a-eberle

User Manual

Power Quality Network Analyser

Model PQI-DA smart

Power-Quality Evaluation Software WinPQ *smart*

GB

Model PQI-DA *smart*

Note:

Please note that these operating instructions 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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1. User prompt

1.1 Warnings

Types of warnings

Warnings are distinguished by the type of risk they represent by the following signal words:

- → **Danger** warns of a risk of death
- → **Warning** warns of physical injury
- → **Caution** warns of damage to property

Structure of the warnings

 **SIGNAL WORD**	**Nature and source of the danger** Actions to avoid the danger.

1.2 Notes

Notes on appropriate use of the device

1.3 Other symbols

Instructions

Structure of the instructions:

Guidance for an action.

Indication of an outcome, if necessary.

Lists

Structure of unstructured 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

2. Scope of Delivery/Order Codes

2.1 Scope of Delivery

- PQI-DA *smart*
- User Manual
- TCP-IP Cable
- Calibration certificate
- CD WinPQ *smart* Software

2.2 Order Codes

PQI-DA *smart*

This version of the device is used as power quality analyser, sequence of events recorder, data logger and power meter

Option IEC61000-4-7 (sampling rate 40.96kHz)	
● 10.24kHz sampling rate; without measuring 2kHz to 9kHz	B0
● Measuring the frequency of voltage and current from 2 kHz to 9 kHz Oscillograph with 40.96kHz sampling rate	B1

The 2kHz to 9kHz option (41kHz sampling rate for oscilloscope images) can be upgraded via a licence code.

Characteristic	Code
Power Quality Interface for Low and Medium Voltage Networks ● 4 voltage converters, 4 current transformers ● In accordance with DIN EN-50160 and IEC 61000-4-30 (Class A) ● 2 digital inputs ● 2 relay outputs ● WinPQ smart software for PQI-DA smart	PQI-DA smart
Supply voltage ● AC 90 V..110 V..264 V or DC 100 V..220 V..300 V ● DC 18 V...60 V...72 V	 H1 H2
Current inputs ● 4 current inputs for metering circuit 1A/5A (range 10A) ● 4 current inputs for protection circuit 1A/5A (range 100A)	 C30 C31
Option communication protocol ● Modbus RTU & TCP ● IEC 61870-5-104 (RJ45) ● IEC61850 (RJ45)	 P0 P1 P2
Option IEC61000-4-7 (40,96kHz sampling) ● 10,24kHz sampling; without 2kHz to 9kHz measurement ● Frequency measurement of voltage and current from 2 kHz to 9 kHz 40.96kHz sampling oscilloscope recorder	 B0 B1
Rated value of the input voltage ● 100V / 400 V / 690 V (CAT IV 300V)	
Operating instructions ● German ● English ● French ● Spanish ● Italian ● Chinese ● Russian	 G1 G2 G3 G4 G5 G6 G7

Software WinPQ smart	Code
Software WinPQ smart For parameterising PQI-DA smart, as well as reading PQI-DA smart measurement data and online / offline data – sold as a package	WinPQ smart
WinPQ database	**Code**
Software WinPQ For the parameterisation, archiving and analysis of PQI-D/DA measurement data with the following basic functions: ● 32-bit/64-bit Windows program interface ● Database for storing measurement data for each measurement point Date access via TCP/IP network ● Possibility of visualization for all measurement variables accessible from a PQI-D/DA as a function of time and as a statistical magnitude ● A second seat license is included in the price	WinPQ
Licences ● Single-user license for 2 x PQI-D/DA/smart ● Single-user license for 2 - 10 x PQI-D/DA/smart ● Single-user license for > 10 x PQI-D/DA/smart	 L0 L1 L2
Operating instructions ● German ● English ● French	 A1 A2 A3

Additions to PQI-DA smart		Code
SD-memory card (external): 4 GByte industrial standard		900.9099.4
DIN-rail, wall mounted housing **Frame for panel mounting**		564.0435 564.0433
Radio time clock interface DFC 77		111.9024.01
GPS clock - H1: AC/DC 88 V...264 V **GPS clock** - H2: DC 18 V...72 V	D2: RS485 D2: RS485	111.9024.45 111.9024.46

3. Safety instructions

- Follow the operating instructions.
- Keep the operating instructions 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.
  (Refer to the technical data)
- 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.
- Clean the device only with commercially available cleaning agents.

4. Technical Data

4.1 PQI-DA *smart* Description

The new Power Quality Analyser and sequence of events recorder PQI-DA *smart* for low, medium-voltage grids is the central component of a system with which all measurement tasks in electrical grids can be solved. The PQI-DA *smart* can be used as either a Power Quality Interface in accordance with grid quality standards or as a measuring device for all physically defined variables in three-phase grids.

In addition to standard evaluations, the PQI-DA *smart* also features a high speed sequence of events recorder with a recording rate of 40.96kHz/10.24kHz as well as an 10ms RMS recorder. This enables a detailed evaluation of faults in the grid.

In particular, the component is suitable for monitoring, registering, evaluating and recording special reference quantities or quality agreements between the energy supplier and the customer

Modern Power Quality measuring devices operate in accordance with the IEC 61000-4-30 (2008) standard. This standard defines measurement methods in order to create a comparable basis for the user.

Devices from different manufacturers that operate according to this standard must give the same results.

The standard distinguishes two classes of measuring devices:

- Class A devices are used mainly for measurements relating to contracts in customer-supplier relationships.
- Class S devices can be used to determine statistical quality values.

The PQI-DA smart meets all demands of the IEC 61000-4-30 (2008) standard for an A-Class device:

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
Supplv voltage unbalance	A
Voltage harmonics	A
Voltage interharmonics	A
Mains signaling voltage	A
Underdevation and overdeviation	A
Measurement aggregation intervals	A
Time-clock uncertainty	A
Flagging	A
Transient influence quantities	A

The PQI-DA smart has been developed for measurements perfromed within public grids as well as for recording PQ data within an industrial environment up to 690V (L-L) measurement voltage.

- No moving parts (fans, hard drives etc.)
- CAT IV
- Extensive storage capability (can be extended up to 32 GB by the user, permitting several years recording without connection to database)
- Optional “IEC61000-4-7 - 2kHz to 9kHz” (B1)
- Frequency measurement of voltage and current according IEC 61000-4-7 from 2 kHz to 9 kHz.
- Standard IEC61000-4-7 describes the measuring of harmonics and interharmonics in power supply grids and connected devices.

4.2 Technical Data

- 1.7-inch colour display
- Keypad for basic/direct device configuration
- 1 GB internal memory
- Input channel bandwidth 20 kHz
- 4 voltage inputs Final value of measurement range: 57/ 230/ 480V L-N, accuracy < 0.1%
- 4 current inputs 1A/5A nominal, Final value of measurement range: 10A
- Simultaneous processing of sampled and calculated voltages and currents
- Oscilloscopic voltage and current recorder sampling rate : 40.96kHz / 10.24kHz
- Half cycle recorder:
  - power frequency, r.m.s. of voltages and currents, voltage and current phasors
  - power recording rate : ~10ms(50Hz) / ~8.33ms (60Hz)
- Powerful recorder triggering
- Online streaming of voltages and currents at 40.96kHz 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.
- Spectral analysis 2 kHz…9 kHz,(35 frequency bands, BW = 200Hz) of voltages and currents according (IEC 61000-4-7)
- Phase of voltage and current harmonics n=2..50
- 2 general purpose digital inputs with 2 input level options
- 2 relay outputs for protection monitoring and alarm
- Complex analysis software WinPQ smart (sold as a package)

- **As an option:**
  - Analysis of the data on an MYSQL-based database using the WinPQ software package. Permanent communication with up to 500 devices.

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

Time synchronisation protocols (Receive / Slave)
– IEEE1344 / IRIG-B000..007
– GPS (NMEA +PPS)
– DCF77
– NTP
– PTP (IEEE1588)

Interfaces	
Ethernet	RJ45 (10/100 Mbit)
2 * RS232/RS485 on terminals	switchable

Dimensions / Weight	
L x B x H	160 x 90 x 58 mm
Weight	500 g

Voltage inputs	
Channels	U1, U2, U3, UN/E/4
Electrical safety DIN EN 61010	300V CAT IV 600V CAT III
Input reference level	PE
Impedance -> PE	10 MΩ || 25pF
Nominal input voltage Un	100V AC /230VAC
Full scale range (FSR)	0…480VAC L-E
Waveform	Any
Maximum crest factor @ Un	3
Bandwidth	DC…20kHz
Nominal power frequency fn	50Hz / 60Hz
Frequency range of the fundamental	fn ± 15% 42.5..50..57.5Hz 51.0..60..69.0Hz
Accuracy	
Fundamental, r.m.s	±0.1% Un (0°C…45°C) ±0.2% Un (-25°C…55°C) @ 10%...150%Un
Fundamental, Phase	±0.01° @ 10%...150%Un
Harmonics n = 2..50, r.m.s.	±5% of reading @ Uh ≥ 1% Un ±0.05% Un @ Uh < 1% Un
Harmonics n = 2..50, Phase	±n·0.01° @ Uh ≥ 1% Un
Interharmonics n = 1..49, r.m.s.	±5% of reading @ Uih = ≥ 1% Un ±0.05% Un @ Uih < 1% Un
Power frequency	±10mHz @ 10%...200%Un
Flicker DIN EN 61000-4-15:2011	Class F2
Dip residual voltage	±0.2% Un @ 10%..100%Un
Dip duration	±20ms @ 10%..100%Un
Swell residual voltage	±0.2% Un @ 100%..150%Un
Swell duration	±20ms @ 100%..150%Un
Interruption duration	±20ms

Voltage inputs	
	@ 1%..100%Un
Voltage unbalance	±0.15% @ 1%..5% reading
Mains signaling voltage (< 3kHz)	±5% of reading @ Us = 3%..15% Un ±0.15% Un @ Us = 1%..3% Un

Current inputs		
Option	C30	C31
Channels	I1, I2, I3, IN/4	
Electrical safety DIN EN 61010	300V CAT III	
Input type	Differential, isolated	
Impedance	≤ 4mΩ	
Nominal input current In	1 A AC / 5 A AC	
Full scale range (FSR)	$10A_{AC}$	$100A_{AC}$
Overload capacity permanent ≤ 10s ≤ 1s	 20 A 100 A 500 A	
Waveform	AC, any	
Maximum crest factor @ In	4	
Bandwidth	25Hz...20kHz	
Accuracy		
Fundamental, r.m.s	< 0,1% FSR 5%...100%	< 0,2% FSR 5% … 10%
Fundamental, Phase	±0,1° 5%...100%	±0,2° 5% … 10%
Harmonics n = 2..50, r.m.s.	5% 5%...100%	10% 5% … 10%
Harmonics n = 2..50, Phase	±n·0,1° 5%...100%	±n·0,2° 5% … 10%
Interharmonics n = 1..49, r.m.s.	±5% 5%...100%	±10% 5% … 10%

Storage of measured values	
Internal memory	1024 MB
SD memory card	1 GByte to 32 GByte

Binary inputs (BI)	
Range	48...250 VAC(/DC)
• H – Level • L – Level	> 35 V < 20 V
Signal frequency	DC ... 70 Hz
Input resistance	> 100kΩ
Electrical isolation	Optocoupler, electrically isolated
Electrical safety DIN EN 61010	300V CAT II

Binary outputs (BO)	
Contact specification (EN60947-4-1, -5-1) : Configuration Rated voltage Rated current Rated load AC1 Rated load AC15, 230VAC Breaking capacity DC1, 30/110/220 V	 SPDT 250VAC 6A 1500VA 300VA 6/0.2/0.12A
No. of switching operations AC1	≥ 60·103 electrical
Electrical isolation	Isolated from all internally potentials
Electrical safety DIN EN 61010	300V CAT II

Power supply		
Feature	**H1**	**H2**
AC	90...264 V	-
DC	100...300 V	18...72 V
Power consumption.	≤ 10 W < 20VA	≤ 10 Watt
Frequency	40...70Hz	-
External fuse characteristics	6A B	6A B

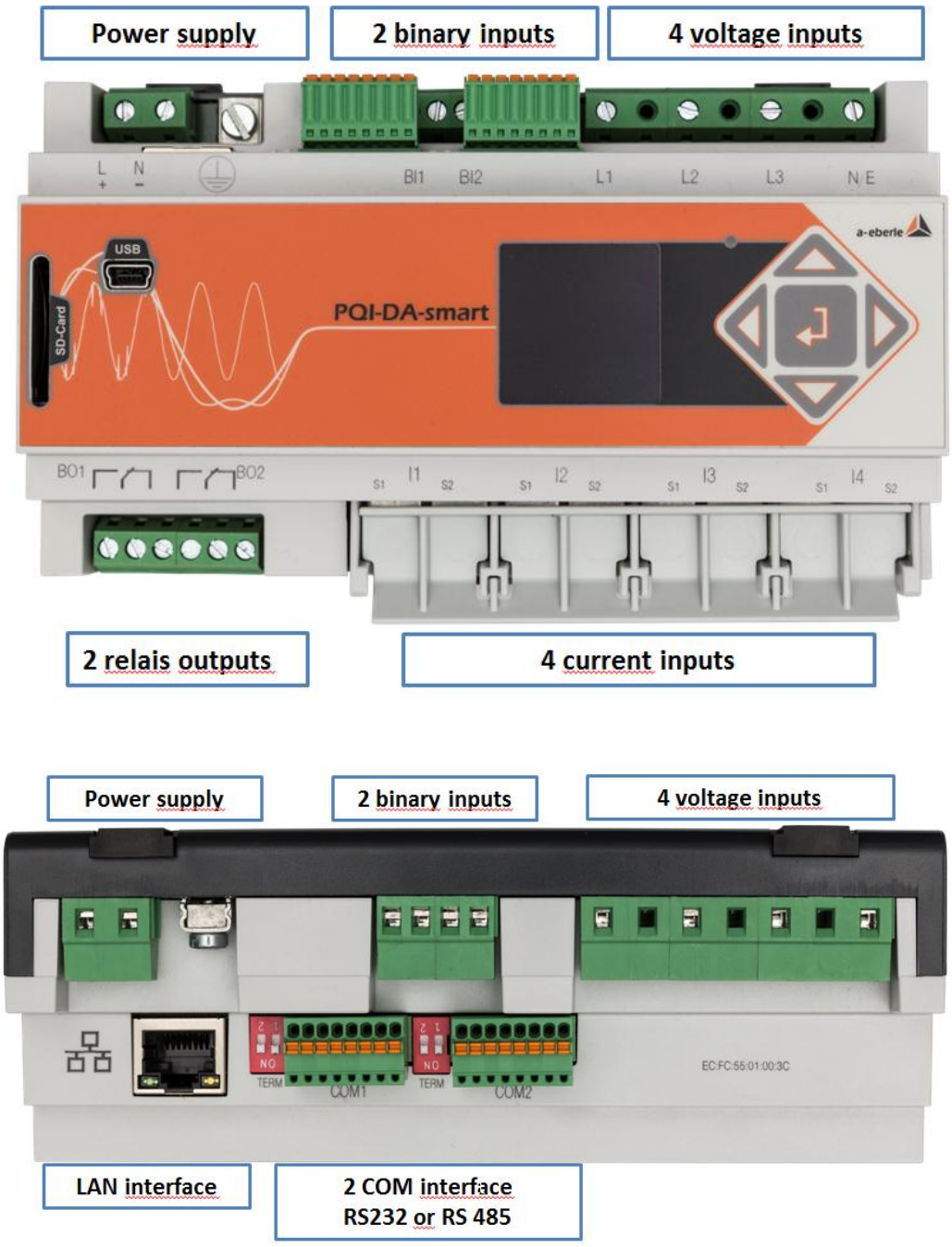
Environmental parameters	Storage and transport	Operation
Ambient temperature : Limit range of operation	IEC 60721-3-1 / 1K5 -40 ... +70°C IEC 60721-3-2 / 2K4 -40 ... +70°C	IEC 60721-3-3 / 3K6 -25 ... +55°C
Ambient temperature : Rated range of operation	---	IEC 60721-3-3 / 3K5 mod. -10 ... +45°C
Relative humidity: 24h average No condensation or ice	5...95 %	5...95 %
Solar radiations	---	700W/m2
Vibration, earth tremors	IEC 60721-3-1 / 1M1 IEC 60721-3-2 / 2M1	IEC 60721-3-3 / 3M1

Electrical safety	
● IEC 61010-1 ● IEC 61010-2-030	
Protection class	1
Pollution degree	2
Overvoltage category mains supply option : H1 H2	 300V / CAT III 150V / CAT III
High voltage test	Pulse voltage 6 kV 5 sec 5.4kV RMS 1 min 3.6kV RMS
Measurement category	300V / CAT IV 600V / CAT III
Altitude	≤ 2000m

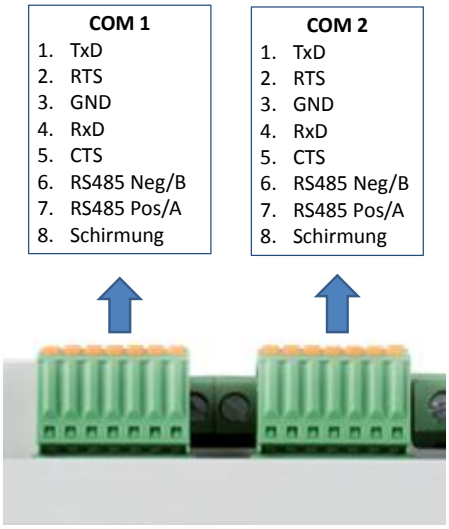
4.3 Mechanical design

The PQI-DA *smart* can be wall-mounted (optional DIN-rail), in-panel mounted (optional mounting frame) or used as a DIN-rail housing. All connections are accessible via Phoenix type terminals. The connections are made by using plug-in/clamping technology, except for the current and voltage inputs.

For the TCP/IP interface one RJ 45-connector is available.



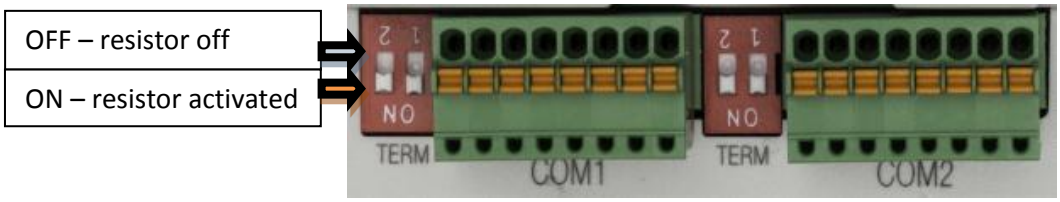
Side view of PQI-DA smart



Pin assignments for RS232 / RS485 COM interfaces

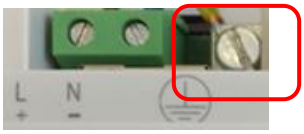
Termination resistor for COM-interface (COM1 / COM2)

- termination resistor„ON“ activated
- termination resistor„OFF“ turned off



4.3.1 Power supply for PQI-DA smart

CAUTION	**Earthing for PQI-DA smart** Always connect the earth for PQI-DA smart.

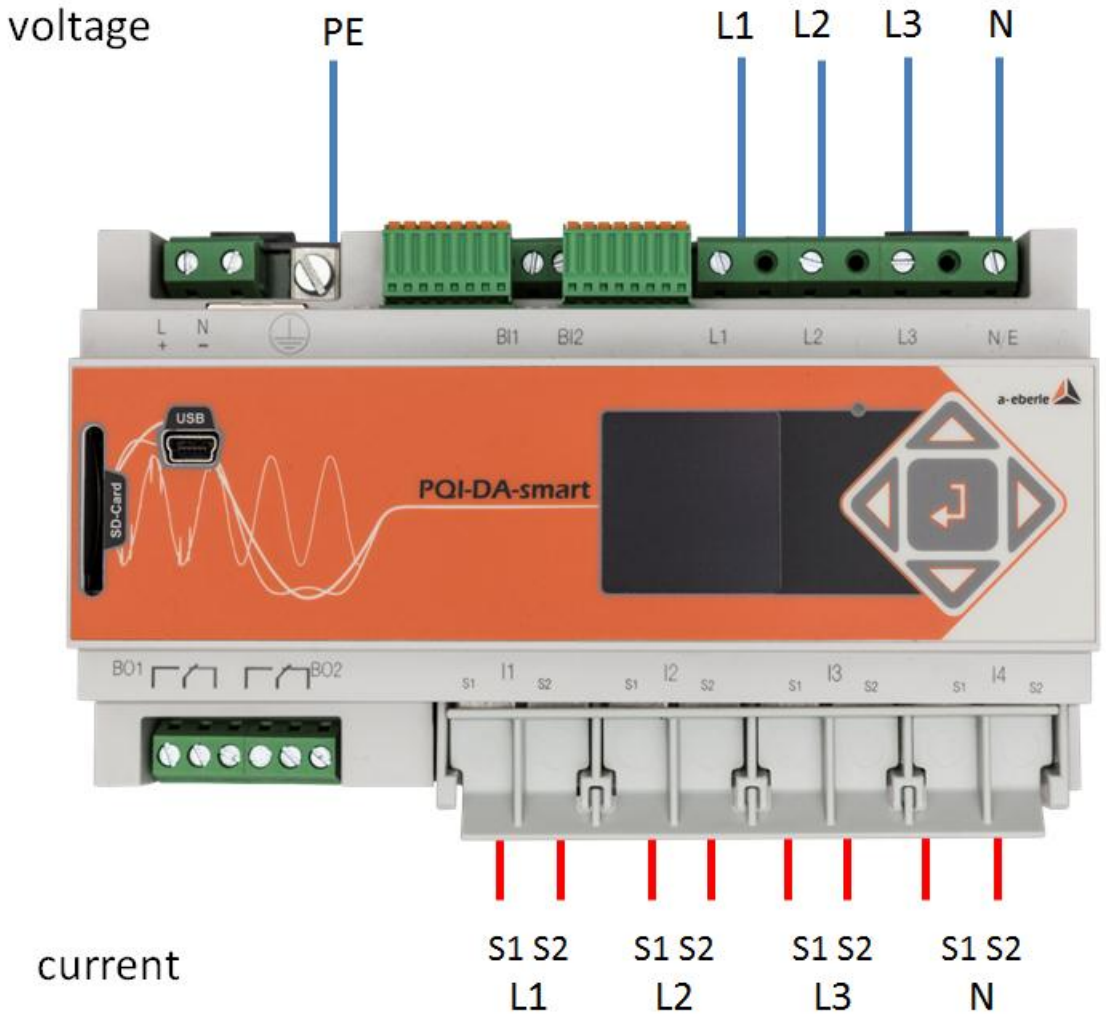


Supply the measuring device in the correct voltage range which corresponds to the power supply unit fitted.

