a-eberle

Operating manual

Power Quality Interface

GB

PQI-DA model

Note:

The current version of the operating manual is based on firmware versions 4.0.05 (2x4xU) and 5.0.11, 7.0.01 (4xU, 4xI) .

It is updated continuously.

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

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Contents

Safety information

Electrical safety

Before you begin to commission the device, you should be aware of some of the dangers that may occur if the device is used improperly.

- **The PQI-DA is a device with degree of protection I. Before it is connected to the voltage, it must first be connected to the system's earthing system via its protective earth connection.**
- **The connected circuits must not exceed the protection category of the device (e.g. measurement inputs: CAT III / 300V).**
- **The device must not be used in circuits that contain corona discharges.**
- **The device must be removed from the network immediately if it is determined that the device can no longer be operated safely due to a mechanical or electrical fault.**
- **Before the terminal connections of the current transformers are removed from the device, the secondary circuits of the current transformers must be short-circuited.**
- **Please note that there is a danger to life wherever a voltage of > 50 V r.m.s. is present.**

Mounting

The operational safety of the device can only be ensured when the electrical connection data of the device supplied match the requirements which apply at the installation location.

Please check the following parameters against the type plate:

- **Auxiliary voltage input: Supply voltage range**

H0 : AC 100V ... 110V ... 240V / DC 100V..220V..300V

H1 : DC 20V...60V...70V

- **Current measurement inputs: Max. continuous current**

C20; C21 : 5A

C30, C31 : 10A

- **Voltage measurement inputs: Max. voltage**

E1 : 200 V AC

E2 : 460 V AC

E9 : 200 V AC, 460 V AC

- **Binary inputs: Maximum input voltage**

M1 : 48…250 V AC/DC
M2 : 10…48 V DC

Technical concept

Application

The state-of-the-art PQI-DA Power Quality Interface for low, medium and high voltage networks is the main component of a system for carrying out all of the required measurement tasks in electrical networks. The PQI-DA can be used as both a power quality interface according to DIN EN 50160 and as a measurement device for measuring all physically defined measurement quantities in three-phase networks.

The component is primarily designed to monitor special reference quantities and quality agreements between the energy supplier and the customer, as well as to record, analyse and save the data.

Modern voltage quality measurement devices operate according to the IEC 61000-4-30 standard. This standard defines measurement methods and so provides the user with a basis for comparison.

Devices from different manufacturers, which fulfil class A of this standard, must provide the same measurement results.

The standard defines two measuring device classes.

Class A measuring devices are used primarily for measurements related to contracts in customer/supplier relationships, while Class B measuring devices can be used for determining statistical quality values.

The PQI-DA complies with the requirements of IEC 61000-4-30 (2008) for class A devices for the all parameters.

Parameter	Class
Accuracy of voltage measurement	A
Determination of time intervals	A
Marking of measurement values for events	A
Harmonics, interharmonics	A
Flicker	A
Frequency	A
Voltage asymmetry	A
Event recording	A
Synchronisation	A

Five procedures are available for event-triggered fault recording:

The **event recorder** stores the messages that denote the type, time and properties of events in chronological order.

The **oscilloscope recorder** stores the sampling values of fault events with pre-event and post-event history.

The **r.m.s. recorder** stores the half-period r.m.s. values of fault events with pre-event and post-event history.

The **signal voltage recorder** stores the 10/12-period r.m.s. values of an adjustable frequency range (e.g. ripple-control frequency).

The **harmonic recorder** stores the 10-minute spectrum of the harmonics from the 2nd to 50th harmonic for voltages and currents.

All fault records are triggered by an event or combination of events which can be freely defined. This enables phase-phase and phase-earth events to be recorded simultaneously.

Event messages (e.g. limit value violations) can also be signalled directly via relays if required.

The device has two RS 232 interfaces (COM 1 and COM 2) and two E-LAN (Energy Local Area Network) system/transport bus interfaces, which can be used to network up to 255 REGSys™ devices.

The PQI-DA can also be optionally equipped with an integrated TCP/IP interface instead of a COM2.

The PQI-DA is accessed via a PC, which in turn can be connected to one or more PQI-DAs via the COM interface.

WinPQ and WinPQ Para Express are available as PC programs.

It supports the parameterisation, download and time-constant backup of measurement data in a database on the PC.

The measurement data can be accessed continuously, cyclically or once only by the device.

Both offline data (from the database) and online data (from the device) can be displayed.

A button protected against unintentional touching is provided for firmware updates.

The device is available in several different versions.

Current inputs are available for the measurement circuit (C20, C30) and for the protective circuit (C21, C31).

The following measurement channel variants can be selected:

- 8 voltage transformers for power quality applications in double busbar systems (feature C10)
- 4 voltage transformers and 4 current transformers for power quality and general measurement tasks (features C20, C21, C30, C31)

PQI-DA power quality interface and disturbance recorder features

- Measuring the voltage quality according to DIN EN 50160
- Class A device according to IEC 61000- 4-30
- Sampling rate 10.24 kHz
- Fault recorder function up to 20 x nominal current (100 x In)
- Phase-phase and phase-earth measurements are possible simultaneously
- Voltage measurement channels for U_{12}, U_{23}, U_{31}, U_{NE}
- Recording of currents I_1, I_2, I_3, I_0
- Determination of over 3000 measurement values
- Freely programmable limit values and outputs using isolated contacts
- Freely programmable binary inputs to start and stop measurements remotely
- Analysis of the data via a mySQL-supported database with the help of the WinPQ software package
- Version with integrated TCP/IP interface available
- Connection to the control system according to IEC 870-5-103 or IEC61850 available as an option.

Description

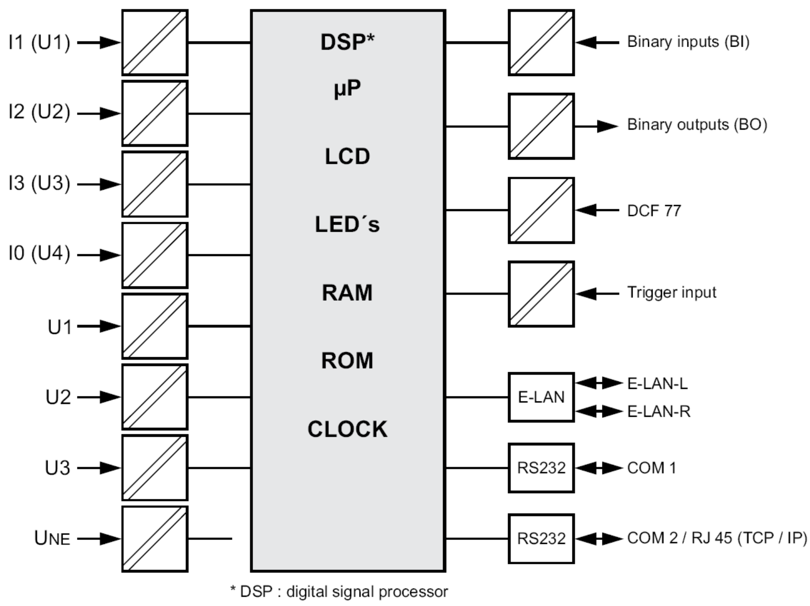
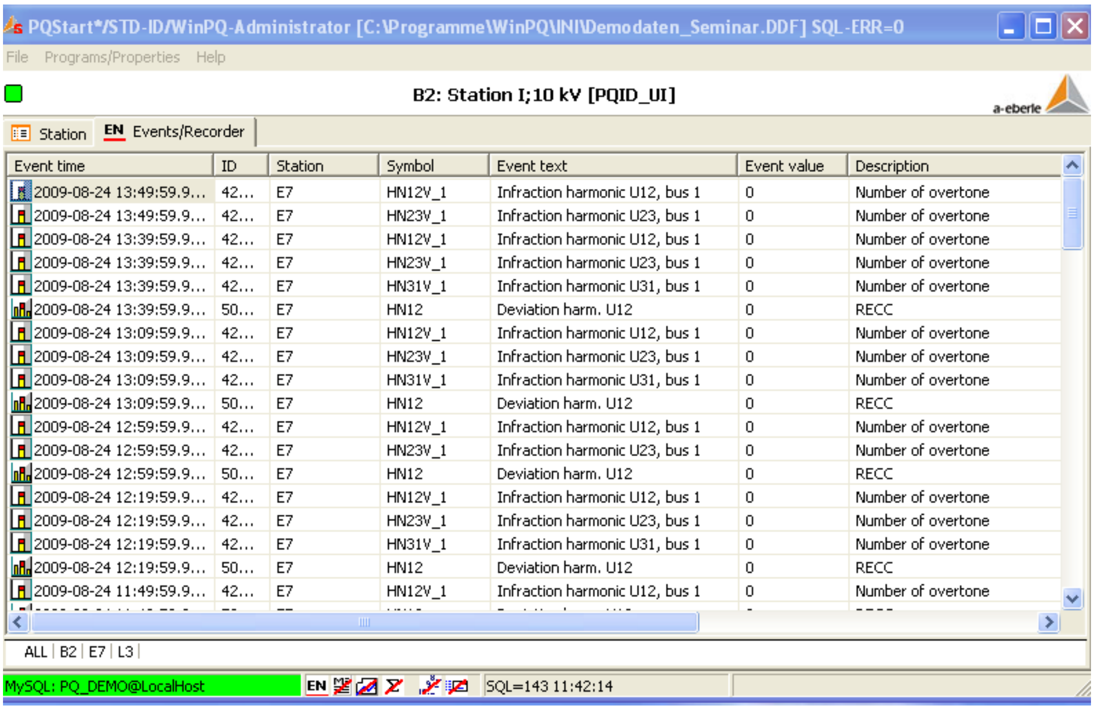


Bild 1: Power quality interface function

Fault recorder

Event recorder



Event time	ID	Station	Symbol	Event text	Event value	Description
2009-08-24 13:49:59.9...	42...	E7	HN12V_1	Infraction harmonic U12, bus 1	0	Number of overtone
2009-08-24 13:49:59.9...	42...	E7	HN23V_1	Infraction harmonic U23, bus 1	0	Number of overtone
2009-08-24 13:39:59.9...	42...	E7	HN12V_1	Infraction harmonic U12, bus 1	0	Number of overtone
2009-08-24 13:39:59.9...	42...	E7	HN23V_1	Infraction harmonic U23, bus 1	0	Number of overtone
2009-08-24 13:39:59.9...	42...	E7	HN31V_1	Infraction harmonic U31, bus 1	0	Number of overtone
2009-08-24 13:39:59.9...	50...	E7	HN12	Deviation harm. U12	0	RECC
2009-08-24 13:09:59.9...	42...	E7	HN12V_1	Infraction harmonic U12, bus 1	0	Number of overtone
2009-08-24 13:09:59.9...	42...	E7	HN23V_1	Infraction harmonic U23, bus 1	0	Number of overtone
2009-08-24 13:09:59.9...	42...	E7	HN31V_1	Infraction harmonic U31, bus 1	0	Number of overtone
2009-08-24 13:09:59.9...	50...	E7	HN12	Deviation harm. U12	0	RECC
2009-08-24 12:59:59.9...	42...	E7	HN12V_1	Infraction harmonic U12, bus 1	0	Number of overtone
2009-08-24 12:59:59.9...	42...	E7	HN23V_1	Infraction harmonic U23, bus 1	0	Number of overtone
2009-08-24 12:59:59.9...	50...	E7	HN12	Deviation harm. U12	0	RECC
2009-08-24 12:19:59.9...	42...	E7	HN12V_1	Infraction harmonic U12, bus 1	0	Number of overtone
2009-08-24 12:19:59.9...	42...	E7	HN23V_1	Infraction harmonic U23, bus 1	0	Number of overtone
2009-08-24 12:19:59.9...	42...	E7	HN31V_1	Infraction harmonic U31, bus 1	0	Number of overtone
2009-08-24 12:19:59.9...	50...	E7	HN12	Deviation harm. U12	0	RECC
2009-08-24 11:49:59.9...	42...	E7	HN12V_1	Infraction harmonic U12, bus 1	0	Number of overtone

The event recorder stores the messages that denote the type, time and properties of events in chronological order.

