 20,480 = 2 seconds recorder length with a sampling frequency of 10,240 Hz and 500ms length with a sampling frequency of 40,960 Hz.

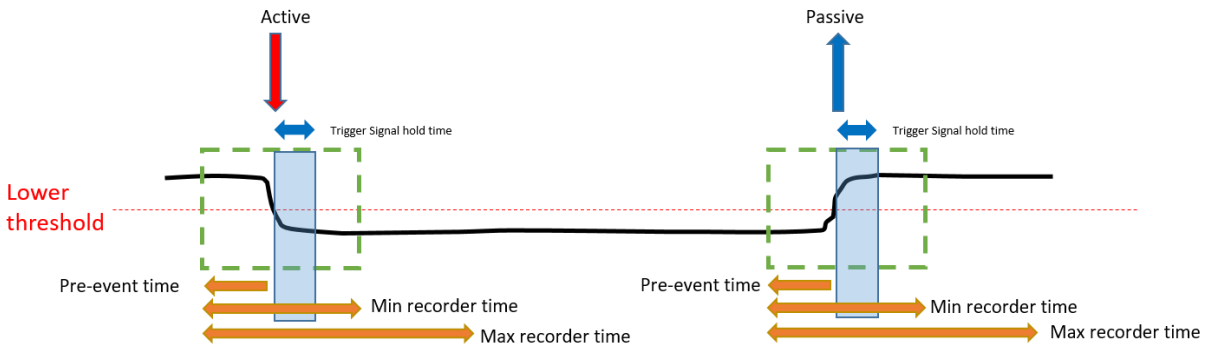
7.5.3.5 ½ cycle recorder

The trigger settings of ½ cycle recorder (10ms at 50 Hz) are independent to oscilloscope recorder.

- WinPQ Interface (CCCI)
- Webserver
- SSH
- Device designation
- IP-Settings
- ▶ License Manager
- ▶ Modbus
- ◢ Thresholds / Recording
  - Significance thresholds and filters
  - Norm Threshold Values
  - Connection settings
  - Recorder Trigger-Thresholds
  - Oscilloscope Recorder (Trigger &
  - TRMS recorder (Trigger & Length)
  - ▶ Measurement supervision
  - Statistics
  - ◢ Recording settings
    - ▶ 200 ms interval
    - ▶ 3 s interval
    - ▶ 10 min interval
    - ▶ 2 h interval
    - ▶ 1 s interval
    - ▶ 10 s interval
    - ▶ N s interval

Parameter Name	Value	Default Value
Minimum recorder length (Nr. of items)	1000	1000
Maximum recorder length (Nr. of items)	3000	3000
Recorder pretime (Nr. of items)	250	250
Undervoltage U1E -> active	✓	✓
Undervoltage U2E -> active	✓	✓
Undervoltage U3E -> active	✓	✓
Undervoltage U12 -> active	✓	✓
Undervoltage U23 -> active	✓	✓
Undervoltage U31 -> active	✓	✓
Undervoltage U1E -> passive	☐	☐
Undervoltage U2E -> passive	☐	☐
Undervoltage U3E -> passive	☐	☐
Undervoltage U12 -> passive	☐	☐
Undervoltage U23 -> passive	☐	☐
Undervoltage U31 -> passive	☐	☐
Overvoltage U1E -> active	✓	✓
Overvoltage U2E -> active	✓	✓
Overvoltage U3E -> active	✓	✓
Overvoltage U12 -> active	✓	✓
Overvoltage U23 -> active	✓	✓

Please see Chapter 7.5.3.3 explanation trigger thresholds

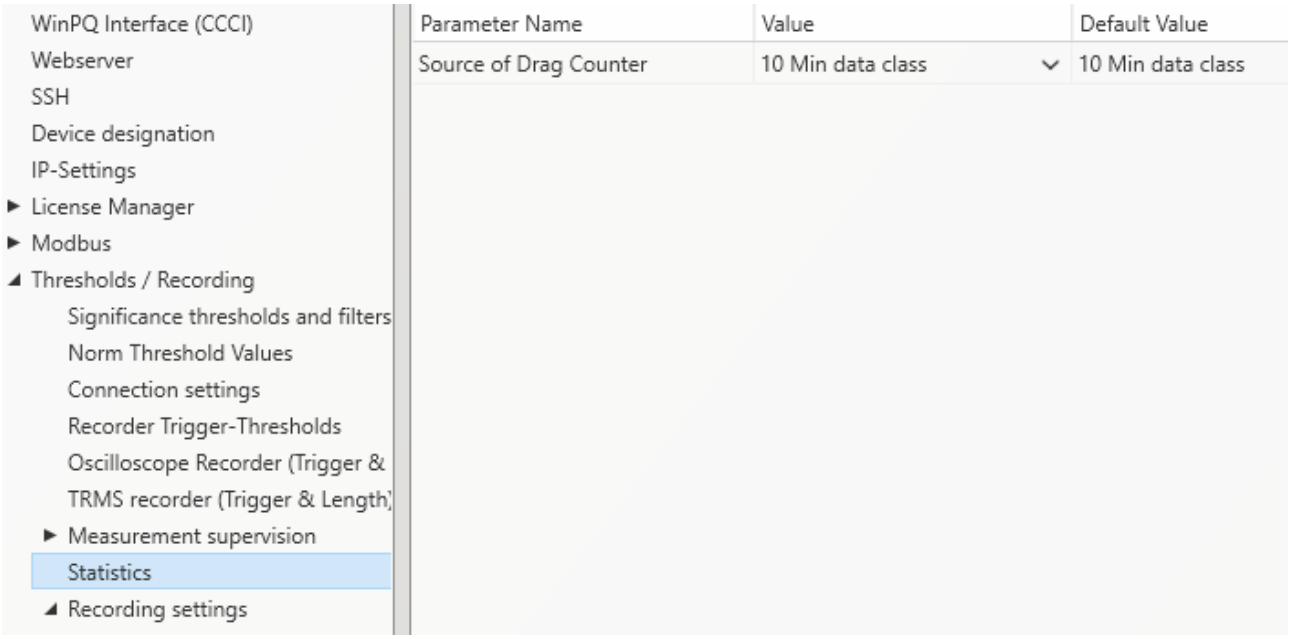


Example recorder length:

3000 x 10ms (at 5 0Hz) RMS values result in a length of 30 seconds for this recorder.

7.5.3.6 Statistic

The data class for the extreme values of voltage and current in the device display can be selected via the Statistics menu.



The following data classes are available for this purpose:

- 10/12 periods (200ms interval)
- 1 second interval
- 10-minute interval
- N x minutes Interval

It is not necessary to activate the required recording parameters for the respective data class!

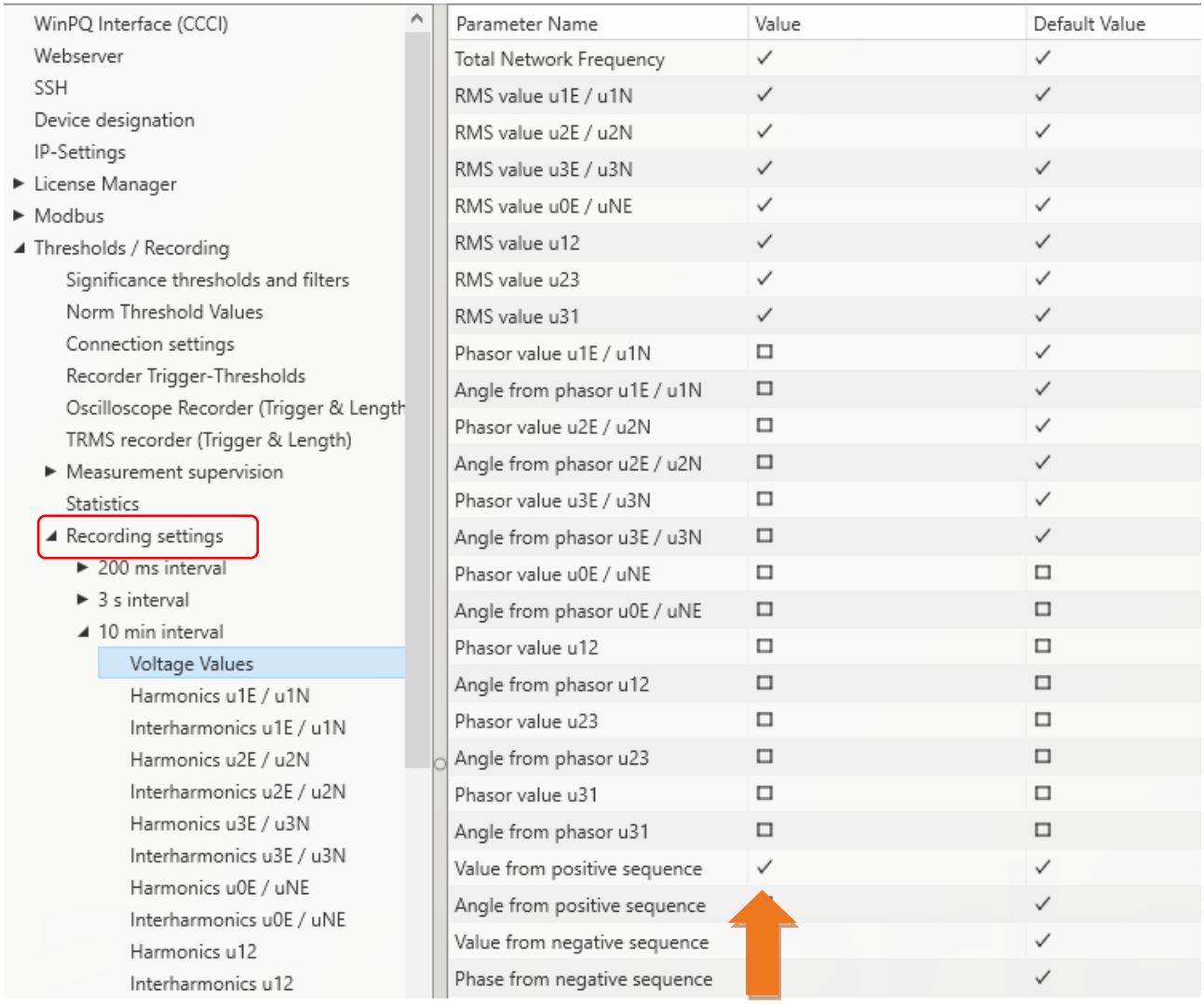
The extreme values voltage and current will reset automatically if the data class is changed.

7.5.4 Recordings parameter

At this point, the selection of all permanent measured values within the interval data class is set.

The following interval data classes available

- 10/12 cycle (200ms interval)
- 150/180 cycle (3 seconds interval)
- 10 minutes interval
- 2-hour interval
- 1 second's interval
- 10 seconds interval
- N x seconds interval (range 2 to 60)
- N x minutes interval (range 1 to 60 – basic setting 15 min.)

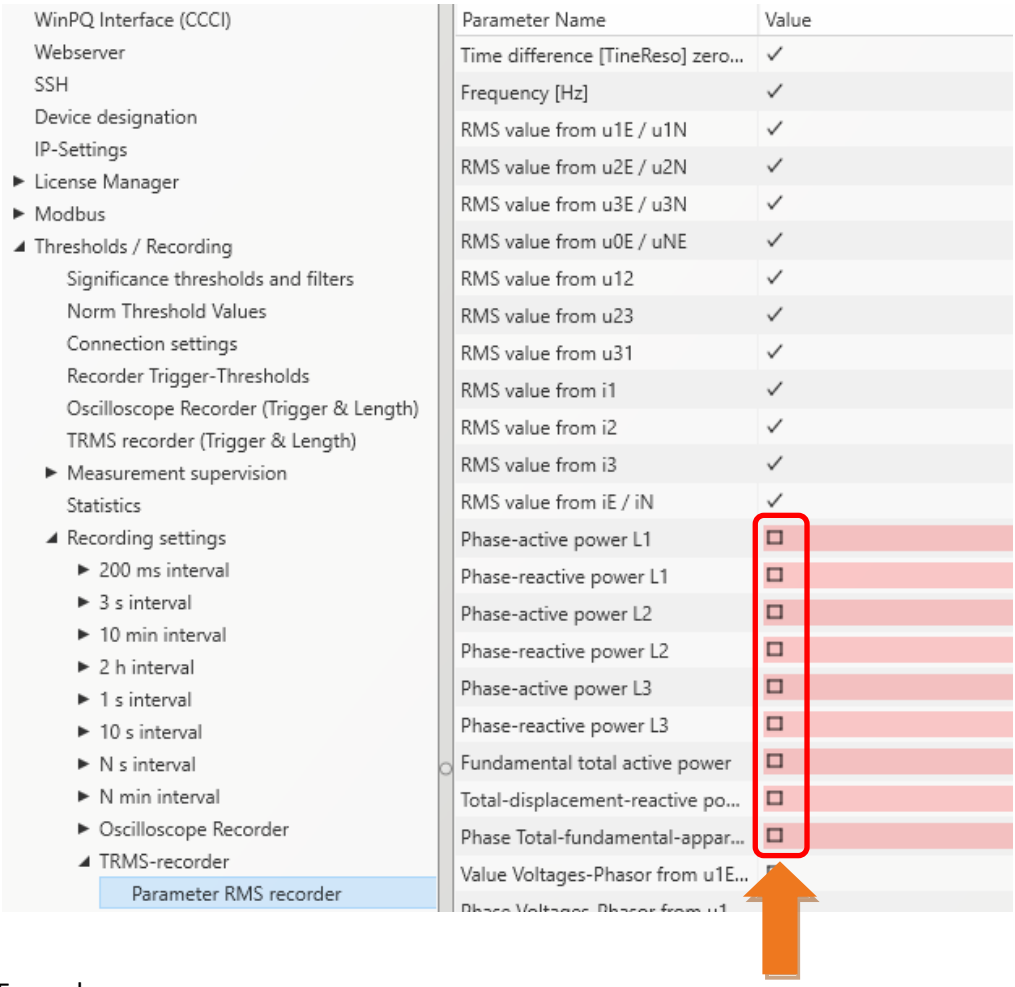


All activated measuring values are permanently recorded in this data class.

With right mouse click you can activate or deactivate all parameters in this list with the function “fill”.

7.5.4.1 Disturbance recorder parameter

For oscilloscope recorder and ½ cycle recorder it is possible to activate and deactivate measurement values.



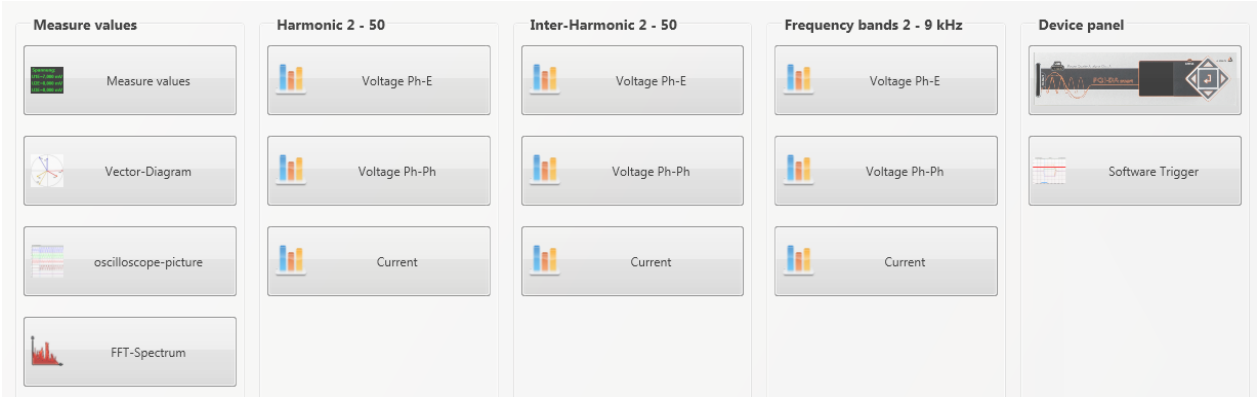
Example:

The ½ cycle recorder should not record the power during a disturbance record.

7.6 Online measurement values

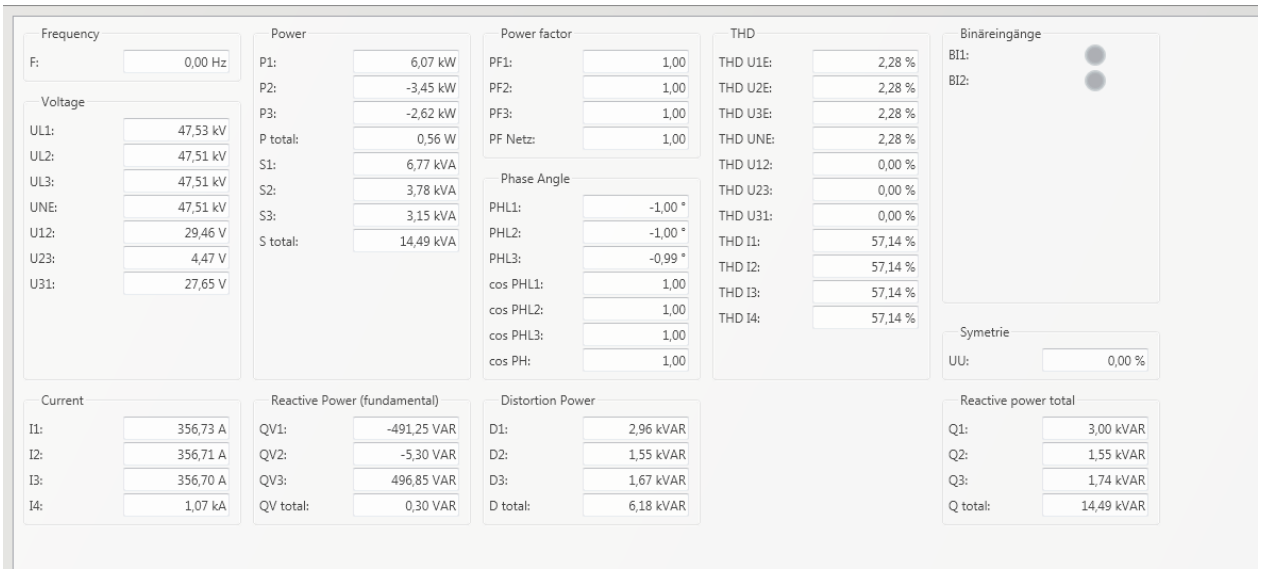
The function offers extensive analysis functions for online measurement values.

Start screen of the online measurement values:

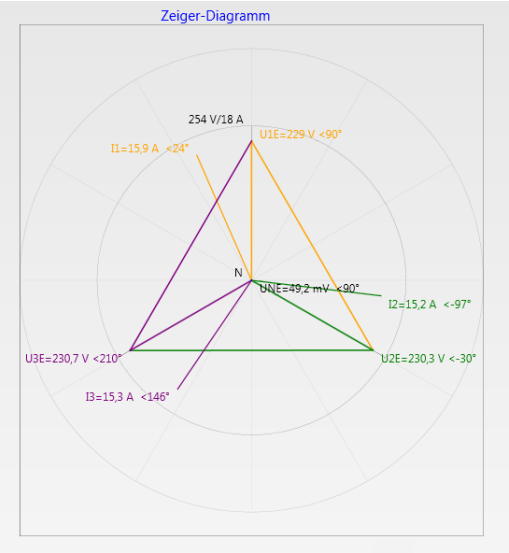


7.6.1 Measurement values

Display of online measurement values for voltages, currents, power and grid frequency.



7.6.2 Vector diagram

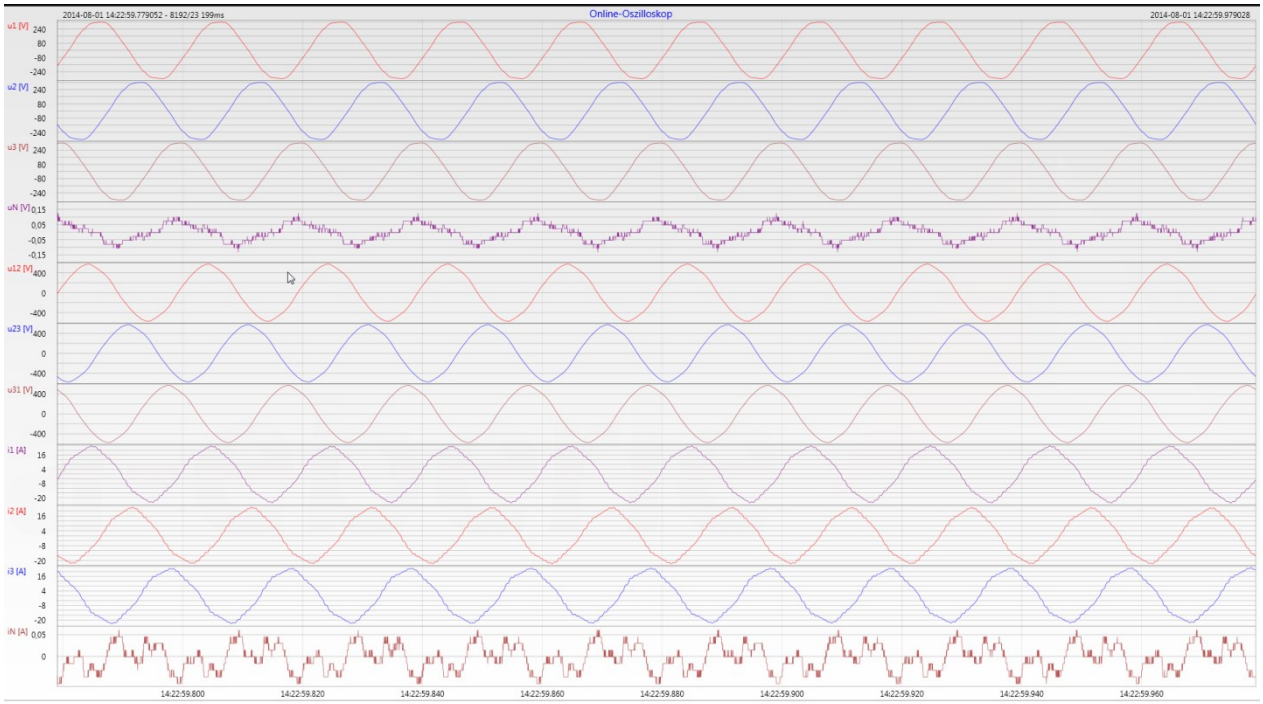


In the vector diagram, connection faults are easy to detect. All phase voltages and currents are displayed with phase angles.