Characteristic	H1	H2
AC	90...264 V	-
DC	100...300 V	18...72 V

4.4 Mains connection for PQI-DA smart

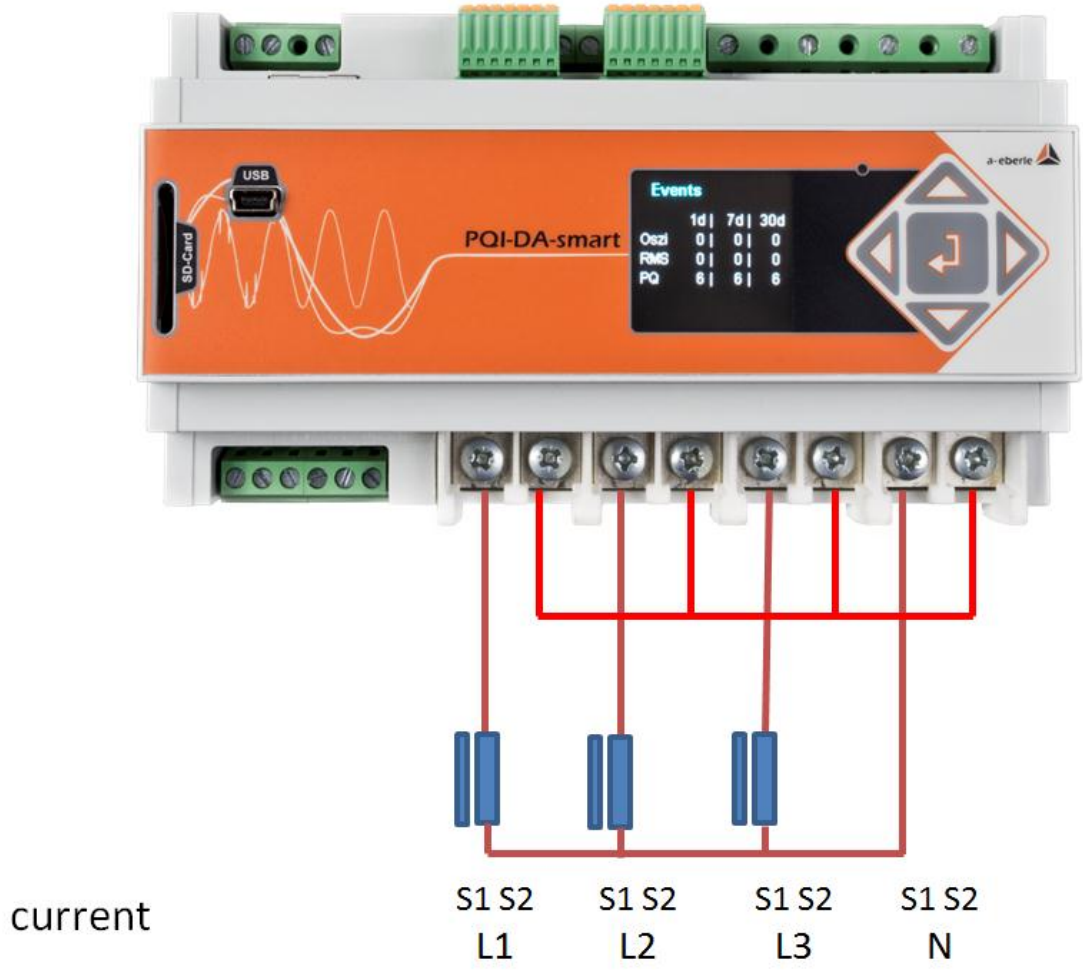
4.4.1 3-phase / 4-wire connection



Voltage connections

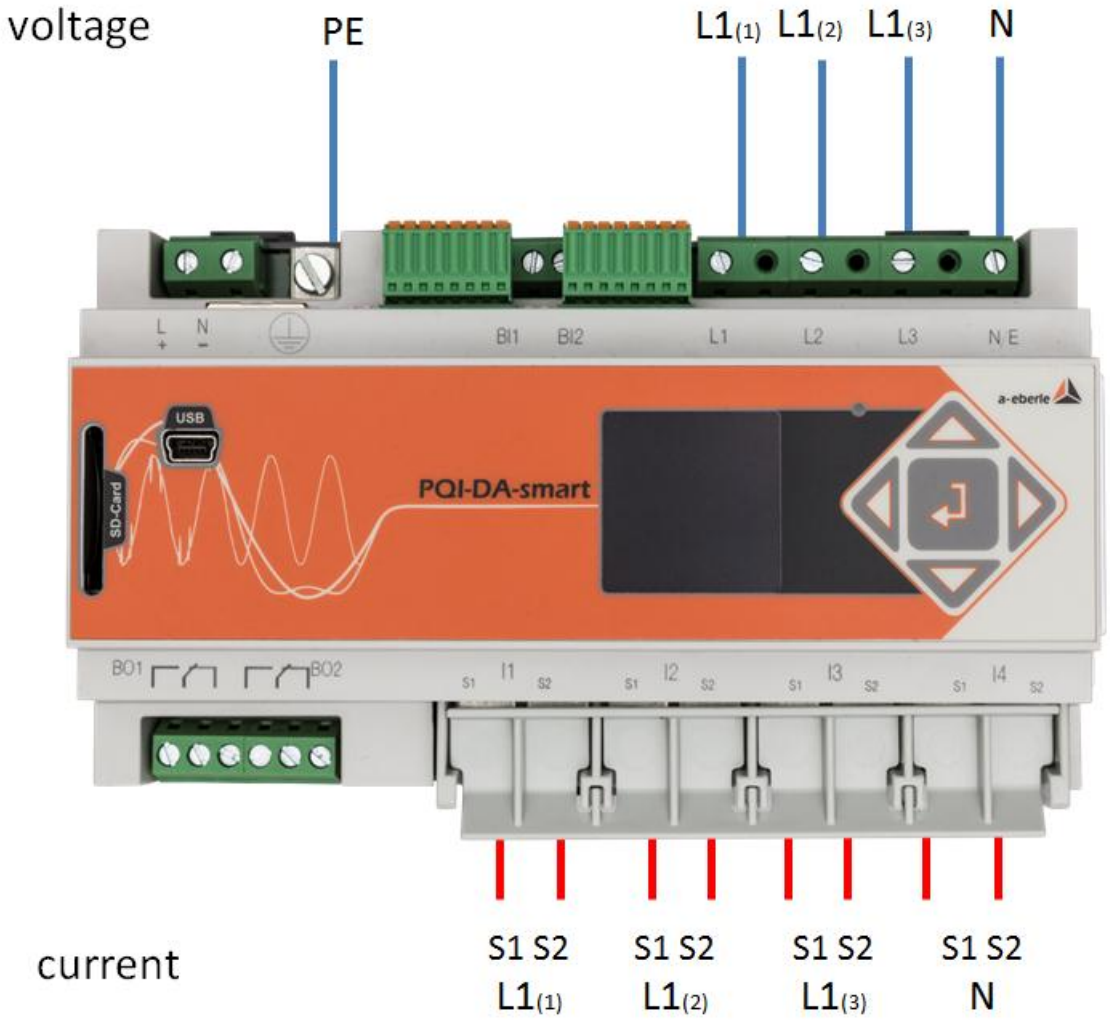
- Please ensure that the PE conductor (earth) is connected to the PQI-DA smart.
- If no N conductor is available, connect E and N together.
- Ensure that switching (4-wire) is selected. (Setting via display or software)

4.4.2 4-wire connection without neutral current



If no neutral current is available in the 3-phase, 4-wire grid, the power inputs of the PQI-DA *smart* are connected as shown in the illustration above.

4.4.3 4-wire 1-phase

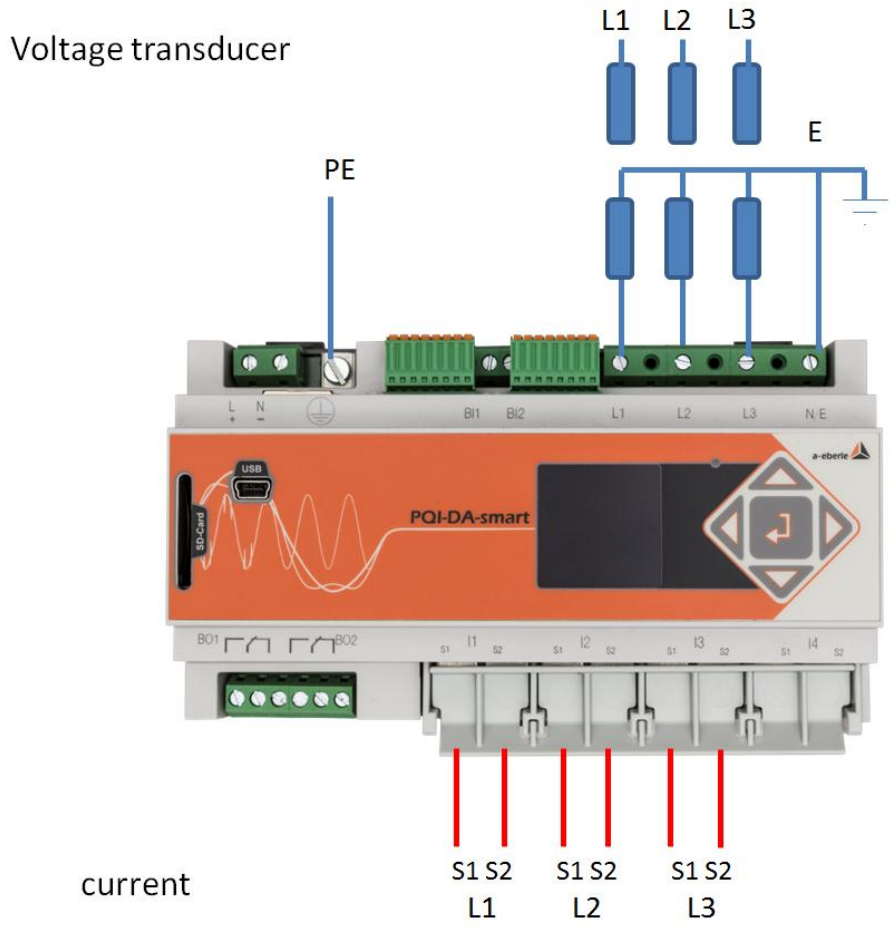


With the 4-wire grid, 1-phase set-up no conductor-conductor events and 3~grid events are evaluated.

Any voltage with the same earth potential can be connected (e.g. three grids with the L1 phase) and any current can be connected.

4.4.4 3-phase / 3-wire connection

Connection to secondary transformer



Connections

- Please ensure that the PE conductor (earth) is connected to the PQI-DA smart.
- Ensure that measurement cable E is connected for each measurement. This is normally the earthing point of the voltage transformer.
- Ensure that switching (3-wire) is selected. (Setting via display or software)
- Set the voltage transformer ratio
- Enter the nominal conductor-conductor voltage
- Set the current transformer ratio

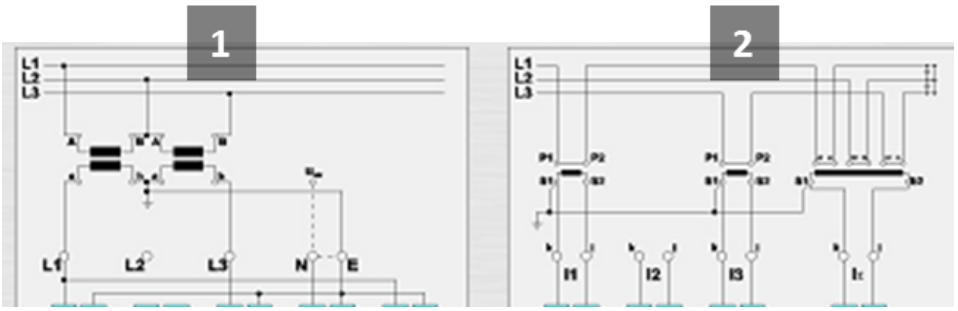
Connecting PQI-DA smart Power IN in a 3-wire grid

If in a 3-wire grid power is connected to the IN input, it will be calculated and recorded.

The values measured for IN are not included in the 3~ power calculations. It is, therefore, possible to use the PQI-DA smart to capture any additional current via the fourth power input.

4.4.5 V connection; Aron connection

The V connection or Aron connection can be configured in the device set-up of the software. These connection types are only available in the 3-wire configuration.



1) V connection (parameterisation via the evaluation software)
2) Aron connection (parameterisation via the evaluation software)

Possible connection configurations in 3-wire grids:

- Voltage converter connections: 1, 2, 3, 4,
- Current transformer connections: 1, 2, 3, 4,

The voltage converter and current transformer selection fields can be parameterised. The grounded voltage in each case or the current that has not been connected is calculated by the measuring device.

▶ **3-phase voltage converter connections:**

Connection configuration	VT	Measuring channel				
		1	2	3	4	Reference potential
Voltage converter: L1, L2, L3, N/E	1	u_1	u_2	u_3	$u_{N/E}$	
V connection, earth L1	2	u_1	u_2	u_3	u_4	E
V connection, earth L2	3	u_1	u_2	u_3	u_4	
V connection, earth L3	4	u_1	u_2	u_3	u_4	

▶ **3-phase current transformer connections:**

Connection configuration	CT	Measuring channel			
		5	6	7	8
Current transformer: L1, L2, L3, N	1	i_1	i_2	i_3	i_N
Current transformer: L2, L3	2	-	i_2	i_3	i_4
Current transformer: L1, L3	3	i_1	-	i_3	i_4
Current transformer: L1, L2	4	i_1	i_2	-	i_4

▶ **The values measured for IN are not included in the 3~ power calculations. It is, therefore, possible to use the PQI-DA smart to capture any additional current via the fourth power input.**

4.5 Measurement / Functions

PQI-DA smart complies with the automatic event detection and measurement standards, which are: EN50160 (2013) / IEC61000-2-2 / IEC61000-2-12 /IEC61000-2-4 (Class 1; 2; 3) / NRS048 / IEEE519 / IEC61000-4-30 class A / IEC6:1000-4-7 / IEC61000-4-15

4.5.1 Continuous Recording:

Five fixed and two variable measurement time intervals are available for continous recording. All measured values can be freely activated or deactivated in the data classes.

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

Time Interval Voltage	10/ 12T	150/ 180T	10 min	2 h	1 s	N* s	N* min
Power frequency	✓	✓	✓	✓	✓	✓	✓
Power frequency, 10s-Value (IEC61000-4-30)							
Extremes, standard deviation of power frequency (10s)			✓				
r.m.s. values (IEC61000-4-30)	✓	✓	✓	✓	✓	✓	✓
Extremes, standard deviation of T/2-values			✓				
Underdeviation [%] , Overdeviation [%] (IEC61000-4-30)	✓	✓	✓	✓			
Harmonic subgroups n= 0..50 (IEC61000-4-7)	✓	✓	✓	✓			
Maximum values of 10/12 T harmonic subgroups n = 2..50			✓				
Interharmonic subgroups n=0..49 (IEC61000-4-7)	✓	✓	✓	✓			
Total Harmonic Distortion (THDS) (IEC61000-4-7)	✓	✓	✓	✓	✓	✓	✓
Partial Weighted Harmonic Distortion (PWHD)	✓	✓	✓	✓	✓	✓	✓
Unbalance, neative-/positive- sequence , sequence sign	✓	✓	✓	✓	✓	✓	✓
Unbalance, zero-/positive- sequence	✓	✓	✓	✓	✓	✓	✓
Positive-, negative-, zero sequence phasors	✓	✓	✓	✓	✓	✓	✓
Phasors (fundamental)	✓	✓	✓	✓	✓	✓	✓
Flicker (IEC61000-4-15)			✓	✓			
Instant flicker (IEC61000-4-15)	✓		✓				
Mains signaling voltages [%] (IEC61000-4-30)	✓	✓					
Phase angle(zero crossings) of phase voltage harmonics n=2..50 to fundamental of reference voltage	✓	✓	✓	✓			
Frequency bands 1..35 , 2kHz..9kHz, r.m.s. (IEC61000-4-7)			✓	✓	✓	✓	✓

Time Interval Current	10/ 12T	150 /18 0T	10 min	2 h	1 s	N* s	N* min
r.m.s. values	✓	✓	✓	✓	✓	✓	✓
Extremes of T/2-values			✓				
Harmonic subgroups n= 0..50 (IEC61000-4-7)	✓	✓	✓	✓			
Maximum values of 10/12 T harmonic subgroups n = 2..50			✓				
Interharmonic subgroups n=0..49 (IEC61000-4-7)	✓	✓	✓	✓			
Total Harmonic Distortion (THDS) (IEC61000-4-7)	✓	✓	✓	✓	✓	✓	✓
Total Harmonic Currents	✓	✓	✓	✓	✓	✓	✓
Partial Weighted Harmonic Distortion (PWHD)	✓	✓	✓	✓	✓	✓	✓
Partial Odd Harmonic Currents (PHC)	✓	✓	✓	✓	✓	✓	✓
K-Factors	✓	✓	✓	✓	✓	✓	✓
Unbalance, neative-/positive- sequence , sequence sign	✓	✓	✓	✓	✓	✓	✓
Unbalance, zero-/positive- sequence	✓	✓	✓	✓	✓	✓	✓
Positive-, negative-, zero sequence phasors	✓	✓	✓	✓	✓	✓	✓
Phasors (fundamental)	✓	✓	✓	✓	✓	✓	✓
Phase angle(zero crossings) of current harmonics n=2..50 to fundamental of reference voltage	✓	✓	✓	✓			
Frequency bands 1..35 , 2kHz..9kHz, r.m.s. (IEC61000-4-7)			✓	✓	✓	✓	✓

Time Interval Energy	10 min	2 h	1 s	N* s	N* min
Active energy, phase	✓	✓	✓	✓	✓
Active energy, total	✓	✓	✓	✓	✓
Exported active energy, phase	✓	✓	✓	✓	✓
Exported active energy, total	✓	✓	✓	✓	✓
Imported active energy, phase	✓	✓	✓	✓	✓
Imported active energy, total	✓	✓	✓	✓	✓
Reactive energy (inductive), phase	✓	✓	✓	✓	✓
Reactive energy (inductive), total	✓	✓	✓	✓	✓
Exported reactive energy (inductive), phase	✓	✓	✓	✓	✓
Exported reactive energy (inductive), total	✓	✓	✓	✓	✓
Imported reactive energy (inductive), phase	✓	✓	✓	✓	✓
Imported reactive energy (inductive), total	✓	✓	✓	✓	✓

Time Interval Power	10 min	2 h	1 s	N* s	N* min
Active power, phase	✓	✓	✓	✓	✓
Active power, total	✓	✓	✓	✓	✓
Active power extremes	✓				
Reactive power, phase	✓	✓	✓	✓	✓
Reactive power, total	✓	✓	✓	✓	✓
Reactive power extremes	✓				
Apparent power, phase	✓	✓	✓	✓	✓
Apparent power, total	✓	✓	✓	✓	✓
Fundamental active power, phase	✓	✓	✓	✓	✓
Fundamental active power, total	✓	✓	✓	✓	✓
Fundamental reactive power, phase	✓	✓	✓	✓	✓
Fundamental reactive power (displacement), total	✓	✓	✓	✓	✓
Fundamental apparent power, phase	✓	✓	✓	✓	✓
Phase angle of fundamental apparent power, phase	✓	✓	✓	✓	✓
Fundamental apparent power, total	✓	✓	✓	✓	✓
Phase angle of fundamental apparent power, total	✓	✓	✓	✓	✓
Reactive distortion power, phase	✓	✓	✓	✓	✓
Reactive distortion power, total	✓	✓	✓	✓	✓
Active power factors, phase, total	✓	✓	✓	✓	✓
Reactive power factors, phase, total	✓	✓	✓	✓	✓
COSφ + sign, phase, total	✓	✓	✓	✓	✓
SINφ + sign, phase, total	✓	✓	✓	✓	✓
COSφ + sign of reactive distortion power, phase, total	✓	✓	✓	✓	✓
Capacitive-, inductive scaling factor of COSφ (-1..0..+1) :	✓	✓	✓	✓	✓
Triggered interval mean active power, phase					
Triggered interval mean active power, total					
Triggered interval mean reactive power, phase					
Triggered interval mean reactive power, total					

4.5.2 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 signaling voltage (150/180T)		✓
voltage harmonics (10min)		✓
voltage THD (10min)		✓
voltage short term flicker PST (10min)		✓
voltage long term flicker PLT (10min)		✓
power frequency (10s)	✓	✓

4.5.3 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)	✓	✓	✓
Binary inputs (debounced)	rising, falling slope		
Command	external		

4.5.4 Output relays

The functions of the output relays have been defined as follows:

- Relay B01 – Watchdog relay

  Self-monitoring of the measuring device

- Relay B02 – Reports new sequence of events recording

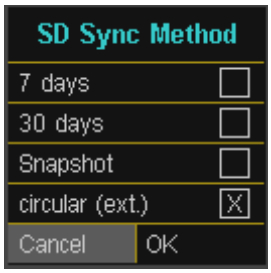
  If a new sequence of events recording is captured and recording and saving has been completed, relay B02 is operated for one second. The message signals that this sequence of events recording can be read out from the device.

4.5.5 Memory management

The PQI-DA *smart* is equipped with an internal memory of one gigabyte.

If a SD-card is inserted in the device, you have to choose to time period for the data.

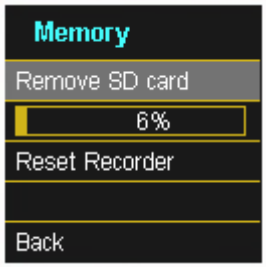
- the last 7 days
- the last 30 days
- snapshot of the whole memory
- circular = the SD-card will stay in the device and will be filled in a circular memory. If the SC-card is bigger than one gigabyte, the time period of the SD-card is much longer than into the PQI-DA smart.



Confirm with “OK” and the PQI-DA *smart* will start automatically to copy the selected internal memory onto the SD card.

The minimum size of an external memory card is one gigabyte. The device can manage memory cards up to a max. of 32gBytes.

In the display menu “memory” the progress of the copy process is shown.



To remove the memory card, operate the "Remove SD card“ function.

The "Remove SD card“ function stops the copying function for the measuring data of the internal memory to the SD memory card and releases the card for removal.

Memory allocation

The memory allocation of the PQI-DA *smart* uses the internal 1 gigabyte memory in a circular ring buffer for all measurement data.

The ring buffer is allocated as follows:

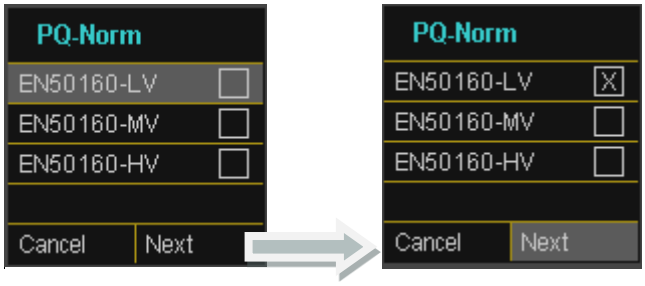
- 512 MB circular buffer for long-term measurement data
- 416 MB circular buffer for sequence of events recordings (oscilloscope images; ½ period RMS values)
- 16 MB circular buffer for log files and Power Quality events

5. Operation of the PQI-DA smart

5.1 Getting started - Wizzard

Wird der Netzanalysator PQI-DA smart zum ersten Mal in Betrieb genommen, meldet sich das Gerät in einem geführten Setupmodus. Der Bediener wird automatisch durch die Erstinbetriebnahme des Messgerätes geführt.

Wizzard page 1

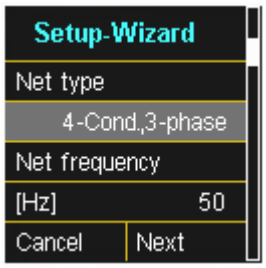


- **Automatic basic settings and limit values for the following voltage level according to EN50160:**
  - Low-voltage grid = EN50160-NS
  - Medium-voltage grid = EN50160-MS
  - High-voltage grid = EN50160-HS

Wizzard page 2

Selecting the Display Language PQI-DA smart

Wizzard page 3



Basic settings / network connection PQI-DA smart

- **For more information about the network connection, see chapter 4.4 Hardware connection**

Grid configuration

Entering the grid type "3-conductor grid", "4-conductor grid" and/or "4 x 1 conductor grid" will determine how the Power Quality events are recorded.