All events have the same data structure and contain the following components

Time stamp	: Time at which the event occurred
Identifier	: Type of event
Event value	: Specific magnitude of event

All relevant system processes are registered in events.

The event recorder can be seen as a log book that provides a central, quick history overview for all procedures with minimal memory requirements. These include messages that refer to detailed records for fault events, for example.

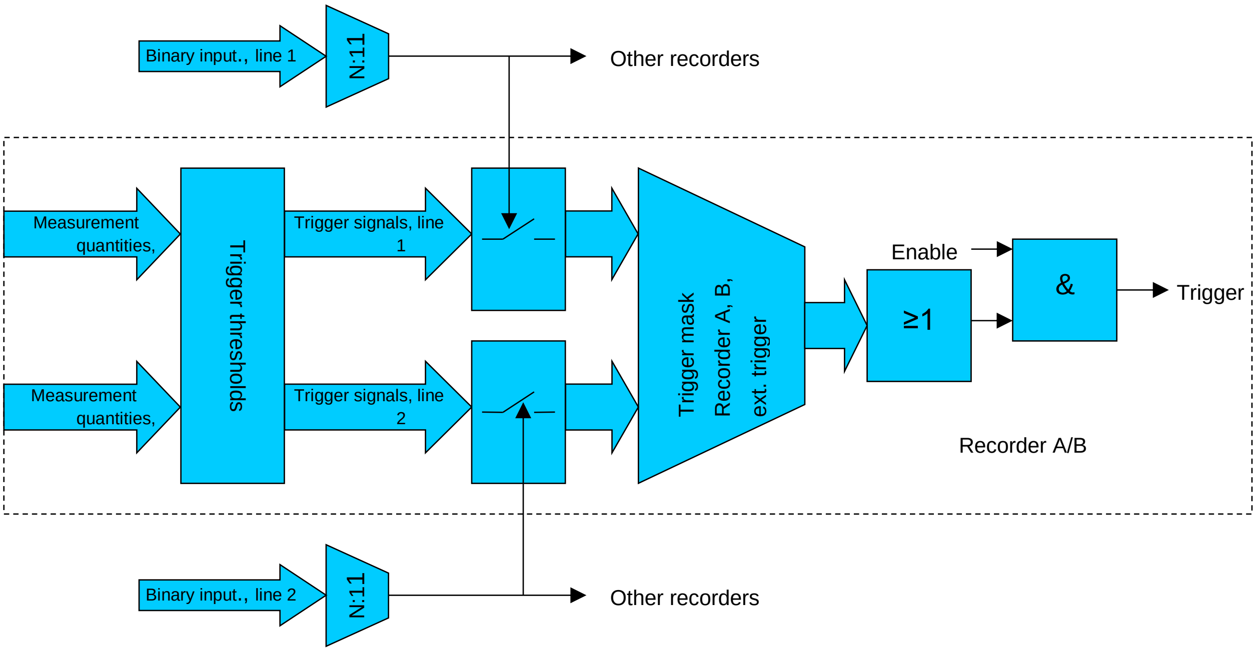
The user can apply a configurable event filter to select the messages that are to be stored.

Oscilloscope, r.m.s. value recorder

The oscilloscope recorder of the PQI-DA is also referred to as recorder A, and the r.m.s. value recorder as recorder B.

Trigger conditions

The central trigger uses the various measurement quantities and associated thresholds to generate corresponding binary trigger signals, which are evaluated using the individual trigger masks of recorders A, B and the external trigger to activate the triggering.



Voltage trigger signals:

Designation	$U_{LE/N}$	U_{NE}	U_L
Lower limit for half-period r.m.s. values	✓		✓
Upper limit for half-period r.m.s. values	✓	✓	✓
Jump in half-period r.m.s. values	✓	✓	✓
Jump in half-period phases	✓		
Envelope curve trigger sampling values	✓	✓	✓
Lower limit of symmetrical components, half-period values	Positive-sequence system		
Upper limit of symmetrical components, half-period values	Positive/negative/zero-sequence system		

Current trigger signals (4xU, 4xI only):

Designation	I_L	$I_{E/N}$
Lower limit for half-period r.m.s. values	✓	
Upper limit for half-period r.m.s. values	✓	✓
Jump in half-period r.m.s. values	✓	✓

Frequency trigger signals:

Designation
Lower limit for half-period frequency
Upper limit for half-period frequency
Jump in half-period frequency

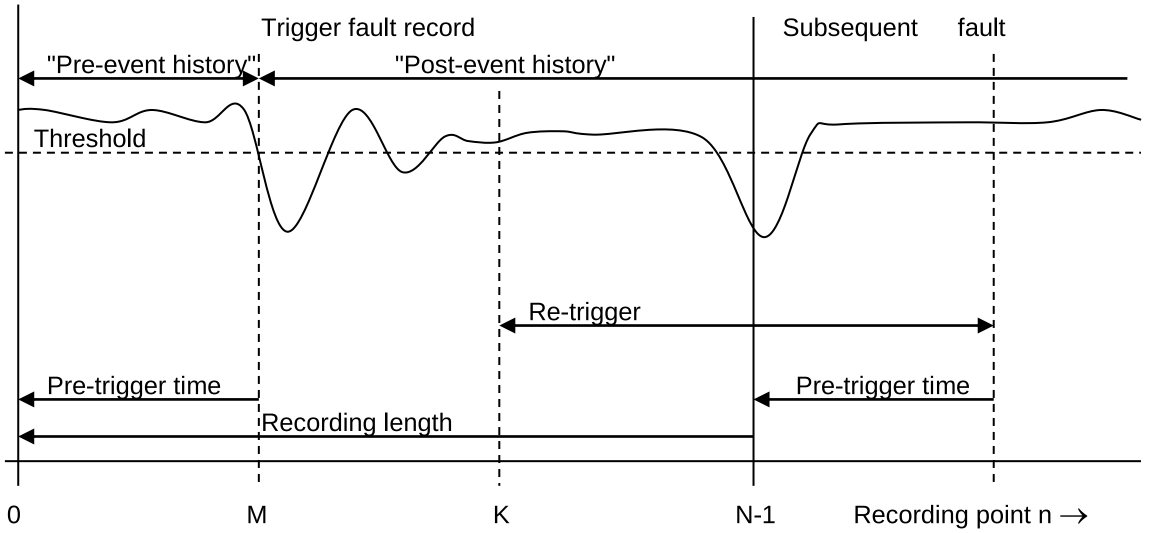
Binary trigger signals:

Designation
External trigger
Binary inputs (debounced) rising/falling edge
Software triggers

External trigger

When a trigger signal becomes active, this signal is enabled in the trigger mask of the external trigger and the output of the external trigger is enabled, a trigger pulse of adjustable length is sent to the trigger bus, where it can be received by other devices and, at the same time, trigger recorders A and B.

Fault record: pre-trigger and re-trigger time



N = number of recording points

Trigger point M = index of the first recording point after triggering with 0 < M < N-1

Re-trigger point K = index of first recording point that can trigger a follow-up fault record with M < K < M + N-1

The number of recording points per fault record can be set for each recorder, as can the position of the pre-trigger point in relation to the first recording point.

The pre-trigger point corresponds to the time of triggering. Correspondingly, the time prior to this is referred to as the pre-event history, the time after it as the post-event history, and the relevant fault record as the trigger fault record. The cause of the trigger is also recorded.

Using a second trigger point, the re-trigger point, repeated triggering can be used to generate follow-up fault records of the same length which, together with the trigger fault record, form a seamless and non-overlapping fault record sequence. The maximum number of follow-up fault records is adjustable.

The following rules apply to the re-trigger point function:

- The re-trigger point may lie between the pre-trigger point and the pre-trigger time after the end of a fault record.
- Trigger fault records can be re-triggered between the re-trigger point and the pre-trigger time after the end of a fault record.
- Follow-up fault records can be re-triggered up to the pre-trigger time after the end of a fault record.
- If the re-trigger point is located on the pre-trigger point, triggering forces the maximum number of follow-up fault records to be recorded, independently of the re-trigger events.

Oscilloscope recorder

Recorder A

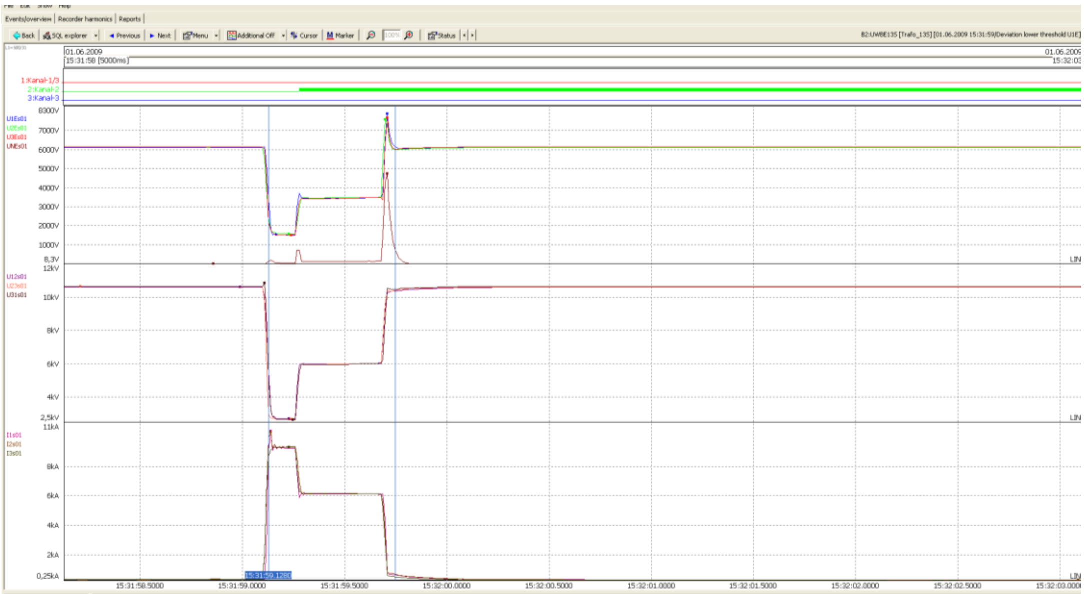
Recorder A records the sampling values for a selection of measured and phase-to-phase voltages (u_{1E}, u_{2E}, u_{3E}, u_{NE}, u_{12}, u_{23}, u_{31}) and currents (i_1, i_2, i_{3E}, i_N, version 4xU and 4xI only) with a fixed sampling frequency of 10.24kHz.

