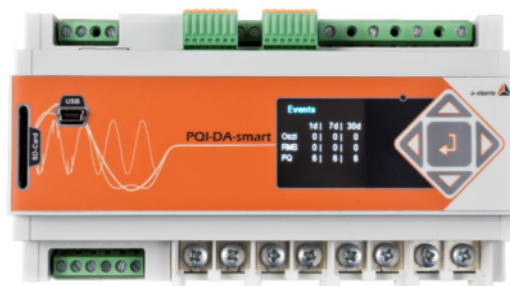


A Power Quality Interface for Low and Medium Voltage Smart Grids

Model PQI-DA smart

- ▶ Wall-mounted housing
- ▶ DIN-Rail housing
- ▶ Panel mounting housing



1. Application

Solving all measurement tasks in electrical grids can be a daunting task. The new Power Quality Interface and Disturbance Recorder *PQI-DA smart*, aimed at low and medium voltage grids, represents the A-Eberle response to such needs. This central component can be used either as Power Quality-Interface in accordance with all Power Quality standards or as a device for all physically defined/measured values in typical three-phase systems.

Beside the possibility of standard evaluations, the *PQI-DA smart* also has a high speed fault recorder capability with a 40.96kHz/10.24kHz recording rate and a half cycle r.m.s. registration, which allows for a detailed analysis of grid disturbances.

In particular, *PQI-DA smart* is suitable for monitoring, registering, evaluating and recording special reference quantities or quality agreements between the supplier of energy and the end customer.

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

Devices from different manufacturers operating according to this standard, must offer the same measurement results.

IEC 61000-4-30 standard distinguishes two classes of measuring devices:

- Class A devices - used for measurements related to contracts in customer-supplier relationships.
- Class S devices - 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
Supply voltage unbalance	A
Voltage harmonics	A
Voltage interharmonics	A
Mains signaling voltage	A
Underdeviation and overdeviation	A
Measurement aggregation intervals	A
Time-clock uncertainty	A
Flagging	A
Transient influence quantities	A

2. Design

The *PQI-DA smart* has been developed for measurements performed within public grids as well as for recording PQ data within an industrial environment up to 690V (L-L) measurement voltage. Its key characteristics, making it suitable for such environments, are:

- 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.

2.1 Characteristics of the Power-Quality Interface *PQI-DA smart*

2.1.1 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
FSR : 480V L-N, Accuracy < 0.1%
- 4 current inputs
1A/5A nominal,
- 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 voltage quality processing
- Recording of DIN EN 50160 power quality events
- 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

L x B x H	160 x 90 x 58 mm
-----------	------------------

Voltage inputs	
Channels	$U_1, U_2, U_3, U_{N/E/4}$
Electrical safety DIN EN 61010	300V CAT IV 600V CAT III
Input reference level	PE
Impedance -> PE	10 M Ω 25pF
Nominal input voltage U_n	230VAC
Full scale range (FSR)	0...480VAC L-E
Waveform	AC & DC, any
Maximum crest factor @ U_n	3
Bandwidth	DC...20kHz
Nominal power frequency f_n	50Hz / 60Hz
Frequency range of the fundamental	$f_n \pm 15\%$ 42.5...50...57.5Hz 51.0...60...69.0Hz
Accuracy	
Fundamental, r.m.s	$\pm 0.1\% U_n$ (0°C...45°C) $\pm 0.2\% U_n$ (- 25°C...55°C) @ 10%...150% U_n
Fundamental, Phase	$\pm 0.01^\circ$ @ 10%...150% U_n
Harmonics $n = 2..50$, r.m.s.	$\pm 5\%$ of reading @ $U_h \geq 1\% U_n$ $\pm 0.05\% U_n$ @ $U_h < 1\% U_n$
Harmonics $n = 2..50$, Phase	$\pm n \cdot 0.01^\circ$ @ $U_h \geq 1\% U_n$
Interharmonics $n = 1..49$, r.m.s.	$\pm 5\%$ of reading @ $U_{ih} \geq 1\% U_n$ $\pm 0.05\% U_n$ @ $U_{ih} < 1\% U_n$
Power frequency	$\pm 10\text{mHz}$ @ 10%...200% U_n
Flicker DIN EN 61000-4-15:2011	Class F2
Dip residual voltage	$\pm 0.2\% U_n$ @ 10%...100% U_n
Dip duration	$\pm 20\text{ms}$ @ 10%...100% U_n
Swell residual voltage	$\pm 0.2\% U_n$ @ 100%...150% U_n
Swell duration	$\pm 20\text{ms}$