7.6.3 Oscilloscope image

Online oscilloscope (40.96 kHz/ 10.24kHz) for the following channels:

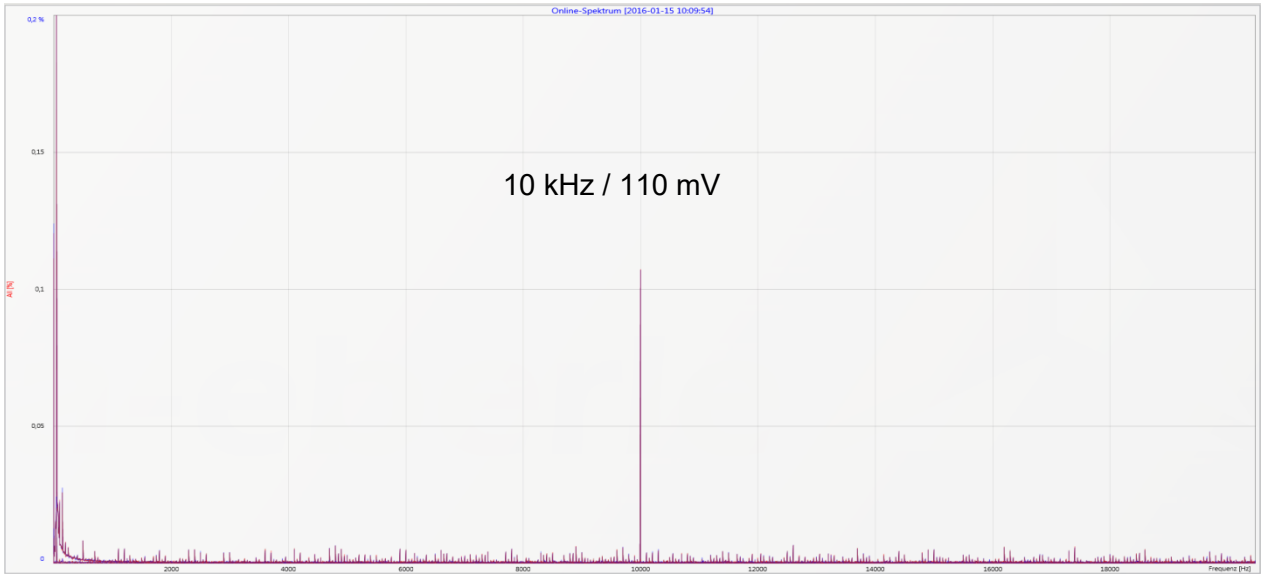
- Conductor-earth voltages L1, L2, L3, NE
- Conductor-conductor voltages L12, L23, L31
- Currents L1, L2, L3, N



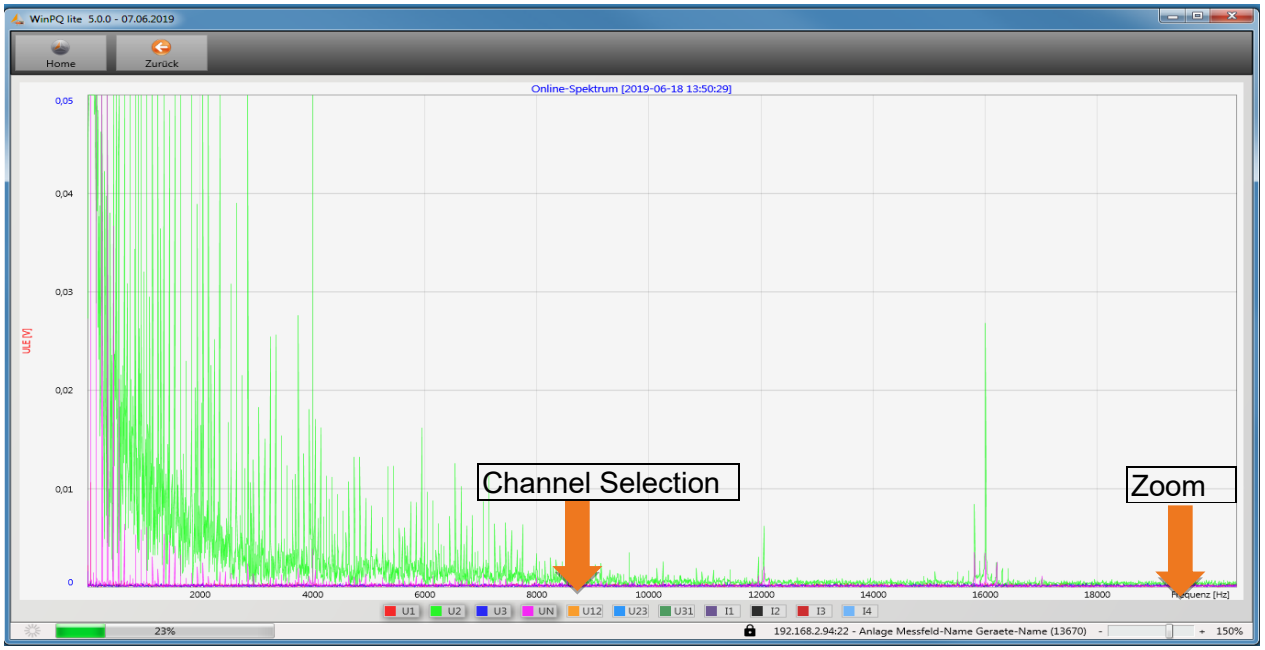
7.6.4 Online spectrum FFT-Analyse

Online-FFT analysis depending on the license of the device

- Sampling frequency 41.96 kHz = FFT analysis up to 20 kHz
- Sampling frequency 10.24 kHz = FFT analysis up to 5 kHz



Example: charging device for electrical cars / 10 kHz sampling frequency visible in the FFT analysis.



Using the zoom function, it is possible to adjust the scaling of the application.

Using the buttons U1 / U2 ...I4 it is possible to fade in and fade out channels every second during refresh.

7.6.5 Harmonic

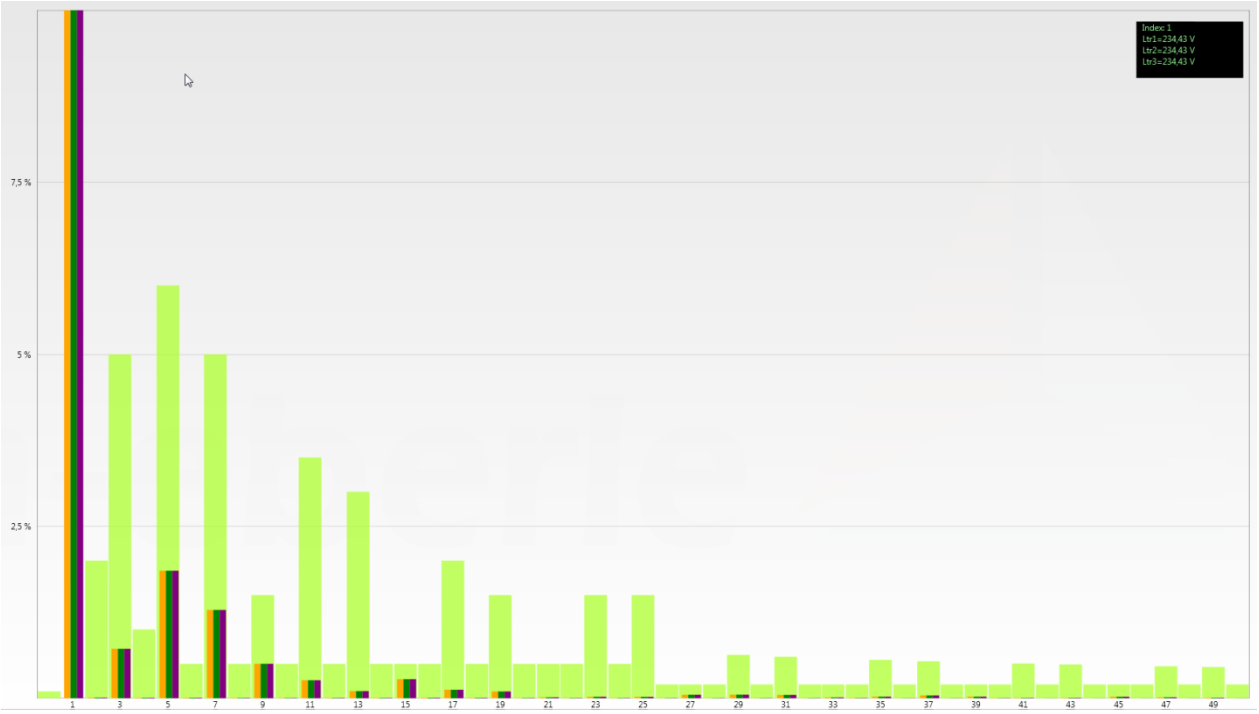
From the **Harmonics** tab page, all the current and voltage harmonics (2nd to 50th) can be displayed online. The measurement data is calculated by the measuring device in accordance with IEC61000-4-30 Class A Ed. 3 and transferred to the PC.

There are three bar charts available:

- Voltage harmonics conductor-earth
- Voltage harmonics conductor-conductor
- Current harmonics

As the EN50160 only specifies limits for harmonics up to the 25th ordinal, the compatibility level of IEC61000-2-2 has been stored for the 26th to the 50th harmonics in the basic settings.

Compatibility levels in accordance with EN50160 & IEC61000-2-2 are shown as green limit value bars.



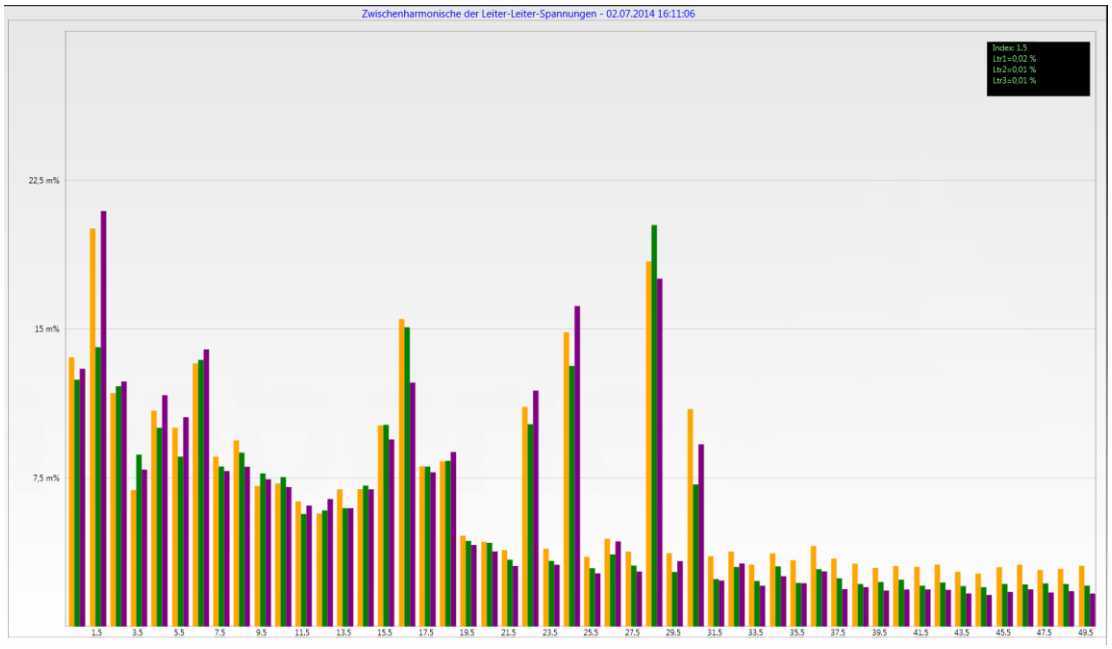
If a harmonic is selected with the mouse pointer, this measurement value is displayed in the field on the top right.

7.6.6 Interharmonic

The **Interharmonic** card is used to display all current and voltage Interharmonic up to 2,500 Hz online. The measurement data is calculated by the measuring device in accordance with IEC61000-4-30 Class A following the grouping process and transferred to the PC.

There are three bar charts available:

- Interharmonic voltages line-earth
- Interharmonic voltages line-earth
- Interharmonic currents

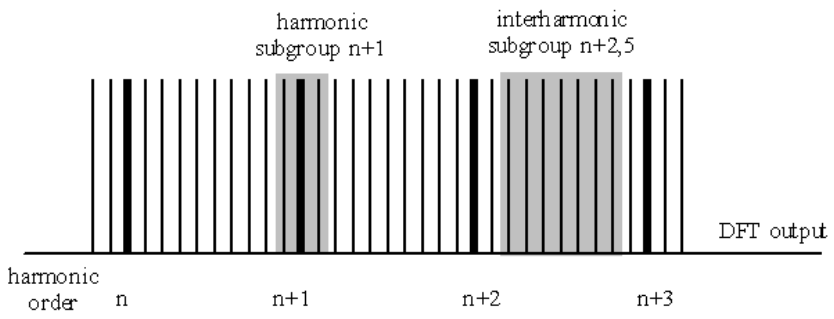


If an Interharmonic is selected with the mouse pointer, this measurement value is displayed in the field on the top right.

Explanation of the grouping process in accordance with the IEC:

To evaluate the Interharmonic in the grid, subgroups are created. In each case, all the Interharmonics between two harmonics are combined into one harmonics subgroup.

Example for 50Hz: Interharmonic H2 includes all frequencies from 110Hz to 140Hz.



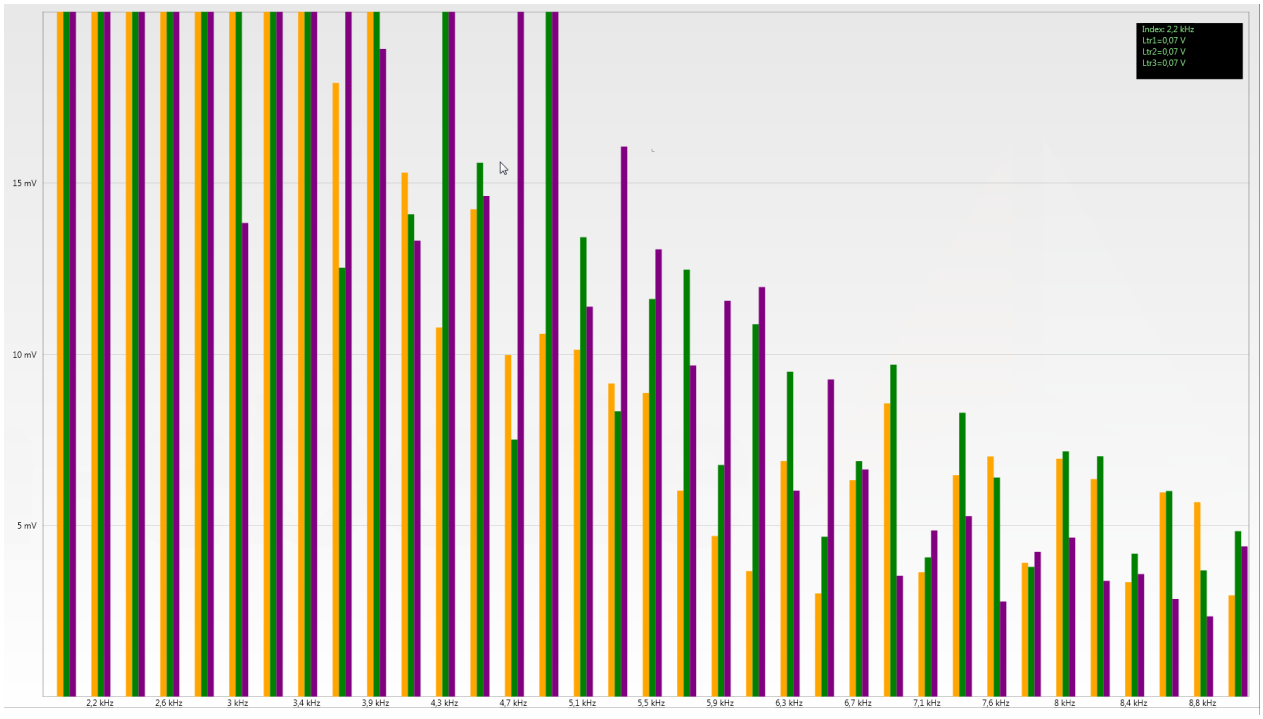
7.6.7 Frequency bands from 2 kHz to 9 kHz

- **The device characteristic "Frequency bands from 2 kHz to 20 kHz" is a device option**

The card **2 to 9 kHz** is used to display all current and voltage harmonics in 200 Hz groups. Evaluation is in accordance with the IEC61000-4-7 standard.

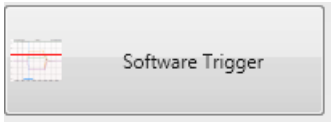
The centre frequency of the corresponding frequency band is stated.

Example: All frequencies from 8,805 Hz to 9,000 Hz are in the 8.9 kHz band.



If a frequency band is selected with the mouse pointer, this measurement value is displayed in the field on the top right.

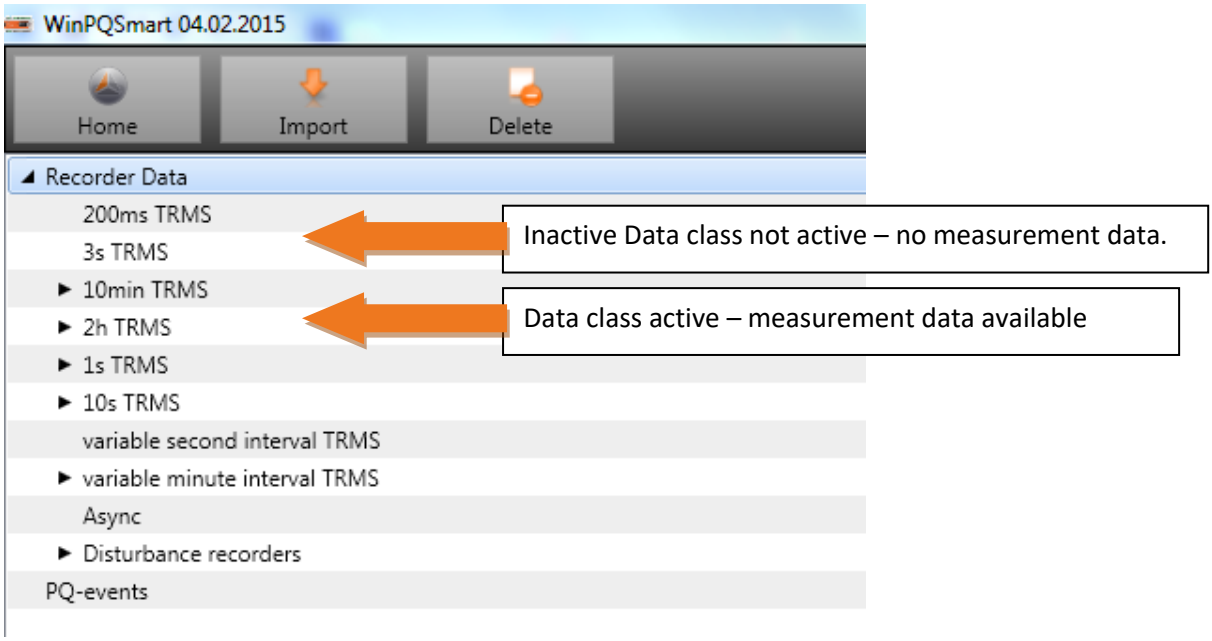
7.6.9 Software trigger (Feature S1 needed)



The **Software Trigger** key can be used to trigger the oscilloscope recorder and ½-period RMS recorder manually. The recorder length corresponds with the settings in the setup menu of the device.