The maximum fault record length is 20480 sampling points, i.e. 2 s.

The device can store a maximum of 512 fault records.

The available memory for this is ~28 MB.

R.m.s. value recorder



Recorder B

Recorder B records the half-period values for a selection of the following measurement quantities:

Symbol	Designation
$U_{1E-1/2}$ / $U_{1N-1/2}$	R.m.s. value of voltage at outer conductor L1 – earth/neutral conductor
$U_{2E-1/2}$ / $U_{2N-1/2}$	R.m.s. value of voltage at outer conductor L2 – earth/neutral conductor
$U_{3E-1/2}$ / $U_{3N-1/2}$	R.m.s. value of voltage at outer conductor L3 – earth/neutral conductor
$U_{NE-1/2}$	R.m.s. value of neutral earth voltage
$U_{12-1/2}$	R.m.s. value of voltage at outer conductor L1 – outer conductor L2
$U_{23-1/2}$	R.m.s. value of voltage at outer conductor L3 – outer conductor L1
$U_{31-1/2}$	R.m.s. value of voltage at outer conductor L3 – outer conductor L1
$I_{1-1/2}$	R.m.s. value of conductor current L1 (versions 4xu and 4xl only)

$I_{2-1/2}$	R.m.s. value of conductor current L2 (versions 4xu and 4xI only)
$I_{3-1/2}$	R.m.s. value of conductor current L3 (versions 4xu and 4xI only)
$I_{E/N-1/2}$	R.m.s. value of sum current/conductor current N (versions 4xu and 4xI only)
$P\sum_{(1/2)}$	Active power with sign (versions 4xu and 4xI only)
$Q\sum_{(1/2)}$	Reactive power with sign of displacement reactive power (versions 4xu and 4xI only)
$S\sum_{(1/2)}$	Apparent power (versions 4xu and 4xI only)
$f_{1/2}$	Network frequency

The maximum fault record length is 12000 sampling points, i.e. ~2min.

The device can store a maximum of 512 fault records.

The memory available for this is ~16 MB.

Signal voltage recorder

The signal voltage recorder of the PQI-DA is also referred to as recorder S.

It stores the 10/12-period r.m.s. values for a selection of the signal voltages ($Us_{1E/N}$, $Us_{2E/N}$, $Us_{3E/N}$, $Us_{NE,}$ Us_{12}, Us_{23}, Us_{31}) without pre-event history.

Triggering takes place when at least one of the 7 signal voltages has exceeded the adjustable threshold.

The maximum fault record length is 3000 sampling points, i.e. ~10min.

The device can store a maximum of 512 fault records.

The memory available for this is ~4 MB.

Harmonic recorder

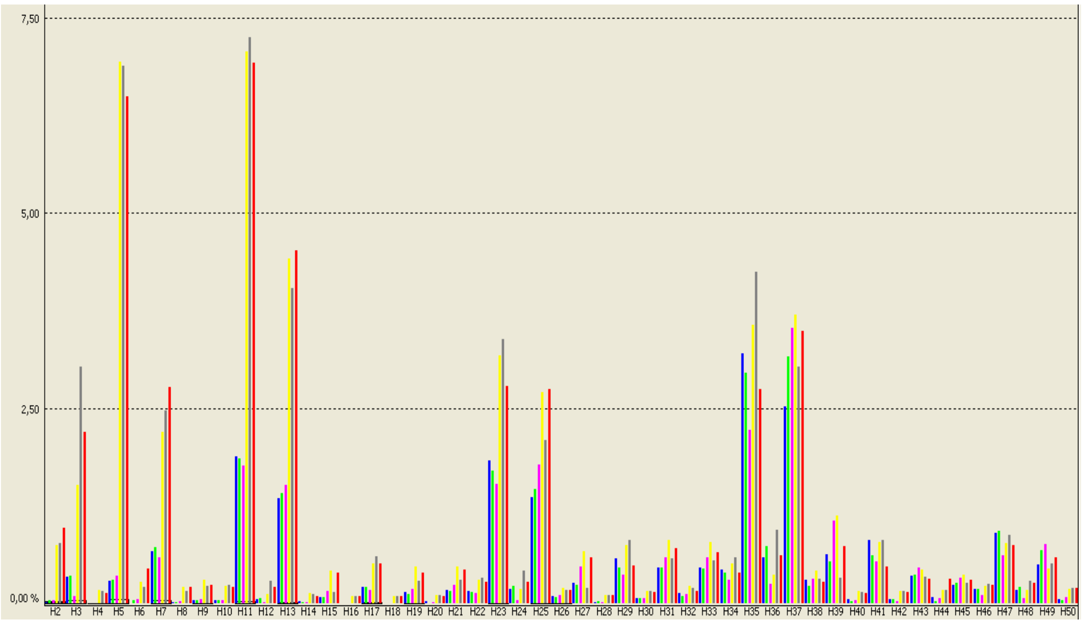
When the harmonic limits or the THD (10-min values) of a voltage are exceeded, the harmonic recorder stores the corresponding harmonic spectra (10-min values) for a selection of voltages and currents with an adjustable number of harmonics (≤49), starting with the 2nd harmonic.

The trigger events can be selected from the corresponding EN50160 events

according to error type (harmonic/THD) and measurement voltage ($U_{1E/N}$, $U_{2E/N}$, $U_{3E/N}$, U_{12}, U_{23}, U_{31}) .

The trigger condition is created by linking selected events together with OR connections.

Alternatively, recording can be set to take place continuously.



Example: Harmonic recorder

Technical data

Regulations and standards

IEC 61010-1	/ DIN EN 61010-1
IEC 60255-4	/ DIN EN 60255-4
IEC 61326-1	/ DIN EN 61326-1
IEC 60529	/ DIN EN 60529
IEC 60068-1	/ DIN EN 60068-1
IEC 60688	/ DIN EN 60688
IEC 61000-6-2	/ DIN EN 61000-6-2
IEC 61000-6-4	/ DIN EN 61000-6-4
IEC 61000-6-5	/ DIN EN 61000-6-5
IEC 61000-4-30	/ DIN EN 61000-4-30
IEC 61000-4-7	/ DIN EN 61000-4-7
IEC 61000-4-15	/ DIN EN 61000-4-15
IEC 61000-3-3	/ DIN EN 61000-3-3
	DIN EN 50160

Voltage inputs

	E1	E2
U_n	100 V AC	230 V AC
Measurement range, sine	200 V AC	460 V AC
Input impedance	360 kΩ	810 kΩ
Isolation	CAT III / 300V	
Bandwidth	DC...3 kHz	
Measurement quantity	**Error limits (IEC 61000-4-30, Class A)**	
Fundamental oscillation: r.m.s.	±0.1% of U_{din} over 10% ~ 150% of U_{din}	
Fundamental oscillation: Phase	± 0.15° over 50% ~ 150% of U_{din} over f_{nom} ±15%	
2nd ... 50th harmonic 50	± 5% of display over U_m = 1% ~ 16% of U_{din} ± 0.05% of U_{din} over U_m < 1% of U_{din}	
2nd .... 49th interharmonic	±5% of display over U_m = 1% ~ 16% of U_{din} ±0.05% of U_{din} over U_m < 1% of U_{din}	
Frequency	± 5mHz over f_{nom} ± 15% (f_{nom} = 50 Hz / 60 Hz)	
Flicker, Pst, Plt	±5% of display over 0.02% ~ 20% of ΔU / U	
Dip residual voltage	±0.2% of U_{din} over 10% ~ 100% of U_{din}	
Dip duration	±20 ms over 10% ~ 100% of U_{din}	
Swell residual voltage	±0.2% of U_{din} over 100% ~ 150% of U_{din}	
Swell duration	±20 ms over 100% ~ 150% of U_{din}	
Interruption duration	±20 ms over 1% ~ 100% of U_{din}	
Voltage asymmetry	±0.15% over 1% ~ 5% of display	
Ripple control voltage	±5% of display over U_m = 3% ~ 15% of U_{din} ±0.15% of U_{din} over U_m = 1% ~ 3% of U_{din}	

Current inputs

	C20	C21	C30	C31
In	1A		5A	
Measurement range, sine	0 < I ≤ 2A	0 < I ≤ 20A	0 < I ≤ 10 A	0 < I ≤ 100A
Input load	< 0.1 V A		< 0.5 VA	
Overload capacity, continu-ous ≤ 10 s ≤ 1 s ≤ 5 ms	5A 10A 30A 100A	10 A 30 A 100 A 500 A		
Isolation	CAT III / 300V			
Measurement quantity	**Error limits**			
Fundamental oscillation: r.m.s.	± 0.1% of end value over measurement range			± 0.2% of end value over measurement range
Fundamental oscillation: Phase	± 0.15° over 10% ~ 100%	± 0.15° over 5% ~ 50%	± 0.15° over 10% ~ 100%	± 1.0° over 5% ~ 10%
Bandwidth	25 Hz...3 kHz			
2nd...50th harmonic	±5% of display over Im = 1% ~ 16% of In ±0.05% of In over Im < 1% of In			±10% of display over Im = 1% ~ 16% of In ±0.1% of In Im < 1% of In
2nd .... 49th interharmonic	±5% of display over Im = 1% ~ 16% of In ±0.05% of In over Im < 1% of In			±10% of display over Im = 1% ~ 16% of In ±0.1% of In over Im < 1% of In

*) **Please note:** Codes, e.g. "E1, E2, C20, C31..."