Voltage inputs	
	@ 100%...150% U_n
Interruption duration	$\pm 20\text{ms}$ @ 1%...100% U_n
Voltage unbalance	$\pm 0.15\%$ @ 1%...5% reading
Mains signaling voltage ($< 3\text{kHz}$)	$\pm 5\%$ of reading @ $U_s = 3\%..15\% U_n$ $\pm 0.15\% U_n$ @ $U_s = 1\%..3\% U_n$

Current inputs		
Option	C30	C31
Channels	I1, I2, I3, IN/4	
Electrical safety DIN EN 61010	300V CAT III	
Input type	Differential, isolated	
Impedance	$\leq 4\text{m}\Omega$	
Nominal input current I_n	5 A _{AC}	
Full scale range (FSR)	10A _{AC}	100A _{AC}
Overload capacity permanent $\leq 10\text{s}$ $\leq 1\text{s}$	20 A 100 A 500 A	
Waveform	AC, any	
Maximum crest factor @ I_n	4	
Bandwidth	25Hz...20kHz	

Accuracy		
Fundamental, r.m.s	$< 0,1\%$ FSR 5%...100%	$< 0,2\%$ FSR 5% ... 10%
Fundamental, Phase	$\pm 0,1^\circ$ 5%...100%	$\pm 0,2^\circ$ 5% ... 10%
Harmonics $n = 2..50$, r.m.s.	5% 5%...100%	10% 5% ... 10%
Harmonics $n = 2..50$, Phase	$\pm n \cdot 0,1^\circ$ 5%...100%	$\pm n \cdot 0,2^\circ$ 5% ... 10%
Interharmonics $n = 1..49$, r.m.s.	$\pm 5\%$ 5%...100%	$\pm 10\%$ 5% ... 10%

Storage of measured values

		Power supply		
Internal memory	1024 MB	Feature	H1	H2
SD memory card	1 GByte to 32 GByte	AC	90...264 V	-
		DC	120...300 V	18...72 V
		Power consumption.	≤ 10 W < 20VA	≤ 10 Watt
		Frequency	40...70Hz	-
		External fuse characteristics	6A B	6A B
		Energy storage	2 sec	2 sec
Binary inputs (BI)				
Range	48...250 VAC(/DC)			
— H – Level	> 35 V			
— L – Level	< 20 V			
Signal frequency	DC ... 70 Hz			
Input resistance	> 100kΩ			
Electrical isolation	Optocoupler, electrically isolated			
Electrical safety DIN EN 61010	300V			
Binary outputs (BO)				
Contact specification (EN60947-4-1, -5-1) :				
Configuration	SPDT			
Rated voltage	250VAC			
Rated current	6A			
Rated load AC1	1500VA			
Rated load AC15, 230VAC	300VA			
Breaking capacity DC1, 30/110/220 V	6/0.2/0.12A			
No. of switching operations AC1	≥ 60·10 ³ electrical			
Electrical isolation	Isolated from all internally potentials			
Electrical safety DIN EN 61010	300V			

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
Measurement category	300V / CAT IV 600V / CAT III
Altitude	≤ 2000m