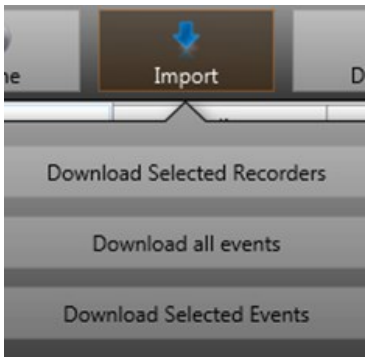
7.7 Measurement data import

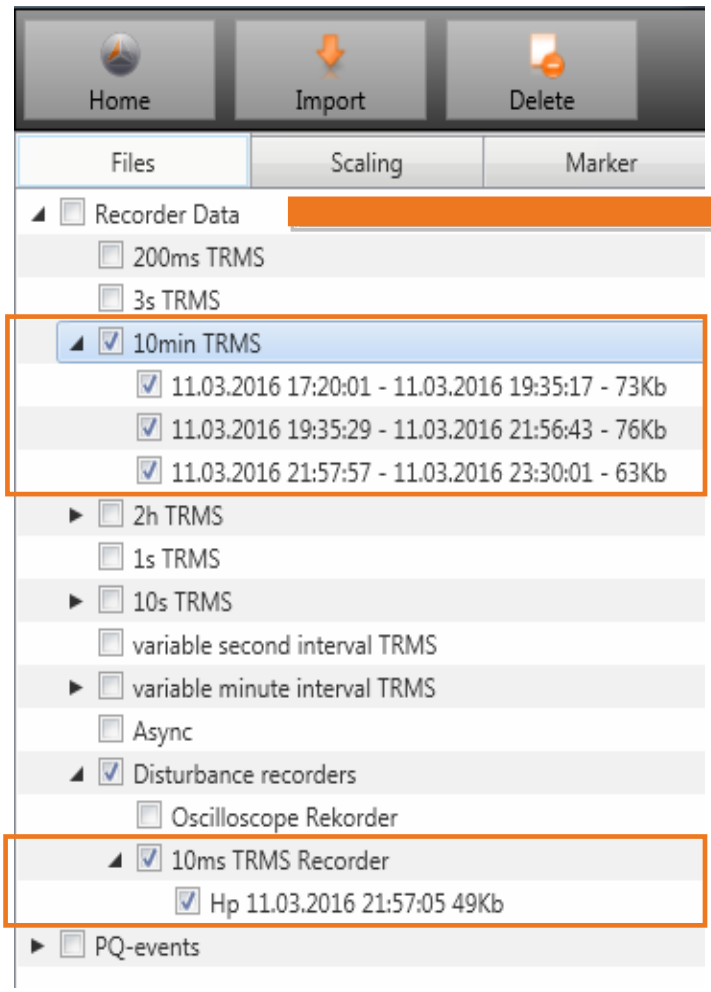
The function can be used to load all measurement data from the PQI-LV to the PC and to evaluate it there.



Import of data can be selected to:

- Only selected data files from the device
- All events
- Selected events





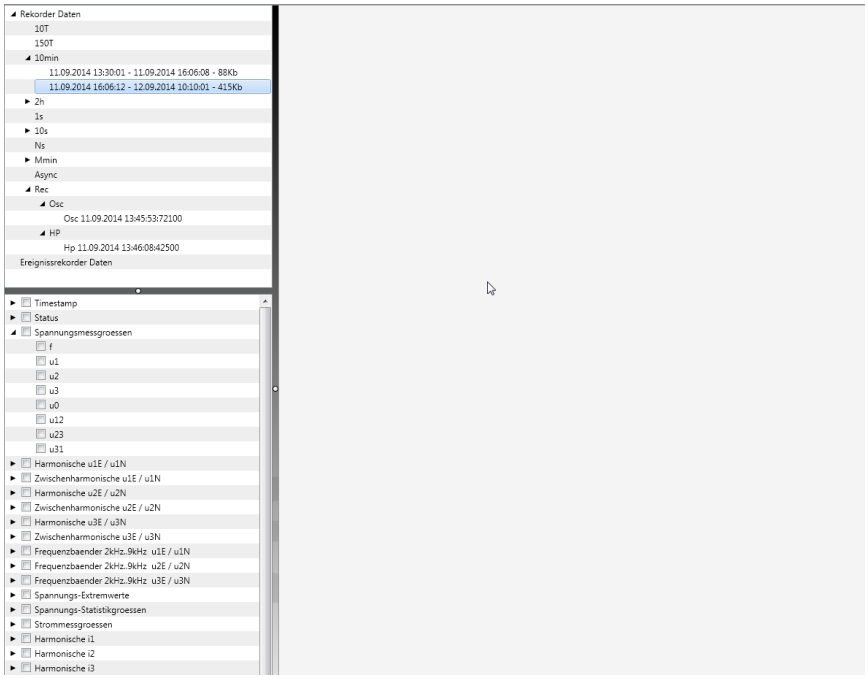
Selecting the main folder “recorder date” will activate all available data for download.

Select the interval data classes three permanent recorder files avail-

Select the number of the triggered sequence of events recordings (oscillo-scope and ½ cycle RMS recorder)

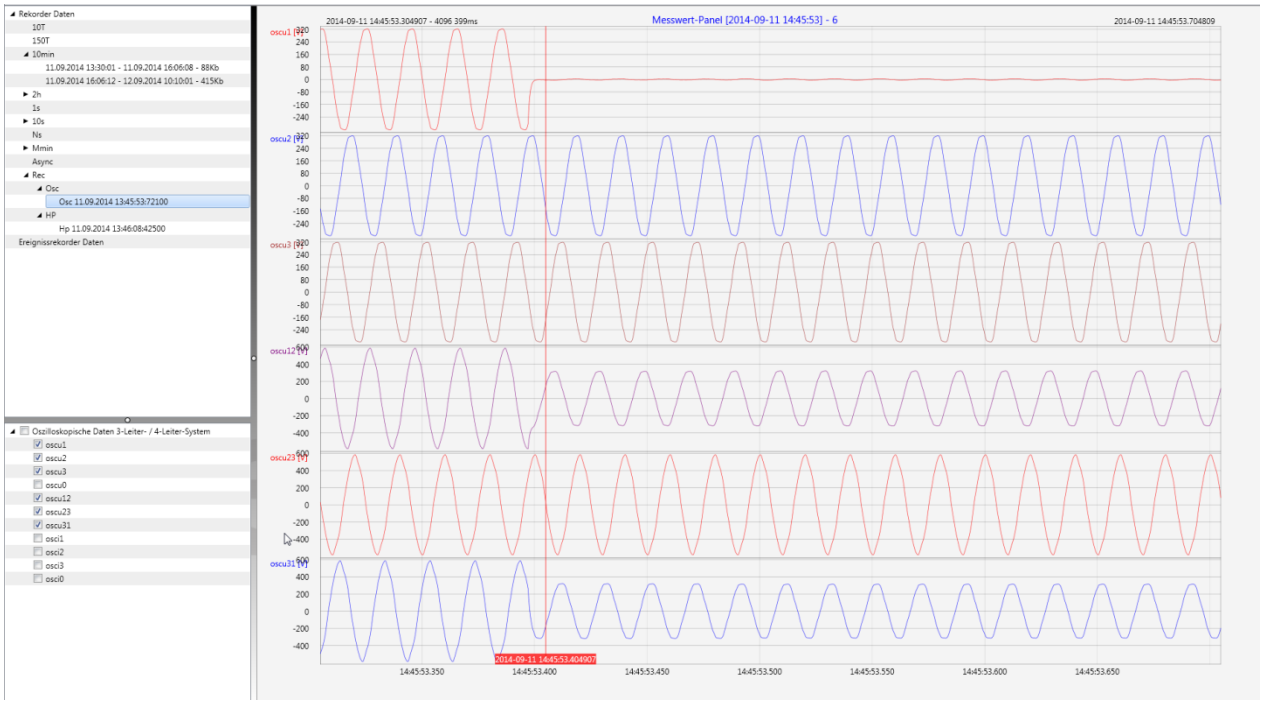
Level-time diagram of permanent measuring data

When a file is selected this measurement data is saved on the PC immediately and a selection field with all available measurement data appears in the window.

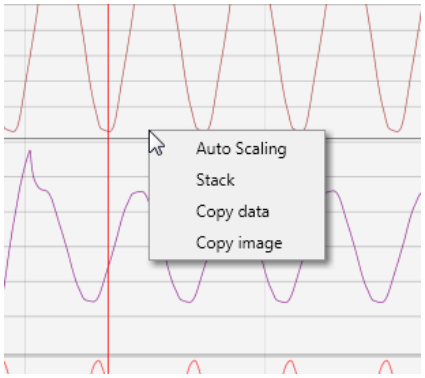


If measurement values are selected, they appear as a level-time diagram on the screen.

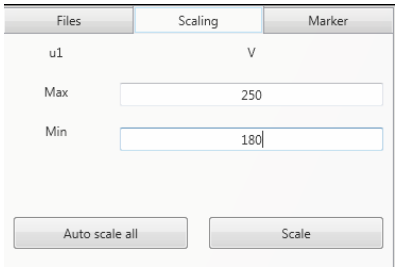
Example: Oscilloscope recorder – selecting voltage L1, L2, L3, L12, L23, L31



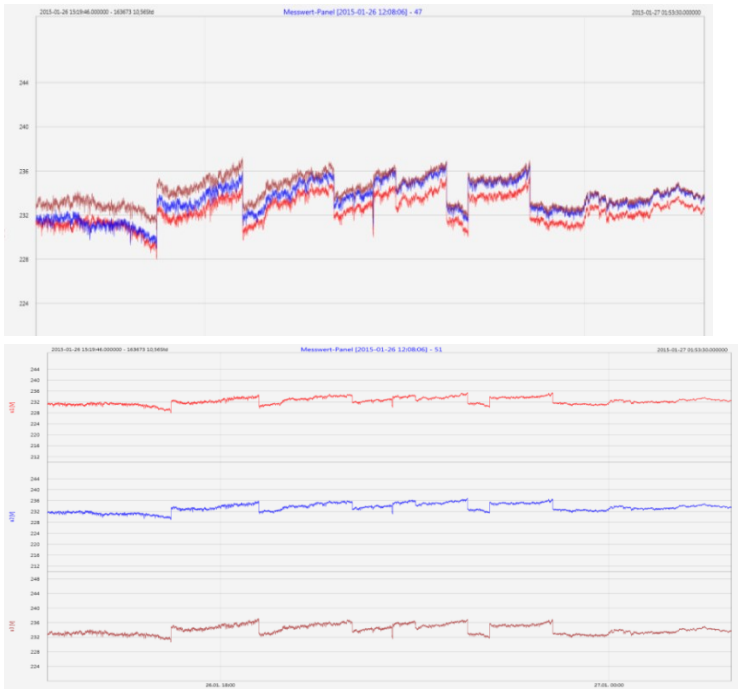
Right clicking the graphics with the mouse will open the following menu:



- **Functions:**
  - **Auto scaling:** The Y-axis of the measurement values is scaled automatically or can be scaled manually.
  - A Menu appears where the last measurement can be scaled free or automatic



  - **Stack** – associated measurement data can be represented with a common scale or separated

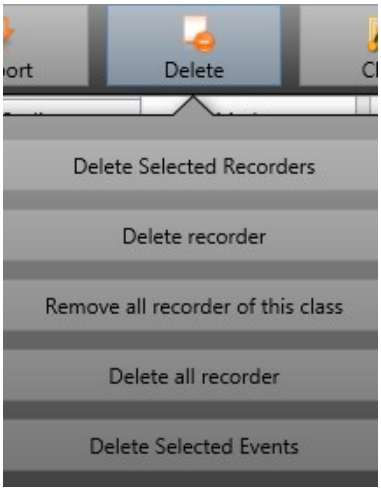


Example: presentation of voltage L1, L2, L3 in two variants

- **Copy data:** Measurement data is copied to the clipboard and can be processed further, e.g., in MS Excel.
- **Copy Image:** Copies the level-time diagram to the Windows clipboard and can then be inserted, e.g., in MS Word.

7.8 Deleting measurement data in the device memory

With the **Delete** function, measurement data can be deleted in the PQI-LV device memory.

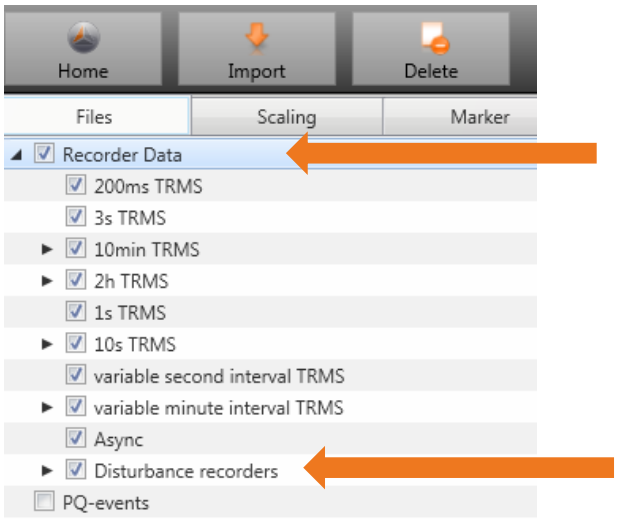


Delete selected recorders – deletes only selected files.

Delete recorder - deletes all recorder file.

Remove all recorders of this class - deletes e.g., all 10-minute data files.

Delete all records – All disturbance recordings and long-term measurement data on the device memory are deleted.



Main folders mark all data files.

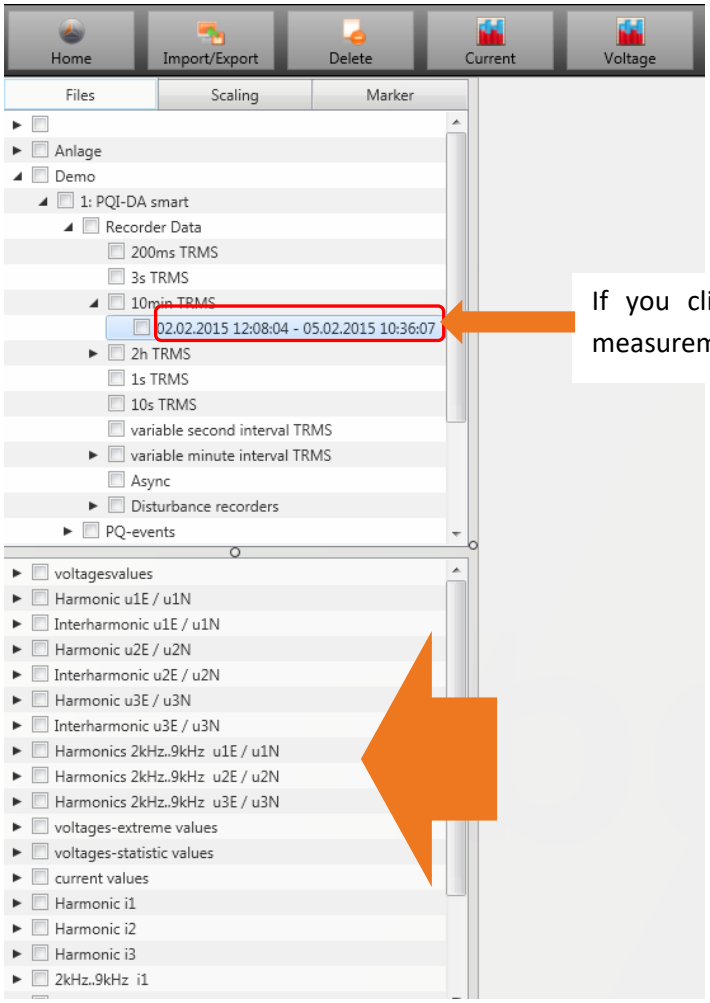
Mark only selected files to delete only these records.

I.e., the disturbance records which were recorded during installation.

7.9 Evaluating measurement data offline

The function can be used to evaluate all measurement data offline.

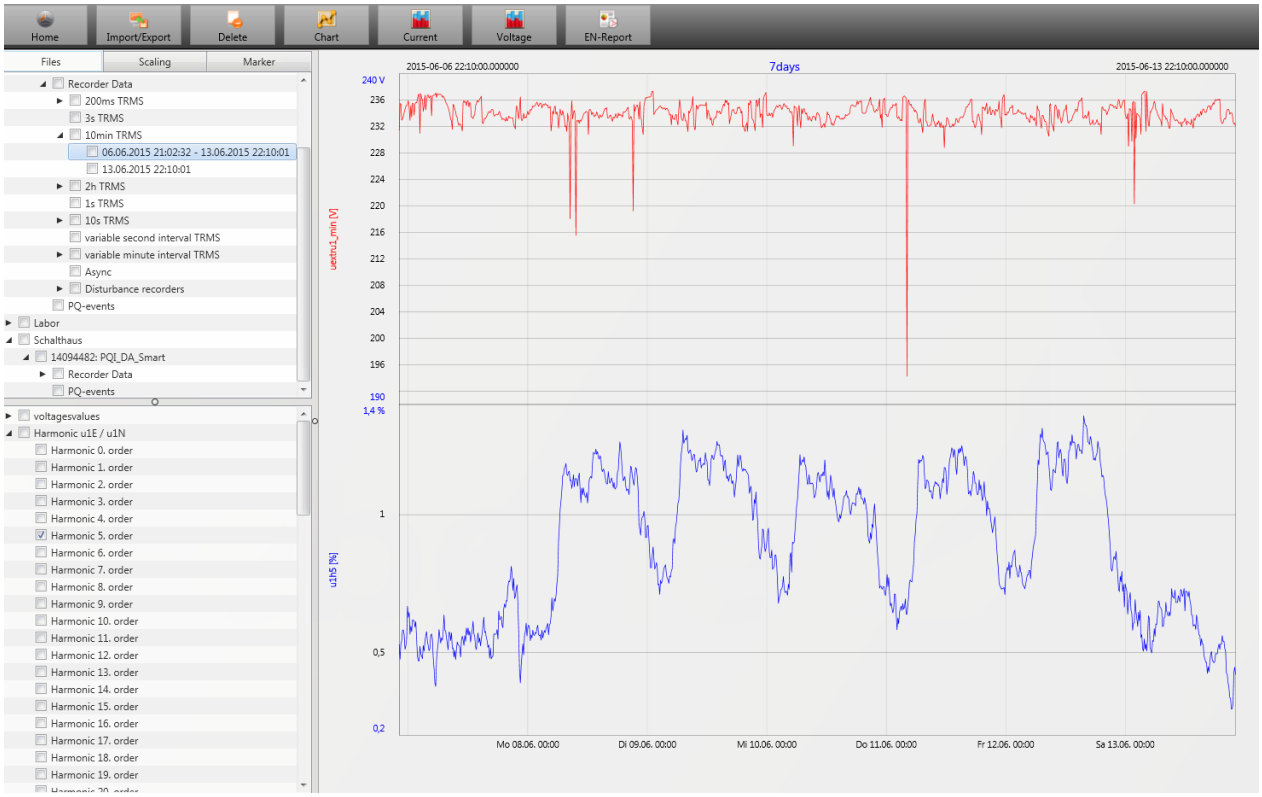
All measurement data which has been selected in the **Import** function is saved automatically on the PC. These can be evaluated offline without being connected to the measuring device.



If you click on the file all available measurement data appears.

Screen: Data folder

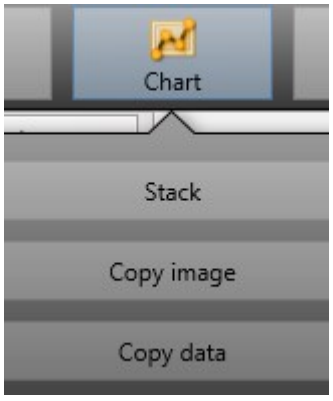
When measurement values or measuring channels have been selected, the associated level-time diagram appears.