Binary inputs (BI)

M1 range	in the range 0 V..0.250 V AC/DC
H level	≥ 48 V
L level	< 10 V
Input resistance	108 kΩ
M2 range	in the range 0 V...48 V AC/DC
H level	≥ 10 V
L level	< 5 V
Input resistance	6.8 kΩ
Signal	DC/AC < 100 Hz
Sampling cycle time	4 ms
Debounce cycles	Adjustable in the range 0... 250 corresponds to 0...1.0 s
Electrical isolation	Optocoupler, E1, E2 earthed E3, E4 earthed

Binary outputs (BO)

Update cycle time	100 ms
Dwell time	Adjustable in the range 0...4 $\cdot 10^6$ s
Electrical isolation	isolated from all device-internal potentials
Type of relay	Changeover contact
Status, R2, R3	individually galvanically isolated
R4, R5	Earthed
Contact load	AC: 250 V, 5 A ($\cos\varphi$ = 1.0) AC: 250 V, 3 A ($\cos\varphi$ = 0.4) DC: 220 V, 150 W switching capacity
No. of switching operations	≥ $1 \cdot 10^4$ electrical

Status LEDs

Status LED	Colour
Operation	Green
Error	Red

Limit value monitoring

Limit values	programmable
Response times	programmable

Overview ofmeasurement quantities

Aggregation intervals: ½ sine wave
10/12 cycles (f_{nom}=50/60Hz)
150/180 cycles (f_{nom}=50/60Hz)
5 / 6 / 6.67 / 7.5 / 10 / 12 / 15 / 20 / 30 min
2 h
Day, week, year

Explanation of symbols:

✓ = calculated and transferred

✓* = calculated but not transferred cyclically

Aggregation interval / Measurement quantities	½ cycle	10/12 cycles	150/180 cycles	10min	2 h	4xU 4xI	2x 4xU
R.m.s. values of $u_{1E/N}$, $u_{2E/N}$, $u_{3E/N}$, u_{NE}, u_{12}, u_{23}, u_{31}, u_{ref}: $U_{1E/N}$, $U_{2E/N}$, $U_{3E/N}$, U_{NE}, U_{12}, U_{23}, U_{31}, U_{ref}	✓*	✓	✓	✓	✓	✓	2x
R.m.s. values of i_1, i_2, i_3, $i_{E/N}$: I_1, I_2, I_3, $I_{E/N}$	✓*	✓	✓	✓	✓	✓	
Active powers of the phases: P_1, P_2, P_3		✓	✓	✓	✓	✓	
Frequency (fundamental oscillation): F	✓*	✓	✓	✓	✓	✓	✓
R.m.s. values of DC component and fundamental oscillation for each of measurement channels 1..8			✓			✓	✓

Deduced measurement quantities:

Aggregation interval / Measurement quantities	½ cycle	10/12 cycles	150/180 cycles	10min	2 h	4xU 4xI	2x 4xU
Harmonic subgroups (n=1..50) of $u_{1E/N}$, $u_{2E/N}$, $u_{3E/N}$, u_{NE}, u_{12}, u_{23}, u_{31}: $U_{1E/N-n}$, $U_{2E/N-n}$, $U_{3E/N-n}$, U_{NE-n}, U_{12-n}, U_{23-n}, U_{31-n}		✓*	✓	✓	✓	✓	2x
Harmonic subgroups (n=1..50) of i_1, i_2, i_3, $i_{E/N}$: I_{1-n}, I_{2-n}, I_{3-n}, I_{E-n}		✓*	✓	✓	✓	✓	
Interharmonic subgroups (n=0..49) of $u_{1E/N}$, $u_{2E/N}$, $u_{3E/N}$, u_{NE}, u_{12}, u_{23}, u_{31}: $U_{1E/N-n+0.5}$, $U_{2E/N-n+0.5}$, $U_{3E/N-n+0.5}$, $U_{NE-n+0.5}$, $U_{12-n+0.5}$, $U_{23-n+0.5}$, $U_{31-n+0.5}$		✓*	✓	✓	✓	✓	2x
Interharmonic subgroups (n=0..49) of i_1, i_2, i_3, $i_{E/N}$: $I_{1-n+0.5}$, $I_{2-n+0.5}$, $I_{3-n+0.5}$, $I_{E-n+0.5}$		✓*	✓	✓	✓	✓	
R.m.s. values of ripple control signals on $u_{1E/N}$, $u_{2E/N}$, $u_{3E/N}$, u_{NE}, u_{12}, u_{23}, u_{31}: U_{S1}, U_{S2}, U_{S3}, U_{SN}, U_{S12}, U_{S23}, U_{S31}		✓	✓			✓	2x
Directions of harmonic energy flow (n=1..32) on L_1, L_2, L_3: FD_{1-n}, FD_{2-n}, FD_{3-n}		✓	✓	✓	✓	✓	

Aggregation interval Measurement quantities	½ cycle	10/12 cycles	150/180 cycles	10min	2 h	4xU 4xI	2x 4xU
Total harmonic distortion (2nd..40th harmonic) of $u_{1E/N}$, $u_{2E/N}$, $u_{3E/N}$, u_{NE}, u_{12}, u_{23}, u_{31}: $THD_{1E/N}$, $THD_{2E/N}$, $THD_{3E/N}$, THD_{NE}, THD_{12}, THD_{23}, THD_{31}		✓	✓	✓	✓	✓	2x
Partial weighted harmonic distortion (14th..40th harmonic) of $u_{1E/N}$, $u_{2E/N}$, $u_{3E/N}$, u_{NE}, u_{12}, u_{23}, u_{31}: $PWHD_{1E/N}$, $PWHD_{2E/N}$, $PWHD_{3E/N}$, $PWHD_{NE}$, $PWHD_{12}$, $PWHD_{23}$, $PWHD_{31}$		✓	✓	✓	✓	✓	2x
Total harmonic distortion (2nd..40th harmonic) of i_1, i_2, i_3, $i_{E/N}$: THD_1, THD_2, THD_3, $THD_{E/N}$		✓	✓	✓	✓	✓	
Partial weighted harmonic distortion (14th..40th harmonic) von i_1, i_2, i_3, $i_{E/N}$: $PWHD_1$, $PWHD_2$, $PWHD_3$, $PWHD_{E/N}$		✓	✓	✓	✓	✓	
Total harmonic currents (2nd..40th harmonic) of i_1, i_2, i_3, $i_{E/}$: THC_1, THC_2, THC_3, $THC_{E/N}$		✓	✓	✓	✓	✓	
Partial odd harmonic currents (21st..39th harmonic) of i_1, i_2, i_3, $i_{E/N}$: PHC_1, PHC_2, PHC_3, $PHC_{E/N}$		✓	✓	✓	✓	✓	
K factors of i_1, i_2, i_3, $i_{E/N}$: k_1, k_2, k_3, $k_{E/N}$		✓	✓	✓	✓	✓	
Average value of I_1, I_2, I_3 with sign(P): I_M		✓	✓	✓	✓	✓	
Collective active power: $P\sum$		✓	✓	✓	✓	✓	
Apparent powers of the phases: S_1, S_2, S_3		✓	✓	✓	✓	✓	
Collective apparent power according to DIN 40110: $S\sum$		✓	✓	✓	✓	✓	
Reactive powers of the phases (with sign): Q_1, Q_2, Q_3		✓	✓	✓	✓	✓	
Collective reactive power (DIN 40110): $Q\sum$		✓	✓	✓	✓	✓	
Current distortion reactive power of the phases: D_1, D_2, D_3		✓	✓	✓	✓	✓	
Collective current distortion reactive power: $D\sum$		✓	✓	✓	✓	✓	
Active power of the fundamental oscillation: P_G	✓*	✓	✓	✓	✓	✓	
Apparent power of the geometrical fundamental oscillation: S_G	✓*	✓	✓	✓	✓	✓	
Displacement reactive power of the fundamental oscillation (with sign): Q_{V-1}	✓*	✓	✓	✓	✓	✓	
Phase angle of geometric apparent power of the fundamental oscillation S_G: φ_G		✓	✓	✓	✓	✓	
Total active energies of the phases: Wt_1, Wt_2, Wt_3		✓*	✓	✓	✓	✓	
Collective total active energy: Wt		✓*	✓	✓	✓	✓	
Drawn active energies of the phases: Wo_1, Wo_2, Wo_3		✓*	✓	✓	✓	✓	
Collective drawn active energy: Wo		✓*	✓	✓	✓	✓	
Supplied active energies of the phases: Wi_1, Wi_2, Wi_3		✓*	✓	✓	✓	✓	
Collective supplied active energy: Wi		✓*	✓	✓	✓	✓	
Total reactive energies of the phases: Wrt_1, Wrt_2, Wrt_3		✓*	✓	✓	✓	✓	
Collective total reactive energy: Wrt		✓*	✓	✓	✓	✓	
Drawn (inductive) reactive energies of the phases: Wro_1, Wro_2, Wro_3		✓*	✓	✓	✓	✓	

Aggregation interval / Measurement quantities	½ cycle	10/12 cycles	150/180 cycles	10min	2 h	4xU 4xI	2x 4xU
Drawn (inductive) collective reactive energy: Wro		✓*	✓	✓	✓	✓	
Supplied (inductive) reactive energies of the phases: Wri_1, Wri_2, Wri_3		✓*	✓	✓	✓	✓	
Supplied (inductive) collective reactive energy: Wri		✓*	✓	✓	✓	✓	
Active powers of phase intervals (events): P_{I1}, P_{I2}, P_{I3}		✓				✓	
Collective active power of phase intervals (event): P_I		✓				✓	
Active factors with sign: PF_1, PF_2, PF_3, PF			✓	✓	✓	✓	
Reactive factors with sign: QF_1, QF_2, QF_3, QF			✓	✓	✓	✓	
COSφ with sign: $COS\varphi_1$, $COS\varphi_2$, $COS\varphi_3$, COSφ			✓	✓	✓	✓	
SINφ with sign: $SIN\varphi_1$, $SIN\varphi_2$, $SIN\varphi_3$, SINφ			✓	✓	✓	✓	
TANφ with sign: $TAN\varphi_1$, $TAN\varphi_2$, $TAN\varphi_3$, TANφ			✓	✓	✓	✓	
Capacitive-inductive representation of COSφ (-1..0..+1): Y_1, Y_2, Y_3, Y			✓	✓	✓	✓	
COSφ with sign of displacement angle: $COSPHV_1$, $COSPHV_2$, $COSPHV_3$, COSPHV			✓	✓	✓	✓	
Voltage-current phase difference (fundamental oscillation): φ_{1-1}, φ_{2-1}, φ_{3-1}		✓	✓	✓	✓	✓	
Current-harmonic phase difference (n=2nd..40th) on L_1, L_2, L_3 in relation to fundamental oscillation of the corresponding phase voltage: φ_{1-n}, φ_{2-n}, φ_{3-n}			✓	✓	✓	✓	
Voltage/reference voltage phase difference (fundamental oscillation) of $u_{1E/N}$, $u_{2E/N}$, $u_{3E/N}$, u_{NE}, u_{12}, u_{23}, u_3: $\varphi_{1E/N}$, $\varphi_{2E/N}$, $\varphi_{3E/N}$, φ_{NE}, φ_{12}, φ_{23}, φ_{31}	✓*	✓	✓	✓	✓	✓	2x
Direction of rotation (fundamental oscillation) with sign: ROT		✓				✓	2x
Flicker magnitudes of $u_{1E/N}$, $u_{2E/N}$, $u_{3E/N}$, u_{12}, u_{23}, u_{31}: $PxT_{1E/N}$, $PxT_{2E/N}$, $PxT_{3E/N}$, PxT_{12}, PxT_{23}, PxT_{31}				✓	✓	✓	2x
Max. flicker detectability of $u_{1E/N}$, $u_{2E/N}$, $u_{3E/N}$, u_{12}, u_{23}, u_{31} : $Pinst_1$, $Pinst_2$, $Pinst_3$, $Pinst_{12}$, $Pinst_{23}$, $Pinst_{31}$		✓*		✓		✓	2x
Voltage positive-sequence / negative-sequence / zero-sequence system	✓*	✓	✓	✓	✓	✓	2x
Voltage asymmetry u_u		✓	✓	✓	✓	✓	2x
Voltage asymmetry u_0		✓	✓	✓	✓	✓	2x
Extrema of $U_{1E/N-1/2}$, $U_{2E/N-1/2}$, $U_{3E/N-1/2}$, $U_{NE-1/2}$, $U_{12-1/2}$, $U_{23-1/2}$,$U_{31-1/2}$				✓		✓	2x
Extrema of $U_{1E/N-10/12}$, $U_{2E/N-10/12}$, $U_{3E/N-10/12}$, $U_{NE-10/12}$, $U_{12-10/12}$, $U_{23-10/12}$,$U_{31-10/12}$				✓		✓	2x
Current positive-sequence / negative-sequence / zero-sequence system		✓	✓	✓	✓	✓	
Current asymmetry u_u		✓	✓	✓	✓	✓	
Current asymmetry u_0		✓	✓	✓	✓	✓	
Extrema of $I_{1-1/2}$, $I_{2-1/2}$, $I_{3-1/2}$, $I_{E/N-1/2}$				✓		✓	
Extrema of $I_{1-10/12}$, $I_{2-10/12}$, $I_{3-10/12}$, $I_{E/N-10/12}$				✓		✓	