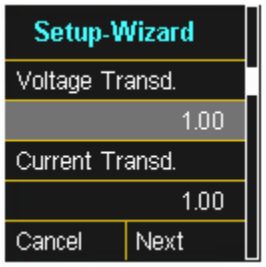
Switch between 3-conductor and 4-conductor grids.

- **In a 3-conductor grid, all events are calculated from the conductor-conductor voltages.**
- **In a 4-conductor grid and/or a 4 x 1 conductor grid all Power Quality events are determined from the conductor-earth voltages.**

Grid frequency

Setting grid frequency to 50Hz or 60Hz

Wizzard page 4



Voltage converter: Corresponds to the ratio between the primary and secondary voltage.

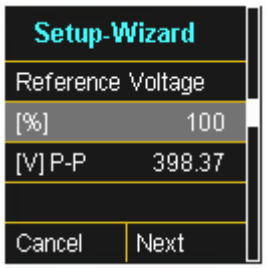
Current transformer: Corresponds to the ratio between the primary and secondary current.

- **Example:**

  Voltage: primary = 20,000V / secondary = 100V; Conversion factor = 200

  primary = 100A / secondary = 5A; Conversion factor = 20

Wizzard page 5



The displayed value for the nominal voltage is:

- In a 4-conductor grid = 230V conductor-earth voltage
- In a 3-conductor grid = 100V conductor-conductor voltage, multiplied by the conversion factor

The % value is used to set the reference voltage at a different value to the nominal voltage.

Example 1: 20,000V * 105% = Reference voltage of 21,000V. This is the reference value for all trigger thresholds as well as Power Quality events.

Example 2: 500V grid (conductor-conductor) 230V * 125% = 287.5V (conductor-earth)

Wizzard page 6

Manual entry of date and time.

Wizzard page 7

Activating or deactivating DHCP

DHCP deactivated = The device is used with a fixed IP address.

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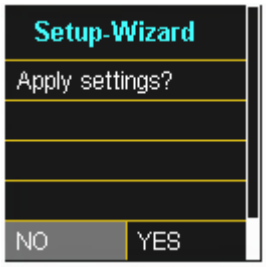
Wizzard Seite 8

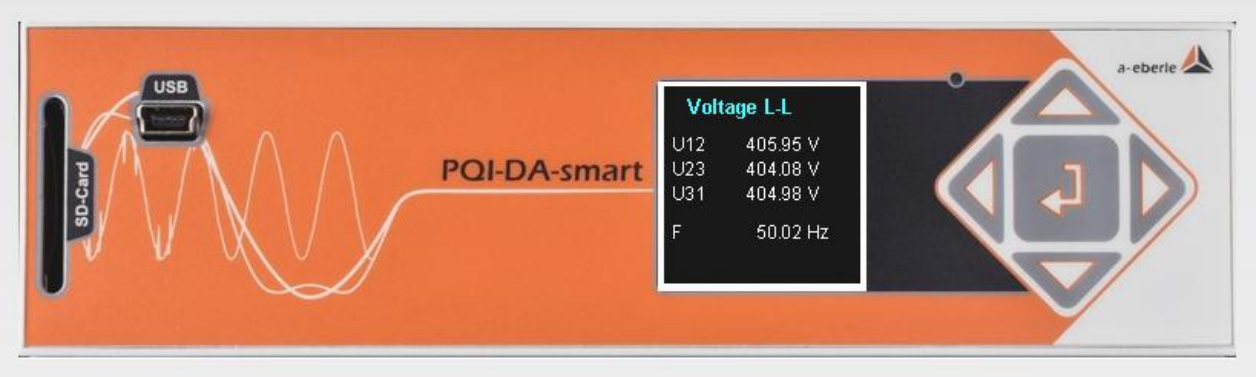


At this point, all the settings for the device can be transferred or canceled.

- **With the confirmation of "Yes", the device restarts, change all settings and delete all old measurement files in the device memory.**
- **The measurement campaign is now started.**

5.2 Display

The colour display of the device provides information about the correct connection of the measuring cables and transducers and shows online data for voltages, currents, total harmonic distortion (THD), power values and energy.

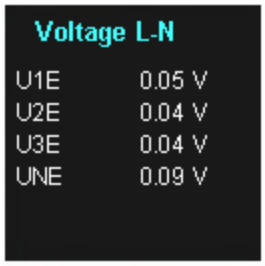


Pressing the "right“ and "left“  keys on the keypad will change the side of the display.

If no key is operated, the screen will switch to sleep mode after 5 minutes.

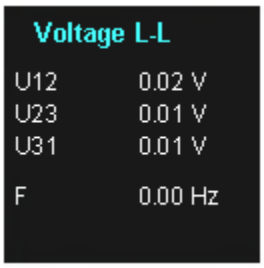
The following screens provide online information of the measured data:

Display page 1



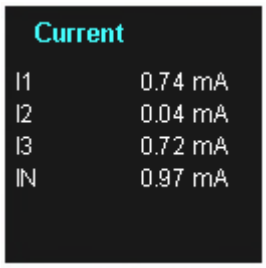
Line-Earth voltages

Display page 2



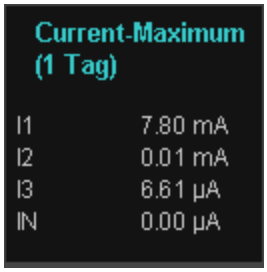
Line-to-line voltages & grid frequency

Display page 3



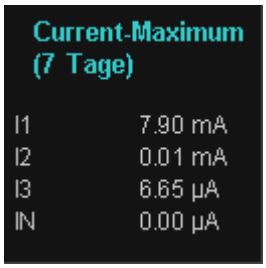
Currents L1, L2, L3, N conductor

Display page 4



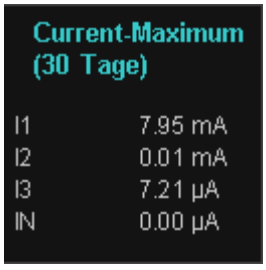
½-periode maximum current for the last day

Display page 5



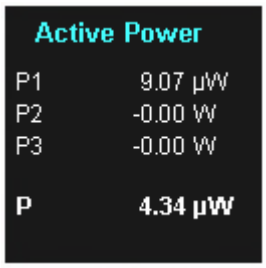
½-periode maximum current for the last 7 days

Display page 6



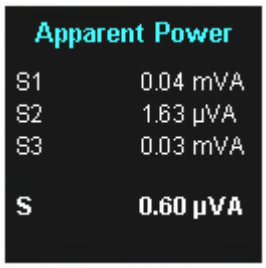
½-periode maximum current for the last 30 days

Display page 7



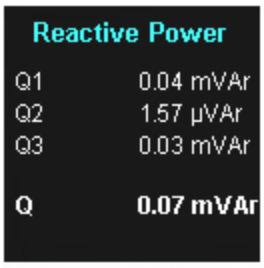
Active power including sign

Display page 8



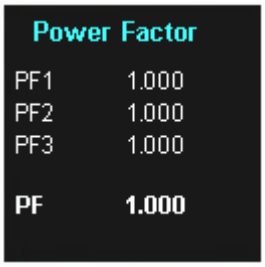
Apparent output

Display page 9



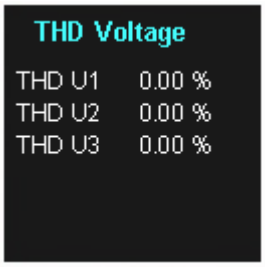
Reactive power including sign

Display page 10



Power factor (active power / apparent output)

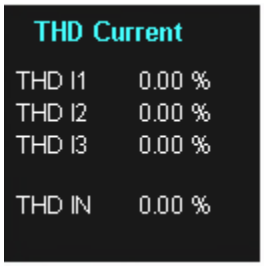
Display page 11



Total harmonic distortion of voltages

The THD calculation H2 to H40 and/or H2 to H50 is adjustable.

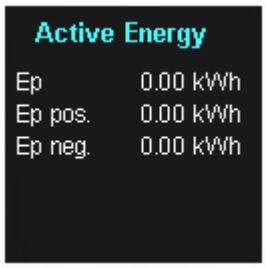
Display page 12



Total harmonic distortion of currents

The calculation H2 to H40 and/or H2 to H50 is adjustable

Display page 13

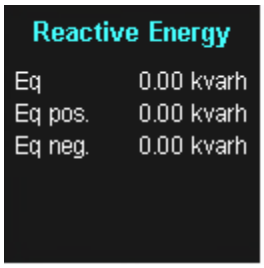


Ep = Total active energy

Ep pos. = Active energy received (positive sign)

Ep neg. = Active energy supplied (negative sign)

Display page 14



Eq = Total reactive energy

Eq pos. = Reactive energy received (positive sign)

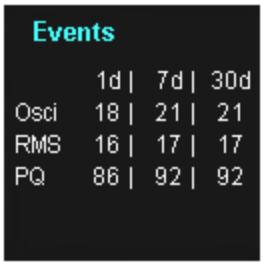
Eq neg. = Reactive energy supplied (negative sign)

Display page 15

Current firmware for PQI-DA smart / Device date and time

Display page 16

The number of PQ events that occurred, oscillograph and RMS value recordings for the last day, last week and last month appear on the device display.

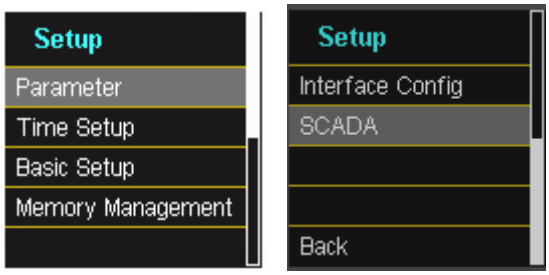


The event counter changes over to the following day at 24:00 hours/12 am each day.

5.3 Setup display

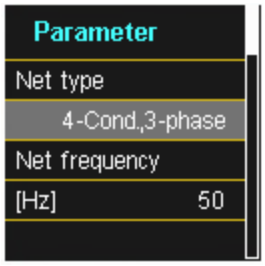
Pressing the  key on the keypad will change the display to the setup menu.

The following main menus are available in setup mode:



5.3.1 Parameter

Parameter page 1



Grid configuration

Entering the grid type "3-conductor grid", "4-conductor grid" and/or "4 x 1 conductor grid" will determine how the Power Quality events are recorded.

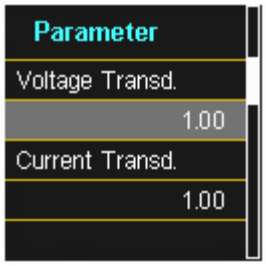
Switch between 3-conductor and 4-conductor grids.

- **In a 3-conductor grid, all events are calculated from the conductor-conductor voltages.**
- **In a 4-conductor grid and/or a 4 x 1 conductor grid all Power Quality events are determined from the conductor-earth voltages.**

Grid frequency

Setting grid frequency to 50Hz or 60Hz

Parameter page 2



Voltage converter: Corresponds to the ratio between the primary and secondary voltage.

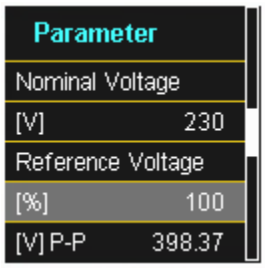
Current transformer: Corresponds to the ratio between the primary and secondary current.

- **Example:**

Voltage: primary = 20,000V / secondary = 100V; Conversion factor = 200

primary = 100A / secondary = 5A; Conversion factor = 20

Parameter page 3



The displayed value for the nominal voltage is:

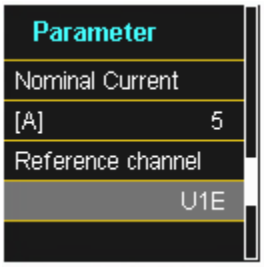
- In a 4-conductor grid = 230V conductor-earth voltage
- In a 3-conductor grid = 100V conductor-conductor voltage, multiplied by the conversion factor

The % value is used to set the reference voltage at a different value to the nominal voltage.

Example 1: 20,000V * 105% = Reference voltage of 21,000V. This is the reference value for all trigger thresholds as well as Power Quality events.

Example 2: 500V grid (conductor-conductor) 230V * 125% = 287.5V (conductor-earth)

Parameter page 4

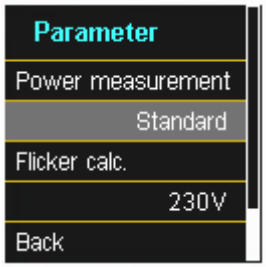


Rated current

All trigger thresholds for the current refer to the set nominal current. The nominal current for the system should be entered here.

Reference channel defines the measuring channel for frequency measurements and grid synchronisation.

Parameter page 5



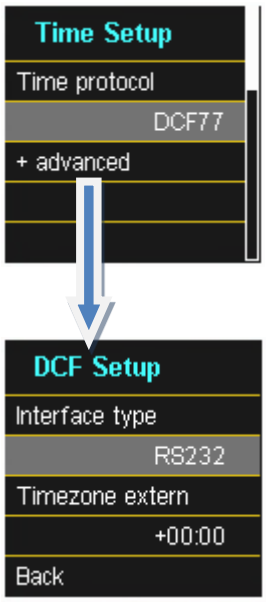
Power measurement: The power calculation in the device firmware can be selected from two measuring functions:

- Power calculation in accordance with DIN 40110, part 2 – including the calculation of the imbalance reactive power (factory setting for the device)
- Simplified power calculation without considering the imbalance reactive power in the 3~ phase power

This setting has an impact on the measured power values on the device display, the online measured values and the recorded measured values.

5.3.2 Time settings

5.3.2.1 DCF77 time setting



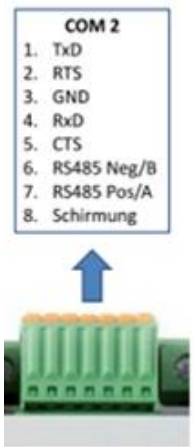
Time synchronisation to an external DCF77 radio-controlled clock

DCF77 settings on the RS232/RS485 interface and the time zone of the DCF signal.

5.3.2.2 Connection DCF77 Funkuhr

To connect the DCF77 time clock art no. 111.9024.01 to PQI-DA smart please use this wiring.

Connection DCF77 time clock:



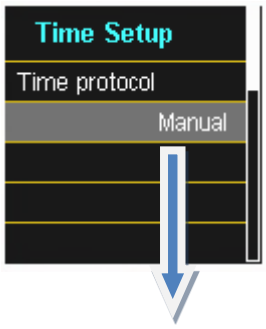
2: RTS → red wire time clock = +6V

3: GND → white wire time clock = GND

4: RxD → green wire time clock = clock signal

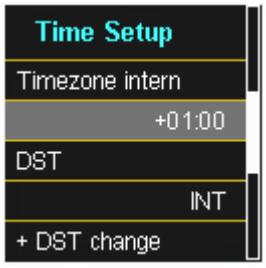
5: CTS → black wire time clock = -6V

5.3.2.3 Manual time setting

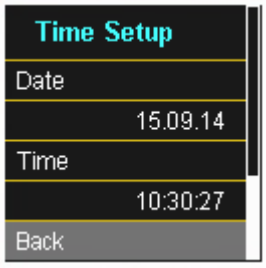


The time is set manually on the device

Summer / winter time setting is switched off (DST = OFF)

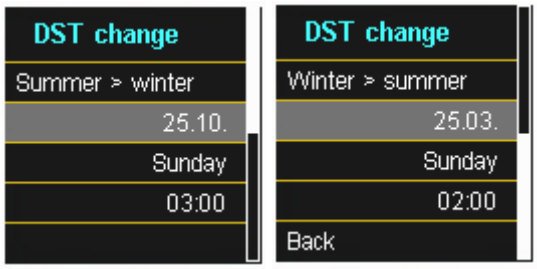


Setting the time zone in which the device is located



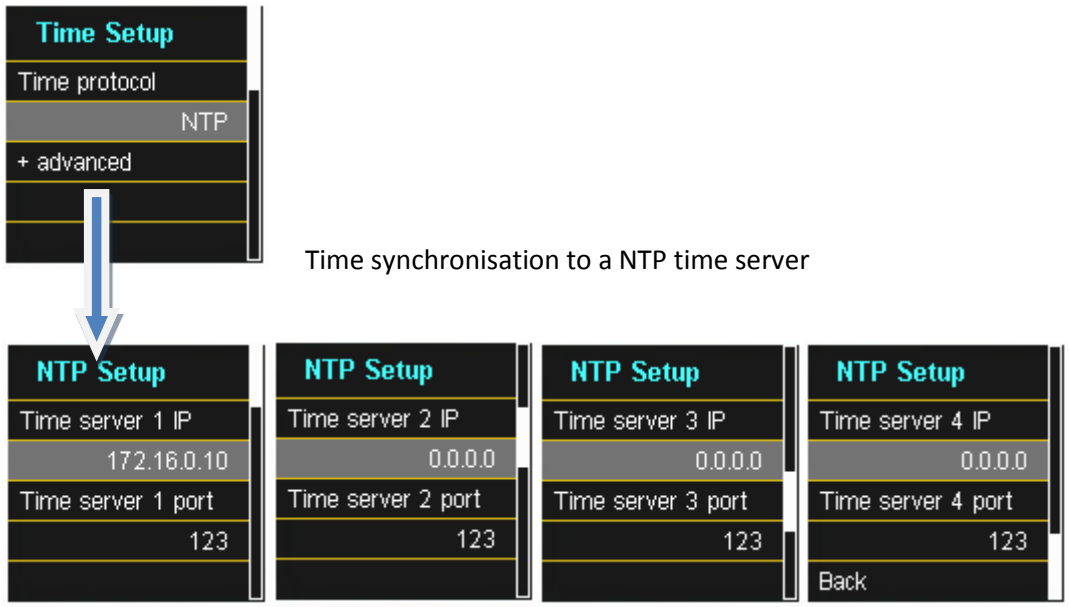
Manual time and date setting for PQI-DA smart

DST – changing from summer to winter time



Setting the date and time for changing from summer to winter time.

5.3.2.4 NTP time setting

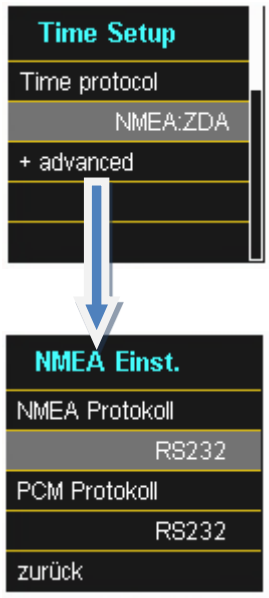


Time synchronisation to a NTP time server

The PQI-DA smart supports up to four time servers in the network.

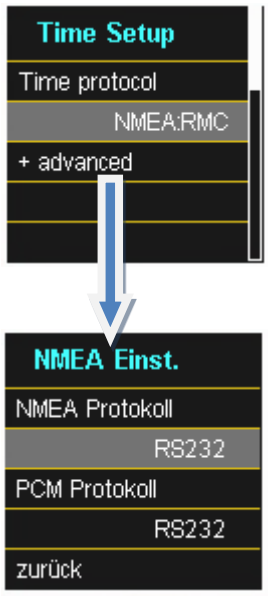
The device automatically uses the strongest signal that is available in the network.

5.3.2.5 NMEA-ZDA time setting



Setting up the RS232/RS485 interface for the NMEA protocol

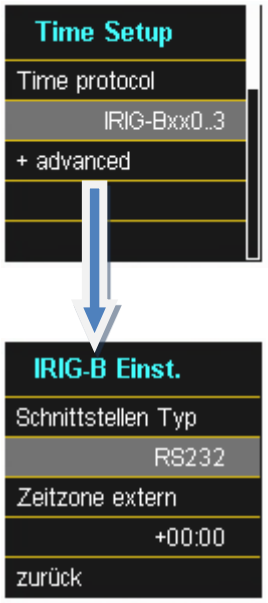
5.3.2.6 NMEA-RMC time setting



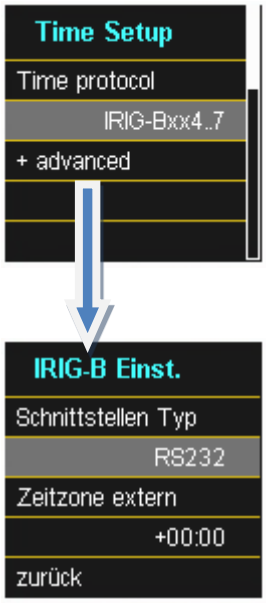
Setting up the RS232/RS485 interface for the NMEA-RMC protocol

5.3.2.7 IRIG-B time setting

IRIG-B formats 0 to 3



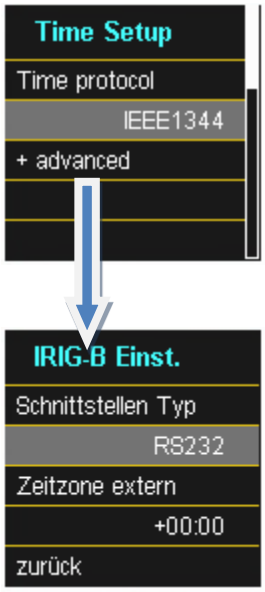
IRIG-B formats 4 to 7



Selecting the IRIG-B format

Setting up the interface and the time zone

5.3.2.8 IEEE 1344 time setting



Time synchronisation to an IRIG-B time protocol (in accordance with IEEE1344)

Setting up the interface and the time zone

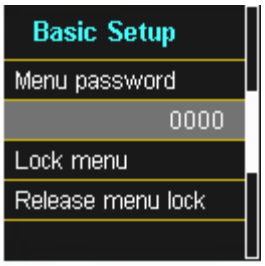
5.3.3 Basic setting

Basic setting page 1

Language: Select the display language

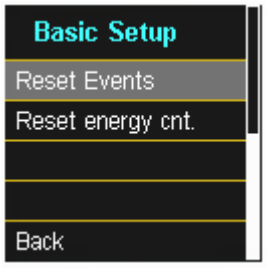
Automatic setup: This function takes you through an automatic device setup. This function is started automatically when the device is put into operation for the first time and does then not appear again. You can go to the guided setup at any time via "Auto Setup".

Basic setting page 2



Access to the device setup can be disabled via a 4-digit password.

Basic setting page 3

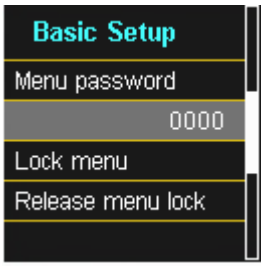


Reset events: The event counter for sequence of events recordings and PQ events on the device display is reset to 0. All measurement data and PQ events are retained in the device memory.

Reset energy counter: The energy counters in the device display and in the device memory are set to 0.

5.3.4 Password lock device display

Access to the device setup can be disabled via a 4-digit password.



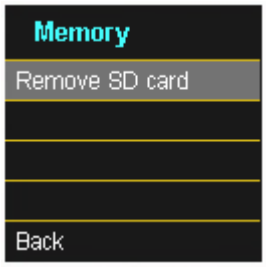
If a password is assigned, no access to the device parameterization via the display is possible.

- Enter your correct password
- Confirm with unlock

Now the device setup over the keys and the display can be achieved. The password has no restriction for the software.

5.3.5 Memory management

The "Remove SD card“ function stops the copying function for the measuring data of the internal memory to the SD memory card and releases the card for removal.

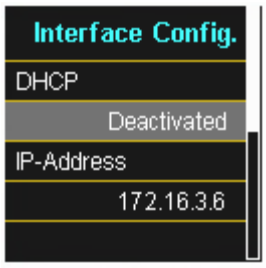


5.3.6 Setting up the device interfaces

PQI-DA smart is supplied with the following default IP address:

192.168.56.95 / 255.255.0.0

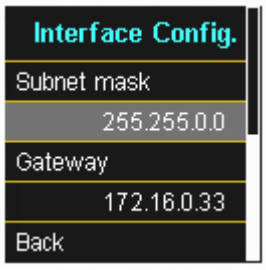
Interfaces page 1



Activating or deactivating DHCP

DHCP deactivated = The device is used with a fixed IP address.