Electromagnetic Compatibility

Immunity

- IEC 61000-6-5, environment G

Emissions

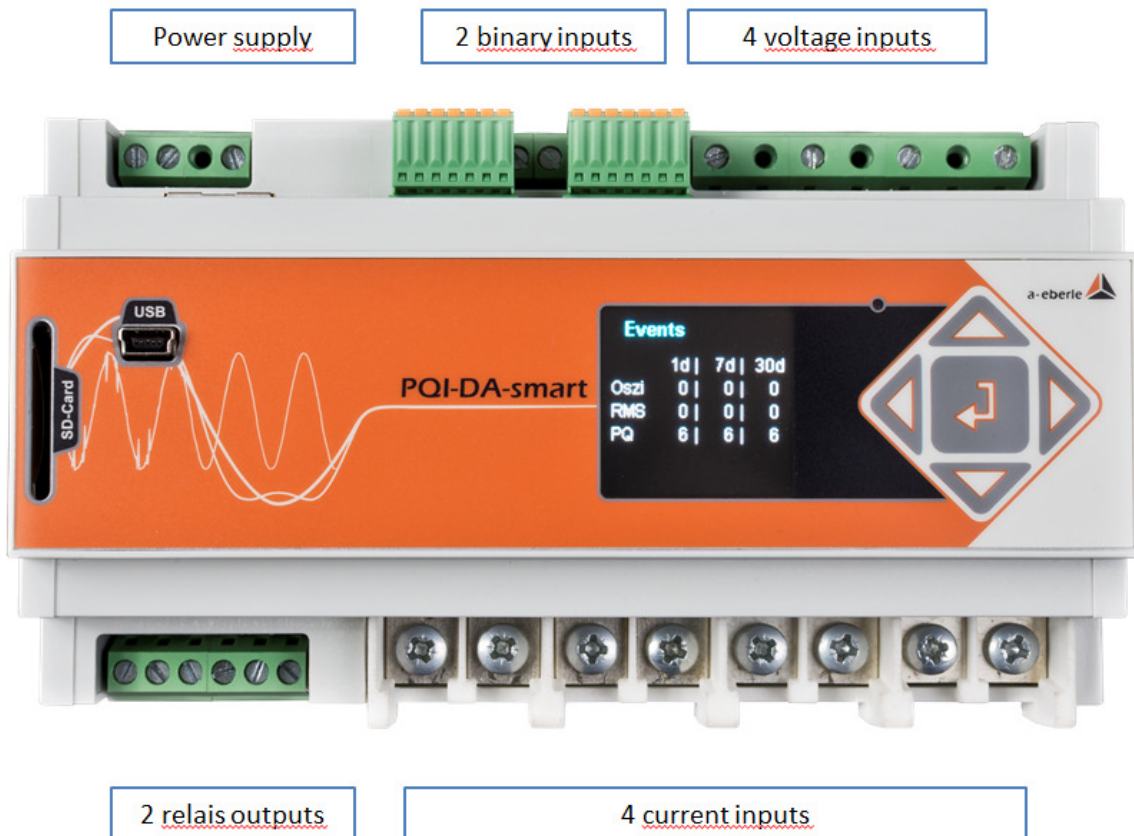
- CISPR22 (EN 55022) , class A

2.1.2 Mechanical design

The PQI-DA smart is mountable on the wall or via its 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.

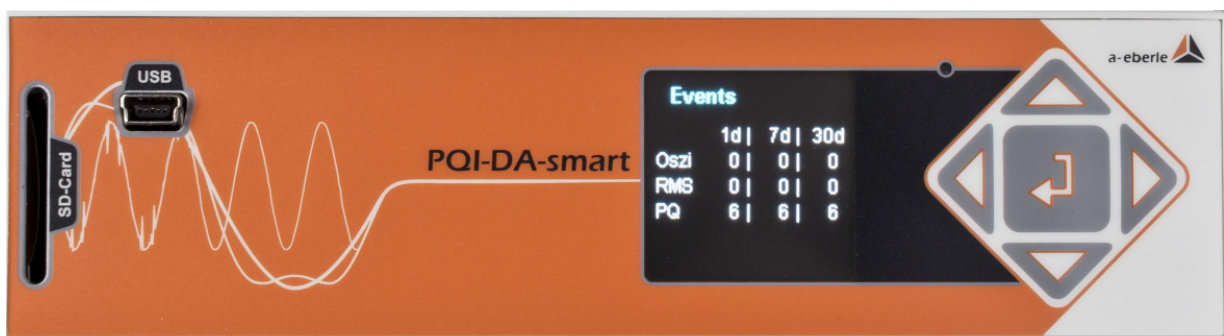
For the TCP/IP interface one RJ 45-connector is available.



2.1.3 Colour display

The device's 1.7-inch colour display provides information about the correct connections for the measuring cables and current transducers, as well as it indicates online data on voltage, current, THD, power values and energy.

The number of PQ-events that occurred, the oscilloscope records and r.m.s. records for different periods (last day, week or month) are also displayed.



2.2 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

Continuous Recording :

Five fixed and two variable measurement time intervals are available for continuous recording:

10/12 T (200ms), 1 sec, n*sec, 150/180 T (3sec), n*min, 10 min, 2 h

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/ 180T	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)			✓	✓	✓	✓	✓