Aggregation interval / Measurement quantities	½ cycle	10/12 cycles	150/180 cycles	10min	2 h	4xU 4xI	2x 4xU
Extrema of $P_{1-10/12}$, $P_{2-10/12}$, $P_{3-10/12}$, $P_{10/12}$				✓		✓	
Extrema of f_{10s} and $f_{10/12}$				✓		✓	✓
Maxima of $U_{S1-10/12}$, $U_{S2-10/12}$, $U_{S3-10/12}$, $U_{SN-10/12}$, $U_{S12-10/12}$, $U_{S23-10/12}$, $U_{S31-10/12}$				✓		✓	2x
Negative deviation [%] of $U_{1E/N}$, $U_{2E/N}$, $U_{3E/N}$, U_{12}, U_{23}, U_{31}		✓	✓	✓	✓	✓	2x
Positive deviation [%] of $U_{1E/N}$, $U_{2E/N}$, $U_{3E/N}$, U_{12}, U_{23}, U_{31}		✓	✓	✓	✓	✓	2x

Statistical quantities:

Aggregation interval / Measurement quantities	Day	Week	Year	4xU 4xI	2x 4xU
Extrema of $U_{1E/N-10/12}$, $U_{2E/N-10/12}$, $U_{3E/N-10/12}$, $U_{NE-10/12}$, $U_{12-10/12}$, $U_{23-10/12}$,$U_{31-10/12}$	✓			✓	2x
Extrema of $U_{1E/N-10min}$, $U_{2E/N-10min}$, $U_{3E/N-10min}$, $U_{NE-10min}$, $U_{12-10min}$, $U_{23-10min}$,$U_{31-10min}$	✓			✓	2x
Maxima of $THD_{1E/N-10min}$, $THD_{2E/N-10min}$, $THD_{3E/N-10min}$, $THD_{12-10min}$, $THD_{23-10min}$, $THD_{31-10min}$	✓			✓	2x
Maxima for harmonic subgroups n = 2nd..40th $U_{1E/N-n-10min}$, $U_{2E/N-n-10min}$, $U_{3E/N-n-10min}$, $U_{NE-n-10min}$, $U_{12-n-10min}$, $U_{23-n-10min}$, $U_{31-n-10min}$ across all phases	✓			✓	2x
Maxima for long-term flicker $PLT_{1E/N}$, $PLT_{2E/N}$, $PLT_{3E/N}$, PLT_{12}, PLT_{23}, PLT_{31}	✓			✓	2x
Extrema of f_{10s}	✓			✓	✓
Extrema of $f_{10/12}$	✓			✓	✓
Extrema of f_{10min}	✓			✓	✓
Extrema of $I_{1-10/12}$, $I_{2-10/12}$, $I_{3-10/12}$, $I_{E/N-10/12}$	✓			✓	
Extrema of $I_{1-10/12}$, $I_{2-10min}$, $I_{3-10min}$, $I_{E/N-10min}$	✓			✓	
Extrema of $P_{1-10/12}$, $P_{2-10/12}$, $P_{3-10/12}$, $P_{10/12}$	✓			✓	
Extrema of $P_{1-10/12}$, $P_{2-10min}$, $P_{3-10min}$, P_{10min}	✓			✓	
Number of auxiliary voltage interruptions	✓	✓	✓	✓	2x
Number of evaluation intervals	✓	✓	✓	✓	2x
Number of frequency deviations, narrow tolerance	✓	✓	✓	✓	2x
Number of frequency deviations, wide tolerance	✓	✓	✓	✓	2x
Number of intermittent overvoltages at the network frequency	✓	✓	✓	✓	2x
Number of fast voltage changes	✓	✓	✓	✓	2x
Number of voltage dips	✓	✓	✓	✓	2x
Number of short voltage interruptions	✓	✓	✓	✓	2x

Aggregation interval / Measurement quantities	Day	Week	Year	4xU 4xI	2x 4xU
Number of long voltage interruptions	✓	✓	✓	✓	2x
Number of 10-minute intervals	✓	✓	✓	✓	2x
Number of slow voltage deviations	✓	✓	✓	✓	2x
Number of times harmonic distortions exceeded	✓	✓	✓	✓	2x
Number of times voltage asymmetry exceeded	✓	✓	✓	✓	2x
Number of 2-hour intervals	✓	✓	✓	✓	2x
Number of times PLT exceeded	✓	✓	✓	✓	2x
Number of times signal voltage exceeded	✓	✓	✓	✓	2x
Number of weeks during which the frequency too frequently exceeds the narrow tolerance range			✓	✓	2x
Number of weeks during which slow voltage changes too frequently exceed the range			✓	✓	2x
Number of weeks during which harmonic distortions too frequently exceed the range			✓	✓	2x
Number of weeks during which voltage asymmetry too frequently exceededs the range			✓	✓	2x
Number of weeks during which flicker PLT too frequently exceeds the range			✓	✓	2x
Number of days on which signal voltage is too frequently exceeded			✓	✓	2x
Time sum for auxiliary voltage interruptions	✓	✓	✓	✓	2x
Time sum for measurement time	✓	✓	✓	✓	2x
Time sum for frequency deviations, narrow tolerance	✓	✓	✓	✓	2x
Time sum for frequency deviations, wide tolerance	✓	✓	✓	✓	2x
Time sum for intermittent overvoltage at the network frequency	✓	✓	✓	✓	2x
Time sum for fast voltage changes	✓	✓	✓	✓	2x
Time sum for voltage dips	✓	✓	✓	✓	2x
Time sum for short voltage interruptions	✓	✓	✓	✓	2x
Time sum for long voltage interruptions	✓	✓	✓	✓	2x
Time sum for exceeded signal voltages	✓	✓	✓	✓	2x

Overview of events:

Symbol	Designation	Event value
RST	System reset, start event	Error code
RSTx	System reset, stop event	Error code
STATERR	Station error flags	Error flags
SYNC	Frequency valid	f
NOTSYNC	Frequency invalid	0
TIMESET	Time setting	Time difference [s]
NEWDAY	New day initialised	Day index

Symbol	Designation	Event value
BININPUT	Status change at binary inputs	Last status Current status
COM1ERR	Error COM1	Error code
TRG_RX	External trigger, receive	0
COM2ERR	Error COM2	Error code
DFN	Frequency deviation (narrow tolerance), start event	10-second trigger value
DFNx	Frequency deviation (narrow tolerance) , stop event	10-second extreme value
DFW	Frequency deviation (wide tolerance), start event	10-second trigger value
DFWx	Frequency deviation (wide tolerance) , stop event	10-second extreme value
TRG_TX	Ext. trigger, send	Bit ID
TRG_W0	Status change in trigger word#0	Status word
TRG_W1	Status change in trigger word#1	Status word
TRG_W2	Status change in trigger word#2	Status word
TEDUR	Duration of transient event [s]	Event duration [s]
RUN_REC	Status change in recording of data classes	Status word
BINOUTPUT	Status change at binary outputs	Last status Current status
TIMESYNC	Status change, external time synchronisation	Status word
EVNTOF	DSP event buffer overflow	Level
RSTEVAL_1	Reset event evaluation, line 1	0
EVAL_1	Event evaluation, start event, line 1	0
EVALx_1	Event evaluation, stop event, line 1	0
RECA_1	New recording in recorder A1	"Absolute index"
RECS_1	New recording in recorder S1	"Absolute index"
RECB_1	New recording in recorder B1	"Absolute index"
TRANSNOSTIC	Status message Transnostic	Status word
TEDUR	Duration of transient event [s]	Event duration [s]
RECC_1	New recording in recorder C1	"Absolute index"
OV1E_1	Overvoltage U1E, start event, line 1	10-ms trigger value
OV1Ex_1	Overvoltage U1E, stop event, line 1	10-ms maximum value
OV2E_1	Overvoltage U2E, start event, line 1	10-ms trigger value
OV2Ex_1	Overvoltage U2E, stop event, line 1	10-ms maximum value
OV3E_1	Overvoltage U3E, start event, line 1	10-ms trigger value
OV3Ex_1	Overvoltage U3E, stop event, line 1	10-ms maximum value
OVNE_1	Overvoltage UNE, start event, line 1	10-ms trigger value