Example: selection voltage extreme value and 5th harmonic L1

7.9.1 Edit measurement data

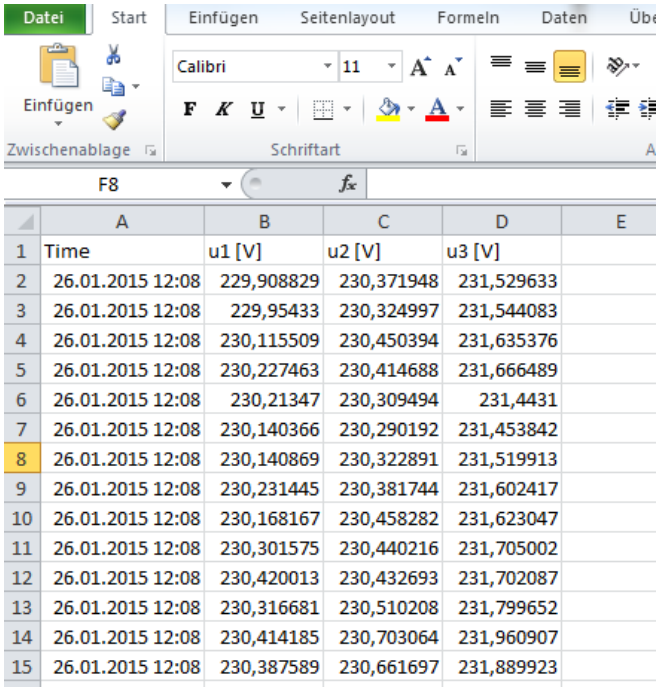
With the icon **Chart**, the following functions are available:



Copy data

Copies all the data displayed in the Windows clipboard

Example – measurement values in MS Excel



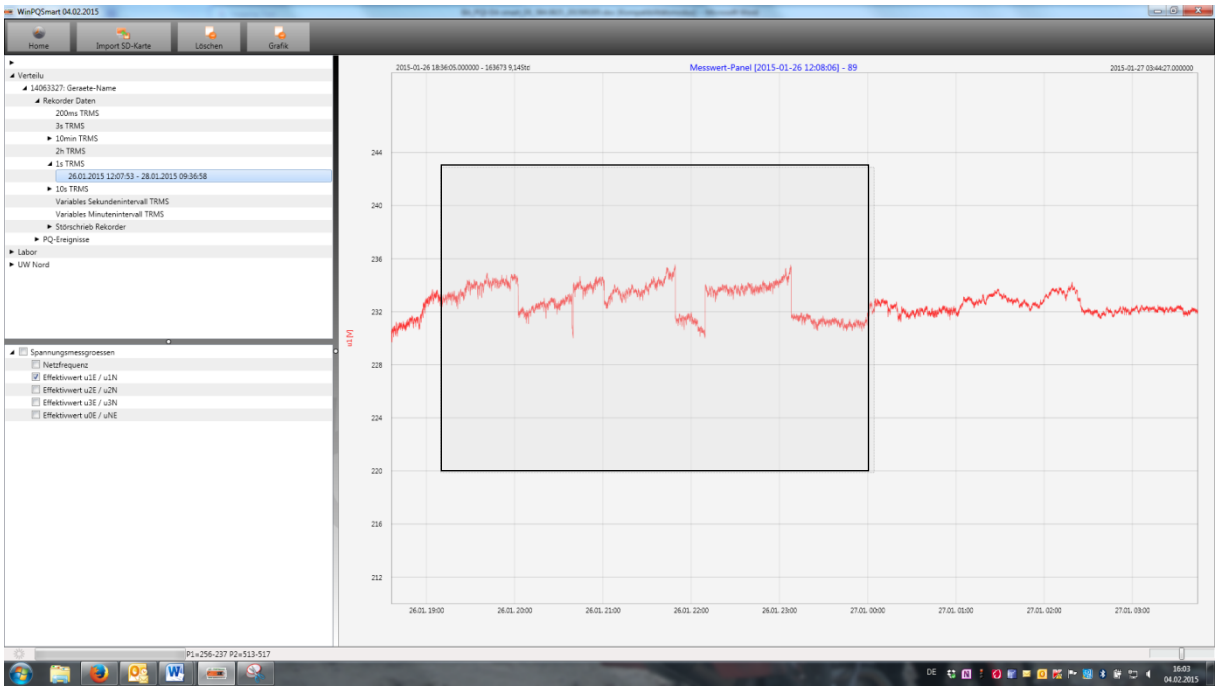
	A	B	C	D	E
1	Time	u1 [V]	u2 [V]	u3 [V]	
2	26.01.2015 12:08	229,908829	230,371948	231,529633	
3	26.01.2015 12:08	229,95433	230,324997	231,544083	
4	26.01.2015 12:08	230,115509	230,450394	231,635376	
5	26.01.2015 12:08	230,227463	230,414688	231,666489	
6	26.01.2015 12:08	230,21347	230,309494	231,4431	
7	26.01.2015 12:08	230,140366	230,290192	231,453842	
8	26.01.2015 12:08	230,140869	230,322891	231,519913	
9	26.01.2015 12:08	230,231445	230,381744	231,602417	
10	26.01.2015 12:08	230,168167	230,458282	231,623047	
11	26.01.2015 12:08	230,301575	230,440216	231,705002	
12	26.01.2015 12:08	230,420013	230,432693	231,702087	
13	26.01.2015 12:08	230,316681	230,510208	231,799652	
14	26.01.2015 12:08	230,414185	230,703064	231,960907	
15	26.01.2015 12:08	230,387589	230,661697	231,889923	

Copy image

Photo is copied to the Windows clipboard

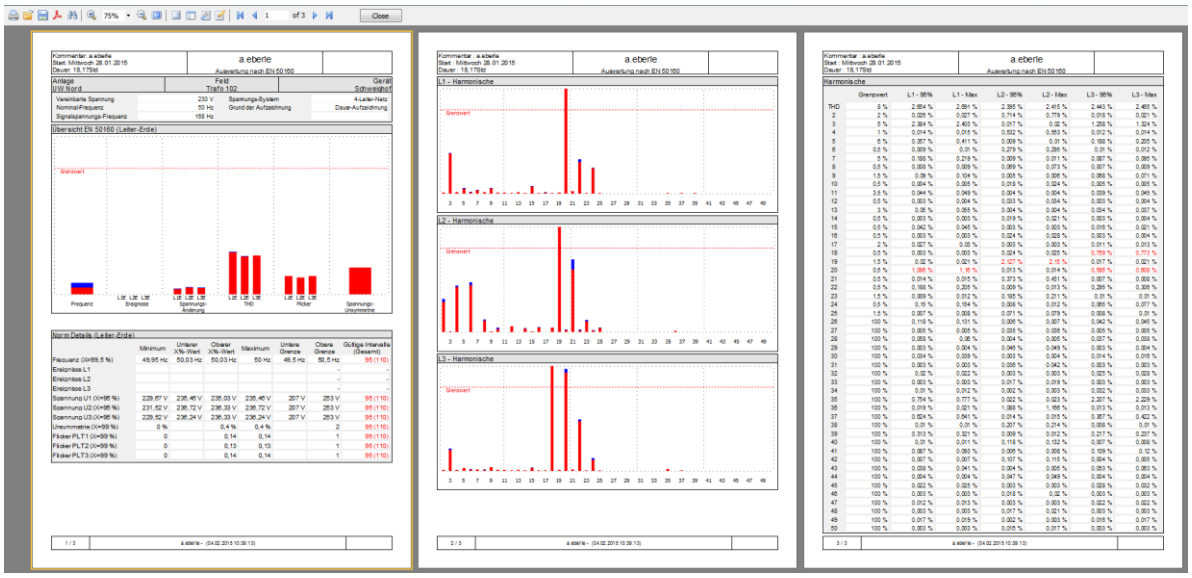
Zoom function

To zoom in an area, you draw with the left mouse button a window from top left to bottom right. To zoom out is the opposite direction. You can zoom in multiple stages or zoom out an image.



7.9.2 EN50160 report

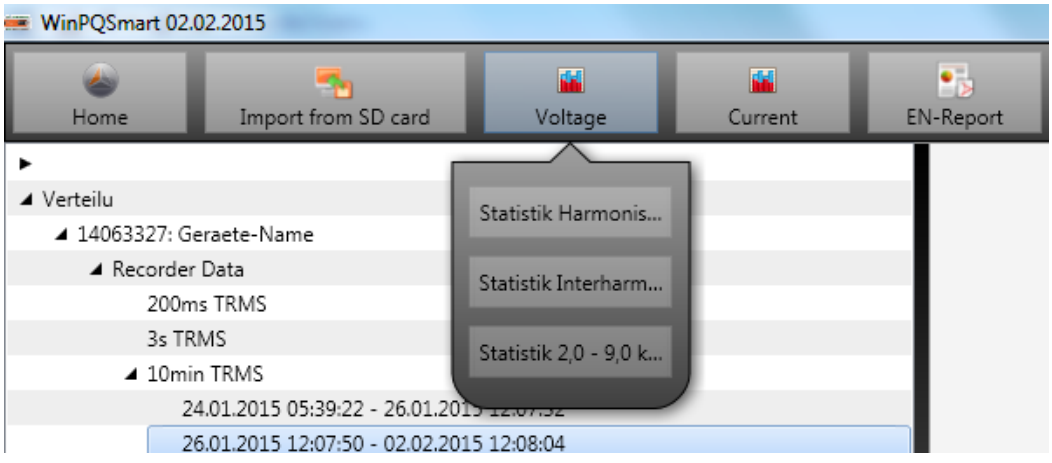
In the 10-minute data class, the EN50160 report is readily available. If you select one measurement file a multipage report is created.

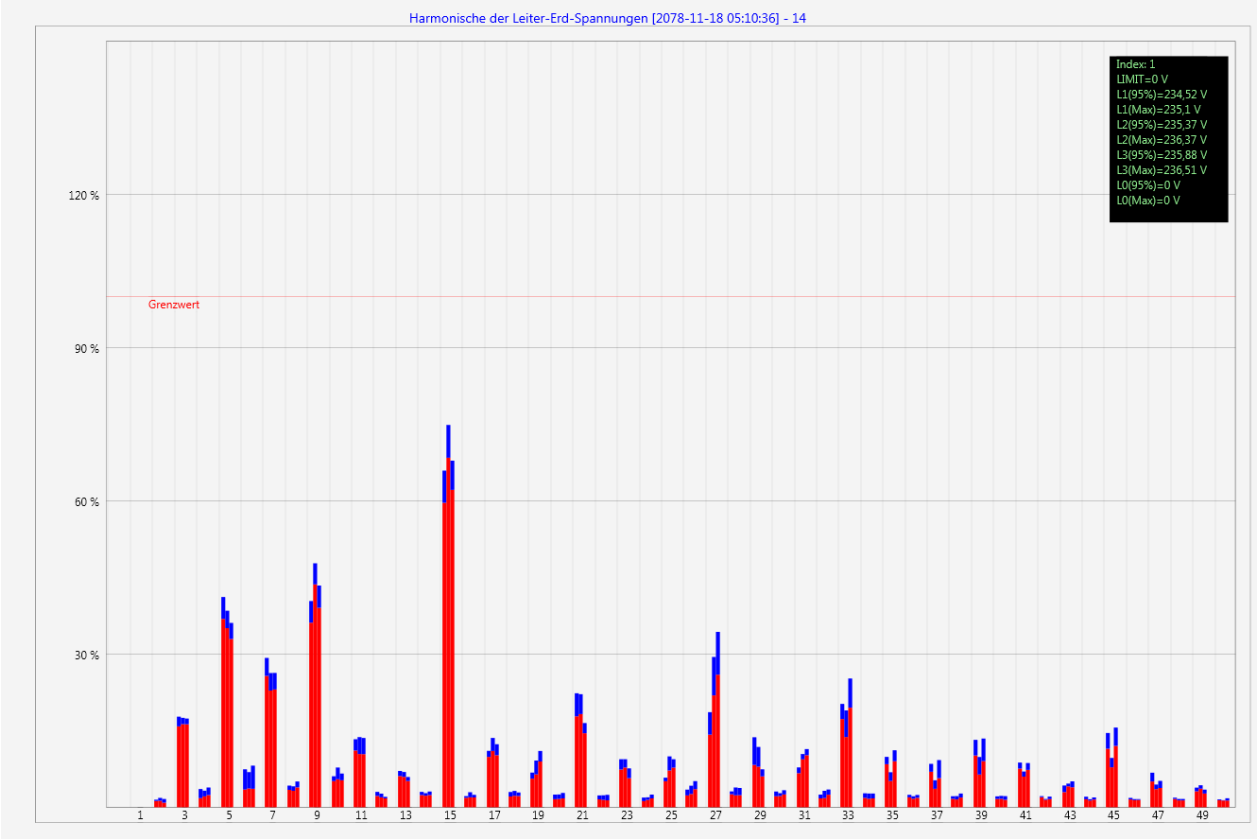


7.9.3 Voltage harmonics and interharmonics

With the Icon 

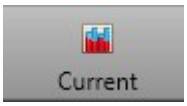
you can reach the statistics of the voltage harmonics, voltage inter-harmonics and supraharmonics 2 kHz to 9 kHz.



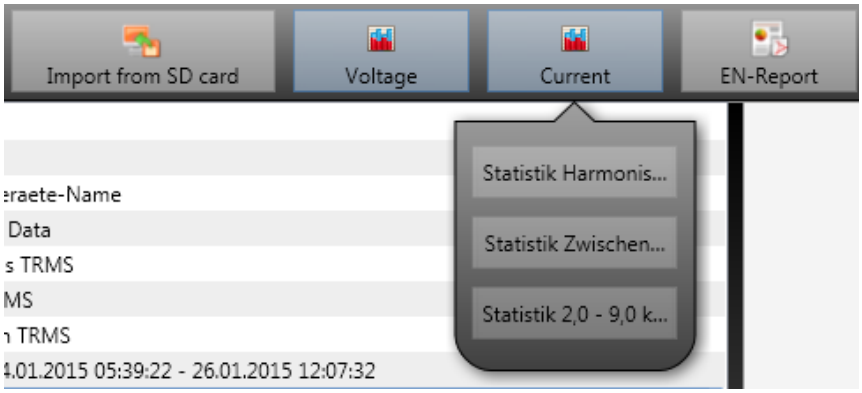


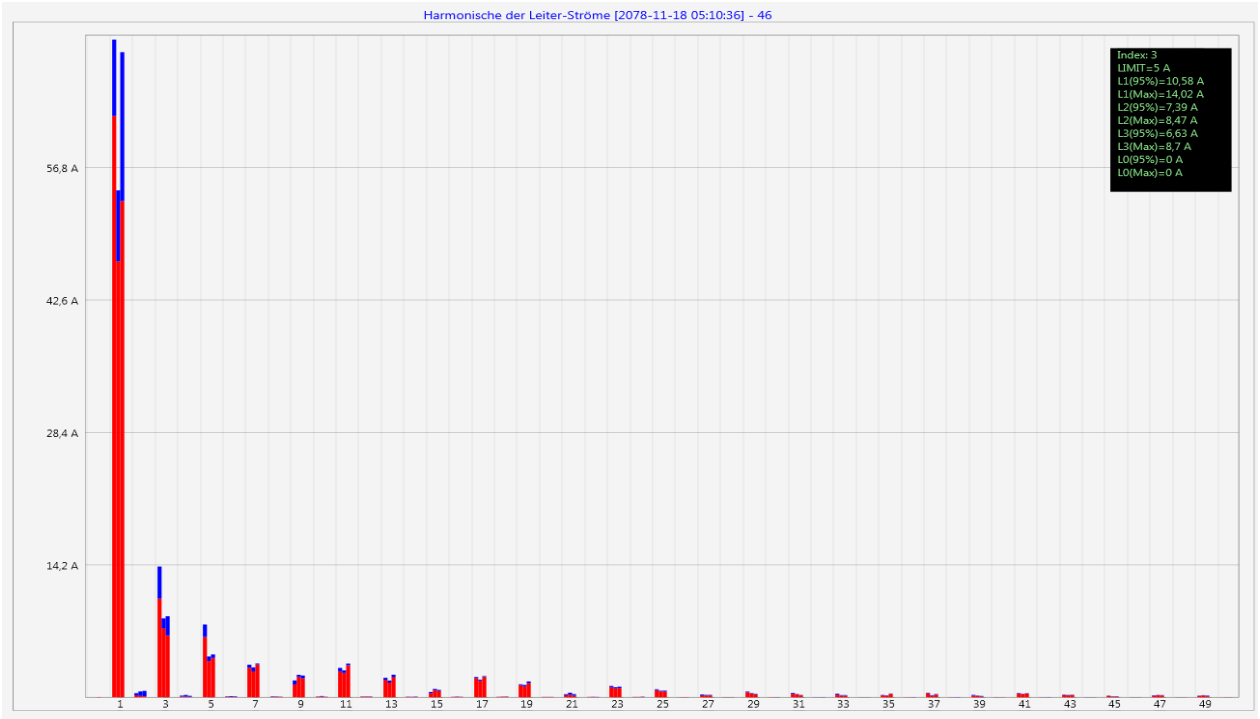
Statistic voltage harmonic - scaled to the corresponding compatibility level of the power quality standard.

7.9.4 Current harmonics and interharmonics

With the Icon 

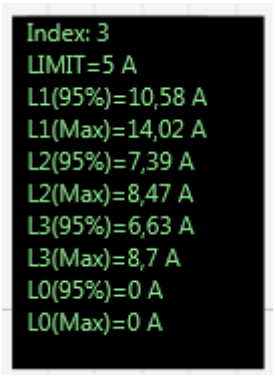
you can reach the statistics of the voltage harmonics, voltage inter-harmonics and supraharmonics 2 kHz to 9 kHz.



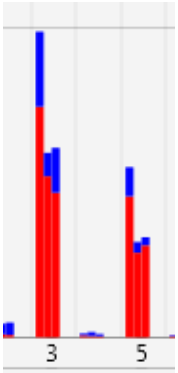


Example: Statistic current harmonics 2nd to 50th - scaling in ampere

If you select with the cursor a particular harmonic, the corresponding measured values are displayed for these harmonics in the display window.



The red bar always shows the 95% values, and the blue bar shows the maximum measured value.



7.10 Measurement supervision

The supervision of measurements gives the possibility to observe 32 different measurands with an individual threshold. Next to the pure threshold it is possible to define a threshold of quitting the supervision state depending on the hysteresis.

Parameter Name	Value	Default Value
Active	✓	☐
Measurement ID	cos phi L1 (I1_cosphi) (...	0
Threshold	0,9	0
Hysteresis [% of threshold]	1	0
Monitor for	Higher than threshold	Higher than threshold
Description	cosPhi_L1	

Figure 2: Example for the parameterization to supervise the cos(Phi)

7.10.1 Parameterization of a supervised measurand

The settings of the measurement supervision can be made in the **Expert Desktop** of the parameterization (chapter 7.4.1). The tab **Measurement supervision**, which contains the 32 states of supervision, is placed in the tab of **Thresholds/Recording** (Figure 3). With the factory settings all states of supervision are deactivated.

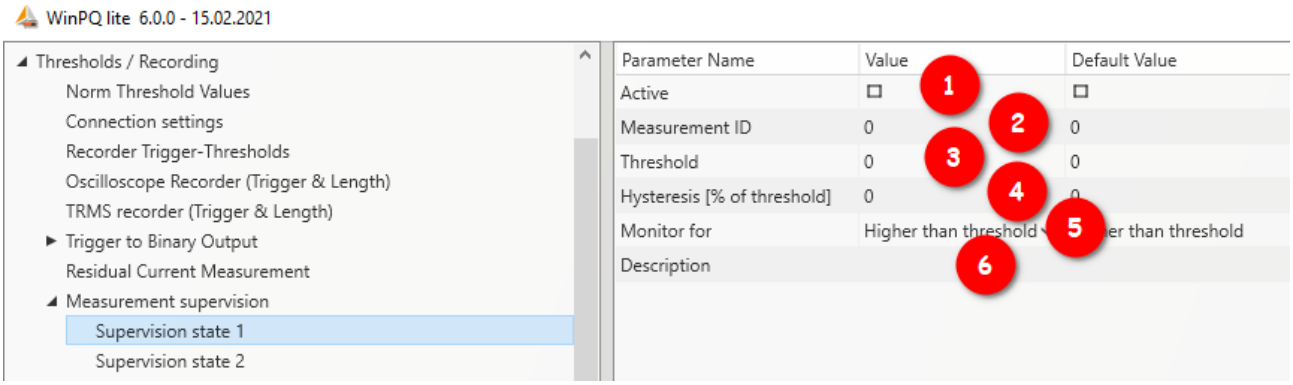


Figure 3: Parameterization of the supervision state

Hence the supervision state must be *activated* first (1). The measurement devices can log many thousands of measurands. To identify them clearly there are used the measurement IDs. With the measurement-ID a clear identification of the measurand depending on the quantity and data classes.

After clicking into the field of the *Measurement-ID* a new window appears (2). All quantities, which can be supervised, can be picked in this setup (Figure 4). Firstly, the correct data class must be chosen with the drop-down-menu. The possible quantities will change depending on the data class. The quantities are grouped into frequency (F), current (I), voltage (U) and other (S). These groups are helpful to choose the concrete measurand. The search mask can only find the Measurement-IDs. It is not possible to search for the English descriptions.

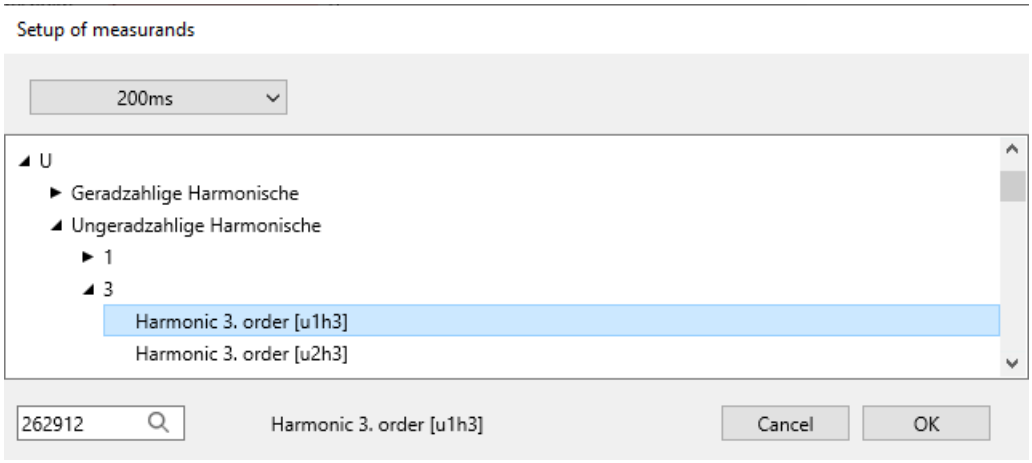


Figure 4: Setup of the measurands

With the chosen Measurement-ID the next step is the *threshold* (3). The threshold must be tipped in as a float value. But there is no check about the plausibility of this value!