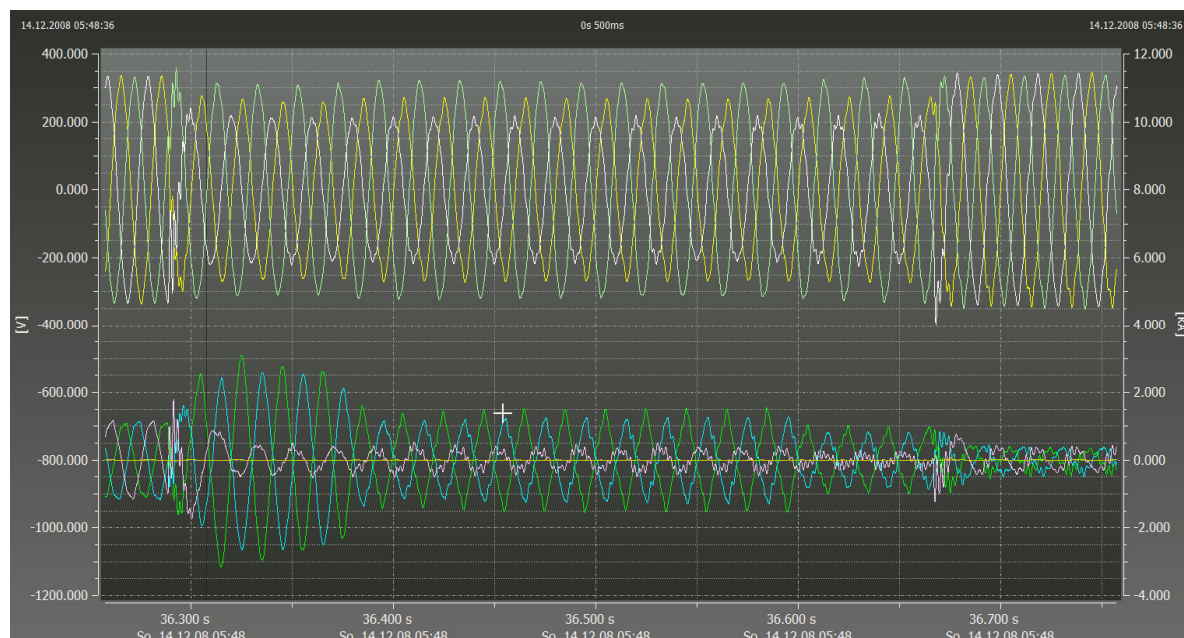
Time Interval Energy	10 min	2 h	1 s	N* s	N* min
Active energy, phase	✓	✓	✓	✓	✓
Active energy, total	✓	✓	✓	✓	✓
Exported active energy, phase	✓	✓	✓	✓	✓
Exported active energy, total	✓	✓	✓	✓	✓
Imported active energy, phase	✓	✓	✓	✓	✓
Imported active energy, total	✓	✓	✓	✓	✓
Reactive energy (inductive), phase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

2.3 Oscilloscopic recorder:

Sampling rate: 40.96kHz or 10.24kHz
 Max. record length: 4s (40.96kHz) or 16s (10.24kHz)

Quantities	
3-wire system	4-wire system
phase – ground voltages	phase –neutral voltages
residual voltage	neutral – ground voltage
phase – phase voltages	
phase currents	
total current	neutral current



2.4 Half cycle recorder:

Recording rate: ~10ms (50Hz) or ~8.333ms (60Hz)

Max. record length: 6min (50Hz) or 5min (60Hz)

Quantities
Power frequency
r.m.s. voltages
r.m.s. currents
Active power, phase
Reactive power, phase
Active power, total
Fundamental reactive power (displacement), total
Phase angle of fundamental apparent power, total
Voltage phasors (fundamental)
Current phasors (fundamental)
Positive-, negative-, zero sequence voltage phasors
Positive-, negative-, zero sequence current phasors