Symbol	Designation	Event value
OVNEx_1	Overvoltage UNE, stop event, line 1	10-ms maximum va-lue
VS1E_1	Swell U1E, start event, line 1	10-ms trigger value
VS1Ex_1	Swell U1E, stop event, line 1	10-ms maximum va-lue
VS2E_1	Swell U2E, start event, line 1	10-ms trigger value
VS2Ex_1	Swell U2E, stop event, line 1	10-ms maximum va-lue
VS3E_1	Swell U3E, start event, line 1	10-ms trigger value
VS3Ex_1	Swell U3E, stop event, line 1	10-ms maximum va-lue
VS12_1	Swell U12, start event, line 1	10-ms trigger value
VS12x_1	Swell U12 stop event, line 1	10-ms maximum va-lue
VS23_1	Swell U23, start event, line 1	10-ms trigger value
VS23x_1	Swell U23, stop event, line 1	10-ms maximum va-lue
VS31_1	Swell U31, start event, line 1	10-ms trigger value
VS31x_1	Swell U31, stop event, line 1	10-ms maximum va-lue
VD1E_1	Dip U1E, start event, line 1	10-ms trigger value
VD1Ex_1	Dip U1E, stop event, line 1	10-ms minimum value
VD2E_1	Dip U2E, start event, line 1	10-ms trigger value
VD2Ex_1	Dip U2E, stop event, line 1	10-ms minimum value
VD3E_1	Dip U3E, start event, line 1	10-ms trigger value
VD3Ex_1	Dip U3E, stop event, line 1	10-ms minimum value
VD12_1	Dip U12, start event, line 1	10-ms trigger value
VD12x_1	Dip U12, stop event, line 1	10-ms minimum value
VD23_1	Dip U23, start event, line 1	10-ms trigger value
VD23x_1	Dip U23, stop event, line 1	10-ms minimum value
VD31_1	Dip U31, start event, line 1	10-ms trigger value
VD31x_1	Dip U31, stop event, line 1	10-ms minimum value
DD1E_1	Voltage dip U1E, start event, line 1	10-ms trigger value
DD1Ex_1	Voltage dip U1E, stop event, line 1	10-ms minimum value
DD2E_1	Voltage dip U2E, start event, line 1	10-ms trigger value
DD2Ex_1	Voltage dip U2E, stop event, line 1	10-ms minimum value
DD3E_1	Voltage dip U3E, start event, line 1	10-ms trigger value
DD3Ex_1	Voltage dip U3E, stop event, line 1	10-ms minimum value
DD12_1	Voltage dip U12, start event, line 1	10-ms trigger value
DD12x_1	Voltage dip U12, stop event, line 1	10-ms minimum value
DD23_1	Voltage dip U23, start event, line 1	10-ms trigger value
DD23x_1	Voltage dip U23, stop event, line 1	10-ms minimum value
DD31_1	Voltage dip U31, start event, line 1	10-ms trigger value

Symbol	Designation	Event value
DD31x_1	Voltage dip U31, stop event, line 1	10-ms minimum value
SI1E_1	Interruption to supply U1E, start event, line 1	10-ms trigger value
SI1Ex_1	Interruption to supply U1E, stop event, line 1	10-ms minimum value
SI2E_1	Interruption to supply U2E, start event, line 1	10-ms trigger value
SI2Ex_1	Interruption to supply U2E, stop event, line 1	10-ms minimum value
SI3E_1	Interruption to supply U3E, start event, line 1	10-ms trigger value
SI3Ex_1	Interruption to supply U3E, stop event, line 1	10-ms minimum value
SI12_1	Interruption to supply U12, start event, line 1	10-ms trigger value
SI12x_1	Interruption to supply U12, stop event, line 1	10-ms minimum value
SI23_1	Interruption to supply U23, start event, line 1	10-ms trigger value
SI23x_1	Interruption to supply U23, stop event, line 1	10-ms minimum value
SI31_1	Interruption to supply U31, start event, line 1	10-ms trigger value
SI31x_1	Interruption to supply U31, stop event, line 1	10-ms minimum value
SVC1E_1	Slow voltage deviation U1E, line 1	10-minute average value
SVC2E_1	Slow voltage deviation U2E, line 1	10-minute average value
SVC3E_1	Slow voltage deviation U3E, line 1	10-minute average value
SVC12_1	Slow voltage deviation U12, line 1	10-minute average value
SVC23_1	Slow voltage deviation U23, line 1	10-minute average value
SVC31_1	Slow voltage deviation U31, line 1	10-minute average value
PLT1E_1	Long-term flicker U1E exceeded, line 1	2-hour average value
PLT2E_1	Long-term flicker U2E exceeded, line 1	2-hour average value
PLT3E_1	Long-term flicker U3E exceeded, line 1	2-hour average value
PLT12_1	Long-term flicker U12 exceeded, line 1	2-hour average value
PLT23_1	Long-term flicker U23 exceeded, line 1	2-hour average value
PLT31_1	Long-term flicker U31 exceeded, line 1	2-hour average value
NUU_1	Voltage asymmetry exceeded, line 1	10-minute average value
THD1EV_1	THD of U1E exceeded, line 1	10-minute average value
THD2EV_1	THD of U2E exceeded, line 1	10-minute average value
THD3EV_1	THD of U3E exceeded, line 1	10-minute average value
THD12V_1	THD of U12 exceeded, line 1	10-minute average value
THD23V_1	THD of U23 exceeded, line 1	10-minute average value

Symbol	Designation	Event value
THD31V_1	THD of U31 exceeded, line 1	10-minute average value
HN1EV_1	Harmonic U1E exceeded, line 1	Order of harmonic
HN2EV_1	Harmonic U2E exceeded, line 1	Order of harmonic
HN3EV_1	Harmonic U3E exceeded, line 1	Order of harmonic
HN12V_1	Harmonic U12 exceeded, line 1	Order of harmonic
HN23V_1	Harmonic U23 exceeded, line 1	Order of harmonic
HN31V_1	Harmonic U31 exceeded, line 1	Order of harmonic
PST1E_1	Short-term flicker U1E exceeded, line 1	10-minute average value
PST2E_1	Short-term flicker U2E exceeded, line 1	10-minute average value
PST3E_1	Short-term flicker U3E exceeded, line 1	10-minute average value
PST12_1	Short-term flicker U12 exceeded, line 1	10-minute average value
PST23_1	Short-term flicker U23 exceeded, line 1	10-minute average value
PST31_1	Short-term flicker U31 exceeded, line 1	10-minute average value
PI1	Interval active power L1	Interval average value
PI2	Interval active power L2	Interval average value
PI3	Interval active power L3	Interval average value
PI	Interval active power of the network	Interval average value
RSTEVAL_2	Reset event evaluation, line 2	0
EVAL_2	Event evaluation, start event, line 2	0
EVALx_2	Event evaluation, stop event, line 2	0
RECA_2	New recording in recorder A2	"Absolute index"
RECS_2	New recording in recorder S2	"Absolute index"
RECB_2	New recording in recorder B2	"Absolute index"
RECC_2	New recording in recorder C2	"Absolute index"
OV1E_2	Overvoltage U1E, start event, line 2	10-ms trigger value
OV1Ex_2	Overvoltage U1E, stop event, line 2	10-ms maximum va-lue
OV2E_2	Overvoltage U2E, start event, line 2	10-ms trigger value
OV2Ex_2	Overvoltage U2E, stop event, line 2	10-ms maximum va-lue
OV3E_2	Overvoltage U3E, start event, line 2	10-ms trigger value
OV3Ex_2	Overvoltage U3E, stop event, line 2	10-ms maximum va-lue
OVNE_2	Overvoltage UNE, start event, line 2	10-ms trigger value
OVNEx_2	Overvoltage UNE, stop event, line 2	10-ms maximum va-lue
VS1E_2	Swell U1E, start event, line 2	10-ms trigger value

Symbol	Designation	Event value
VS1Ex_2	Swell U1E, stop event, line 2	10-ms maximum va-lue
VS2E_2	Swell U2E, start event, line 2	10-ms trigger value
VS2Ex_2	Swell U2E, stop event, line 2	10-ms maximum va-lue
VS3E_2	Swell U3E, start event, line 2	10-ms trigger value
VS3Ex_2	Swell U3E, stop event, line 2	10-ms maximum va-lue
VS12_2	Swell U12, start event, line 2	10-ms trigger value
VS12x_2	Swell U12 stop event, line 2	10-ms maximum va-lue
VS23_2	Swell U23, start event, line 2	10-ms trigger value
VS23x_2	Swell U23, stop event, line 2	10-ms maximum va-lue
VS31_2	Swell U31, start event, line 2	10-ms trigger value
VS31x_2	Swell U31, stop event, line 2	10-ms maximum va-lue
VD1E_2	Dip U1E, start event, line 2	10-ms trigger value
VD1Ex_2	Dip U1E, stop event, line 2	10-ms minimum value
VD2E_2	Dip U2E, start event, line 2	10-ms trigger value
VD2Ex_2	Dip U2E, stop event, line 2	10-ms minimum value
VD3E_2	Dip U3E, start event, line 2	10-ms trigger value
VD3Ex_2	Dip U3E, stop event, line 2	10-ms minimum value
VD12_2	Dip U12, start event, line 2	10-ms trigger value
VD12x_2	Dip U12, stop event, line 2	10-ms minimum value
VD23_2	Dip U23, start event, line 2	10-ms trigger value
VD23x_2	Dip U23, stop event, line 2	10-ms minimum value
VD31_2	Dip U31, start event, line 2	10-ms trigger value
VD31x_2	Dip U31, stop event, line 2	10-ms minimum value
DD1E_2	Voltage dip U1E, start event, line 2	10-ms trigger value
DD1Ex_2	Voltage dip U1E, stop event, line 2	10-ms minimum value
DD2E_2	Voltage dip U2E, start event, line 2	10-ms trigger value
DD2Ex_2	Voltage dip U2E, stop event, line 2	10-ms minimum value
DD3E_2	Voltage dip U3E, start event, line 2	10-ms trigger value
DD3Ex_2	Voltage dip U3E, stop event, line 2	10-ms minimum value
DD12_2	Voltage dip U12, start event, line 2	10-ms trigger value
DD12x_2	Voltage dip U12, stop event, line 2	10-ms minimum value
DD23_2	Voltage dip U23, start event, line 2	10-ms trigger value
DD23x_2	Voltage dip U23, stop event, line 2	10-ms minimum value
DD31_2	Voltage dip U31, start event, line 2	10-ms trigger value
DD31x_2	Voltage dip U31, stop event, line 2	10-ms minimum value
SI1E_2	Interruption to supply U1E, start event, line 2	10-ms trigger value
SI1Ex_2	Interruption to supply U1E, stop event, line 2	10-ms minimum value