It is also possible to define the *hysteresis* of the supervision state (4). This makes it possible to define a threshold of quitting the supervision state which is different from the threshold. If the hysteresis equals 0% both thresholds have the same value. Depending on the monitoring for higher/lower of the threshold the hysteresis of quitting has different influence:

- Exceeding threshold: threshold of quitting=threshold * (100% - hysteresis)
- Falling threshold: threshold of quitting = threshold * (100% + hysteresis)

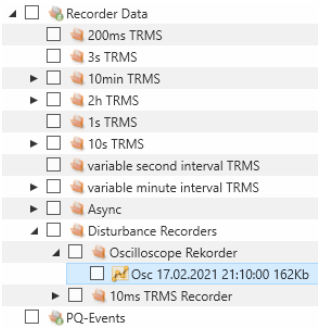
In addition, it is possible to specify whether exceeding (higher) or falling (lower) below the defined limit value is to be *monitored* (5). The field *description* is open to the user, but it would be helpful to fill it with the data class and the quantity of the measurand (6).

7.10.2 Parameterization of the reaction after exceeding the threshold

The device can react with two different actions if the thresholds are exceeded or deceeded.

The table with possible events of these recorders also contains the supervision states. They are placed in the bottom.

7.10.3 Evaluation of the supervision states



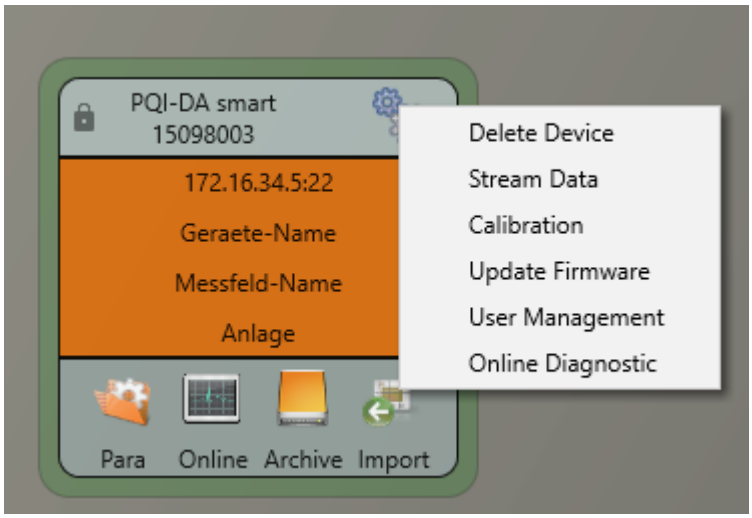
The evaluation of the states with measurement supervision, which are triggered with the oscilloscope- and/or TRMS-recorder, can be done with the **Import**-function of the WinPQlite. The triggered disturbance records are in the tab **Disturbance Recorder** for more information about evaluating disturbance records is chapter 7.7 recommended.

The export of the parameterization of **Thresholds/Recording** will make this evaluation easier (chapter 7.4.1). Because it helps to differentiate between classical events and the measurement supervision.

At least it is possible to check the supervision states via Modbus. The register is read-only and give for each state just the information if it is active (1) or not active (0). The table of datapoints and more information about Modbus can be find in chapter 13.1. For reading the supervision states via Modbus it is necessary to restart the device after the parameterization of the first supervision state once.

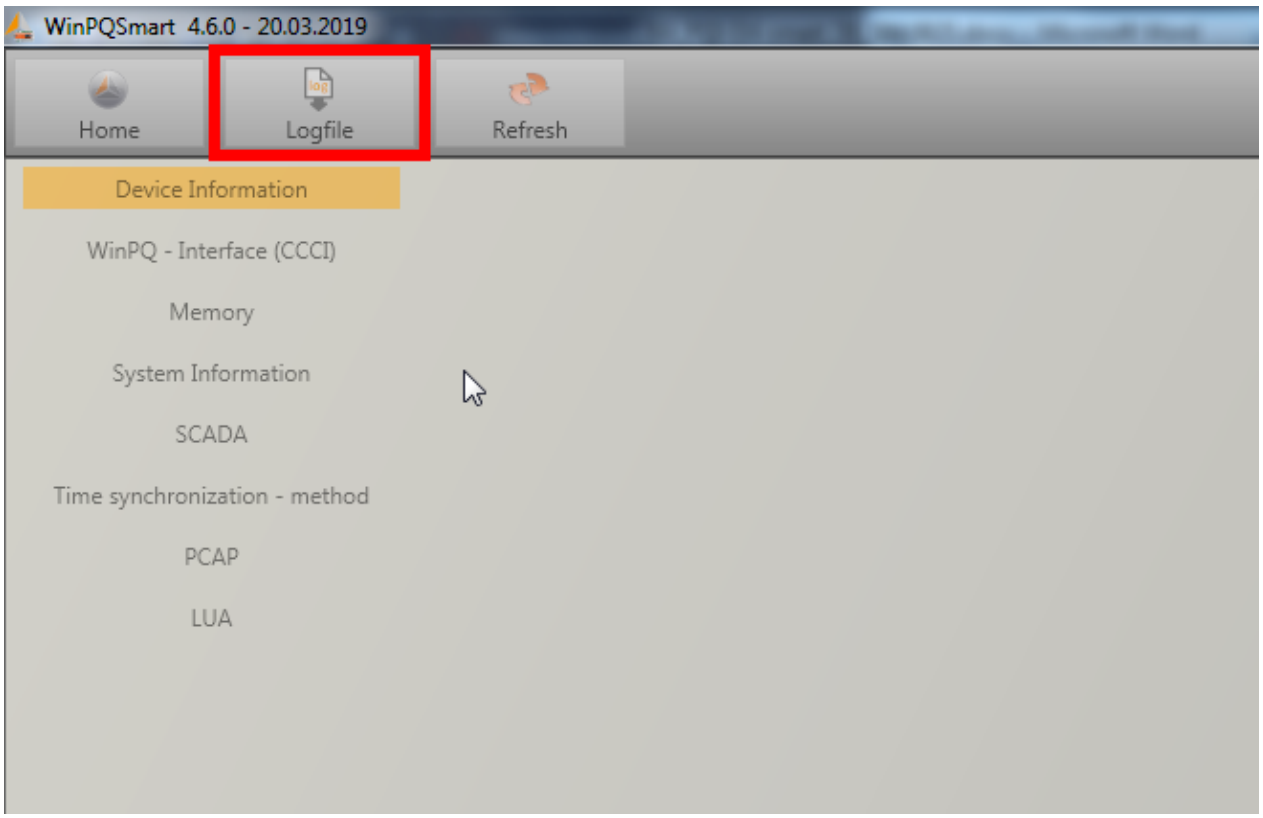
8. Online Diagnostic

With the help of device status, the most important information of the PQI-LVs can be read out via Streaming. The device status can be seen as well as the complete device properties.



8.1 Device Information

In the **Device information** part, the device log file can be loaded from the device using the **Logfile** button.

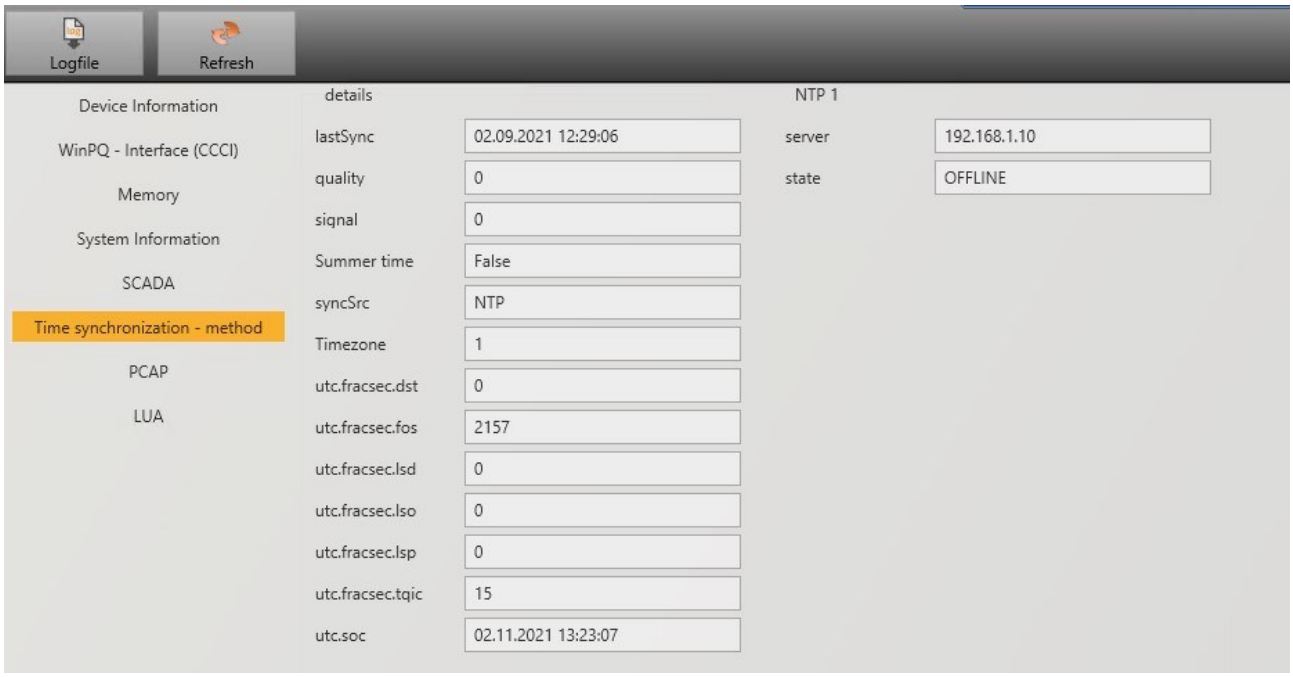


8.2 Time synchronization method

The quality as well as the current state of the time synchronization can be checked in this menu.

Legend to the line names of the WinPQlite:

- lastSync: time of the last time setting
- quality: Signal quality
- signal:
  - 0, if no signal is detected
  - unequal 0, if a signal is detected and the appropriate protocol is selected
- Sync.Src: specification of the synchronization protocol
- Utc.fracsec.tqic: quality of the device time in relation to the time source
  - 15 - device time not synchronized or deviates from the time source by more than 10s
  - ≤10 - device time synchronized and deviation from the time source is less than 1s



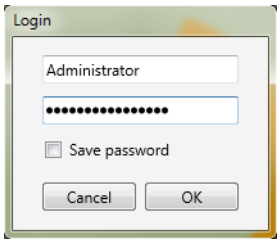
9. User database and access rights

The measuring device is equipped with a user role and user rights concept including user database, which corresponds to the current IT security guidelines.

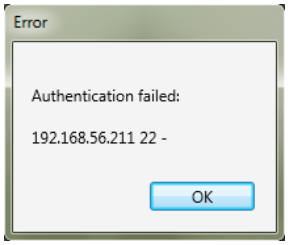
The main functions are:

- Any number of users can be stored in the device with uniquely identifiable names.
- The users are to be assigned to a role.
- The roles (administrator, operator and user) define the rights.
-

The detailed description of the rights and roles with specification of the rights is listed in the security documentation.



Whenever a function is called from the WinPQ lite software, such as Read parameterization (Para), Online data (Online), Data Explorer (Import), the encoder checks by entering the username and password whether the user has the required rights for this function.

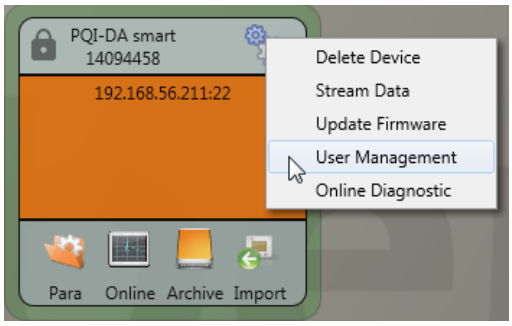


If the password and or the username are entered incorrectly or if the user does not have the right to access a function, this is reported back accordingly.

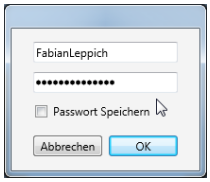
- If incorrect entries are made, the connection to the device via the SSH tunnel is automatically disconnected!
- The number of failed attempts (factory setting: 3) before a user is locked in a certain time (factory setting: 1 hour) can be set.
- Failed attempts are logged internally and output via Audit Syslog and can also be queried via the user administration.

9.1 Adding and Editing Users

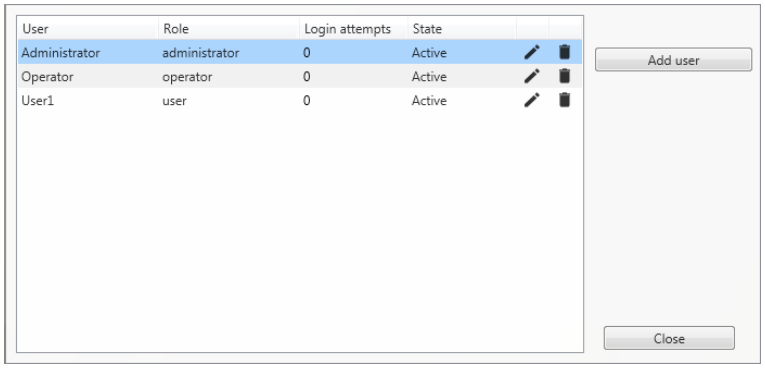
If the meter is set up in Security Mode (see chapter 6.2) any number of users can be created in the meter. During the first setup, one user each for the roles "User", "Operator", "Administrator" and, if applicable, "Machine-to-Machine" was stored in the measuring device. To store additional users or edit, block or delete users that have already been created, proceed as follows:



Click on "Edit user" in the device settings.



Enter the username of the administrator and the corresponding password.

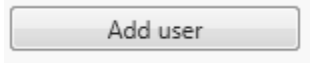


User information is downloaded from the meter and displayed.

Functions:

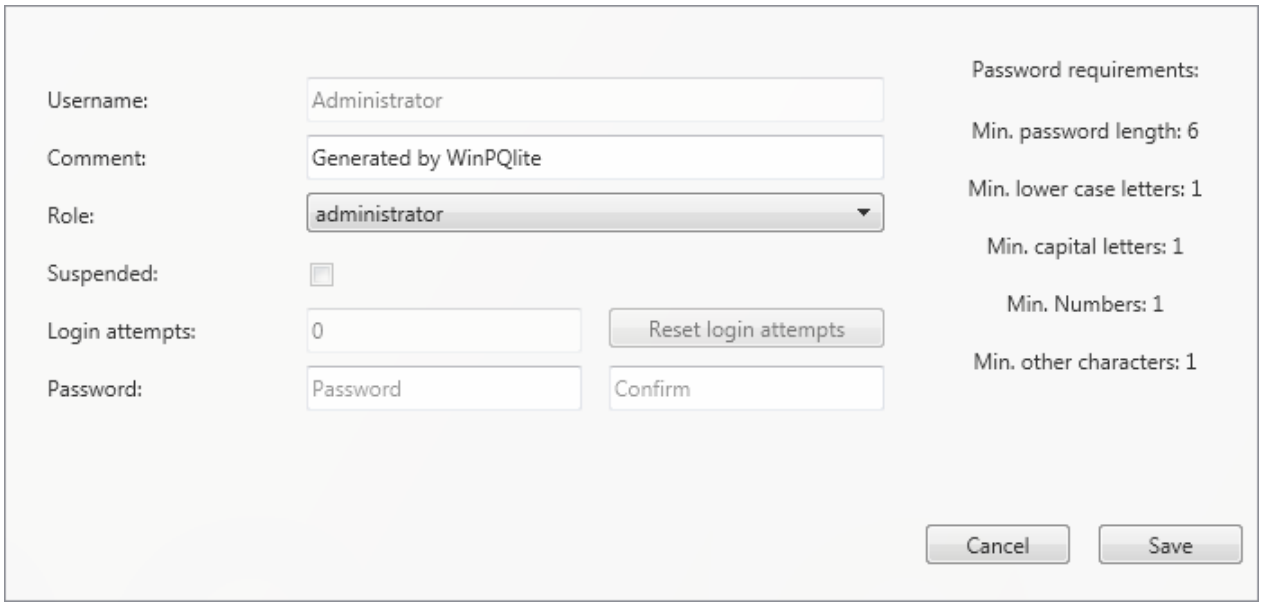
Edit user

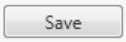
Delete user



Add new user

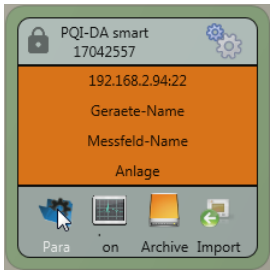
If clicking on "Edit user" or on "Add user", an input mask for the parameterisation of the user opens.



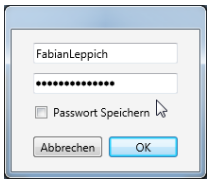
Click on  to transfer the settings to the PQI-LV, store them and activate them from this point on.

9.2 IT security settings and password requirements

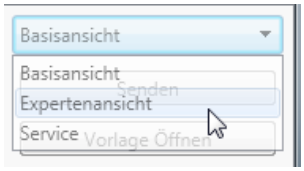
The administrator has the possibility to specify the assignment of passwords via the so-called password policy. Proceed as follows to make the settings:



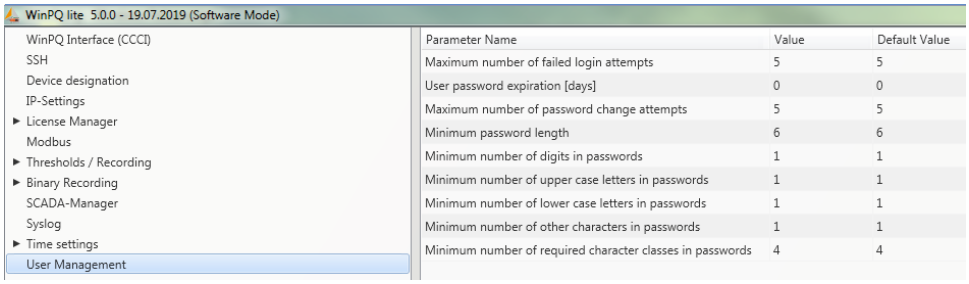
Click on **Para** to download the complete device parameterization from the PQI-LV.



Enter the username of the administrator and the associated password since the policy can only be set by the administrator.



Changing the interface from the **basic view** to the **expert view**



In the menu item **User administration parameters,** the following necessary parameters can be defined in addition to the password guidelines:

- **Maximum number of failed logon attempts**: Number of logons attempts on the device before a user can log on to the device again for a configurable time (factory setting: 1 hour). The parameter can be freely set via the SSH console if required for the lockout period.
- **User password expiration [days]:** After the set days have expired, the user can no longer log on to the device without having to change the password.
- **Maximum number of password change attempts:** Number of attempts to change the password on the device.

The password should be as complex as possible!

It is always recommended to adhere to the relevant known and country-specific guidelines!

Germany: It is recommended to adhere to the guidelines for passwords of the Federal Office for Information Security (BSI).

10. Firmware update for PQI-LV

Power Quality devices are constantly evolving in terms of functions and standards. It may therefore become necessary to update a device, e.g., due to changes in standards, new functions or necessary (security) patches. You will find the latest firmware version with a transparent changelog to check whether an update is necessary using the following link:

For a firmware update administrative rights are necessary!

https://www.a-eberle.de/en/download-center-categories/f%C3%BCr-festinstallierte-ger%C3%A4te-0

A.Eberle generally provides two firmware packages which differ in their function:

- **Incremental update (patch) - available on the homepage**

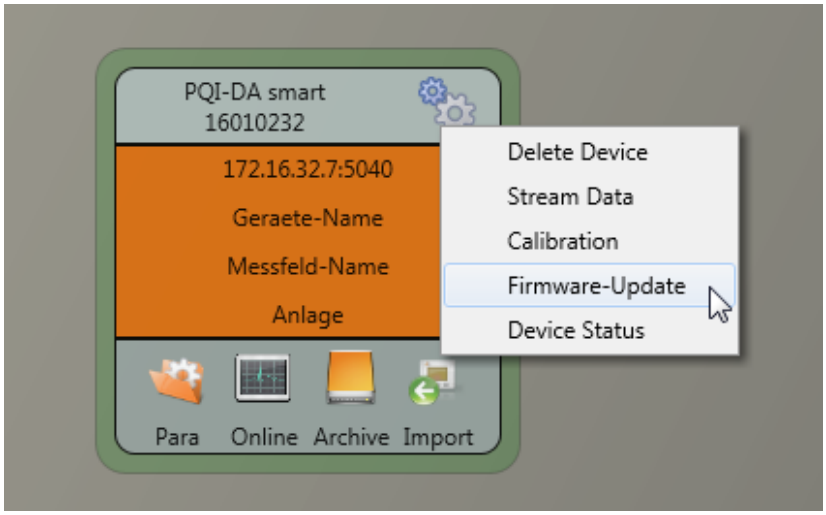
The incremental update does not change any parameters or settings. It also does not delete any measurement data, but only updates the changes to the last version.

The file name is e.g., "PQI-DA_Smart_v1.8.10_11544.zip". The incremental update is the common way to bring the measuring instruments up to date.