Interfaces page 2



6. WinPQ smart software

The free WinPQ smart evaluation software has been created exclusively for the Network Analyser PQI-DA smart and includes the following functions:

- Parameterisation of the Network Analyser PQI-DA *smart*
- Online analysis of the measurement data
- Reading the measurement data from the measuring device
- Evaluating measurement data
- Firmware update for PQI-DA *smart*

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.

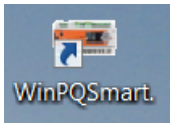
6.1 Installing the evaluation software

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

.

The installation complies with the Windows standard, including uninstalling the program system via the "Software" option on the Control Panel. The installation location of the program (target directory) can be freely selected during installation.

Install the software in a directory in which you also have read and write rights.

The start icon 

is created automatically on your PC's Desktop.

Uninstalling the software via the control panel

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

Under "Software“, "WinPQ smart“ 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

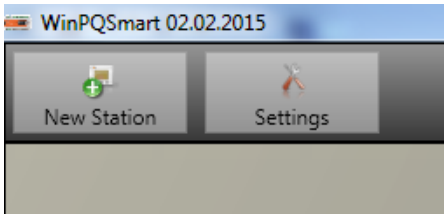
You can find the evaluation software and all updates and the current device firmware, free of charge, on our website under the product group "Power Quality / Software WinPQ smart":

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 *smart*, example with 6 PQI-DA *smart* devices

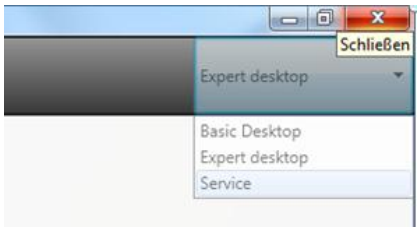
6.2 Basic setting for Software



Under the "Settings“ menu point, the following changes can be made:

Language setting for the software (the software must be restarted after any change)

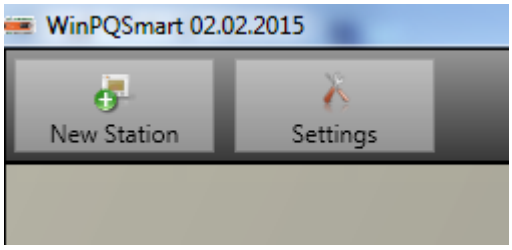
Visibility of the setup parameters



- Basic Desktop = Basic user with restricted selection of main parameters
- Expert Desktop = Expert mode with all setting options displayed

6.3 Setting up a new PQI-DA smart

A device is set up as a tile on the screen via the "New station" function.



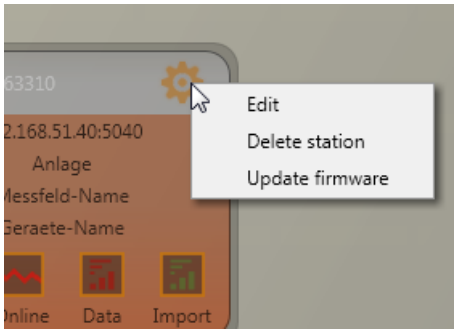
The TCP-IP address of the PQI-DA smart is stored in the "IP" field.

The port number of the device can be allocated any number. The device is delivered with the value "5040" set as the port number.

The values will be adopted by pressing OK, and a station tile for this device is then stored on the software interface. An unlimited number of devices can be set up.

Deleting a station tile

Station tiles can be deleted via the "Setup general" station menu.



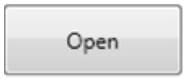
6.4 Device parameterisation

The function "Para" opens the device setup for PQI-DA smart.

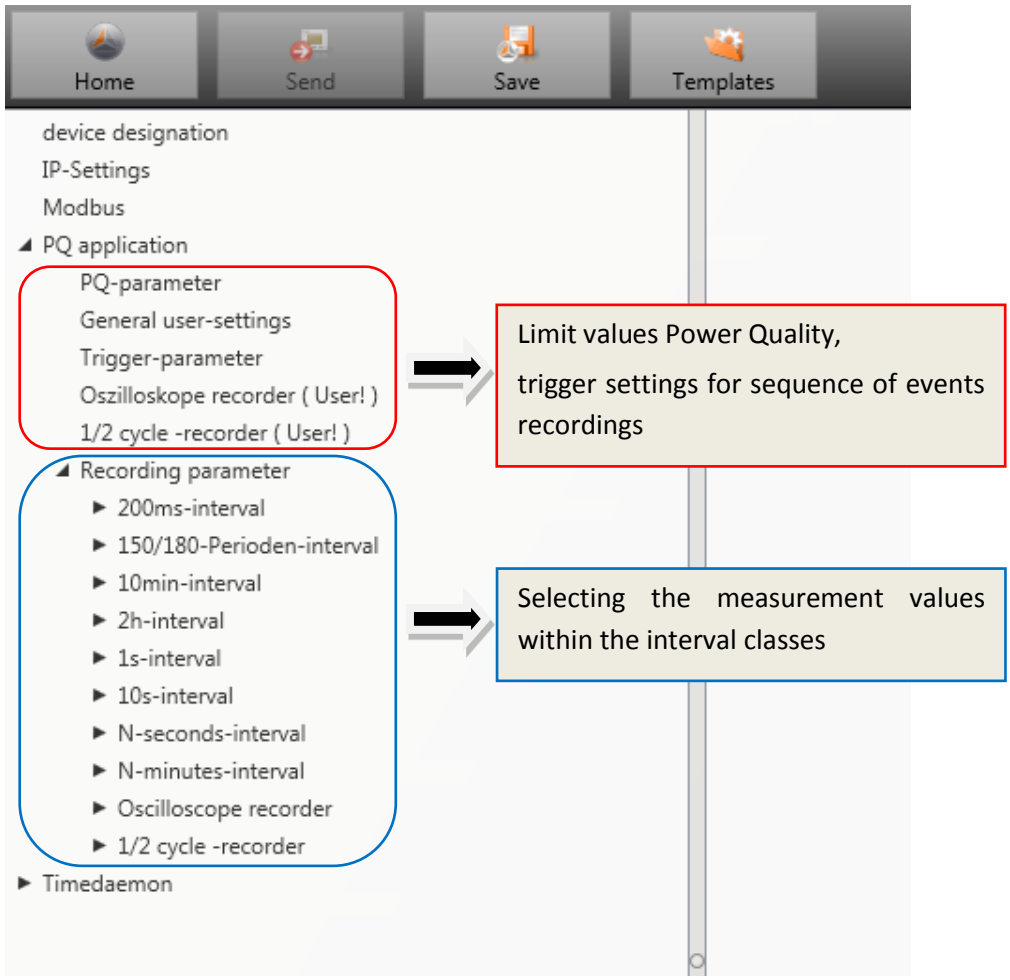
The following basic functions are available:

Send device settings (measurement values, limit values, trigger thresholds) to the device

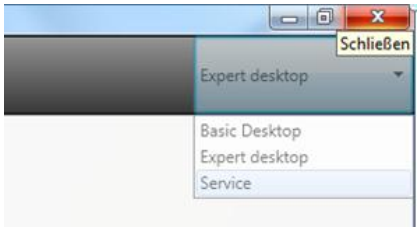
Save all device settings as a template on the PC.



Open own settings that have already been saved on the PC (for instance, to send these to another device) – "Open default" provide two standard settings, for low voltage network and medium voltage network.



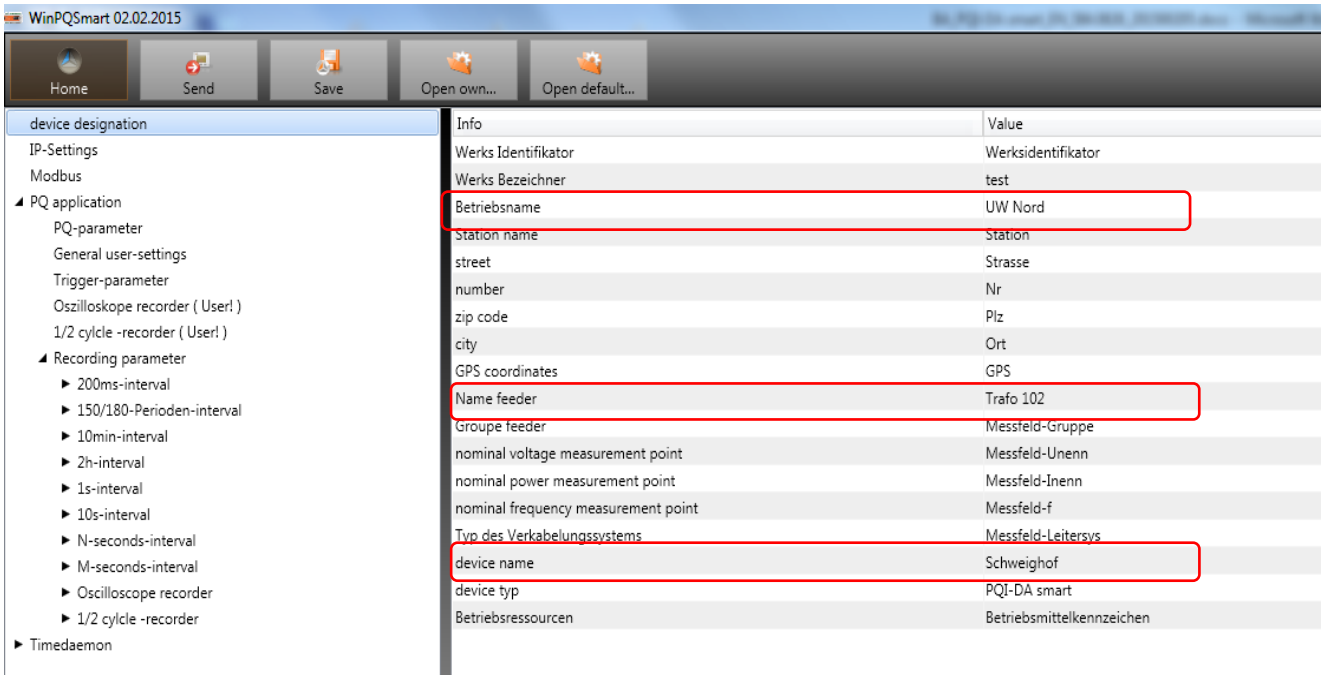
- **Visibility of the setup parameters**



  - Basic Desktop = Basic user with restricted selection of main parameters
  - Expert Desktop = Expert mode with all setting options displayed
  - Service = Passwort protected for service only

6.4.1 Device designation

In the menu "Device designation", the description of the device is determined.

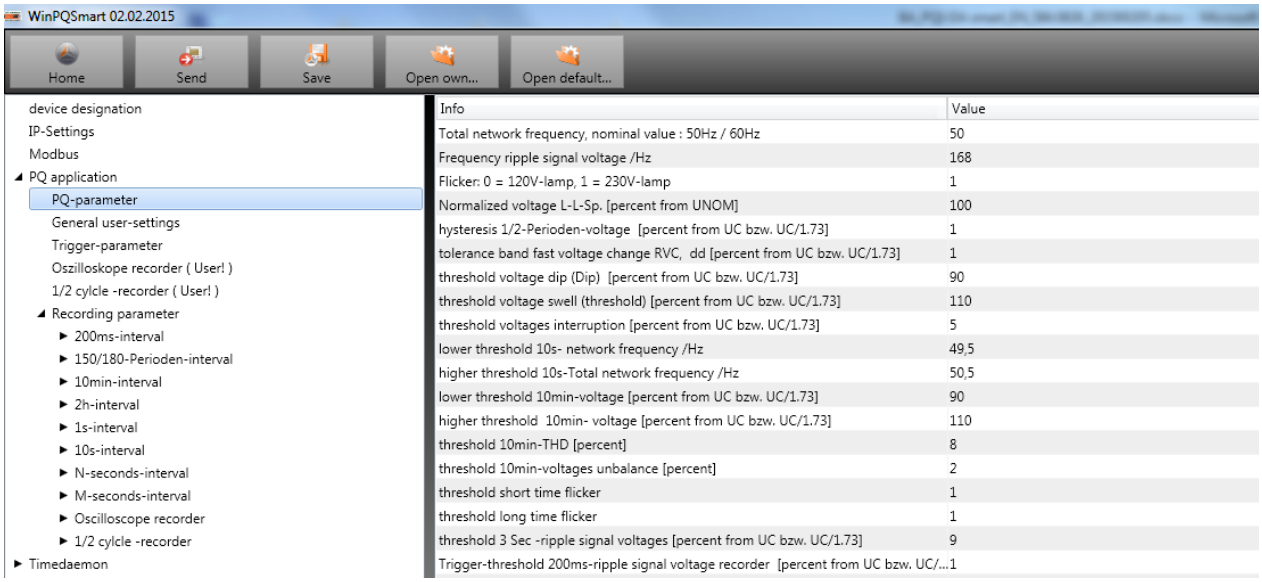


The fields marked in red describe the station icon as well as all the fault records and data in the archive.

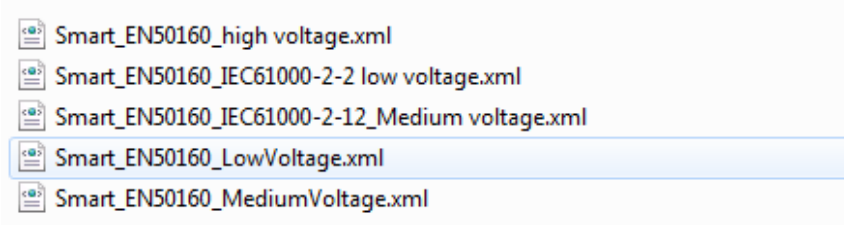
6.4.2 PQ Parameter

In PQ parameter 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.

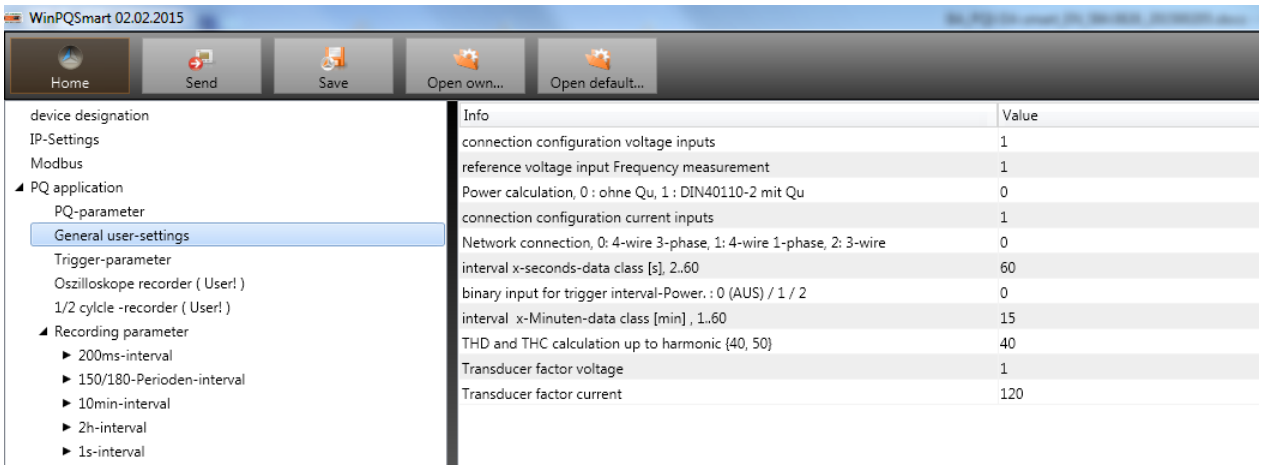
- Value: Value of PQI-DA smart – this value can be changed
- Default: Default setting
- Minimum: Smallest value
- Maximum: Biggest value



Under "Open default setting" templates are located for a low and a medium and high-voltage network.



6.4.3 General user settings



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

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

Connection configuration	VT	Voltage inputs				
		1	2	3	4	
Voltage : L1, L2, L3, N/E	1	u_1	u_2	u_3	$u_{N/E}$	PE
V-connection, earth L1	2	u_1	u_2	u_3	u_4	
V- connection, earth L2	3	u_1	u_2	u_3	u_4	
V- connection, earth L3	4	u_1	u_2	u_3	u_4	

- Reference voltage: 1 … 7
  Determining the frequency measurement input channel: U1, U2, U3, Une, U12, U23, U31

- Power calculation:
  1 = according DIN40110-2; with calculation of the unbalance reactive power (basic setting of the device)
  2 = Simplified power calculation - without calculation of unbalance power

This setting has also an effect on the power values in the display of the PQI-smart

- Connection current inputs:

Connection configuration	CT	Current			
		I1	I2	I3	I4
Current : L1, L2, L3, N	1	i_1	i_2	i_3	i_N
Aron connection : L2, L3	2	-	i_2	i_3	i_4
Aron connection : L1, L3	3	i_1	-	i_3	i_4
Aron connection : L1, L2	4	i_1	i_2	-	i_4

- Network connection:
  0 = 4-wire network (3 phase network with earth)
  1 = 4-wire (single phase – 4 x L1)
  2 = 3-wire netzwork – without earth

- Interval x-seconds data class:
  Free interval - 2 seconds to 60 seconds

- Binary input for power intervals:
  0 = Time interval intern
  1 = time interval synchronized to binary input 1
  2 = time interval synchronized to binary input 1

- Interval x-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} bis 50^{th} harmonic

- Voltage transducer factor (basic setting = 1)

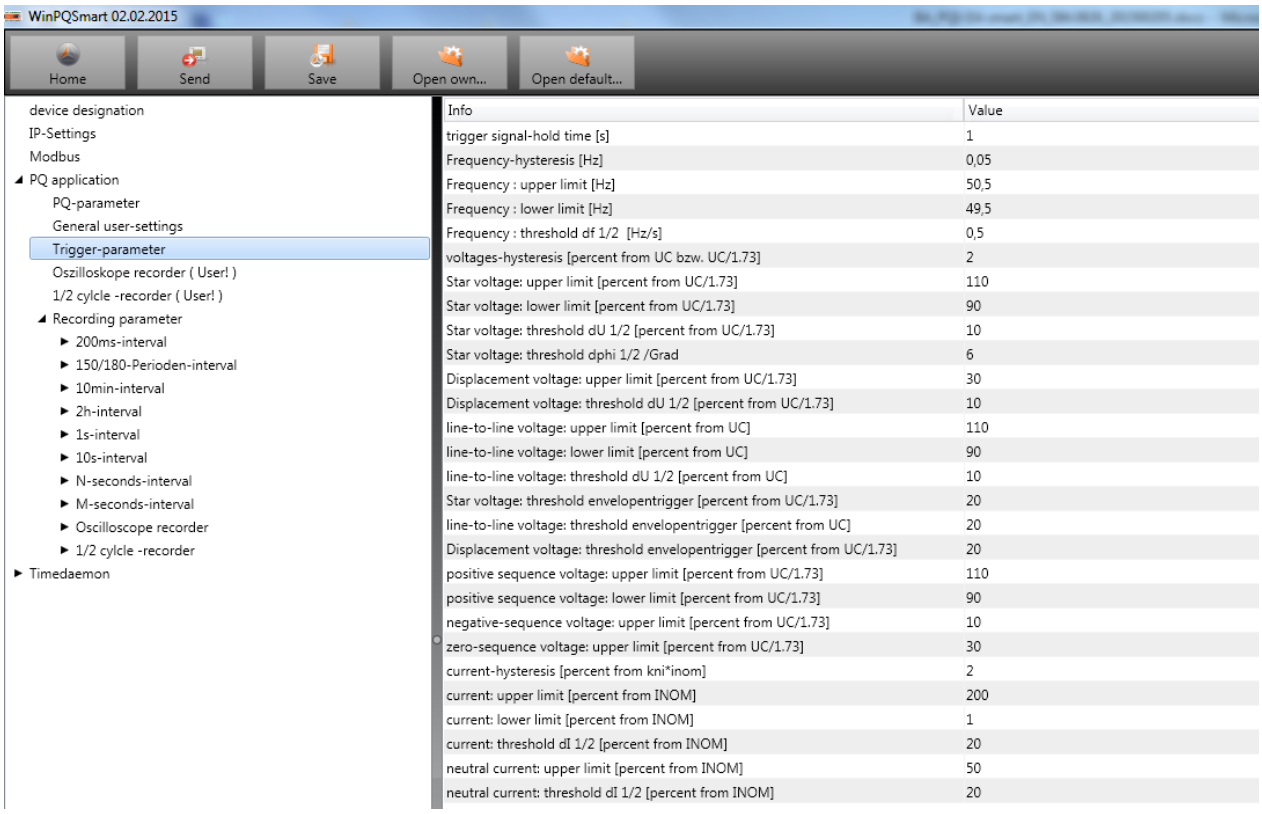
- Current transducer factor (basic setting = 1)

6.4.4 Trigger parameter for disturbance recorder

In this menue all limits for triggering of fault records can be changed.

These thresholds are independently to the Power Quality thresholds.

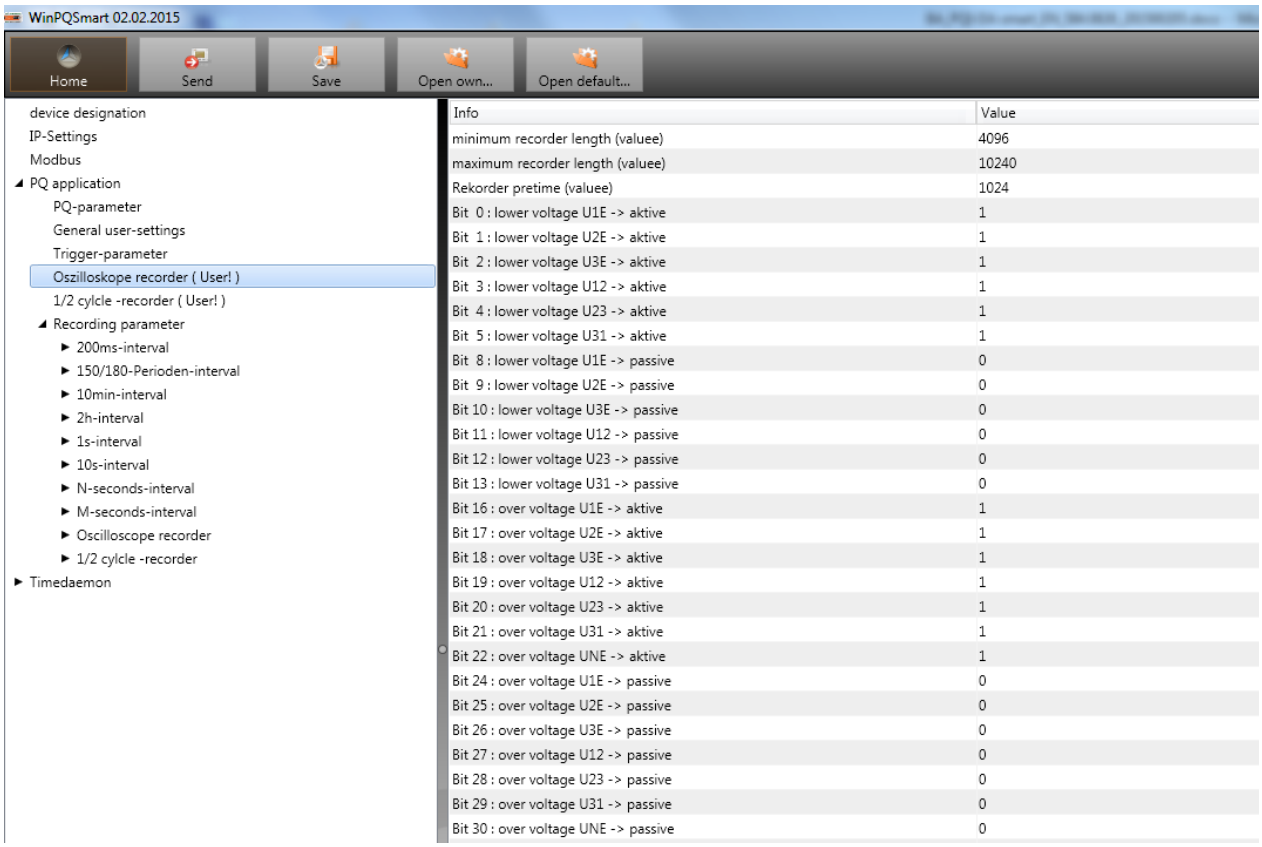
Upper and lower trigger thresholds für frequency, voltage, current oder unballance can be set.