Symbol	Designation	Event value
SI2E_2	Interruption to supply U2E, start event, line 2	10-ms trigger value
SI2Ex_2	Interruption to supply U2E, stop event, line 2	10-ms minimum value
SI3E_2	Interruption to supply U3E, start event, line 2	10-ms trigger value
SI3Ex_2	Interruption to supply U3E, stop event, line 2	10-ms minimum value
SI12_2	Interruption to supply U12, start event, line 2	10-ms trigger value
SI12x_2	Interruption to supply U12, stop event, line 2	10-ms minimum value
SI23_2	Interruption to supply U23, start event, line 2	10-ms trigger value
SI23x_2	Interruption to supply U23, stop event, line 2	10-ms minimum value
SI31_2	Interruption to supply U31, start event, line 2	10-ms trigger value
SI31x_2	Interruption to supply U31, stop event, line 2	10-ms minimum value
SVC1E_2	Slow voltage deviation U1E, line 2	10-minute average value
SVC2E_2	Slow voltage deviation U2E, line 2	10-minute average value
SVC3E_2	Slow voltage deviation U3E, line 2	10-minute average value
SVC12_2	Slow voltage deviation U12, line 2	10-minute average value
SVC23_2	Slow voltage deviation U23, line 2	10-minute average value
SVC31_2	Slow voltage deviation U31, line 2	10-minute average value
PLT1E_2	Long-term flicker U1E exceeded, line 2	2-hour average value
PLT2E_2	Long-term flicker U2E exceeded, line 2	2-hour average value
PLT3E_2	Long-term flicker U3E exceeded, line 2	2-hour average value
PLT12_2	Long-term flicker U12 exceeded, line 2	2-hour average value
PLT23_2	Long-term flicker U23 exceeded, line 2	2-hour average value
PLT31_2	Long-term flicker U31 exceeded, line 2	2-hour average value
NUU_2	Voltage asymmetry exceeded, line 2	10-minute average value
THD1E_2	THD of U1E exceeded, line 2	10-minute average value
THD2E_2	THD of U2E exceeded, line 2	10-minute average value
THD3E_2	THD of U3E exceeded, line 2	10-minute average value
THD12_2	THD of U12 exceeded, line 2	10-minute average value
THD23_2	THD of U23 exceeded, line 2	10-minute average value
THD31_2	THD of U31 exceeded, line 2	10-minute average value
HN1E_2	Harmonic U1E exceeded, line 2	Order of harmonic
HN2E_2	Harmonic U2E exceeded, line 2	Order of harmonic

Symbol	Designation	Event value
HN3E_2	Harmonic U3E exceeded, line 2	Order of harmonic
HN12_2	Harmonic U12 exceeded, line 2	Order of harmonic
HN23_2	Harmonic U23 exceeded, line 2	Order of harmonic
HN31_2	Harmonic U31 exceeded, line 2	Order of harmonic
PST1E_2	Short-term flicker U1E exceeded, line 2	10-minute average value
PST2E_2	Short-term flicker U2E exceeded, line 2	10-minute average value
PST3E_2	Short-term flicker U3E exceeded, line 2	10-minute average value
PST12_2	Short-term flicker U12 exceeded, line 2	10-minute average value
PST23_2	Short-term flicker U23 exceeded, line 2	10-minute average value
PST31_2	Short-term flicker U31 exceeded, line 2	10-minute average value
US1_2	US1-3s exceeded, start event, line 2	Trigger value
US1x_2	US1-3s exceeded, stop event, line 2	Maximum value
US2_2	US2-3s exceeded, start event, line 2	Trigger value
US2x_2	US2-3s exceeded, stop event, line 2	Maximum value
US3_2	US3-3s exceeded, start event, line 2	Trigger value
US3x_2	US3-3s exceeded, stop event, line 2	Maximum value
US12_2	US12-3s exceeded, start event, line 2	Trigger value
US12x_2	US12-3s exceeded, stop event, line 2	Maximum value
US23_2	US23-3s exceeded, start event, line 2	Trigger value
US23x_2	US23-3s exceeded, stop event, line 2	Maximum value
US31_2	US31-3s exceeded, start event, line 2	Trigger value
US31x_2	US31-3s exceeded, stop event, line 2	Maximum value
US1_1	US1-3s exceeded, start event, line 1	Trigger value
US1x_1	US1-3s exceeded, stop event, line 1	Maximum value
US2_1	US2-3s exceeded, start event, line 1	Trigger value
US2x_1	US2-3s exceeded, stop event, line 1	Maximum value
US3_1	US3-3s exceeded, start event, line 1	Trigger value
US3x_1	US3-3s exceeded, stop event, line 1	Maximum value
US12_1	US12-3s exceeded, start event, line 1	Trigger value
US12x_1	US12-3s exceeded, stop event, line 1	Maximum value
US23_1	US23-3s exceeded, start event, line 1	Trigger value
US23x_1	US23-3s exceeded, stop event, line 1	Maximum value
US31_1	US31-3s exceeded, start event, line 1	Trigger value
US31x_1	US31-3s exceeded, stop event, line 1	Maximum value
FVC1_1	Voltage change U1E/U1N, start event, line 1	Trigger value
FVC1x_1	Voltage change U1E/U1N, stop event, line 1	Maximum value
FVC2_1	Voltage change U2E/U2N, start event, line 1	Trigger value

Symbol	Designation	Event value
FVC2x_1	Voltage change U2E/U2N, stop event, line 1	Maximum value
FVC3_1	Voltage change U3E/U3N, start event, line 1	Trigger value
FVC3x_1	Voltage change U3E/U3N, stop event, line 1	Maximum value
FVC12_1	Voltage change U12, start event, line 1	Trigger value
FVC12x_1	Voltage change U12, stop event, line 1	Maximum value
FVC23_1	Voltage change U23, start event, line 1	Trigger value
FVC23x_1	Voltage change U23, stopt event, line 1	Maximum value
FVC31_1	Voltage change U31, start event, line 1	Trigger value
FVC31x_1	Voltage change U31, stop event, line 1	Maximum value
FVC1_2	Voltage change U1E/U1N, start event, line 2	Trigger value
FVC1x_2	Voltage change U1E/U1N, stop event, line 2	Maximum value
FVC2_2	Voltage change U2E/U2N, start event, line 2	Trigger value
FVC2x_2	Voltage change U2E/U2N, stop event, line 2	Maximum value
FVC3_2	Voltage change U3E/U3N, start event, line 2	Trigger value
FVC3x_2	Voltage change U3E/U3N, stop event, line 2	Maximum value
FVC12_2	Voltage change U12, start event, line 2	Trigger value
FVC12x_2	Voltage change U12, stop event, line 2	Maximum value
FVC23_2	Voltage change U23, start event, line 2	Trigger value
FVC23x_2	Voltage change U23, stopt event, line 2	Maximum value
FVC31_2	Voltage change U31, start event, line 2	Trigger value
FVC31x_2	Voltage change U31, stop event, line 2	Maximum value
F10S	Network frequency	10-second frequency value

Overview of binary message singals, 4xU and 4xI

ID	Symbol	Description
0	NoSignal	No signal
1	Rst	Auxiliary voltage interruption
2	IntErr	Internal error
3	ComErr	COM error
4	LanErr	LAN error
5	WDT1	Communication watchdog 1 : Timeout
6	FsyncErr	Frequency synchronisation error (V2 and V3 only!)
7	ClipErr	Measurement range exceeded
8	MSRs2	New 10/12-period values
9	MSR3s	New 150/180-period values
10	MSR10min	New 10-min values
11	MSR2h	New 2-hour values
12	MSRDay	New daily values
13	MSRRecA	New fault record in recorder A1
14	MSRRecB	New fault record in recorder B1

ID	Symbol	Description
15	MSRRecC	New fault record in recorder C
16	MSREvnt	New event
17	MEMs2	Maximum level of 0.2-second buffer exceeded
18	MEM3s	Maximum level of 3-second buffer exceeded
19	MEM10min	Maximum level of 10-minute buffer exceeded
20	MEM2h	Maximum level of 2-hour buffer exceeded
21	MEMDay	Maximum level of day buffer exceeded
22	MEMRecA	Maximum level of recorder A exceeded
23	MEMRecB	Maximum level of recorder B exceeded
24	MEMRecC	Maximum level of recorder C exceeded
25	MEMEvnt	Maximum level of event buffer 1 exceeded
26	Nfc	Frequency deviation, narrow tolerance
27	Wfc	Frequency deviation, wide tolerance
28	Tov	Intermittent overvoltage at the network frequency
29	Fvc	Fast voltage change
30	Fvd	Voltage dip
31	Si	Short voltage interruption
32	Li	Long voltage interruption
33	SVC	Slow voltage deviation (10 minutes)
34	HD	Harmonic distortions exceeded (10 minutes)
35	UU	Voltage asymmetry exceeded (10 minutes)
36	PST	PST exceeded (10 minutes)
37	PLT	PLT exceeded (2 hours)
38	DINNfc_w	Narrow frequency range too frequently exceeded [week]
39	DINNfc_y	Narrow frequency range too frequently exceeded [year]
40	DINTov_y	Maximum number of intermittent overvoltages at the network frequency exceeded [year]
41	DINFvc_d	Maximum number of fast voltage changes exceeded [day]
42	DINFvc_y	Maximum number of fast voltage changes exceeded [year]
43	DINFvd_y	Maximum number of voltage dips exceeded [year]
44	DINSi_y	Maximum number of short supply interruptions exceeded [year]
45	DINLi_y	Maximum number of long supply interruptions exceeded [year]
46	DINSVC_w	Slow voltage change range exceeded too frequently [week]
47	DINHD_w	Harmonic distortion range exceeded too frequently [week]
48	DINUU_w	Asymmetrical voltage range exceeded too frequently [week]
49	DINPLT_w	Flicker range exceeded too frequently [week]
50	DINSig_d	Signal voltage exceeded too frequently [day]
51	DINSig_w	Signal voltage exceeded too frequently [week]
52	DINSig_y	Maximum number of days exceeded on which the signal voltage is exceeded too frequently [year]
53	Sig	Signal voltage exceeded

ID	Symbol	Description
54	MSRRecS	New fault record in recorder S
55	MEMRecS	Maximum level of recorder S exceeded
56	TIMESYNC	Status of external time synchronisation
57	TIMESET	Time setting
58	WDT2	Communication watchdog 2 : Timeout
59	TN_K1P	TRANSNOSTIC : Phase-earth short-circuit in own network (behind measurement point)
60	TN_K2P	TRANSNOSTIC : Phase-phase short-circuit in own network (behind measurement point)
61	TN_K3P	TRANSNOSTIC : 3-phase short-circuit in own network (behind measurement point)
62	TN_KIM	TRANSNOSTIC : Short-circuit before measurement point
63	TN_PEX	TRANSNOSTIC : Peak in own network (behind measurement point)
64	TN_PIM	TRANSNOSTIC : Peak before measurement point
65	BIN_1	Binary input 1
66	BIN_2	Binary input 2
67	BIN_3	Binary input 3
68	BIN_4	Binary input 4
69	BIN_5	Binary input 5
70	BIN_6	Binary input 6
71	BIN_7	Binary input 7
72	BIN_8	Binary input 8
73	BIN_9	Binary input 9
74	BIN_10	Binary input 10
75	BIN_11	Binary input 11
76	BIN_12	Binary input 12
77	BIN_13	Binary input 13
78	BIN_14	Binary input 14
79	BIN_15	Binary input 15
80	BIN_16	Binary input 16
81	Eval	Enable event evaluation
82	ENs2	Enable recording of 10/12-period values
83	EN3s	Enable recording of 150/180-period values
84	EN10min	Enable recording of 10-minute values
85	EN2h	Enable recording of 2-hour values
86	ENDay	Enable recording of daily values
87	ENRecA	Enable recording of fault records in recorder A
88	ENRecB	Enable recording of fault records in recorder B
89	ENRecC	Enable recording of fault records in recorder C
90	ENRecS	Enable recording of fault records in recorder S
91	ENEvnt	Enable event recording
92	TrgTx	External trigger signal sent