2.5 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		

2.6 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)	✓	✓

2.7 Online mode for direct readings:

Measurement / Functions

Oscilloscopic recorder

Power cube for active, reactive, apparent power and distortion power

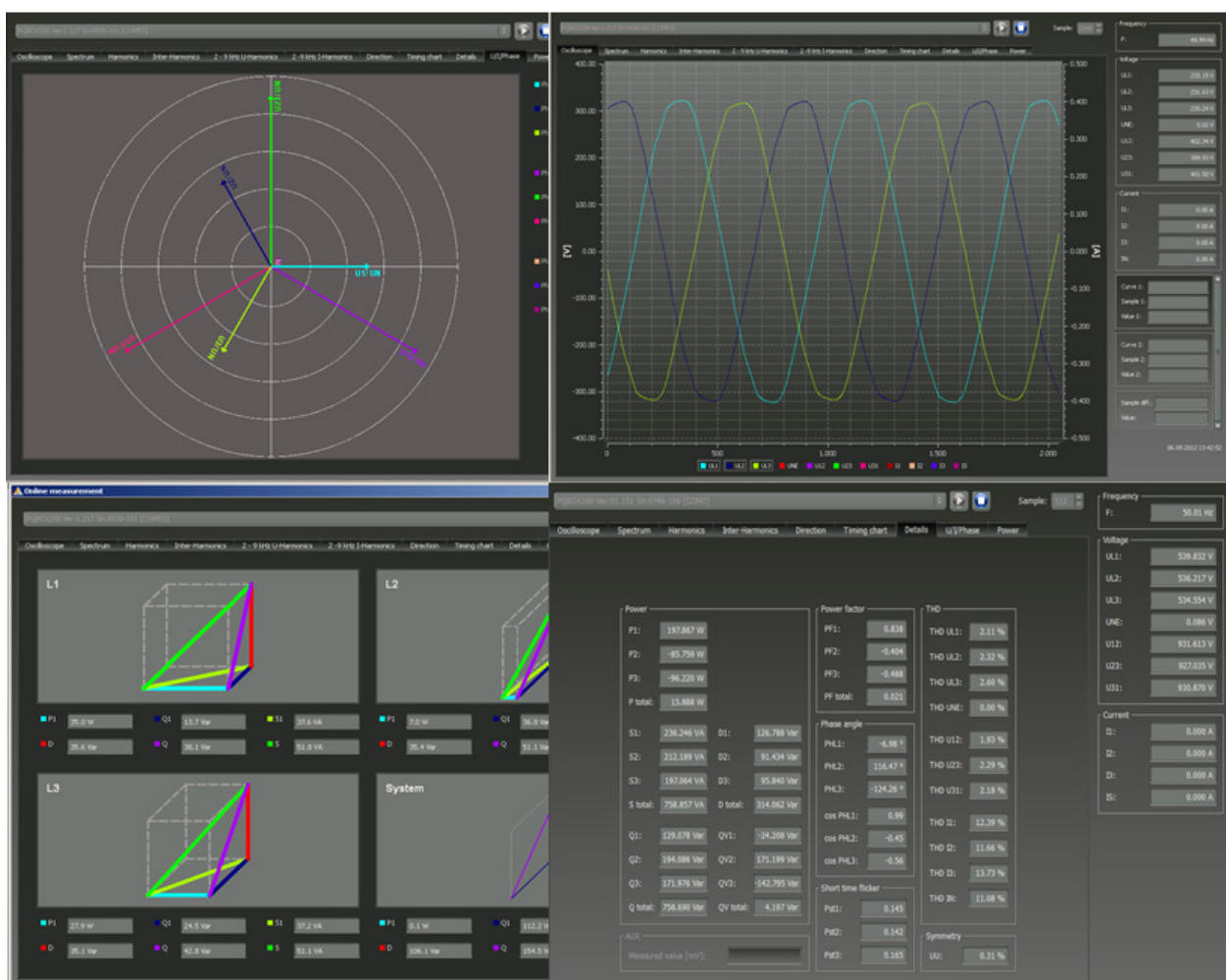
Voltage and current harmonics $n=2..50$

Voltage and current interharmonics $n=0..49$

Phase of current harmonics $n=2..50$

Harmonic power $n=2..50 : \pm P_n, \pm Q_n$

Frequency spectra up to 20kHz of voltages and currents



3. Order specifications *PQI-DA smart*

For determining the smart code ordering details:

- Only one unit can be ordered for codes with the same capital letter.
- When a code's capital letter is followed by the number 9, additional information in plain text is required.
- When a code's capital letter is followed only by zeros, the code may be omitted.

Characteristic	Code
Power Quality Interface for Medium and High 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 <i>PQI-DA smart</i>	<i>PQI-DA smart</i>
Current inputs ● 4 current inputs for metering circuit 1A/5A (range 10A) ● 4 current inputs for protection circuit 1A/5A (range 100A)	C30 C31
Supply voltage ● AC 90 V..110 V..264 V or DC 120 V..220 V..300 V ● DC 18 V...60 V...72 V	H1 H2
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
Option communication protocol ● Modbus RTU & TCP ● IEC 60870-5-104 (RJ45) ● IEC61850 (RJ45)	P0 P1 P2
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

3.1 Option PQI-DA smart

AE Toolbox SW	Code
Software WinPQ smart For parameterising <i>PQI-DA smart</i> , as well as reading <i>PQI-DA smart</i> measurement data and online data as a single-user licence – 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 Data 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	564.0435
Frame for panel mounting	564.0433
Radio time clock interface DFC 77	111.9024
GPS clock - H1: AC/DC 88 V...264 V D2: RS485	111.9024.45
GPS clock - H2: DC 18 V...72 V D2: RS485	111.9024.46

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