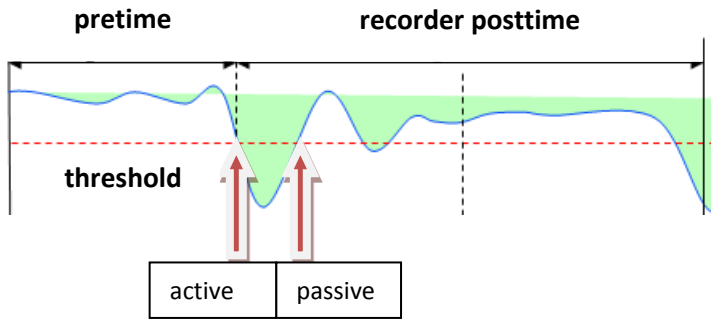
Info	Value
trigger signal-hold time [s]	1
Frequency-hysteresis [Hz]	0,05
Frequency : upper limit [Hz]	50,5
Frequency : lower limit [Hz]	49,5
Frequency : threshold df 1/2 [Hz/s]	0,5
voltages-hysteresis [percent from UC bzw. UC/1.73]	2
Star voltage: upper limit [percent from UC/1.73]	110
Star voltage: lower limit [percent from UC/1.73]	90
Star voltage: threshold dU 1/2 [percent from UC/1.73]	10
Star voltage: threshold dphi 1/2 /Grad	6
Displacement voltage: upper limit [percent from UC/1.73]	30
Displacement voltage: threshold dU 1/2 [percent from UC/1.73]	10
line-to-line voltage: upper limit [percent from UC]	110
line-to-line voltage: lower limit [percent from UC]	90
line-to-line voltage: threshold dU 1/2 [percent from UC]	10
Star voltage: threshold envelopentrigger [percent from UC/1.73]	20
line-to-line voltage: threshold envelopentrigger [percent from UC]	20
Displacement voltage: threshold envelopentrigger [percent from UC/1.73]	20
positive sequence voltage: upper limit [percent from UC/1.73]	110
positive sequence voltage: lower limit [percent from UC/1.73]	90
negative-sequence voltage: upper limit [percent from UC/1.73]	10
zero-sequence voltage: upper limit [percent from UC/1.73]	30
current-hysteresis [percent from kni*inom]	2
current: upper limit [percent from INOM]	200
current: lower limit [percent from INOM]	1
current: threshold dI 1/2 [percent from INOM]	20
neutral current: upper limit [percent from INOM]	50
neutral current: threshold dI 1/2 [percent from INOM]	20

6.4.5 Oscilloscope recorder

Settings for Oscilloscope recorder can be changed here.



- Minimum recorder length: Setting of the standard faultrecorder length
- Maximum recorder length: If one fault last longer than the minimum recorder length, the PQI-DA smart will enlarge the recorder length up to a maximum recorder length. The maximum recorder length of one recorder file can be set here.
- Recorder pretime is the time of the recorder file bevore the trigger threshold occurred.

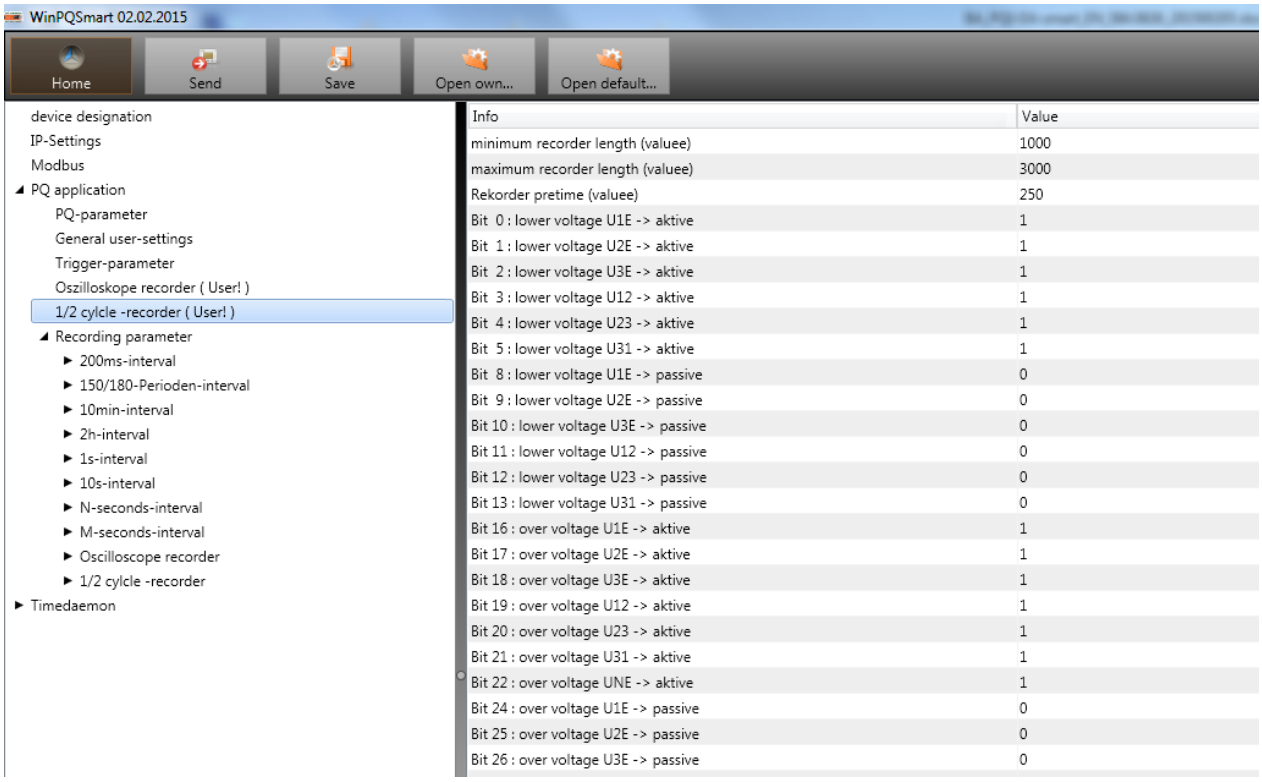


- Active trigger = value exceeds or falls below threshold (start of the event)
- Passive trigger = value comes back to normal (end of the event)

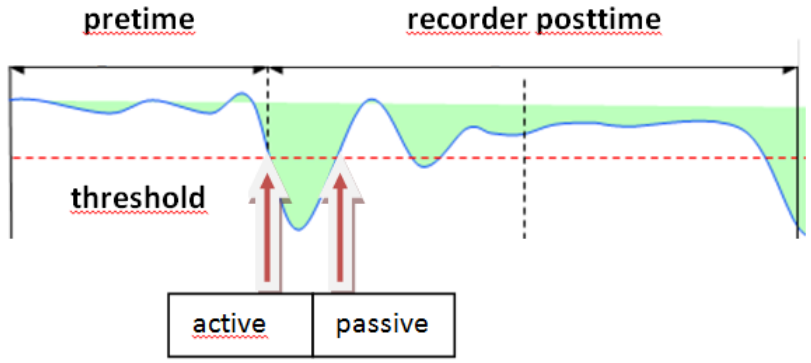
- Sampling frequency of oscilloscope recorder can be changed from 10240 Hz to 40960 Hz (40960Hz is only available with option B1)

6.4.6 ½ cycle recorder

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



Please see chapter 6.4.4 – explanation trigger thresholds



6.4.7 Control of recording via binary inputs

With the input signal of the two digital inputs, it is possible to start and stop the PQI-DA smart recorders.

The following functions can be started or stopped via the digital input:

- All permanent recorder
- Oscilloscope recorder
- ½-cycle rms recorder

To control the recording of PQI-DA smart, of the two binary inputs are inserted in the parameter setting. The following text must be placed in the selected row:

- Binary input no. 1 = "/dev/slot_0/module_0/bi0"
- Binary input no. 2 = "/dev/slot_0/module_0/bi1"

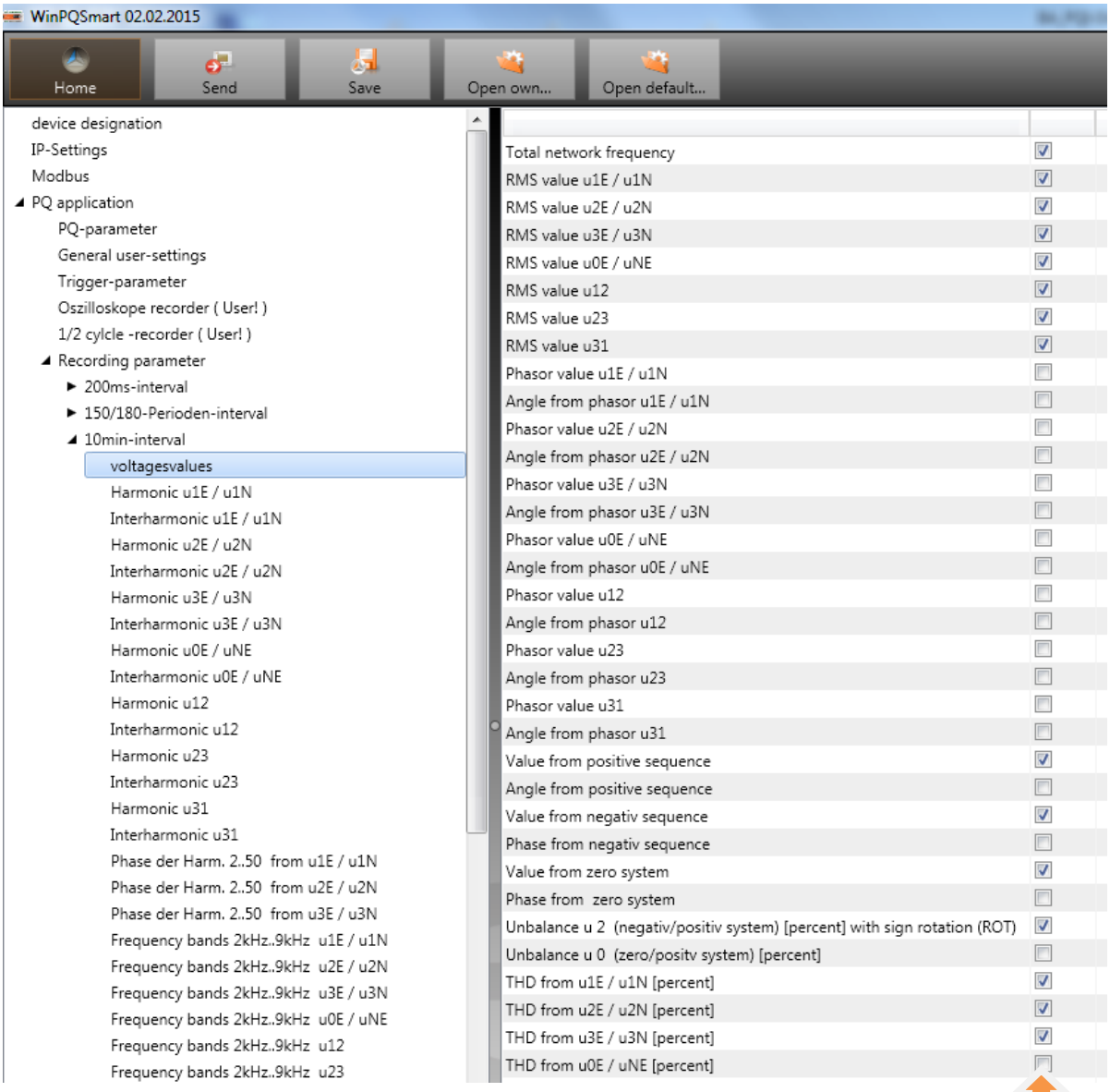
With the function "logic level recording control" the signal may be negated.

- 0 = Recording is running at low level and stops at high level
- 1 = Recording is running at high level and stops at low level

6.4.8 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

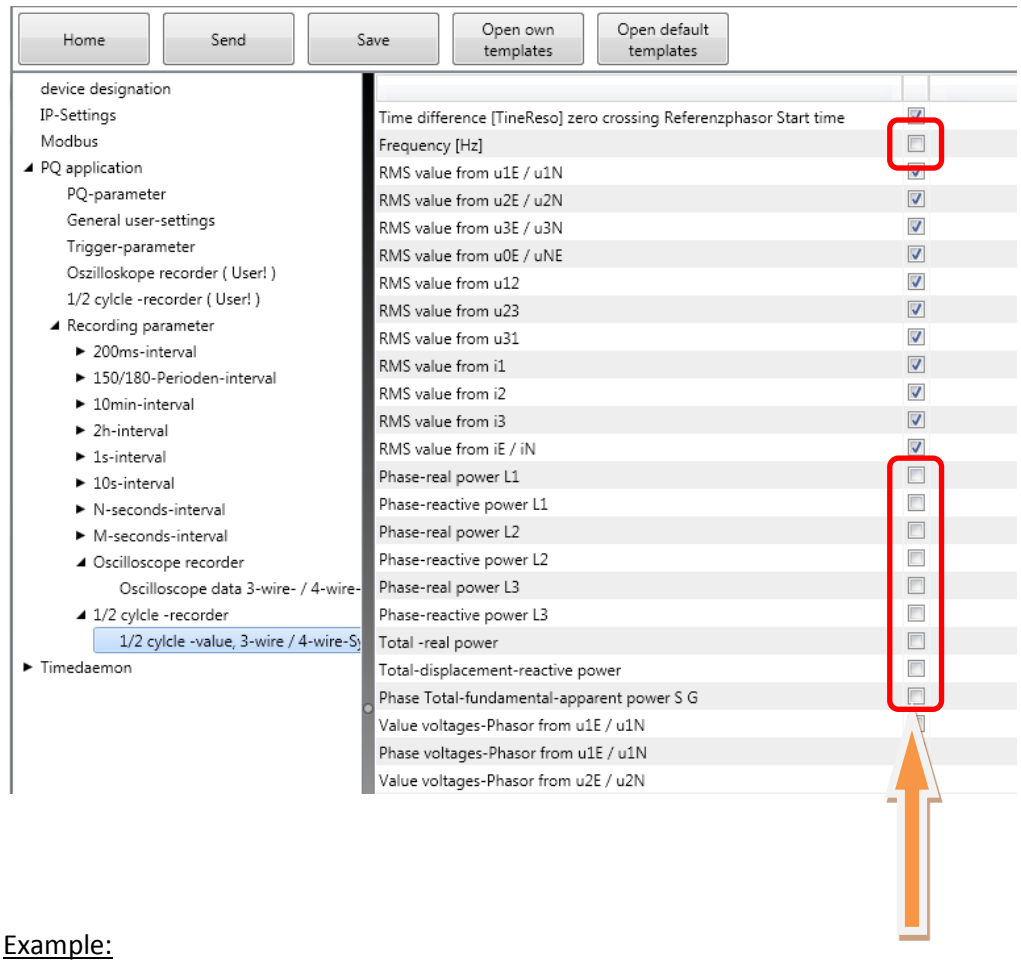
- 10/12 cycle (200ms interval)
- 150/180 cycle (3 seconds interval)
- 10 minutes interval
- 2 h interval
- 1 seconds interval
- 10 seconds interval
- N x seconds interval (range 2 to 60)
- N x minutes interval (range 1 to 60 – basic setting 15 min.)



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

6.4.9 Disturbance recoder parameter

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



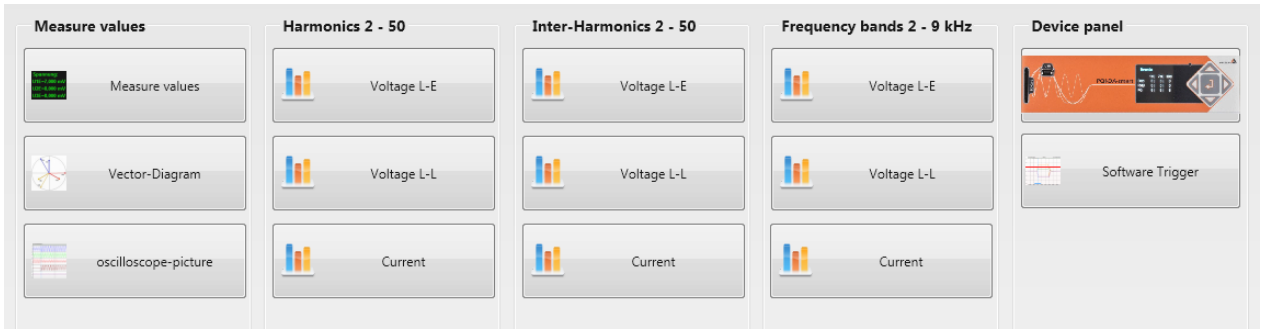
Example:

The ½ cycle recorder should also record the power and the frequency during a disturbance record.

6.5 Online measurement values

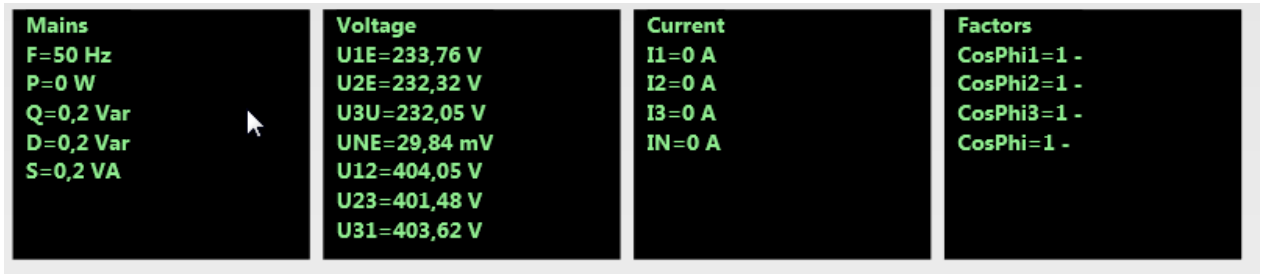
The "Online" function offers extensive analysis functions for online measurement values.

Start screen of the online measurement values:

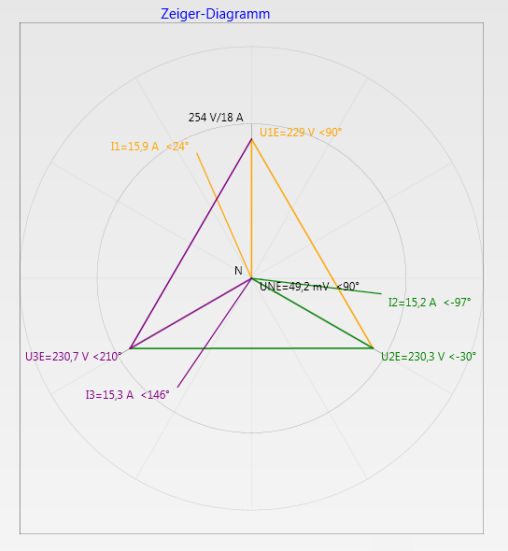


6.5.1 Measurement values

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



6.5.2 Vector diagram

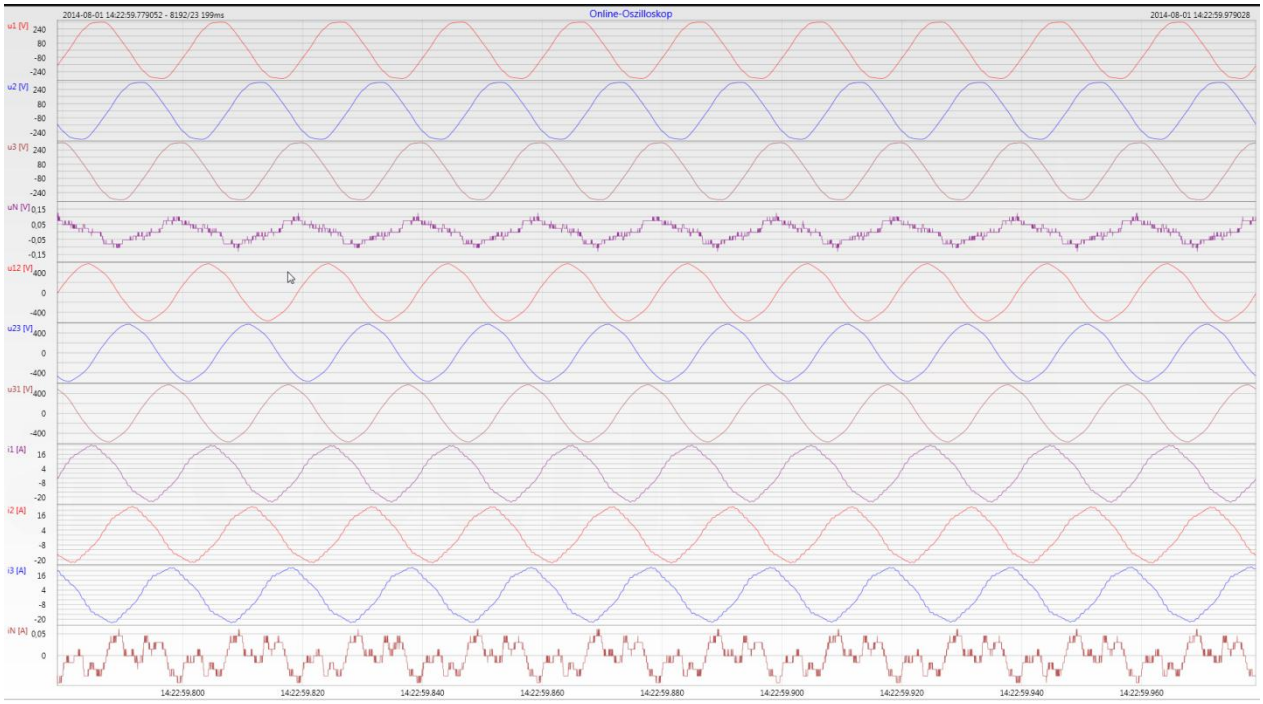


In the vector diagram, connection faults are easy to detect. All phase voltages and currents are displayed with phase angles.