- **Factory Update - only available on request**

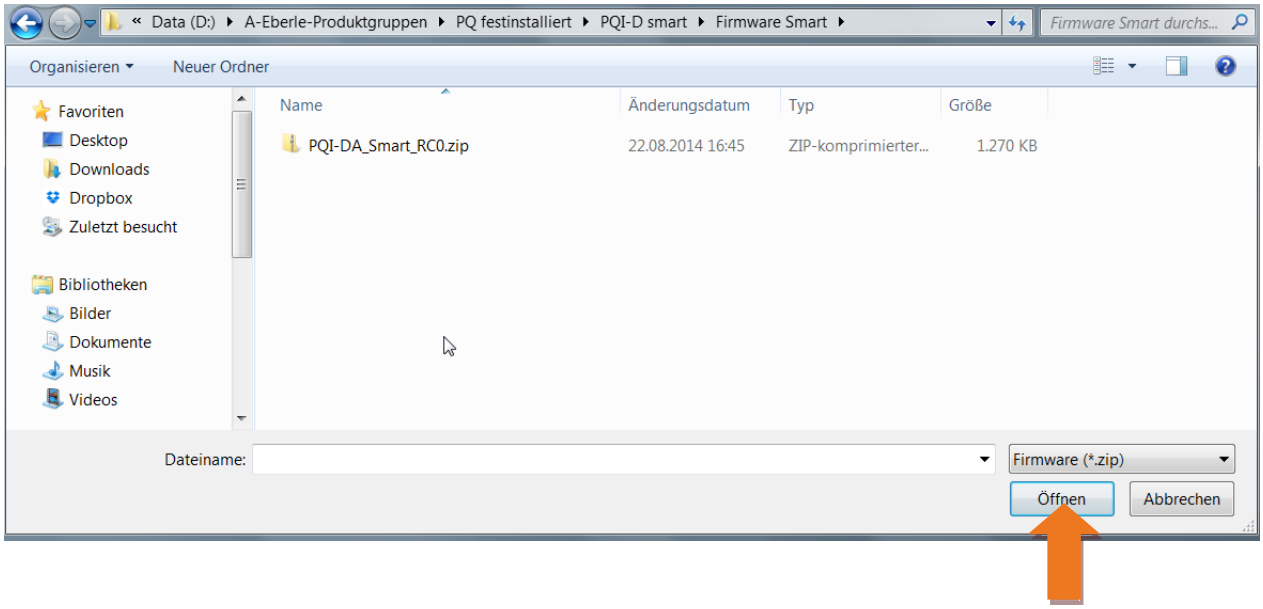
This update deletes all settings including all recorded data and resets the device to factory settings. The file name of the update has the extension "factory" Example: "PQI-DA_Smart_**factory**_v1.8.10_11544.zip". The factory update should only be used in consultation with product support.

10.1 Firmware update with software WinPQ lite



The **General setup** device function tile can be used to carry out a firmware update for the PQI-LV measuring device.

- Select the folder where the file for the firmware update is located.
- The Öffnen function is used to transfer the firmware to the network analyser.



When the transfer of the firmware to the measuring device has been completed, it will automatically re-start and install the new version.

10.2 Ensuring the integrity of firmware updates

The archive of the firmware update and the update procedure are protected by a digital signature including certificate handling. Detailed documentation on this can be found in the associated security documentation.

If a firmware archive should have an invalid digital signature, the unit immediately interrupts the update process for security reasons.

10.3 Automatic firmware update of many devices

Using the WinPQ system software, many PQI-LVs can be updated with just a few clicks, with full clarity and control. Further information can be found in the documentation "WinPQ Commissioning Instructions" of the WinPQ system software.

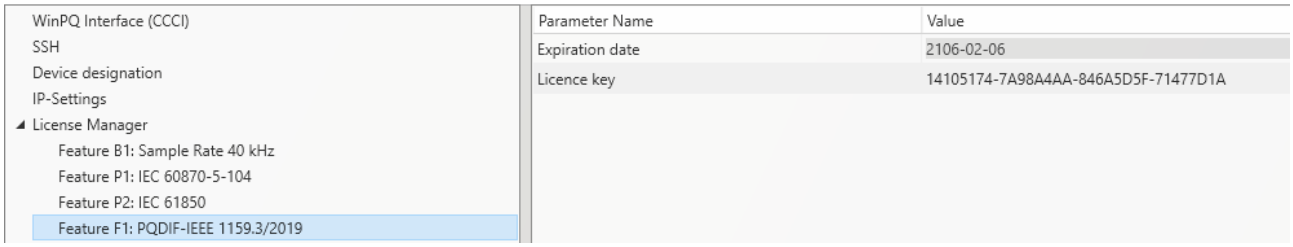
11. License Update PQI-LV

The network analyser PQI-LV can be equipped with various options. These options can be activated via a license code, even after the purchase, at any time.

To order an option the following information to create a license code are required:

- Serial number of the instrument
- Article number of the instrument
- Option to install

If you received a valid license for the connected device, please paste it to the device setting.



Example: Upgrading Option PQDIF for PQI-LV

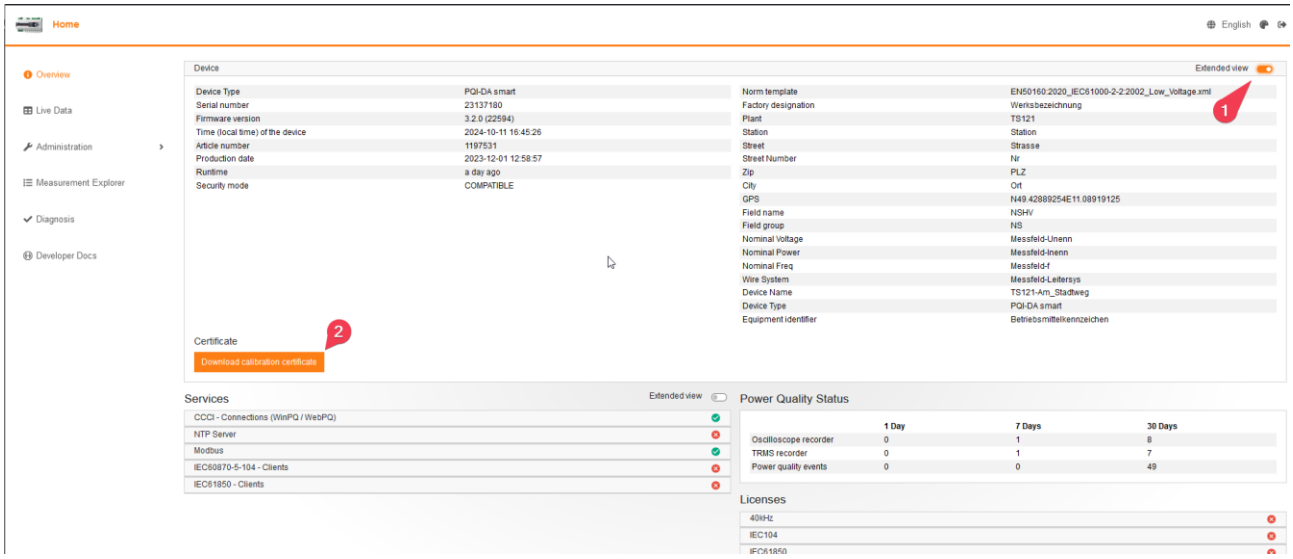
▶ **The following options are available:**

- S1: Fault Recording
- B1:40.96 kHz sampling (2 kHz to 20 kHz harmonic measurement)
- P1: IEC 60870-5-104
- P2: IEC 61850
- P3: Modbus Master recording
- F1: PQDIF regarding IEEE 1159.3

Licences should be sent to the unit without further adjustment of the parameterization and their acceptance checked in the display, Webserver or o online diagnosis. Only then are individual parameters of the added option available.

12. Calibration

The device has a factory calibration. The certificate can be downloaded via the web server.



13. SCADA settings

In the device settings **SCADA,** the following protocols can be selected:

- Modbus supplied as standard
- IEC60870-104 chargeable device option
- IEC61850 chargeable device option

13.1 Modbus

The following data classes are available in the PQI-LV via Modbus TCP or Modbus RTU:

Data class	Measurand	Function code
10 ms	All measurands	Read Holding Register
200 ms	All measurands	Read Holding Register
1 sec	All measurands	Read Holding Register
3 sec	All measurands	Read Holding Register
N sec	All measurands	Read Holding Register
10 min	All measurands	Read Holding Register
N min	All measurands	Read Holding Register
2 h	All measurands	Read Holding Register

The available measurands of each data class are shown in the technical datasheet of the device.
Additionally, these events can be requested via Modbus:

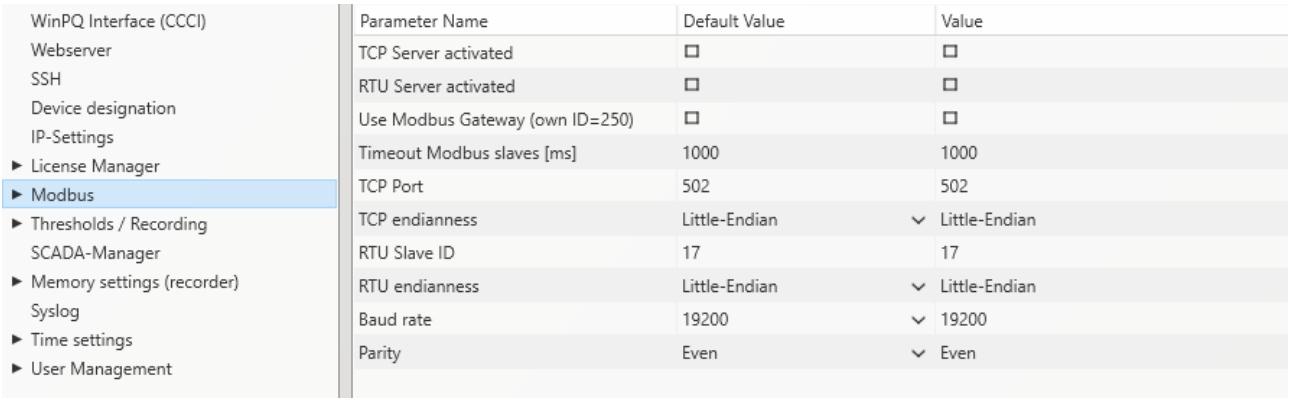
Event	Function code
Messages (trigger command, 32 supervision states)	Read Coils
Endless counter for disturbance recorder and PQ-Events	Read Coils
Power Quality settings – write Modbus, only in contact with the support	

13.1.1 Modbus interface list

Please download the extensive Modbus interface point list from our website www.a-eberle .de

For Modbus there are over 10.000 measurement values available. Also, as Excel-sheet available, please contact our Support.

13.1.2 Set-up parameter Modbus with WinPQ



The Modbus TCP and Modbus RTU interfaces can be modified via the WinPQ lite software. Modbus could be activated via the parameters TCP or RTU Server (0 = OFF / 1 = ON)

- **Parameter serial:**

RTU Server activated	Activation of Modbus RTU
Baud rate	Baud rate of the serial interface for Modbus RTU
Parity	Serial port parity for Modbus RTU
RTU - byte order	See chapter 13.1.2.1

- **Parameter TCP/IP**

TCP Server activated	Activation of Modbus TCP
TCP - Port	Change of the TCP / IP Ports for Modbus TCP / IP
TCP - byte order	See chapter 13.1.2.1

- **Parameter Modbus Gateway (see chapter 13.1.3)**

TCP Server activated	Activation of Modbus TCP
Use Modbus Gateway	Activation of Modbus Gateway
TCP - Port	Change of the TCP / IP Ports for Modbus TCP / IP
TCP - byte order	See chapter 13.1.2.1
Baud rate	Baud rate of the serial interface for Modbus RTU
Parity	Serial port parity for Modbus RTU
RTU - byte order	See chapter 13.1.2.1

13.1.2.1 Byte Order

According to the Modbus specification, data is transmitted in the byte order Big-Endian. Regarding a 16-bit Modbus register, the data on the client side is interpreted without conversion. The following example illustrates this with the example value 0x1A2B:

Address	Communication (Big-Endian)	Client-Side (Big-Endian)
High Byte	0x1A	0x1A
Low Byte	0x2B	0x2B

13.1.2.2 Modbus-Register-Order

Interpreting the data transferred via multiple Modbus registers (e.g., 32 bits Unsigned Integer => 2 x 16-bit Modbus registers), a distinction must be made between the Little-Endian and Big-Endian sequences. In this case, the entire register contents and not the bytes are exchanged. In the default configuration, the software is operated in Little-Endian mode. The following examples illustrate the variants:

- **32 Bit-value *0x1A2B3C4D* - Modus Little-Endian:**

Address	Example (Big-Endian)	Communication (Little-Endian)	Client-Side (Big-Endian)
Register 0 High Byte	0x1A	0x3C	0x1A
Register 0 Low Byte	0x2B	0x4D	0x2B
Register 1High Byte	0x3C	0x1A	0x3C
Register 1Low Byte	0x4D	0x2B	0x4D

- **32 Bit-Wert `0x1A2B3C4D` - Mode Big-Endian:**

Address	Example (Big-Endian)	Communication (Little-Endian)	Client-Side (Big-Endian)
Register 0 High Byte	0x1A	0x1A	0x1A
Register 0 Low Byte	0x2B	0x2B	0x2B
Register 1High Byte	0x3C	0x3C	0x3C
Register 1Low Byte	0x4D	0x4D	0x4D

13.1.2.3 Data bits

By default, a Modbus packet with 8 data bits and one stop bit is built up at the measuring device.

13.1.2.4 Data Types

The Modbus implementation in the PQI-LV currently works with the following data types.

- **Unsigned Integer 32 Bit (uint32_t)**

This data type stores unsigned integer values. According to the width of 32 bits, they are stored in two registers.

- **Float 32 Bit (float32)**

Float 32-bit floating-point numbers are transmitted according to the IEEE 754 standard. These are stored in two registers. The interpretation of the values is described in detail at https://de.wikipedia.org/wiki/IEEE_754

- **Float 64 Bit (double)**

Float 64-bit floating-point numbers are also transmitted according to the IEEE 754 standard. The width of 64 bits requires storage in four registers. The interpretation of these values is also described at https://de.wikipedia.org/wiki/IEEE_754 .

- **Status (status_t)**

The status value has a width of 32 bits. It is stored accordingly in two registers. The meaning of the individual bits is listed in the following table:

Bit-Number	Meaning
0	RVC, Voltage U1E
1	Dip, Voltage U1E
2	Swell, Voltage U1E
3	Interruption, Voltage U1E
4	Overload, Voltage U1E
5	RVC, Voltage U2E
6	Dip, Voltage U2E
7	Swell, Voltage U2E
8	Interruption, Voltage U2E
9	Overload, Voltage U2E
10	RVC, Voltage U3E
11	Dip, Voltage U3E
12	Swell, Voltage U3E

13	Interruption, Voltage U3E
14	Overload, Voltage U3E
15	RVC, Voltage U12
16	Dip, Voltage U12
17	Swell, Voltage U12
18	Interruption, Voltage U12
19	Overload, Voltage U12
20	RVC, Voltage U23
21	Dip, Voltage U23
22	Swell, Voltage U23
23	Interruption, Voltage U23
24	Overload, Voltage U23
25	RVC, Voltage U31
26	Dip, Voltage U31
27	Swell, Voltage U31
28	Interruption, Voltage U31
29	Overload, Voltage U31
30	State Frequency Synchronization
31	free

- **Timestamp (uint32_t)**

The 32-bit-wide time stamp is stored in two registers and must be interpreted as an integer value without sign. This is a UNIX time stamp, that is, the number of seconds since 1 January 1970, 00:00 hours (coordinated world time UTC), with no switching counts being counted.

Example: 1478787619 (0x58248223)

Value of time: 11. October 2016 14:20:19 (UTC)

Further information and an implementation example can be found at https://en.wikipedia.org/wiki/Unix_time.

- **Sub seconds (tmFracSec_t)**

The sub second value has a width of 32 bits and is accordingly stored in two registers. The data type is based on the time format, which is defined in IEEE C37.118. The meaning of the individual bits is listed in the following table:

Bit-Number	Meaning
0..23	Sub seconds in 100 ns increments

24..27	time quality indicator
28	Set as the announcement of a switch (1 min before)
29	Set, 24 hours after a switch
30	Add Leap Second (0) or remove (1)
31	Indicator wintertime (0) or summertime (1)

13.1.3 Modbus Gateway

The measurement device can be parameterized as Master in an RTU-bus. This Master can transform the data transparently to Modbus TCP. In this case the measurement device acts as a TCP-Server. The counter-part is the TCP-client. With RS-485 there are 32 participants in total allowed on the bus.

To parameterize the device as Modbus Gateway the expert settings in the WinPQlite are required. The checkboxes of TCP-Server and Modbus Gateway need to be activated. A parallel activation of TCP-Server and RTU-Server is not allowed. Additionally, the TCP-settings and RTU-settings which are listed in chapter 13.1.2 should be parameterized.

With these settings the TCP-Client can connect to the Modbus Gateway device. To request the register of the device itself (Modbus-Gateway/RTU-Master) the ID 250 needs to be used, this ID is hardcoded. Any unique slave IDs between 1 and 31 can be selected for the slaves. Within a TCP session, any registers of all RTU slaves can be queried.

With activated mode „Modbus Gateway“ only one connection of a TCP Client to the device is possible!

Notes on electrical wiring can be found in chapter 5.10.1.1.

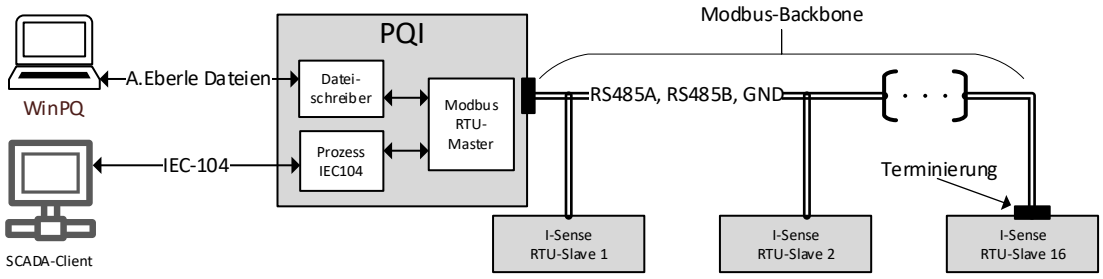
13.1.4 Modbus Master with recording

The device can be parameterized on an RTU bus as a master, which saves the register data of the slaves in internal recording files. With the help of the I-Sense feeder measurement technology, a complete measurement of up to 16 outgoing feeders for e.g., local network stations are possible. In addition, the solution can read third-party components such as meters, energy measurement technology or even door contacts and temperature sensors on the bus and record them locally in the device. These recording files of the so-called slaves can then be evaluated using the WebPQ and WinPQ(lite) software solutions.

The Modbus master recording function is licensed via feature P3, which can be purchased subsequently for the measurement devices (see Chap. 11).

The meter polls the Modbus slaves via an internal RTU master. Internally, the measured values of the registers can be transferred to various processes. On the one hand, the measured values can be saved in a recording file analogous to the known 10-minute files. These files can be further processed by WinPQ(lite). On the other hand, the instantaneous values, which are available from the last polling of the RTU master, can be queried via IEC 60870-5-104.

A.Eberle PQI – Modbus Master mit SCADA



13.1.4.1 Parameterization of the I-Sense - A. Eberle feeder measurement

The correct connection of the bus with I-Sense is described in the technical data sheet of the I-Sense feeder measuring technology and is mandatory for a correct function! The default parameterization of the measuring devices is selected in such a way that the activation of the outgoing measurement with the I-Sense feeder measurement technology can be carried out as quickly as possible. To do this, open the expert view in the parameterization interface. Only the following settings must be made on the measuring device.

Templates are available in WinPQ lite to enable quick connection of I-Sense devices – see: “Template
”

Modbus RTU adaptation:

The I-Sense devices are preconfigured on the RS485 bus with the following settings:

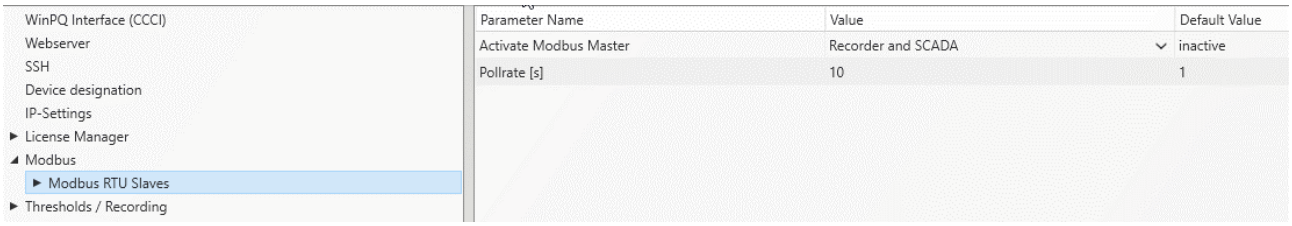
- Baud rate: 19200
- Parity: Even

Accordingly, these parameters must be set on the PQI:

- Baud rate = 19200
- Parity = Even
- Interface = RS485

Activation of the function „Modbus Master“

Open the "Modbus" tab, select the Modbus RTU Slaves tab and activate the checkbox:



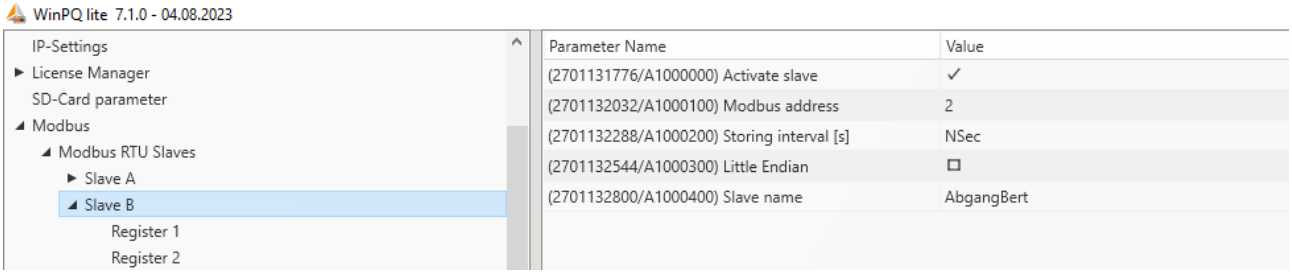
To read the data of the connected Modbus slaves on the bus, this function must be activated. There are two options:

- **Recorders and SCADA:** Saving the measurement data of all activated slaves and all activated registers in the device's recording files and providing the instantaneous values for a selected SCADA protocol.
- **SCADA:** Exclusive provision of instantaneous values for a selected SCADA protocol.