6.5.3 Oscilloscope image

Online oscilloscope (41.96kHz / 10.24kHz) for the following channels:

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



6.5.4 Harmonic

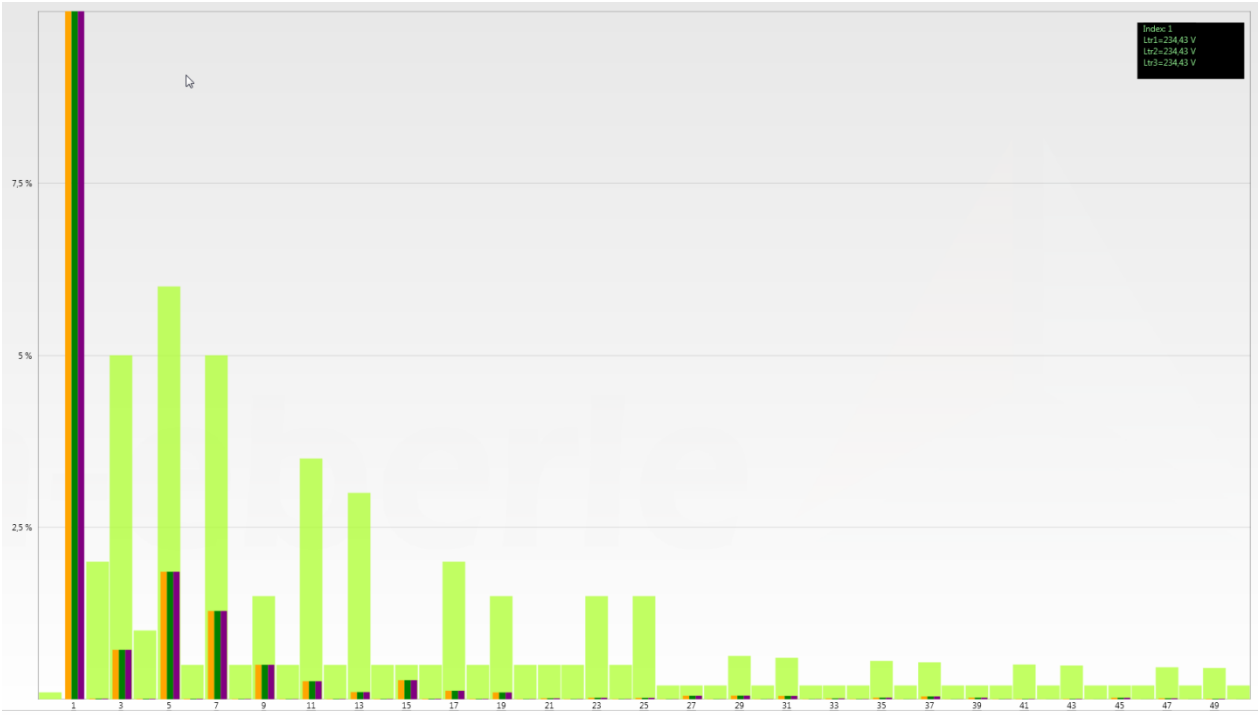
From the "Harmonics" tab page, all of the current and voltage harmonics (2nd to 50th) can be displayed online. The measurement data is calculated by the measuring device in accordance with IEC61000-4-30 Class A and transferred to the PC.

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.



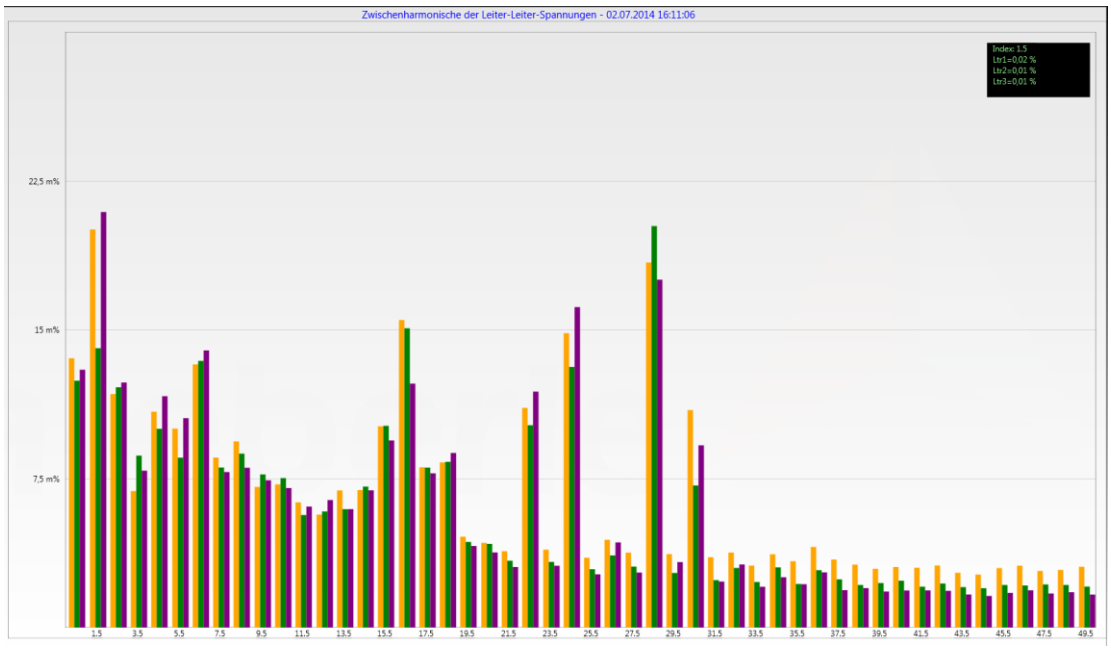
If a harmonic is selected with the mouse pointer, this measurement value is displayed in the field on the top right.

6.5.5 Interharmonics

The "Interharmonics“ card is used to display all current and voltage interharmonics 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 conductor-earth
- Interharmonic voltages conductor-earth
- Interharmonic currents

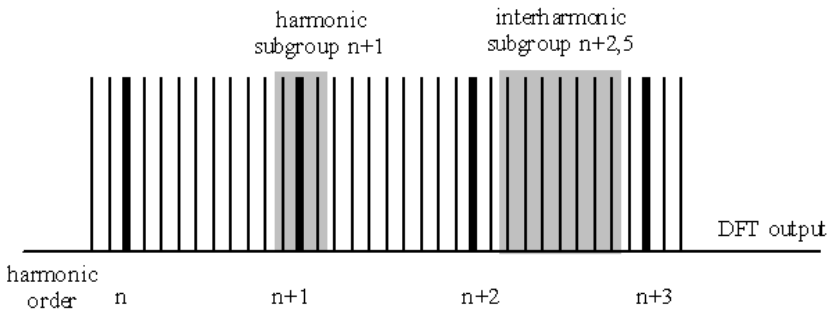


If an interharmonic is selected with the mouse pointer, this measurement value is displayed in the field on the top right.

Explanation of the grouping process in accordance with the IEC:

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

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



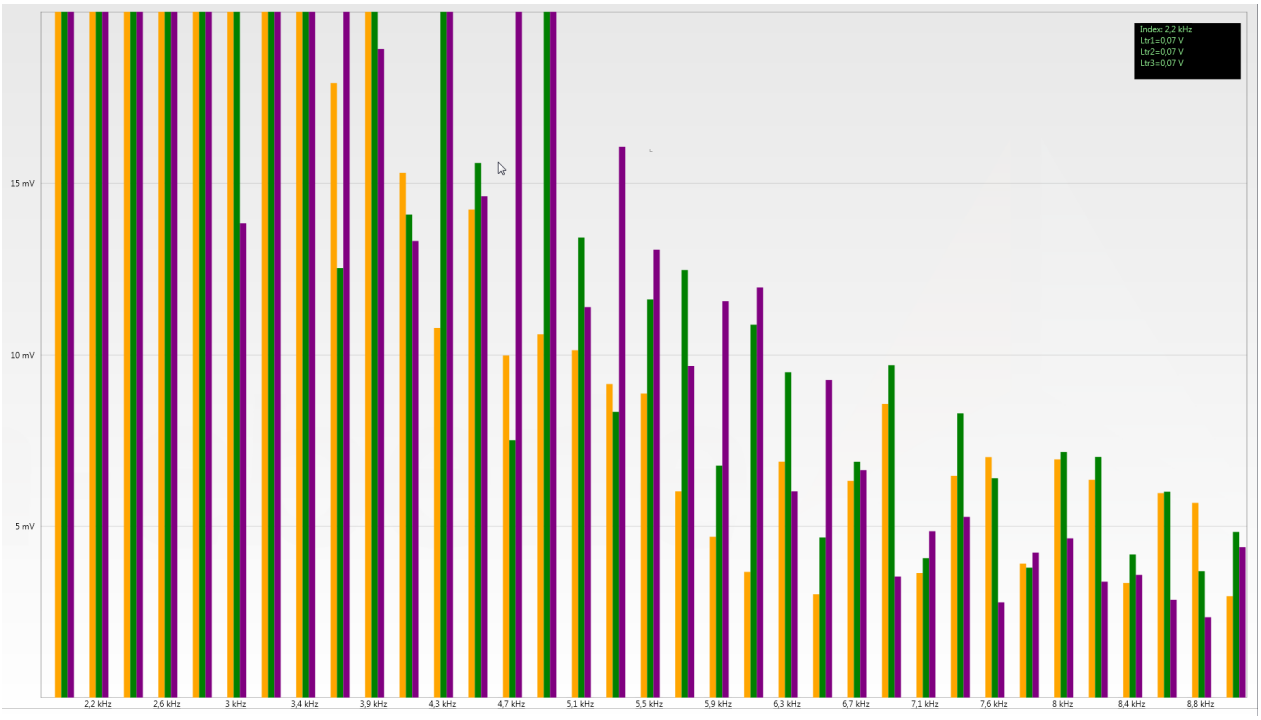
6.5.6 Frequency bands from 2kHz to 9kHz

The device characteristic "Frequency bands from 2kHz to 9kHz" is a device option

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

The centre frequency of the corresponding frequency band is stated.

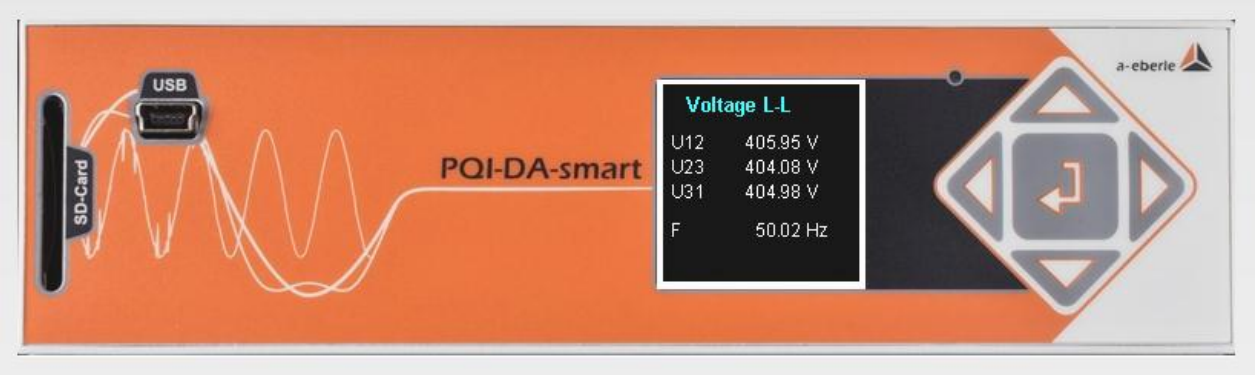
Example: All frequencies from 8,805Hz to 9,000 Hz are located in the 8.9 kHz band.



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

6.5.7 Device panel

The device panel can be used for the remote control of the device via the 5-key keypad.

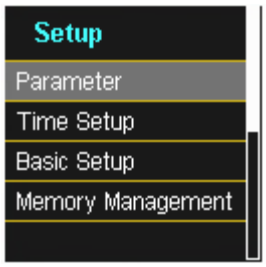


- Scrolling the measurement value displays (right – left keys)

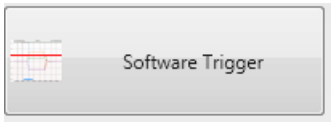
The left and right keys can be used to scroll the measurement value screens.

- Setup settings

The Enter key is used to open the setup menu of the device.



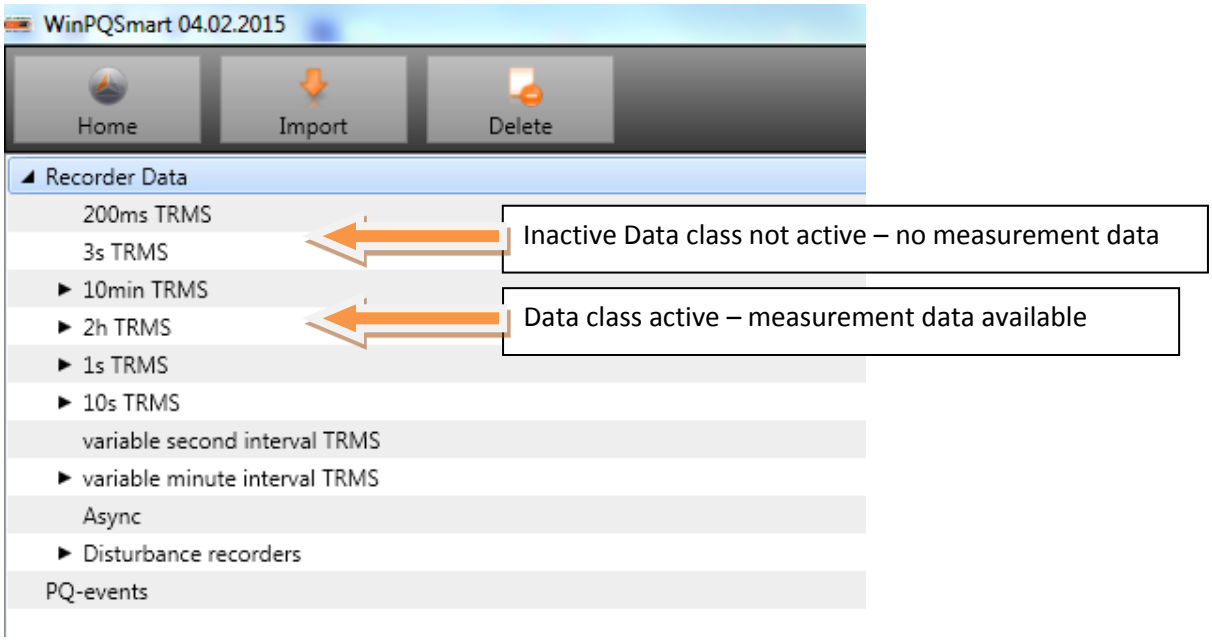
6.5.8 Software trigger

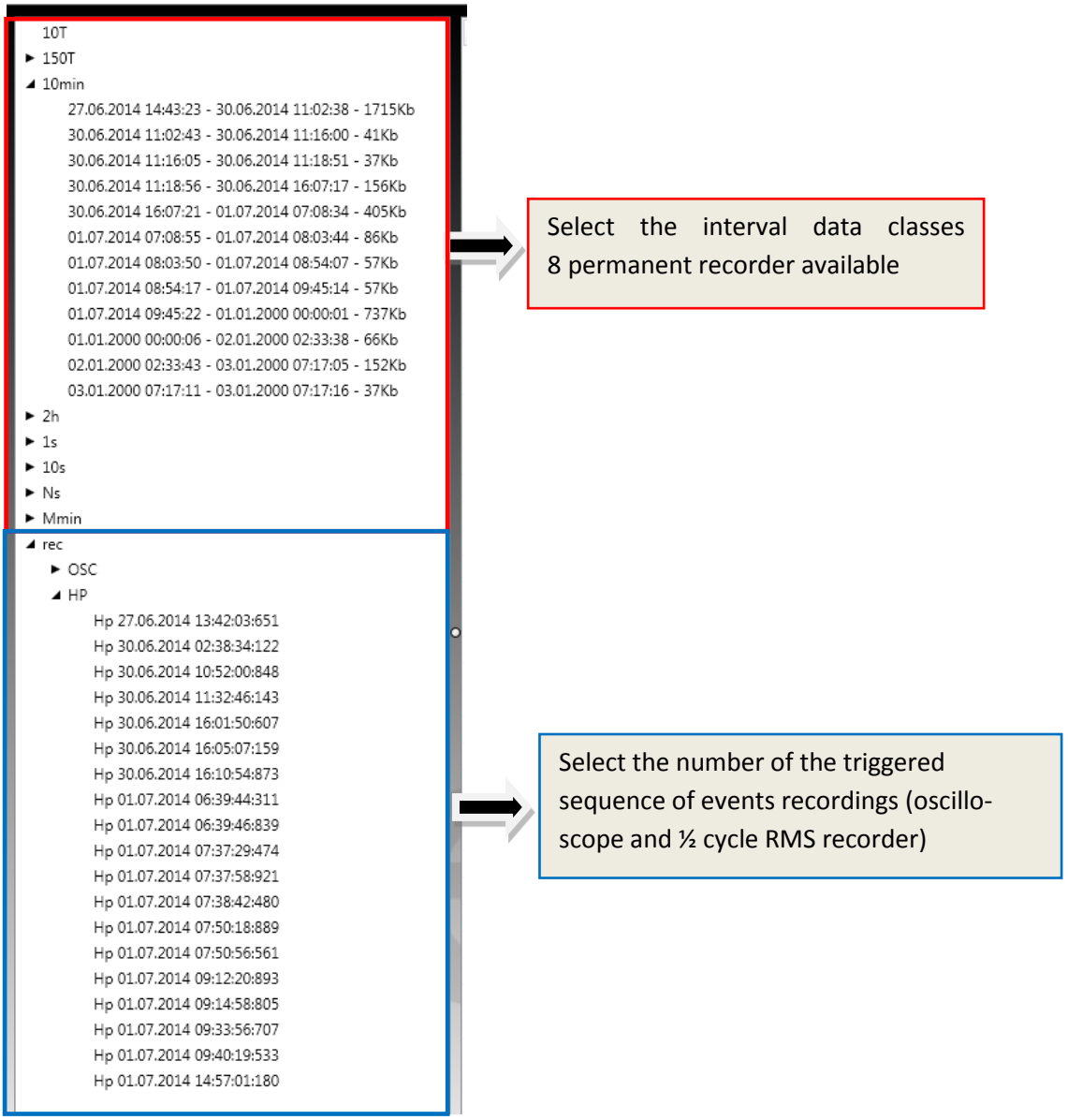


The "Software Trigger" key can be used to trigger the oscilloscope recorder and ½-period RMS recorder manually. The recorder length corresponds with the settings in the setup menu of the device.

6.6 Measurement data import

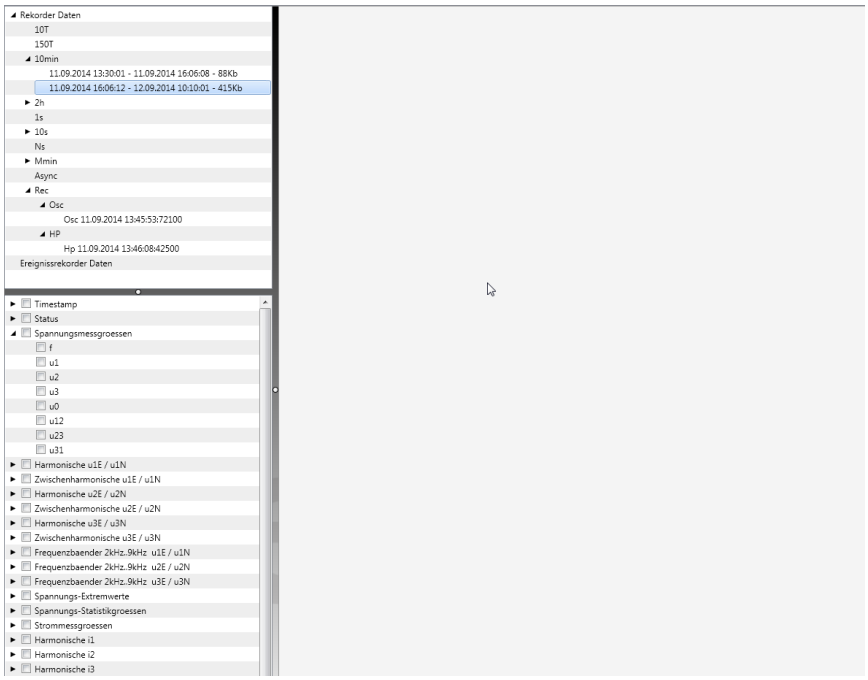
The "Import" function can be used to load all measurement data from the PQI-DA smart to the PC and to evaluate it there.




10T
150T
10min
27.06.2014 14:43:23 - 30.06.2014 11:02:38 - 1715Kb
30.06.2014 11:02:43 - 30.06.2014 11:16:00 - 41Kb
30.06.2014 11:16:05 - 30.06.2014 11:18:51 - 37Kb
30.06.2014 11:18:56 - 30.06.2014 16:07:17 - 156Kb
30.06.2014 16:07:21 - 01.07.2014 07:08:34 - 405Kb
01.07.2014 07:08:55 - 01.07.2014 08:03:44 - 86Kb
01.07.2014 08:03:50 - 01.07.2014 08:54:07 - 57Kb
01.07.2014 08:54:17 - 01.07.2014 09:45:14 - 57Kb
01.07.2014 09:45:22 - 01.01.2000 00:00:01 - 737Kb
01.01.2000 00:00:06 - 02.01.2000 02:33:38 - 66Kb
02.01.2000 02:33:43 - 03.01.2000 07:17:05 - 152Kb
03.01.2000 07:17:11 - 03.01.2000 07:17:16 - 37Kb
2h
1s
10s
Ns
Mmin
rec
OSC
HP
Hp 27.06.2014 13:42:03:651
Hp 30.06.2014 02:38:34:122
Hp 30.06.2014 10:52:00:848
Hp 30.06.2014 11:32:46:143
Hp 30.06.2014 16:01:50:607
Hp 30.06.2014 16:05:07:159
Hp 30.06.2014 16:10:54:873
Hp 01.07.2014 06:39:44:311
Hp 01.07.2014 06:39:46:839
Hp 01.07.2014 07:37:29:474
Hp 01.07.2014 07:37:58:921
Hp 01.07.2014 07:38:42:480
Hp 01.07.2014 07:50:18:889
Hp 01.07.2014 07:50:56:561
Hp 01.07.2014 09:12:20:893
Hp 01.07.2014 09:14:58:805
Hp 01.07.2014 09:33:56:707
Hp 01.07.2014 09:40:19:533
Hp 01.07.2014 14:57:01:180
Select the interval data classes 8 permanent recorder available
Select the number of the triggered sequence of events recordings (oscillo-scope and ½ cycle RMS recorder)

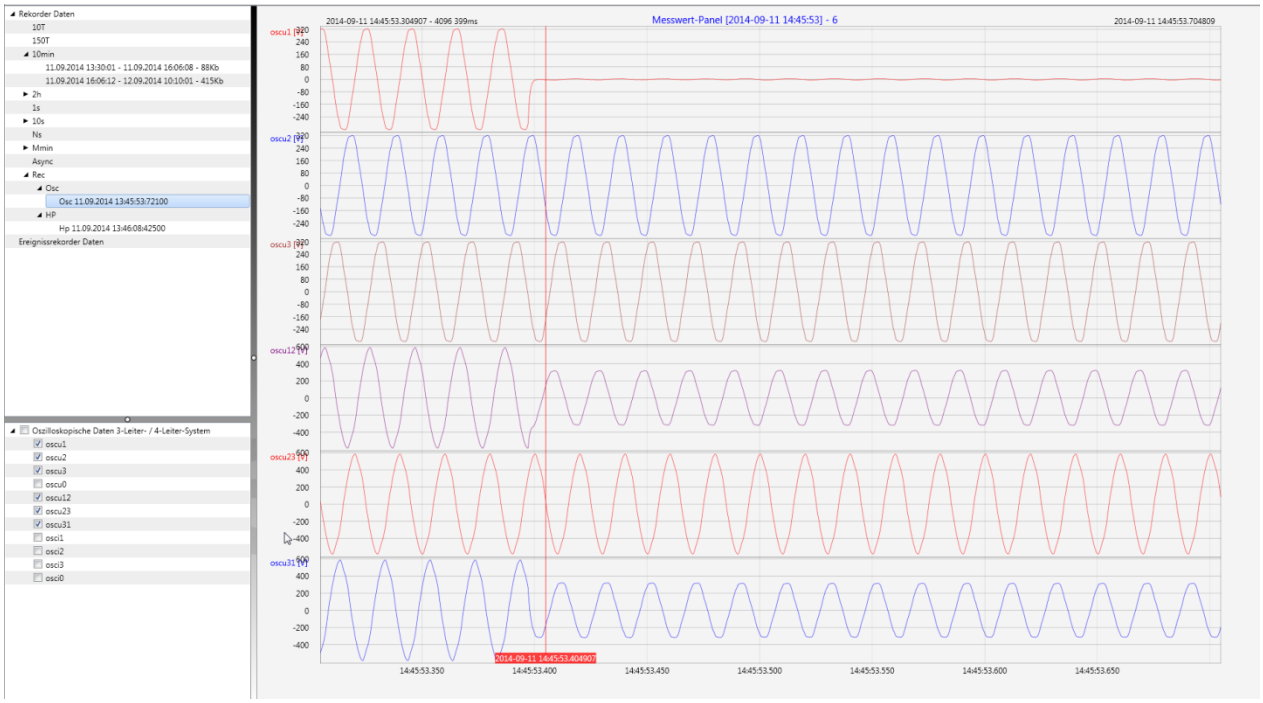
Level-time diagram of permanent measuring data

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.