The selection refers to all activated slaves and all activated registers. The description of the activation of the Modbus data gateway in the IEC-104 protocol can be found in section 13.2.2.2.

Activation of the single slaves A - P

Selection of the respective slave and activation of the checkbox. If necessary, individual name assignment:



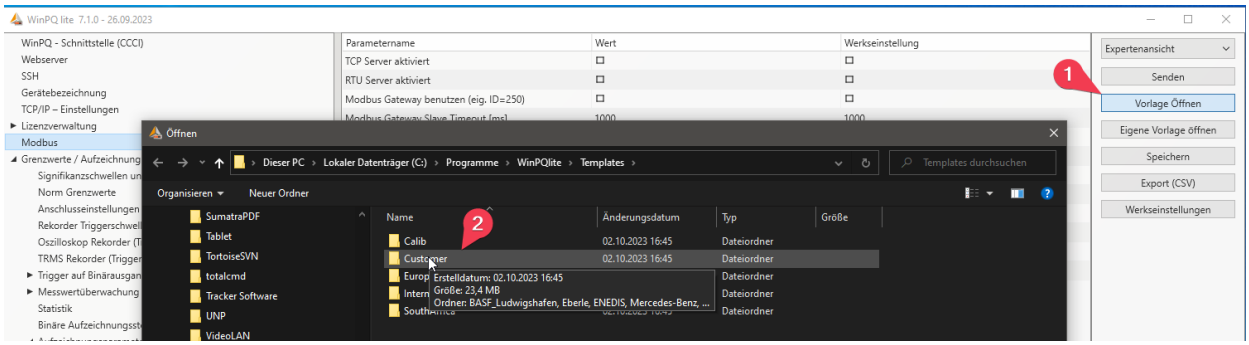
Slaves which are not electrically connected are to be deactivated in the parameterization

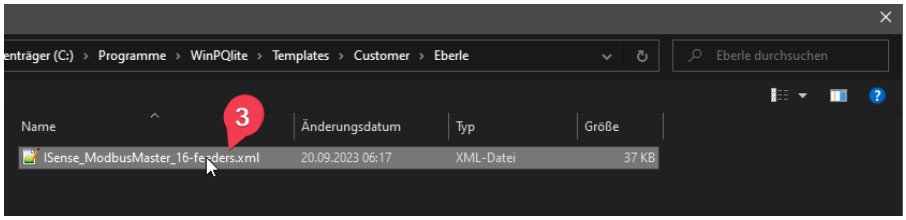
The other default parameters are according to the I-Sense factory settings:

- Pollrate: 10sec
- Storing interval: Nsec with N=60s
- Activated registers 5-16: 12x (4x I_avg, 4x I_min, 4x I_max)
- Deactivated registers 1-4: 4x I_live

Template

In the templates area (1), various templates are stored as parameterization templates in the “Customer/Eberle” folder (2) from WinPQ (lite) V 7.2. These files only need to be adapted to the number of active feeders. All other settings have already been selected to match the respective applications and hardware used. These templates are available both for the exclusive operation of the Modbus master and for the additional use of control technology protocols. For example, the file ISense_ModbusMaster_16-feeders.xml (3) for the I-Sense4 without SCADA protocol.





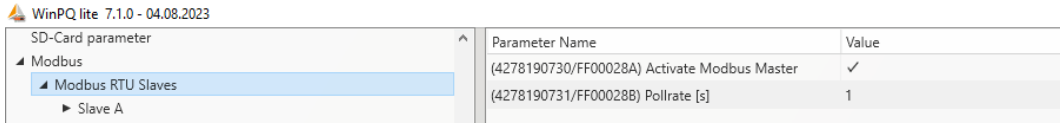
13.1.4.2 Parameterization of the Modbus Master for Third Party Devices

For the physical structure of the bus, the general information from Chap. 5.10.1.1 must be observed.

The parameterization is freely selectable for the connection of all devices corresponding to the Modbus standard, so that any external devices with any measured variables can be connected.

Global settings

On the tab "Modbus RTU Slaves" the function Modbus Master must be activated first, and the poll rate must be selected. A minimum of 0.1s is permitted for the poll rate, which can only be reached by the process for individual slaves and registers. Generally, it must be considered for the poll rate that all activated slaves and registers are read one after the other. If individual registers (blocks) or slaves are not accessible, the poll duration of the entire process is delayed by time constants for reconnect and timeout. This may cause the internal poll duration to exceed the parameterized poll rate. Therefore, it is necessary to ensure that the storage rate of each slave is set at least twice as high as the poll rate. In addition, the registers should be grouped in blocks according to ascending registers of the RTU slave, uniform data types and uniform Modbus function codes.



Slave settings

By clicking on the designation of a slave, the settings for each slave can be made selectively.

Activate slave: De-/activation of the slave

Modbus address: Input of the Modbus address of the slave at the RS485 bus

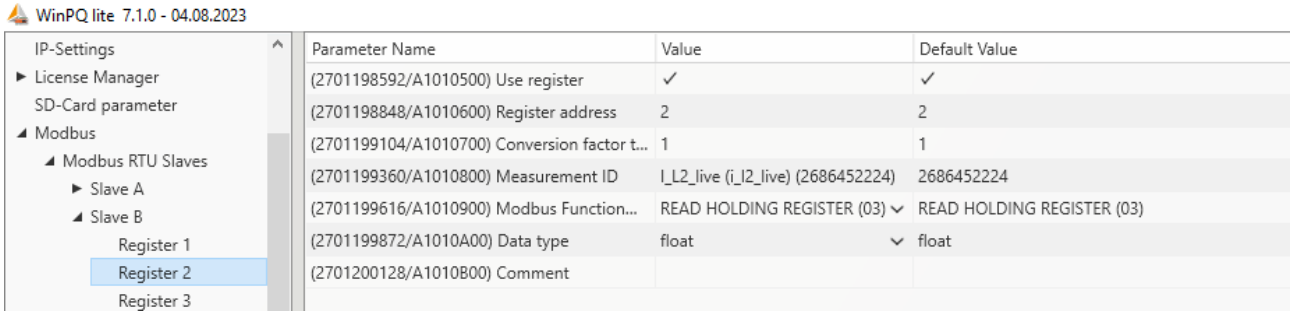
Storing interval: Storage interval of the polled data, to be noted: Storage rate > poll rate * 2
The storage of the polled data is independent of the poll rate. However, the polled values are not cached and aggregated to the interval. Instead, the last obtained value of a storage interval is written to the record file. In terms of the I-Sense connection, this means that the sliding 1min average value of the I-Sense is saved at the n*sec clock strike. This ensures the highest possible synchronization to the internal data classes of the PQ measuring device minus the run times in the Modbus protocol.

Little Endian: Selection of the byte order of the slave, in case of deactivation big endian is assumed.

Slave name: Insertion of an individual device name, which will be displayed in WinPQ and WebPQ.

Register settings

For each register several individual settings are possible. These are reached by opening of the respective slave:



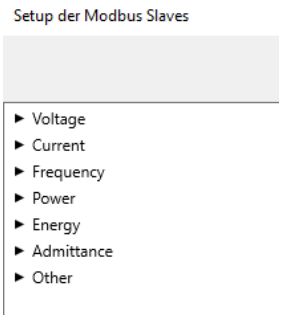
Use register: De-/activation of the register

Register address: Input of the register address of the relevant measured value at the slave.

If a register cannot be read out, the value "0" is stored for it in the WinPQ software.

Conversion factor: In the PQ meter, all quantities are saved in the SI units without SI prefixes (kilo, mega, etc.). With the conversion factor, the read-out measured value can be referred to the SI base unit.

Measurement ID: With the help of the measured value ID, the measured value at the slave is linked to already known physical variables of the A.Eberle PQ products. This makes it possible to access unique contexts in the further chain in the PQ system. For this purpose, clicking on the measured value ID opens a popup menu for selecting the available variables.



If a slave records an unknown quantity at a register, a placeholder can be selected for this in the area *Other* → *Reserved quantities* for Modbus slaves. On request, it is possible to store an additional physical variable for one of the reserved variables (e.g., air pressure with a fixed unit). You are welcome to contact the support for this purpose: pqsys-support@a-eberle.de

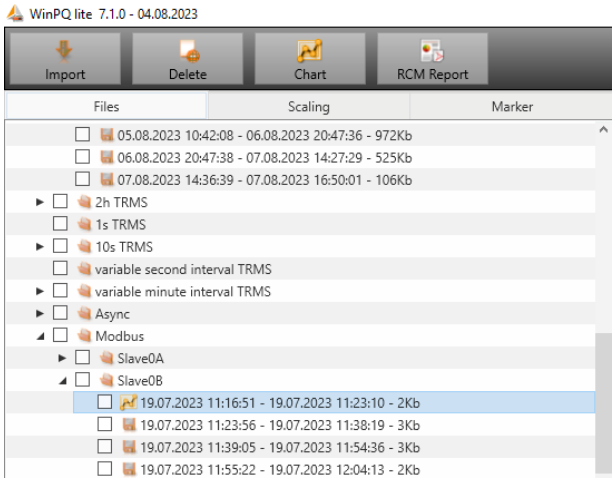
Modbus Function code: So far this feature supports only **READ HOLDING REGISTER (03)** (Firmware V2.14)

Data type: Input of the data type with which the data is made available at the selected register (float32, (U)Int8/16/32).

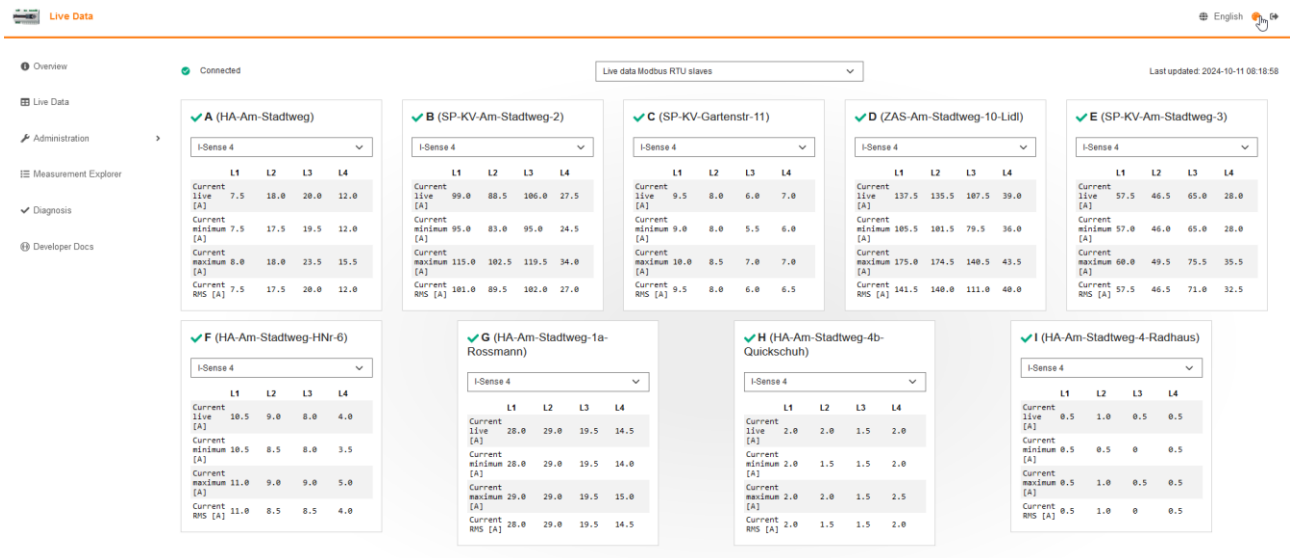
All electrically connected slaves in the parameterization must be activated! Slaves that are not electrically connected must be deactivated in the parameterization.

13.1.4.3 Recording

The recorded channels are saved in individual recording files per slave and can be retrieved in the data explorer of WinPQlite in the "Modbus" area:



The live data displayed on the web server allows the measured values and the connection status of the individual slaves to be visualized directly.



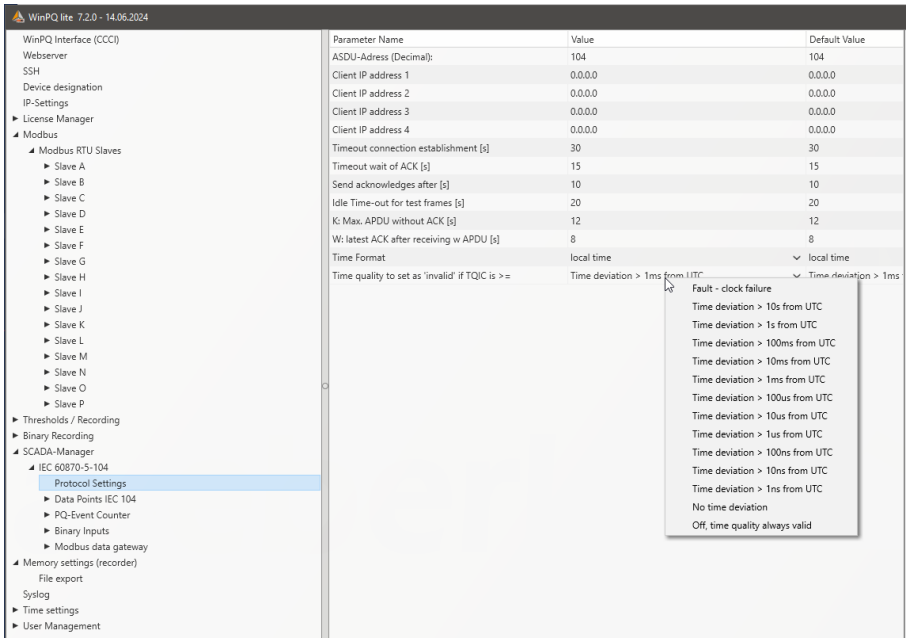
13.2 IEC60870-104

The IEC60870-104 protocol is used for connecting to real-time systems such as SCADA or control systems.

13.2.1 IEC60870-104 Data point

Please download the detailed description and data point list from our website www.a-eberle.de in the section on permanently installed power quality devices.

13.2.2 IEC60870-104 Settings in WinPQ lite



IEC60870-104 settings can be modified via the WinPQ lite software.

- **ASDU Address:**

The ASDU address must be entered unstructured as a decimal number and has a value range of 0 - 65586

Example: Address of the PQI is "104" - which would correspond to "0" (high byte) - "104" (low byte) in a structured display.

- **Client IP – Addresses:**

It is possible to enter several client IP addresses (up to a maximum of 4) into the set-up of the interface, whereby only one client can actively access the PQI . If the setting for all four-client IP addresses is set to "0.0.0.0", any IEC60870-5-104 server could theoretically connect to the PQI-LV. **However, this is not recommended for safety reasons!**

- **Time quality**

This parameter can be used to define whether the time quality should be set to invalid if the time deviation exceeds a certain threshold. The time deviation levels are based on the Time Quality Indication Codes (TQIC) from IEEE C37.118. The default check is for <1ms.

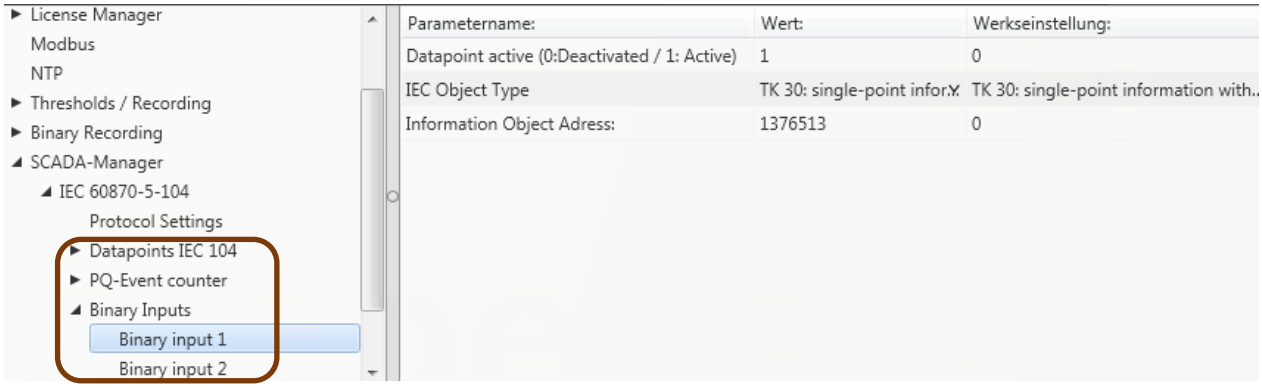
13.2.2.1 Settings of the data points for IEC60870-5-104

The IEC 60870-5-104 interface has the following data types with the corresponding settings for each individual data point:

- TK 30: Single message with time stamp (UTC).
- TK 36: Measured value floating point with time stamp (UTC), e.g., Voltage current

Each data point can be activated or deactivated individually to reduce the amount of data. A special feature is that all TK 36 measurement values can be scaled via the scale Factor parameter

TIP: Since the parameterization of the individual modules, e.g., “Limits / Recording” or “IEC60870-5-104”, can be individually transferred to the currently open parameterization or individually sent to the device, it is recommended to save a template that can be used for all devices.

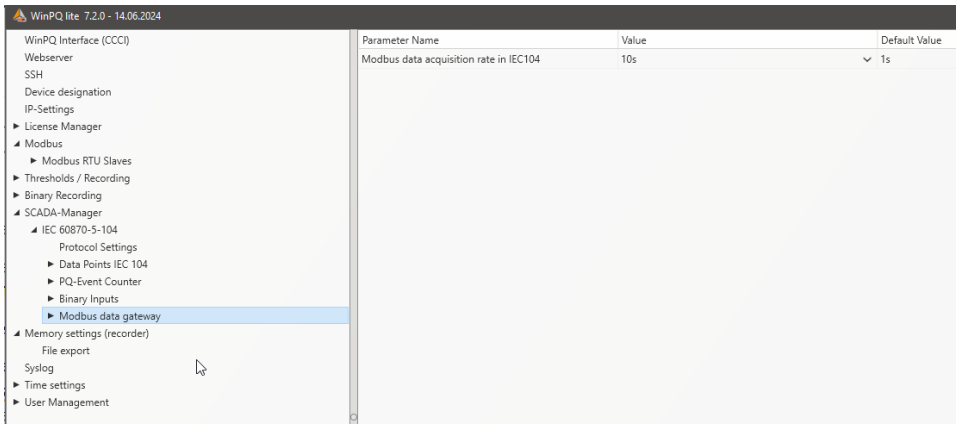


13.2.2.2 Settings of the data points of the Modbus Data Gateway

To enable the transmission of measurement data from Modbus slaves via IEC104, the Modbus master must first be set up in the Modbus area, see chapter 13.1.5.1.

- **Modbus acquisition rate on page IEC104**

First, the interval for recording and transmitting the data of the Modbus slaves by the IEC104 protocol must be defined. It should be noted that this time should not be shorter than the stored poll rate of the Modbus process.



All electrically connected slaves in the parameterization must be activated! Slaves that are not electrically connected must be deactivated in the parameterization.

- **Activation of data acquisition per slave**

This parameter is used to determine whether the registers of the respective slave are transmitted as data points via IEC104.

- **Activation of registers**

Each register can be activated individually as a data point and the IEC object type and information object address can be defined. These settings are analogous to the other IEC104 data points, see 13.2.2.1.

- **Templates**

Templates are available to make parameterization easier and faster; see chapter 13.1.5.1.

13.3 IEC61850

The IEC61850 interface offers the possibility to connect 6 clients directly to the IEC61850 server (PQI-LV). The implementation of the IEC 61850 has been implemented based on edition 2.1 of IEC 61850. The interface has the most important Power Quality parameters according to EN50160.