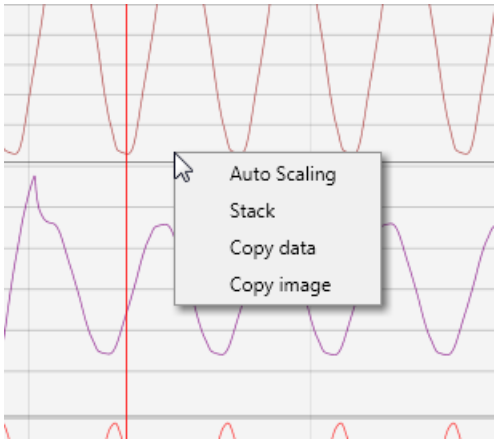


If measurement values are selected, they appear as a level-time diagram on the screen.

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



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



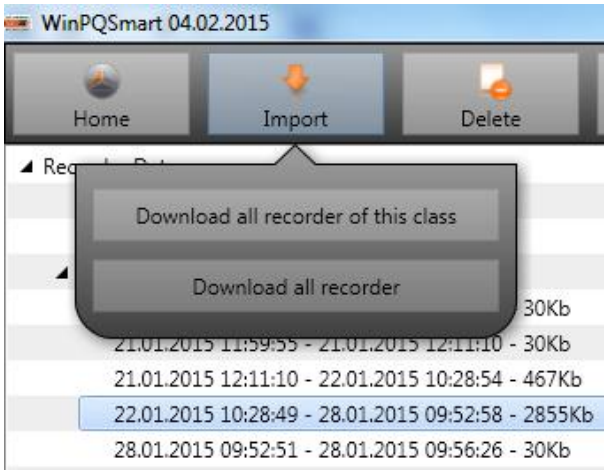
Functions:

- Auto scaling: The Y-axis of the measurement values is scaled automatically
- Data on the clipboard: Measurement data is copied to the clipboard and can be processed further, e.g. in MS Excel.
- Image on the clipboard: Copies the level-time diagram to the Windows clipboard and can then be inserted, e.g. in MS Word.

  Stack: This function changes how the measurement data is displayed in stacks. Measurement values can contain grouped or separate y-scales.

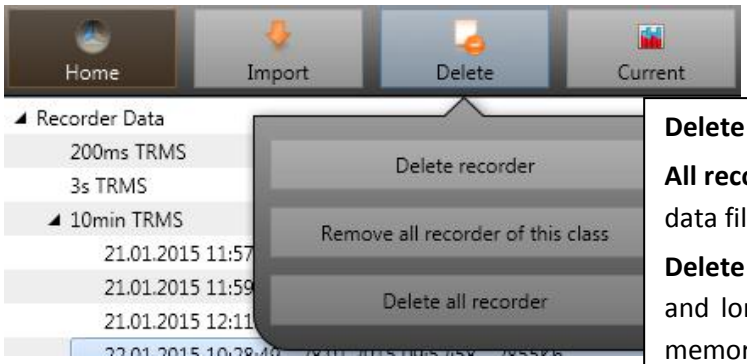
With “Import” it is possible to select between:

- Download all measurement files of the recorder (f.e. 10min recorder files)
- Download all disturbance recorder and permanent recorder from PQI-DA smart



6.7 Deleting measurement data in the device memory

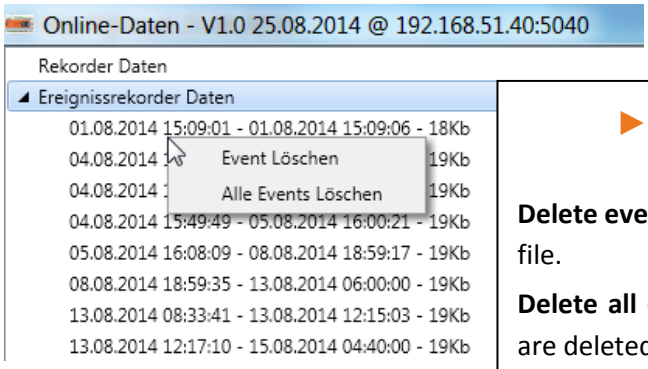
With the "Delete" function, measurement data can be deleted in the PQI-DA *smart* device memory.



Delete recorder - only deletes the selected file.

All records of this class - deletes f.e. all 10-minute data files.

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

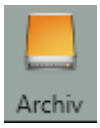


▶ **Right-click with the mouse to open the menu.**

Delete event - deletes only the selected event file.

Delete all events – all event files on the device are deleted.

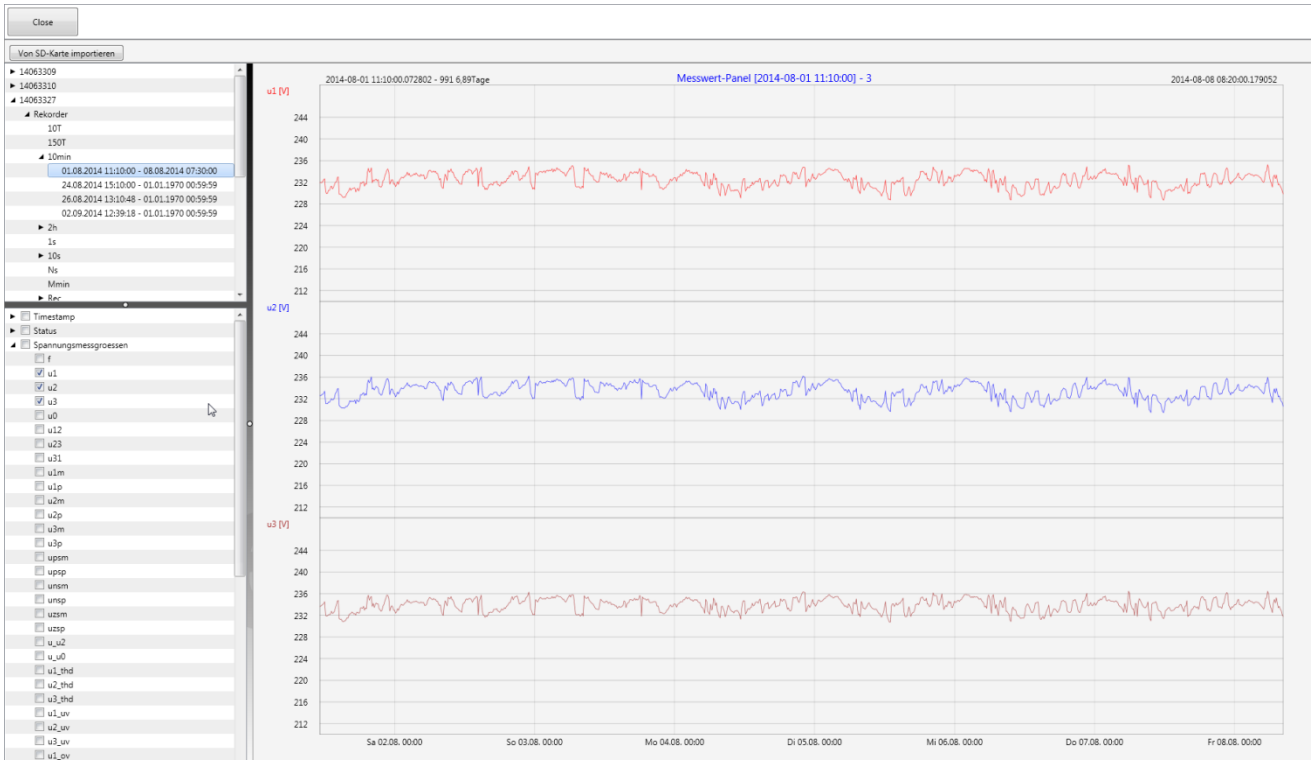
6.8 Evaluating measurement data offline



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

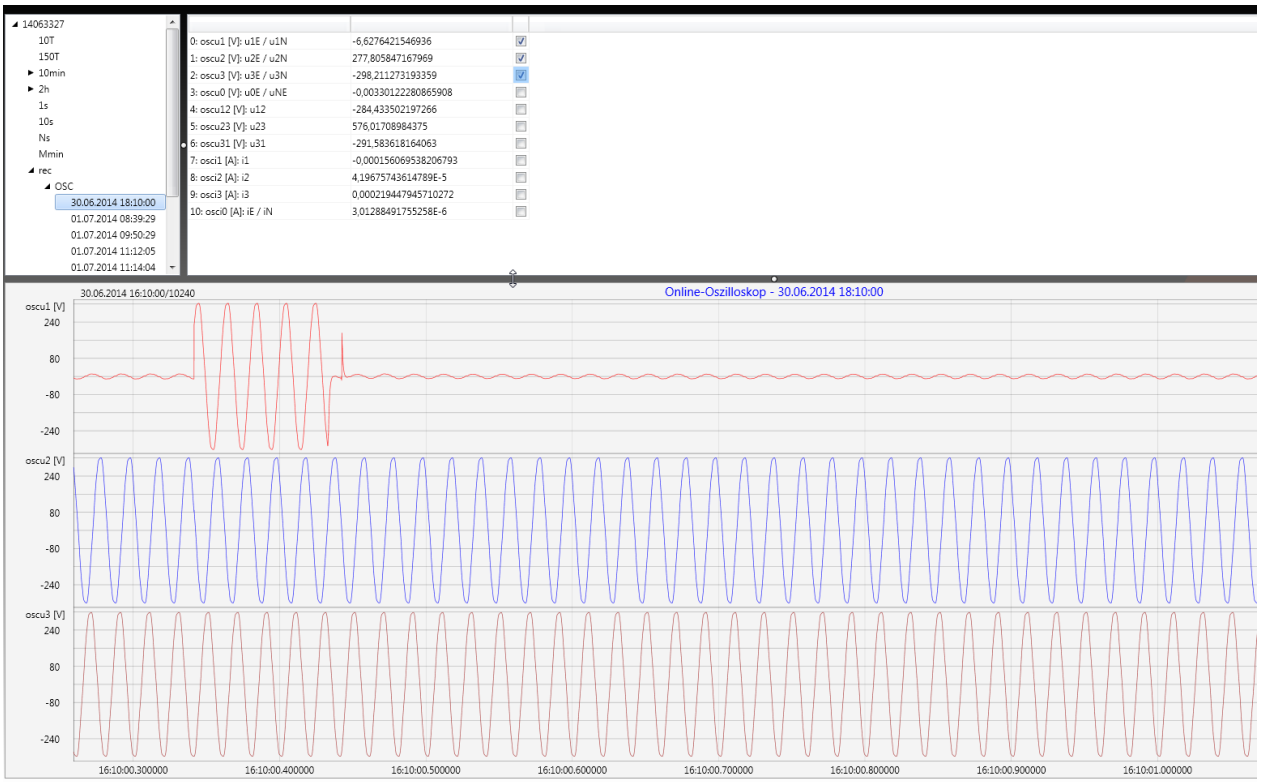
All measurement data which has been selected in the "Import" function is saved automatically on the PC. These can be evaluated offline without being connected to the measuring device.

Screen: Data folder



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

Example: Oscilloscope image – selecting voltage for L1E, L2E, L3E

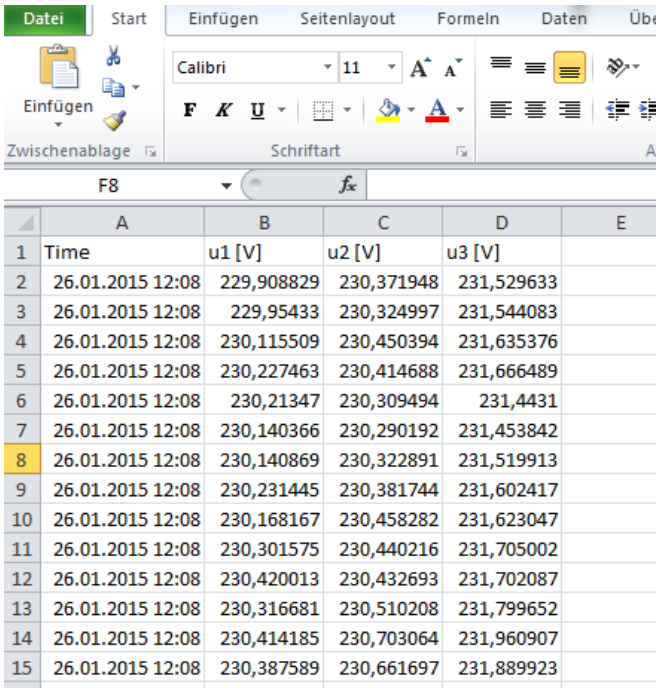


6.8.1 Edit measurement data

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

- **Copy data – copies all the data displayed in the Windows clipboard**

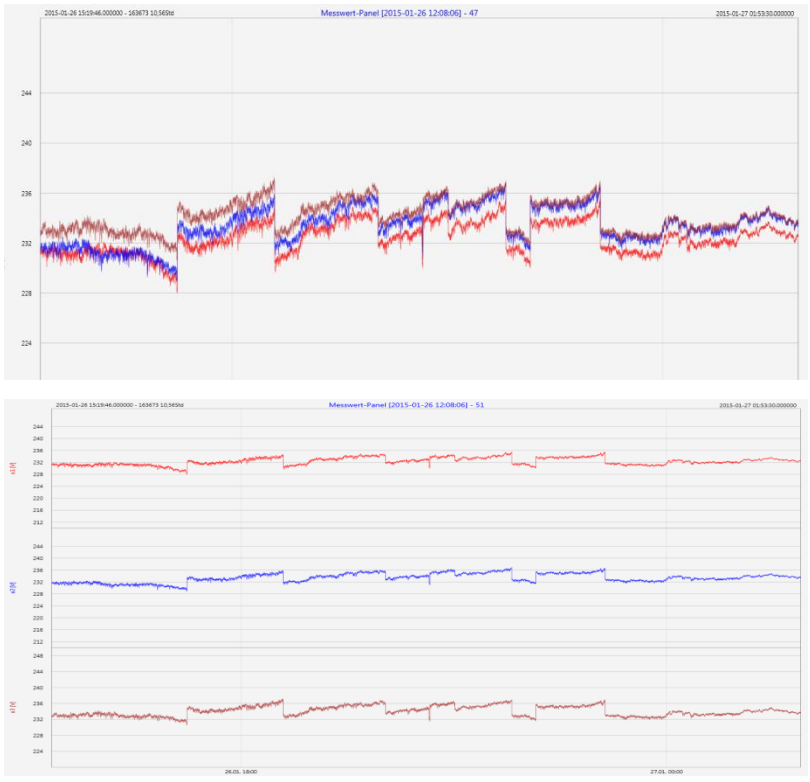
Example – measurement values in MS Excel



	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	

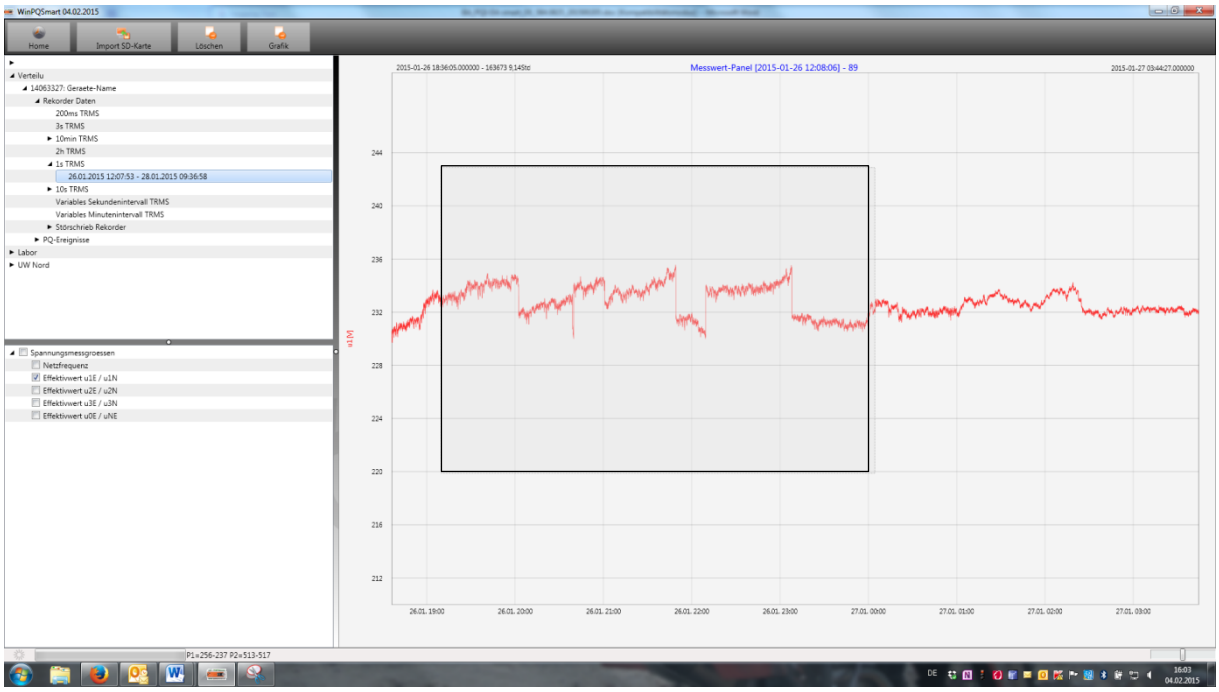
- **Copy image – photo is copied to the Windows clipboard**
- **Stack – associated measurement data can be represented with a common scale or separated**

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



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.

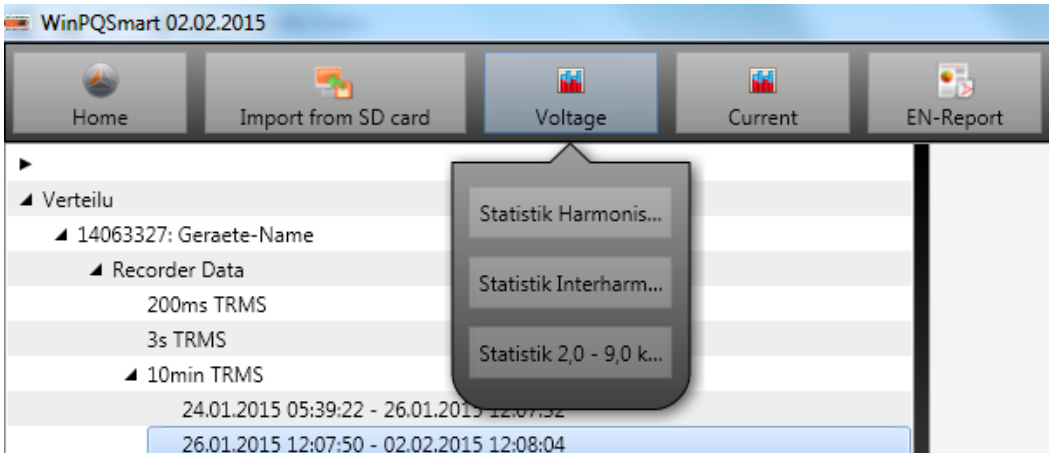


6.8.2 EN50160 report

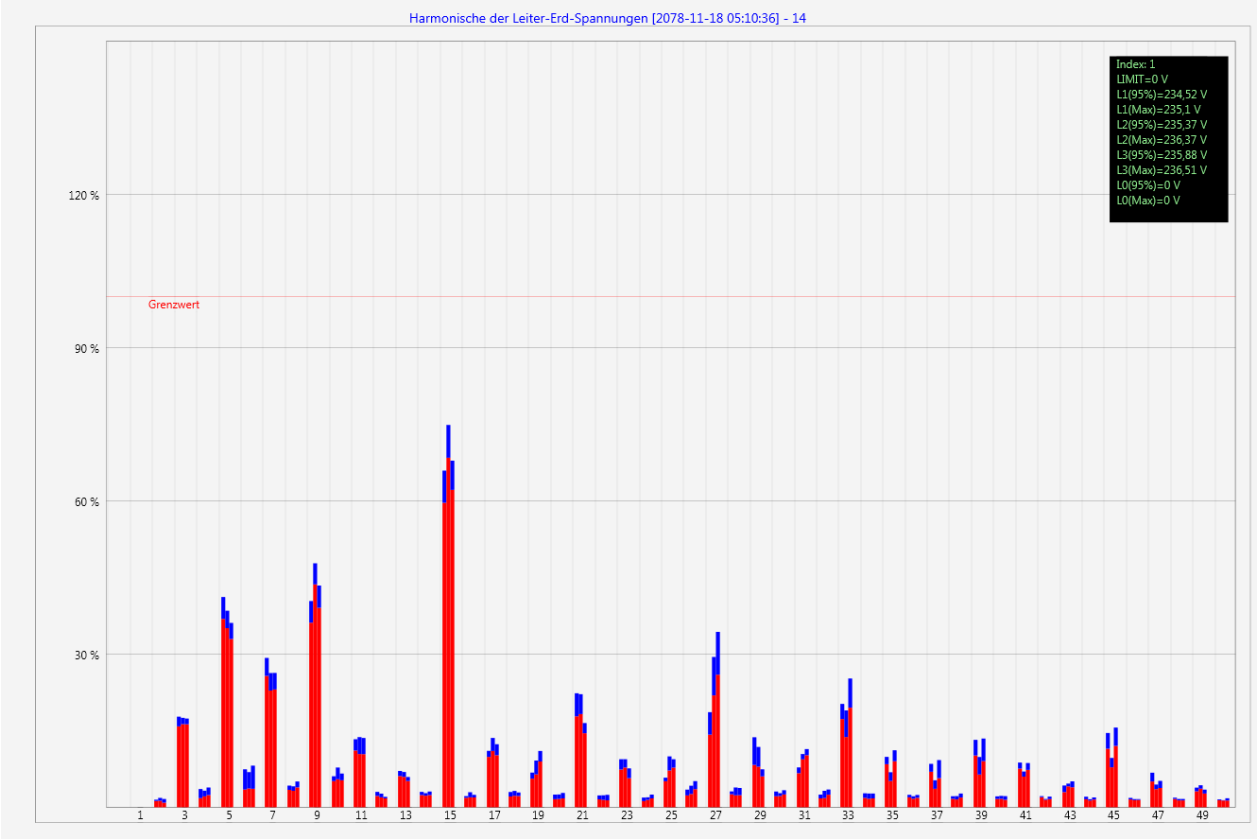
In the 10 minute data class, the EN50160 report is available. If you select one measurement file a multipage report is created.

6.8.3 Voltage harmonics - interharmonics

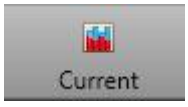
With the Icon “Voltage” you can reach the statistics of the voltage harmonics, voltage inter-harmonics and frequency bands 2 kHz to 9 kHz.



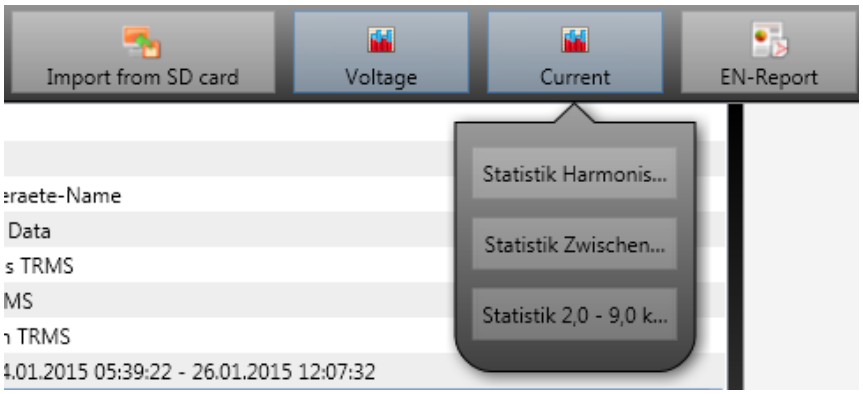
Example: Statistic voltage harmonic - scaled to the corresponding compatibility level of the power quality standard.



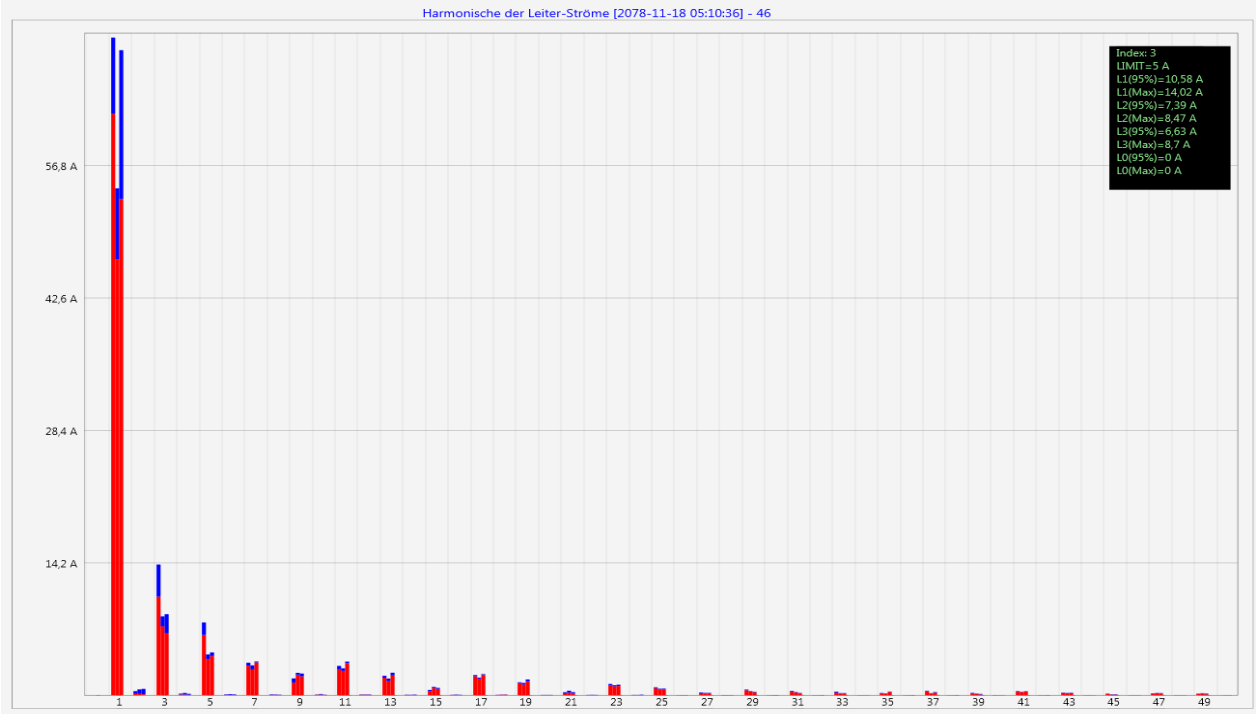
6.8.4 Currentharmonics – Interharmonics



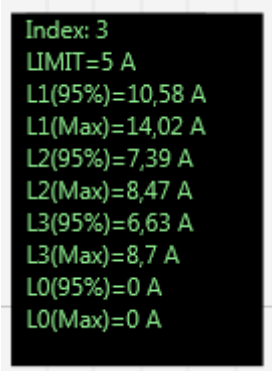
With the Icon “Voltage” you can reach the statistics of the voltage harmonics, voltage inter-harmonics and frequency bands 2 kHz to 9 kHz.



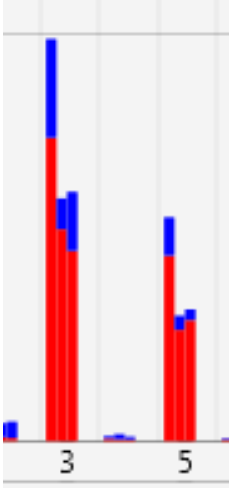
Example: Statistic current harmonics 2nd to 50th - scaling in ampere



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



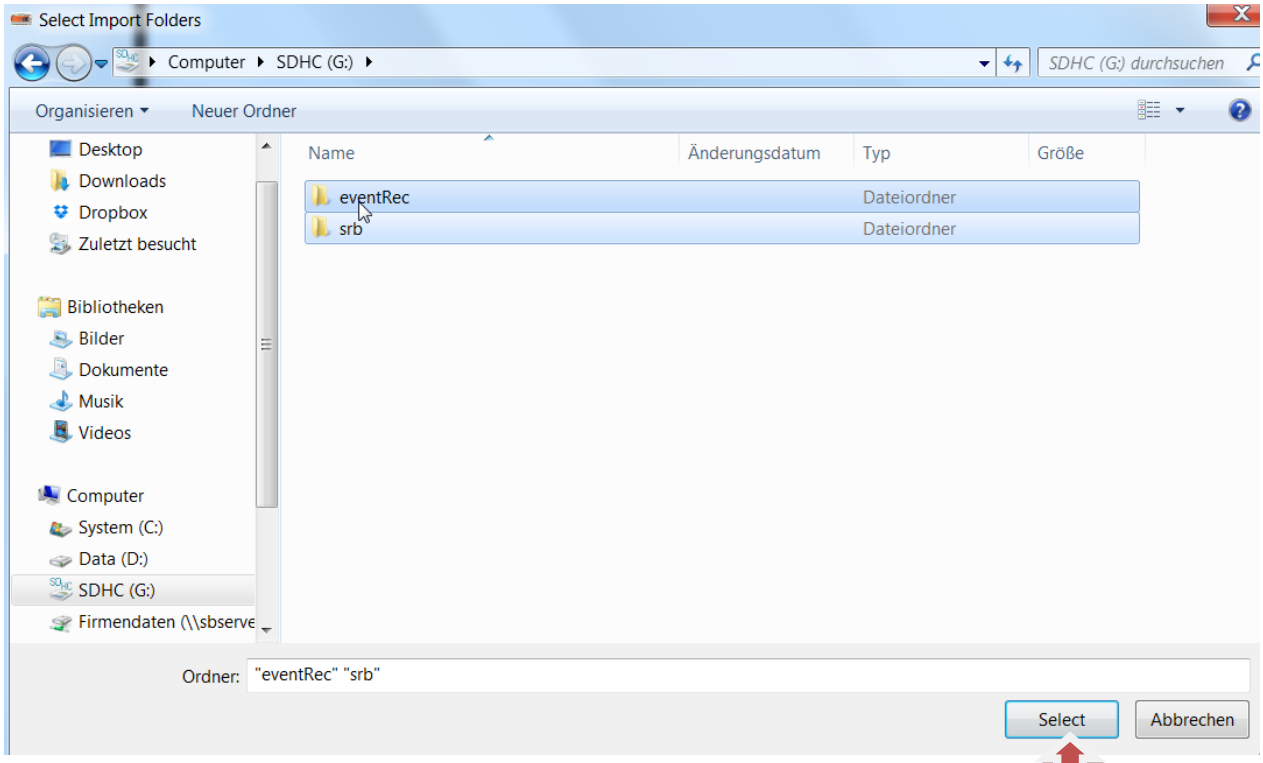
The red bar always shows the 95% values and the blue bar shows the maximum measured value.



6.9 Importing measurement data from an SD card

The function "Import from SD“ function is used to transfer selected measurement data from the SD memory card to the PC.

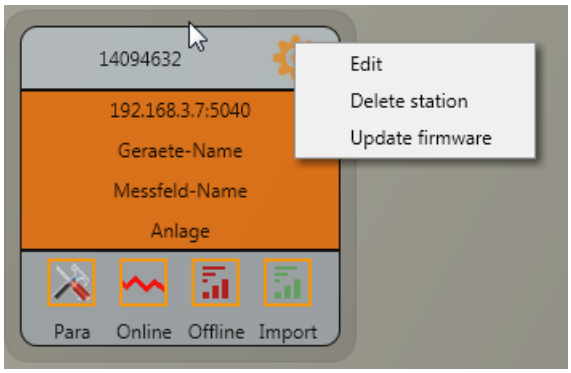
- Event Recorder – includes all Power Quality events
- srb – includes all long-term measurement data and sequence of events recordings



- **Highlight a folder**
- **Press "Select" to import**

7. Firmware update for PQI-DA smart

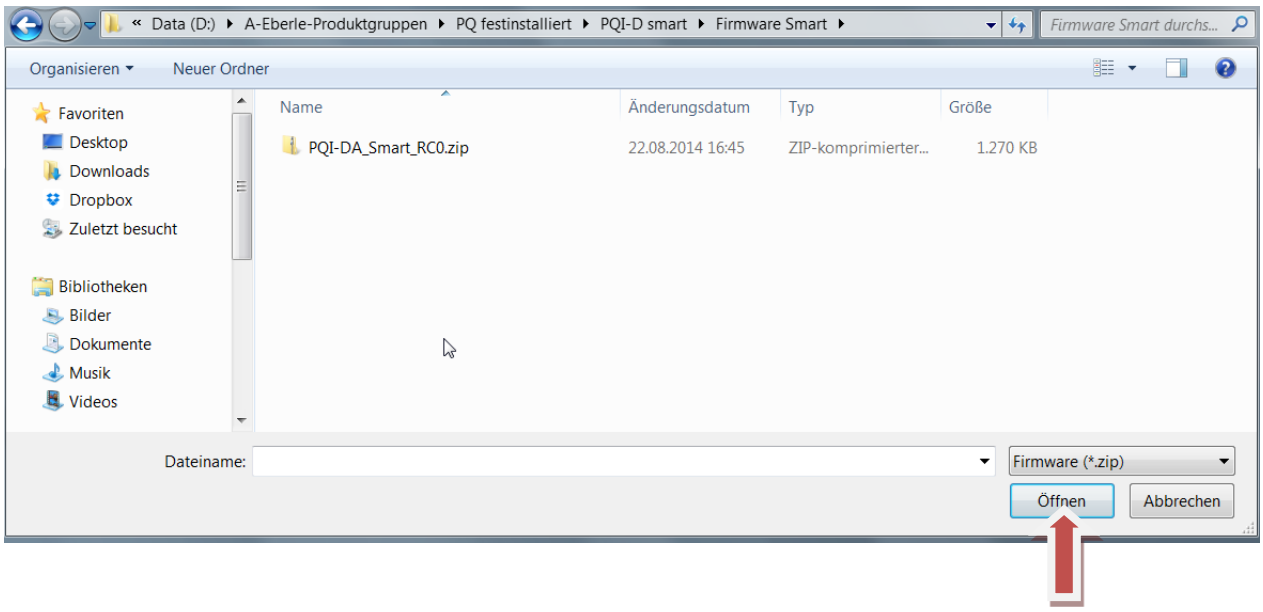
7.1 Firmware update with software WinPQ smart



The "General setup" function of the station tile can be used to carry out a firmware update for the PQI-DA *smart* 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.

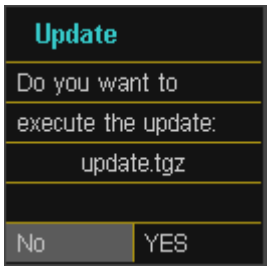


When the transfer of the firmware to the measuring device has been completed, it will automatically restart and install the new version.

7.2 Firmware update with SD-memory card

It is possible to make a firmware update on the PQI-DA smart using an SD memory card.
If an appropriate firmware is stored on the SD card, the instrument automatically detects this file after plugging.

- The following message appear automatically



- Press YES to install the firmware update on this device
- The PQI-DA smart does a reboot, after a successful installation.

8. License Update PQI-DA smart

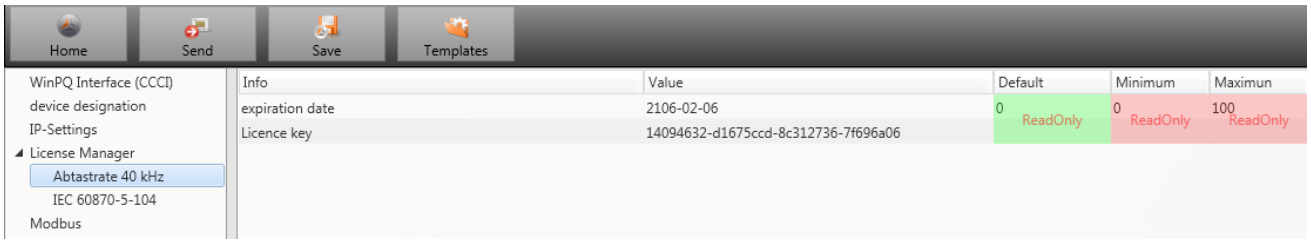
The network analyzer PQI-DA Smart can be equipped with various options. These options can be activated via a license code even after the purchase at any time.

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

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

Did you receive a valid license for the connected device, so please paste it to the device setting.

Example: Upgrading Option 40,96kHz for PQI-DA smart



The following options are available:

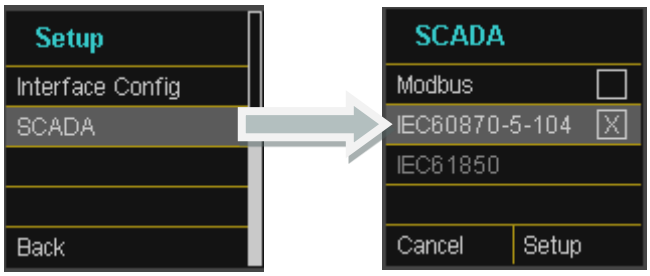
- 40,96kHz sampling (2kHz to 9kHz harmonic measurement)
- IEC 60870-5-104
- IEC 61850

9. SCADA

SCADA settings

In the device settings "SCADA" following protocols can be selected:

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



9.1 Modbus

The following data classes and events are available in the PQI-DA smart about Modbus TCP or Modbus RTU:

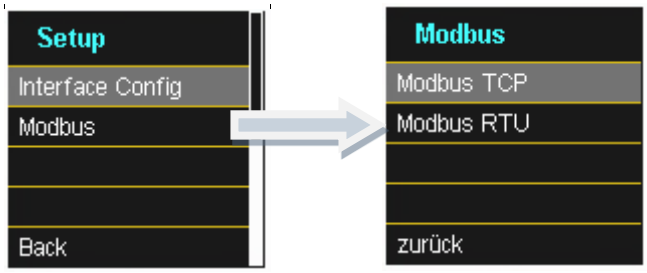
- 200ms data class (frequency, voltage L1, L2, L3)
- 1 sec data class (all measurement values)
- 10 min data class (all measurement values)
- N x min data class (power measurement values)
- 2h data class Plt long term flicker value
- Status of two binary inputs
- Power Quality and disturbance event counter (display PQI-DA smart)
- Endless counter for disturbance recorder
- Power Quality settings – write Modbus

9.2 Modbus data list

Please download the extensive Modbus data point list from our website www.a-Eberle .de
For Modbus are over 5000 measurement values available.

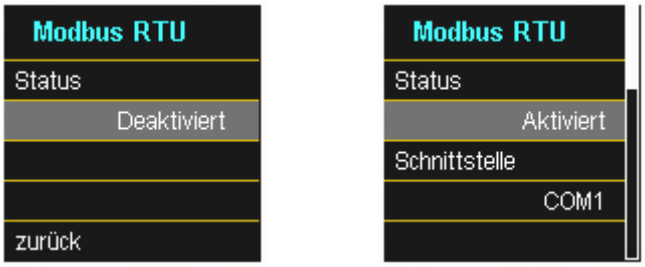
9.3 Modbus settings

Settings of the Modbus TCP and Modbus RTU interface can be changed via the device setup.

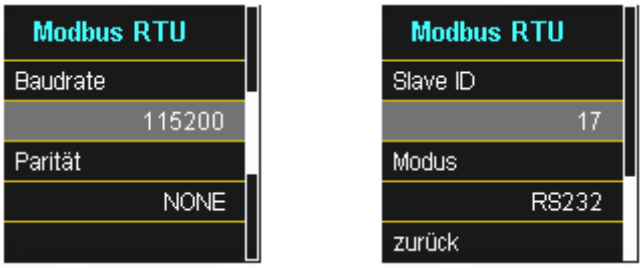


9.3.1 Modbus RTU

You can enable Modbus RTU and assign the interface. (COM1 or COM2)

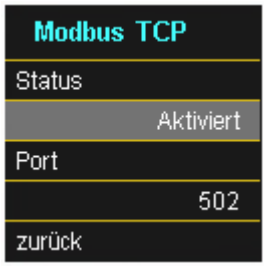


The interface can be changed to Modbus RTU RS232 or RS485.



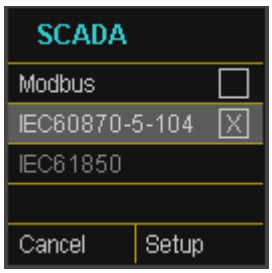
9.3.2 Modbus TCP

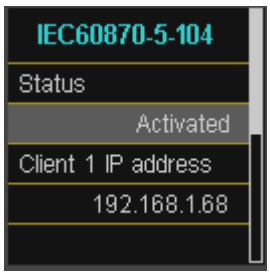
Modbus TCP is deactivated by default and can be enabled at this point.
The port number can be parameterized.



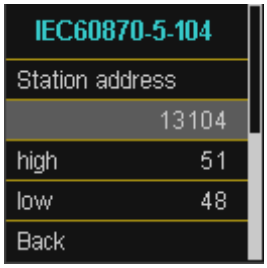
9.4 IEC60870-104

Under Device Settings / SCADA protocol can be selected and activated IEC60870-104.





You can setup the station address and client address directly in the display menue.



9.5 IEC60870-104 Data point

Please download the extensive IEC60870-104 data point list from our website www.a-Eberle .de
BA-SCADA PQI-DA smart

10. Intended use

The product is intended for measuring and evaluating voltage and current signals in the energy grid only.

11. Measurement data – measurement methods PQI-DA smart

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-DA *smart* 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.

The interval length Pst has been fixed to 10 minutes and is independent of the measurement interval set.

Formula for P_{lt} calculation:

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

The flickermeter can be parameterised in the device setup for the following grid configurations:

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

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

The sampling rate is at the nominal frequency 40.96 kSamples/s.

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

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

U 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)

Any interharmonics can be set In the PQ-Box 200 setup. 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. Pst and Plt are defined in EN 61000-4-15: 2010.

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

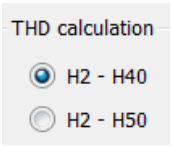
Formula for P_{lt} calculation:

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

THD – PWHD – K factor

All calculations are based on a 10/12 cycle averaging interval (50 Hz = 10 cycles / 60 Hz = 12 cycles),

according the formula of IEC61000-4-7 (exactly 2024 sample values will be used for calculation)



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

THD voltage:

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

THD current in %:

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

THD(A) current in Ampere:

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

PWHD - Partial Weighted Harmonic Distortion

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

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

PHC - Partial Odd Harmonic Current

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

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

K Factor

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

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

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

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

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

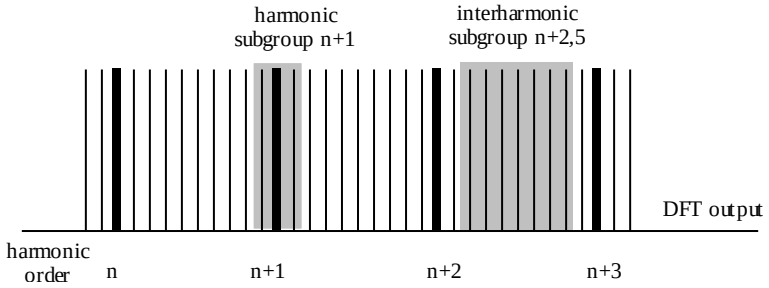
The device shows the K factor for the current. Only the K values that appear at maximum power are of interest. Just as with the THD of the currents in %, the value is not relevant at very low currents.

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

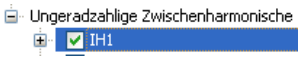
Harmonics / Interharmonics

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-DA smart 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):

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

Current harmonics:

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

Frequency analysis 2 kHz to 9 kHz

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

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

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

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

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:

$$Q_{L-10/12} = Sgn(\varphi_{L-10/12}) \cdot \sqrt{S_{L-10/12}^2 - P_{L-10/12}^2}$$

$$Q_{10/12} = Sgn(\varphi_{1-10/12}) \cdot \sqrt{S_{10/12}^2 - P_{10/12}^2}$$

Reactive energy:

"Supply reactive energy" inductive reactive energies +EQ.

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

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

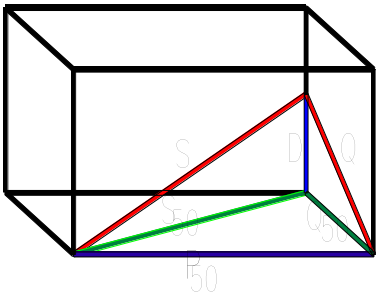
"Consumer reactive energy" capacitative reactive energies -EQ.

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

Distortion reactive power - D

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

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



Power Factor PF

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

The ration is expressed in the following equation:

Power Factor PF: λ = IPI / S

Apparent Power - S

In the setup of the PQ Box 200 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 synchronisation cycle.

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

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

The 10 min values are calculated as linear averages.

The collective effective power is defined for 4-wire 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 [%].

12. Service

This unit is maintenance-free for customers.

 **DANGER**	**Danger of 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

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

13. Disposal

To dispose of the device and its accessories, please return all components to A. Eberle.

14. Product Warranty

A. Eberle warrants that this product and its accessories shall be free from defects in materials and workmanship for a period of three years from the date of purchase. This warranty does not cover damage caused by accident, misuse or abnormal operating conditions.

To make a claim under this warranty, please contact A.Eberle GmbH & Co KG in Nürnberg, Germany.

A. Eberle GmbH & Co. KG

Frankenstraße 160
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Germany

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http://www.a-eberle.de

No. 584.0826

Vers. PQI-DA *smart* – 07/22/2015

Power Quality Network Analyser – Model PQI-DA smart