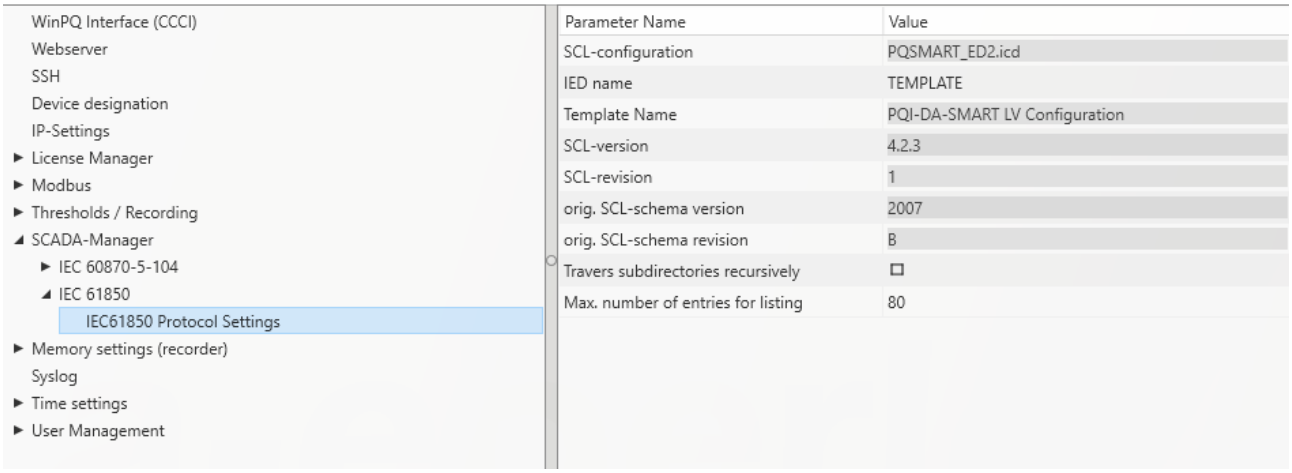
13.3.1 IEC61850 Data Points

Please download the comprehensive description and data point list from our website www.a-eberle.de. The PQI-LV is supplied with one standard ICD file in the basic delivery with activated IEC61850 license. The profile (ICD file) matching the voltage level is selected automatically depending on the basic setting used (commissioning assistant).

- Low Voltage

In the low voltage (EN50160 LV - Low Voltage) template, the harmonics and events (line to earth) are evaluated and correspondingly also made available in the IEC61850 interface. The basic settings of the measuring instrument are described in detail in chapter 6.1 and must be performed once.

13.3.2 IEC61850 settings in WinPQ lite

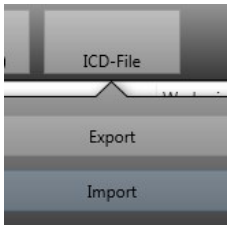


IED – name:

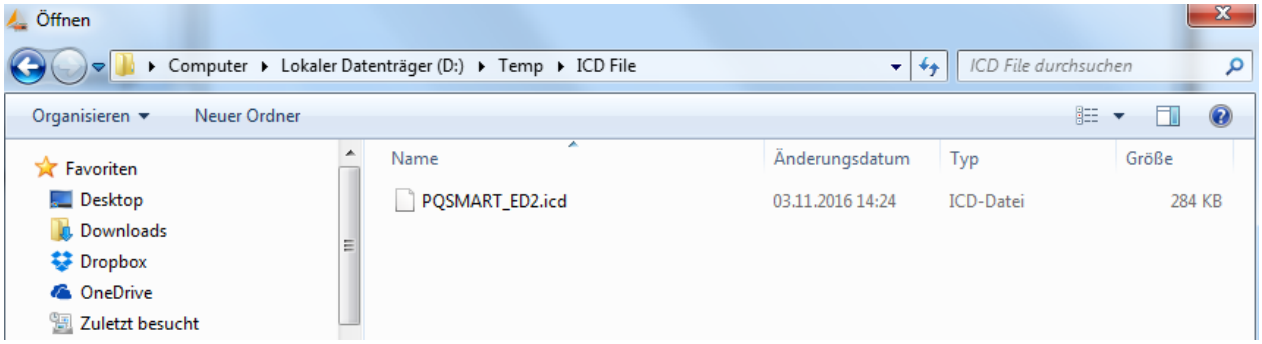
Each participant in an IEC61850 subnet requires a unique identifier. This can be adjusted using the "IED name" parameter. The IED name must meet the following standards (according to IEC61850):

- The IED name can consist of a maximum of 64 characters (letters, numbers and '_')
- Letter "Umlauts" or blanks are not allowed
- The first character must be a letter

If the IED name has been changed in the interface and sent with "Send" to the PQI-LV, the IED name is automatically taken over in the ICD file. The next readout of the set-up also takes the IED name into the ICD file and displays it.



The icon **ICD File** can be used to download the ICD file in the device to be able to import it back into the SCADA system.



- **Max. Number of entries for directory listing**

If not, all files can be placed in the same PDU, the standard splitting procedure with "MORE" is used. By default, the server responds with a maximum of 80 files / PDU This parameter is freely adjustable in its limits.

- **Search directories recursively**
  - ON:

On client request, the device itself creates a listing of all sub-directories required in IEC61850. This list is then made available to the client.

  - OFF:

The client must query the subdirectories itself sequentially or selectively.

Only files from the requested directory will be included in the response.

- **Export file format**

There are several options for selecting the export formats; these are described in Chapter 15.3.

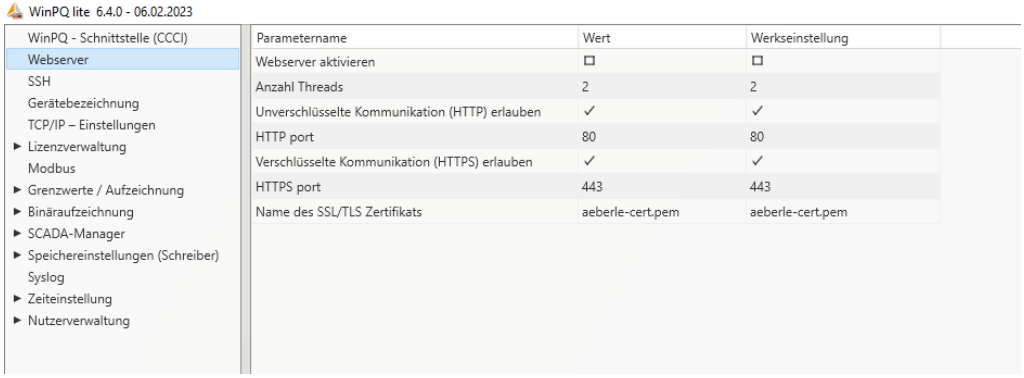
Up to firmware version V2.10.4, the selection of the export file is directly in the IEC61850 settings. After updating to a version V2.12 and newer, the parameter is overwritten and must be set again according to chapter 15.3.

14. REST-API

A REST API is implemented on the device, through which both the standard export formats described in chap. 15 and the proprietary recording files can be downloaded from the device.

14.1 Activation of the Webserver

For usage of REST-API the activation of the Webserver is required. The web server is deactivated by default and must first be activated via the parameterization in the expert view of **WinPQlite**.
Communication is technically possible both unencrypted via http and encrypted via https. For encrypted communication, the self-signed certificate "aeberle-cert.pem" from A.Eberle is stored.

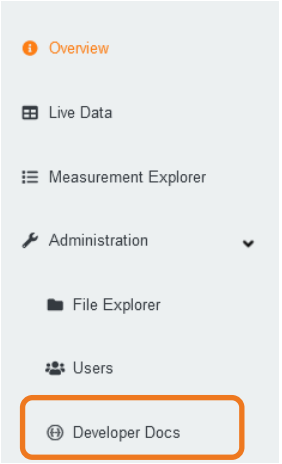


14.2 Access and documentation of REST-API

The web server can be called up directly by entering the IP address in the web browser:

- Unencrypted: http://<IP address>
- Encrypted: https://<IP address>

In the section “Administration” → “Developer Docs” the documentation of the interface is available in the Swagger UI. It is also possible to access the Swagger UI directly through the direct link [https://<IP-Adresse>/swagger.html]. As of firmware V3.0, only the V2 requests, which are marked by the path "/api/v2", are functionally supported.



15. Data exchange formats

The device basically records all measurements in a proprietary format. In parallel, it is possible to generate the recordings directly on the unit in standard formats. These include the COMTRADE and PQDIF formats. The differences between the two formats and parameters for activating the respective recording are explained in this chapter.

These files can be exported via the web server (chap. **Fehler! Verweisquelle konnte nicht gefunden werden.**) and IEC-61850 (chap. 13.3).

15.1 COMTRADE

The “Common format for Transient Data Exchange for power systems” (COMTRADE) is an exchange format standardised according to IEEE C37.111 for storing oscilloscopic disturbance records. The measuring instrument can record an oscilloscopic and 10ms TRMS disturbance record. Therefore, a COMTRADE file is generated by the device for both disturbance records.

A COMTRADE file consists of several files which can only be evaluated together:

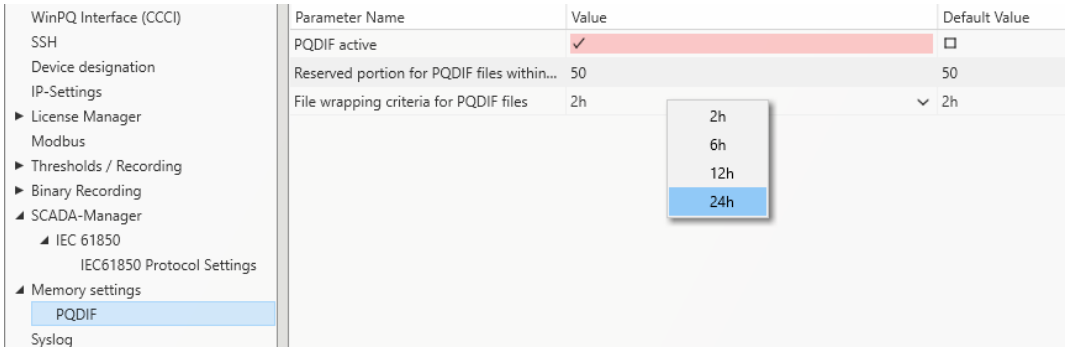
- .CFG file: This file contains the information about the mapping of the recorded quantities and timestamps which are necessary to reconstruct the data in the .DAT file. This file is in a human-readable format.
- .DAT file: This non-human readable file contains the recording data of the fault record.
- .HDR file: This human-readable file contains supplementary information about the .DAT file that is not contained in the .CFG file.

15.2 PQDIF

The “Power Quality Data Interchange Format” (PQDIF) is a data exchange format for power quality measurements defined by the IEEE 1159.3 standard. This data can be obtained from the device via the control technology protocol of IEC 61850.

To be able to save the measurement data in the PQDIF format in addition to the previous format, the following requirements must be met:

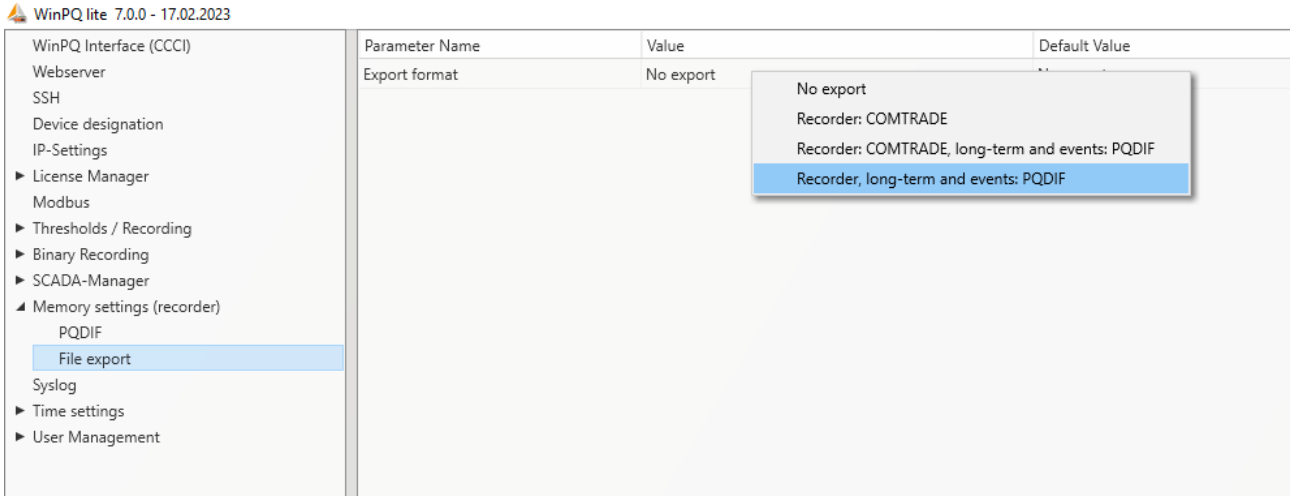
- **A valid license for PQDIF must be installed on the device via the parameterization (see chapter 11).**
- **Activation of the PQDIF functionality. This is possible in the Expert view under the PQDIF memory settings:**



- The parameter "PQDIF active" is deactivated by default and must be set to active for the use of PQDIF.
- The total synchronous memory of the PQI-LV is approx. 500MB by default. A fixed area of this memory is reserved for backing up the PQDIF files, which can be set here. Since the memory requirement for PQDIF is like that for the usual recording data, a proportion of 50% is recommended. **Annotation:** As soon as the parameterization with these settings has been sent to the device, the synchronous memory is emptied so that the memory portion reserved for PQDIF is free. Therefore, it should be ensured beforehand that the existing, historical recording data has been saved on a server or SD card.
- The device saves the 10s, 10min and 2h data classes as well as the fault records in the PQDIF. The file wrapping criterion defines the time duration contained in a PQDIF file of the synchronous data classes. You can choose between 2h, 6h, 12h and 24h. With a wrapping of 2h, a new file is created every 2h (synchronous on UTC) for the 10s, 10min and 2h data classes, with 24h it is only one (correspondingly larger) file per day and data class.

15.3 Selection of the export format

To select the export format, the *Export format* parameter is included in the *Memory settings* → *File export*. There are three different options to choose from:



- Recorder: COMTRADE:

Disturbance records are generated in COMTRADE format (oscilloscope and 10ms TRMS records).

- Recorder: COMTRADE, long-term and events: PQDIF:

Disturbance records are generated in COMTRADE format (oscilloscope and 10ms TRMS records). The long-term data and PQ events are generated in parallel in PQDIF format.

- Recorder, long-term und events: PQDIF:

Disturbance records (oscilloscope and 10ms TRMS records), long-term data and PQ events are generated as PQDIF files.

For the export to the PQDIF format to succeed, make sure that the PQDIF function is activated according to chapter 15.2.

PQDIF is a module that requires a licence and must be activated via licence F1.

16. Measurement methods PQI-LV

The aggregation of the measurement values is carried out in accordance with the IEC61000-4-30 (2008) standard for class A devices.

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

U eff / I eff

The interval value of the voltage or current is the mean of the RMS values of the length of the selected interval.

U min / max; I min / max

Per measurement period, the highest and lowest 10 ms voltage or current RMS value is saved in addition to the average.

- **Ripple control signal**

U Ripple Control (200 ms)

In the PQI-LV setup any interharmonic can be set. This is displayed as the 200 ms maximum value within a measurement interval.

- **Flicker levels Pst / Plt**

The **Short term flicker levels P_{st}** (10 min) and **Long term 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 source for implementation recommendations is "EMV Messung von Spannungsschwankungen und Flickern mit dem IEC-Flickermeter“ by W.Mombauer, VDE-Verlag, VDE-Schriftenreihe „Normen verständlich“, ISBN 3-8007-2525-8.

Formula for P_{lt} calculation:

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

The flicker meter can be parameterized in the device setup for the following grid configurations:

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

THD – PWHD – K factor

Total harmonic content calculated using the following formulae in accordance with IEC61000-4-7.

Calculating the THD values of the voltages and signal sampling:

- H2 up to H40 (based on EN50160)
- H2 up to H50 (based on IEC61000-x-x)

- 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.

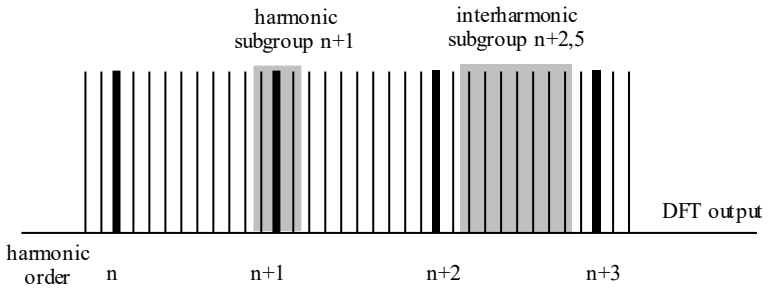
The device shows the K factor for the current. Only the K values that appear at maximum power are of interest. Just as with the THD of the currents in %, the value is not relevant at very low currents.

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

Harmonics / Interharmonics

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

The PQI-LV recognizes for all voltage and current channels, respectively, the harmonics up to the 50th ordinal. To evaluate the interharmonics, harmonic subgroups are created. 50 subgroups are recorded for all current and voltage channels.



Example:

"IH1“ is the first interharmonics 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):

$$U_{hn-10/12} = \frac{\sqrt{\sum_{k=n\cdot N-1}^{n\cdot N+1} U_{n-10/12}^2}}{U_{1-10/12}}$$

Current harmonics:

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

Reactive power / Reactive energy

In the setup of the device two variants of the power calculation are adjustable

- Simplified power calculation

Reactive power without unbalanced reactive power calculation:

$$Q = \sqrt{Q_V{}^2 + D^2}$$ Q ∑ = Q L1+ Q L2 + Q L3

- Reactive power calculation according DIN40110 part 2

Reactive power calculation with unbalanced power:

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

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

- Reactive energy:

"Supply reactive energy" inductive reactive energies +EQ.

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

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

"Consumer reactive energy" capacitive reactive energies -EQ.

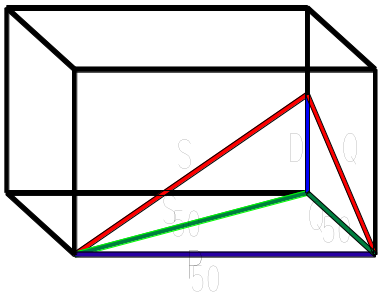
$$Q_S(n) = \left|Q_{L-10/12}(n)\right| \qquad für: Q_{L-10/12}(n) < 0$$

Distortion reactive power - D

The distortion-reactive power - also called harmonic oscillation power - describes a special form of reactive power caused by alternating and three-phase current through nonlinear loads such as rectifiers in power supplies. The harmonics of the current in combination with the mains voltage give reactive power components, which are referred to as distortion-blocking powers.

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

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



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: λ = IPI / S

Apparent Power - S

In the setup of the device two variants of the power calculation are adjustable

- Simplified power calculation

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

- 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 RMS 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 systems as

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

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

$$P_\Sigma = P_1 + P_2 + P_3 + P_E$$

Fundamental oscillation - active power (line):

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

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

- 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:

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

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

- **UU Unbalance**

The unbalanced voltages are calculated from the corresponding values of the modal positive sequence, negative sequence and zero sequence components.

For the EN50160 (events) only the voltage unbalance u_u is relevant and corresponds to the ratio of the negative sequence to the positive sequence. The value is expressed in [%].

- **Frequency analysis 2 kHz to 20 kHz**

In the frequency analysis 2 kHz to 20 kHz respectively 200 Hz frequency bands are summarized.

The specification of each frequency is the centre frequency in this 200 Hz band. In the recording files themselves the supraharmonics up to 20 kHz can be recorded. Up to 18.6 kHz the 200 Hz wide frequency bands are calculated according to IEC 61000-4-7. Above this, the attenuation of the internal filter is not as high as specified by the standard. Therefore, these measured quantities are marked with a "*".

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

Example: Frequency band 8.9 kHz corresponds to all 5 Hz spectral lines from 8,805 Hz to 9,000 Hz.

17. Service

This unit is maintenance-free for customers.

⚠ DANGER!	**Risk of death due to electric shock!** ➲ Do not open the unit. ➲ Maintenance of the device must only be carried out by A. Eberle.

➲ For service, contact A-Eberle.

Service address:

A. Eberle GmbH & Co KG

Frankenstraße 160
D-90461 Nuremberg

▶ **Cleaning:**

Use a short, slightly damp, lint-free cloth. Make sure no liquid gets in the housing. Do not use window cleaner, household cleaners, sprays, solvent, cleaners that contain alcohol, ammonia solutions or abrasive cleaning agents. Please use only water for cleaning.

18. Disposal

Directive 2012/19/EU, better known as the WEEE2 Directive, deals with the return and recycling of waste electronic and electrical equipment to recover valuable raw materials. This concerns all A. Eberle products marked with the symbol of a waste garbage can shown.

➲ Our WEEE registration number is: DE 37396879

For old devices, please also note the
information on our homepage:
https://www.a-eberle.de/en/about-us/take-back-recycling/

19. Product Warranty

We guarantee that every product A. Eberle GmbH & Co KG is free from material and manufacturing defects under normal use.

The detailed conditions for the warranty can be found in our general terms and conditions of business under: https://www.a-eberle.de/en/general-terms/

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http://www.a-eberle.de

Firmware Version: v3.2
WinPQ lite Version: v7.2

Version: 3/12/2025 8:07 AM