ID	Symbol	Description
93	TrgRx	External trigger signal received
94	TrgLTF	Trigger signal: Lower limit for half-period frequency
95	TrgUTF	Trigger signal: Upper limit for half-period frequency
96	TrgSTF	Trigger signal: Half-period frequency jump
97	TrgSW	Trigger signal: Software triggers
98	TrgLT1	Trigger signal: Lower limit for half-period voltage U1
99	TrgLT2	Trigger signal: Lower limit for half-period voltage U2
100	TrgLT3	Trigger signal: Lower limit for half-period voltage U3
101	TrgLT12	Trigger signal: Lower limit for half-period voltage U12
102	TrgLT23	Trigger signal: Lower limit for half-period voltage U23
103	TrgLT31	Trigger signal: Lower limit for half-period voltage U31
104	TrgUT1	Trigger signal: Upper limit for half-period voltage U1
105	TrgUT2	Trigger signal: Upper limit for half-period voltage U2
106	TrgUT3	Trigger signal: Upper limit for half-period voltage U3
107	TrgUT12	Trigger signal: Upper limit for half-period voltage U12
108	TrgUT23	Trigger signal: Upper limit for half-period voltage U23
109	TrgUT31	Trigger signal: Upper limit for half-period voltage U31
110	TrgUTN	Trigger signal: Upper limit for half-period voltage UNE
111	TrgST1	Trigger signal: Half-period voltage jump U1
112	TrgST2	Trigger signal: Half-period voltage jump U2
113	TrgST3	Trigger signal: Half-period voltage jump U3
114	TrgST12	Trigger signal: Half-period voltage jump U12
115	TrgST23	Trigger signal: Half-period voltage jump U23
116	TrgST31	Trigger signal: Half-period voltage jump U31
117	TrgSTN	Trigger signal: Half-period voltage jump UNE
118	TrgSTP1	Trigger signal: Half-period voltage phase jump U1
119	TrgSTP2	Trigger signal: Half-period voltage phase jump U2
120	TrgSTP3	Trigger signal: Half-period voltage phase jump U3
121	TrgET1	Trigger signal: Envelope curve U1
122	TrgET2	Trigger signal: Envelope curve U2
123	TrgET3	Trigger signal: Envelope curve U3
124	TrgET12	Trigger signal: Envelope curve U12
125	TrgET23	Trigger signal: Envelope curve U23
126	TrgET31	Trigger signal: Envelope curve U31
127	TrgETN	Trigger signal: Envelope curve UNE
128	TrgLPS	Trigger signal: Lower limit for half-period voltage in a positive-sequence system
129	TrgUPS	Trigger signal: Upper limit for half-period voltage in a positive-sequence system
130	TrgUNS	Trigger signal: Upper limit for half-period voltage in a negative-sequence system

ID	Symbol	Description
131	TrgUZS	Trigger signal: Upper limit for half-period voltage in a zero-sequence system
132	TrgLT1_I	Trigger signal: Lower limit for half-period current I1
133	TrgLT2_I	Trigger signal: Lower limit for half-period current I2
134	TrgLT3_I	Trigger signal: Lower limit for half-period current I3
135	TrgUT1_I	Trigger signal: Upper limit for half-period current I1
136	TrgUT2_I	Trigger signal: Upper limit for half-period current I2
137	TrgUT3_I	Trigger signal: Upper limit for half-period current I3
138	TrgUTN_I	Trigger signal: Upper limit for half-period current IN
139	TrgST1_I	Trigger signal: Half-period current jump I1
140	TrgST2_I	Trigger signal: Half-period current jump I2
141	TrgST3_I	Trigger signal: Half-period current jump I3
142	TrgSTN_I	Trigger signal: Half-period current jump IN

Device 8 x U

ID	Symbol	Description
0	NoSignal	No signal
1	Rst	Auxiliary voltage interruption
2	IntErr	Internal error
3	ComErr	COM error
4	LanErr	LAN error
5	WDT1	Communication watchdog 1 : Timeout
6	FsyncErr	Frequency synchronisation error
7	ClipErr_1	Measurement range exceeded, line 1
8	MSRs2_1	New 10/12-period values, line 1
9	MSR3s_1	New 150/180-period values, line 1
10	MSR10min_1	New 10-min values, line 1
11	MSR2h_1	New 2-hour values, line 1
12	MSRDay_1	New daily values, line 1
13	MSRRecA_1	New fault record in recorder A, line 1
14	MSRRecB_1	New fault record in recorder B, line 1
15	MSRRecC_1	New fault record in recorder C, line 1
16	MSREvnt_1	New event, line 1
17	MEMs2_1	Maximum level of 0.2-second buffer exceeded, line 1
18	MEM3s_1	Maximum level of 3-second buffer exceeded, line 1
19	MEM10min_1	Maximum level of 10-minute buffer exceeded, line 1
20	MEM2h_1	Maximum level of 2-hour buffer exceeded, line 1
21	MEMDay_1	Maximum level of day buffer exceeded, line 1
22	MEMRecA_1	Maximum level of recorder A exceeded, line 1
23	MEMRecB_1	Maximum level of recorder B exceeded, line 1
24	MEMRecC_1	Maximum level of recorder C exceeded, line 1

ID	Symbol	Description
25	MEMEvnt_1	Maximum level of event buffer exceeded, line 1
26	Nfc_1	Frequency change, narrow tolerance, line 1
27	Wfc_1	Frequency change, wide tolerance, line 1
28	Tov_1	Intermittent overvoltage at the network frequency, line 1
29	Fvc_1	Fast voltage change, line 1
30	Fvd_1	Voltage dip, line 1
31	Si_1	Short voltage interruption, line 1
32	Li_1	Long voltage interruption, line 1
33	SVC_1	Slow voltage deviation (10 minutes), line 1
34	HD_1	Harmonic distortions exceeded (10 minutes), line 1
35	UU_1	Voltage asymmetry exceeded (10 minutes), line 1
36	PST_1	PST exceeded (10 minutes), line 1
37	PLT_1	PLT exceeded (2 hours), line 1
38	DINNfc_w_1	Narrow frequency range too frequently exceeded [week], line 1
39	DINNfc_y_1	Narrow frequency range too frequently exceeded [year], line 1
40	DINTov_y_1	Maximum number of intermittent overvoltages at the network frequency exceeded [year], line 1
41	DINFvc_d_1	Maximum number of fast voltage changes exceeded [day], line 1
42	DINFvc_y_1	Maximum number of fast voltage changes exceeded [year], line 1
43	DINFvd_y_1	Maximum number of voltage dips exceeded [year], line 1
44	DINSi_y_1	Maximum number of short interruptions to the supply exceeded [year], line 1
45	DINLi_y_1	Maximum number of long interruptions to the supply exceeded [year], line 1
46	DINSVC_w_1	Slow voltage change range exceeded too frequently [week], line 1
47	DINHD_w_1	Harmonic distortion range exceeded too frequently [week], line 1
48	DINUU_w_1	Asymmetrical voltage range exceeded too frequently [week], line 1
49	DINPLT_w_1	Flicker range exceeded too frequently [week], line 1
50	ClipErr_2	Measurement range exceeded, line 2
51	MSRs2_2	New 10/12-period values, line 2
52	MSR3s_2	New 150/180-period values, line 2
53	MSR10min_2	New 10-min values, line 2
54	MSR2h_2	New 2-hour values, line 2
55	MSRDay_2	New daily values, line 2
56	MSRRecA_2	New fault record in recorder A, line 2
57	MSRRecB_2	New fault record in recorder B, line 2
58	MSRRecC_2	New fault record in recorder C, line 2
59	MSREvnt_2	New event, line 2
60	MEMs2_2	Maximum level of 0.2-second buffer exceeded, line 2
61	MEM3s_2	Maximum level of 3-second buffer exceeded, line 2
62	MEM10min_2	Maximum level of 10-minute buffer exceeded, line 2
63	MEM2h_2	Maximum level of 2-hour buffer exceeded, line 2

ID	Symbol	Description
64	MEMDay_2	Maximum level of day buffer exceeded, line 2
65	MEMRecA_2	Maximum level of recorder A exceeded, line 2
66	MEMRecB_2	Maximum level of recorder B exceeded, line 2
67	MEMRecC_2	Maximum level of recorder C exceeded, line 2
68	MEMEvnt_2	Maximum level of event buffer exceeded
69	Nfc_2	Frequency change, narrow tolerance, line 2
70	Wfc_2	Frequency change, wide tolerance, line 2
71	Tov_2	Intermittent overvoltage at the network frequency, line 2
72	Fvc_2	Fast voltage change, line 2
73	Fvd_2	Voltage dip, line 2
74	Si_2	Short voltage interruption, line 2
75	Li_2	Long voltage interruption, line 2
76	SVC_2	Slow voltage deviation (10 minutes), line 2
77	HD_2	Harmonic distortions exceeded (10 minutes), line 2
78	UU_2	Voltage asymmetry exceeded (10 minutes), line 2
79	PST_2	PST exceeded (10 minutes), line 2
80	PLT_2	PLT exceeded (2 hours), line 2
81	DINNfc_w_2	Narrow frequency range too frequently exceeded [week], line 2
82	DINNfc_y_2	Narrow frequency range too frequently exceeded [year], line 2
83	DINTov_y_2	Maximum number of intermittent overvoltages at the network frequency exceeded [year], line 2
84	DINFvc_d_2	Maximum number of fast voltage changes exceeded [day], line 2
85	DINFvc_y_2	Maximum number of fast voltage changes exceeded [year], line 2
86	DINFvd_y_2	Maximum number of voltage dips exceeded [year], line 2
87	DINSi_y_2	Maximum number of short interruptions to the supply exceeded [year], line 2
88	DINLi_y_2	Maximum number of long interruptions to the supply exceeded [year], line 2
89	DINSVC_w_2	Slow voltage change range exceeded too frequently [week], line 2
90	DINHD_w_2	Harmonic distortion range exceeded too frequently [week], line 2
91	DINUU_w_2	Asymmetrical voltage range exceeded too frequently [week], line 2
92	DINPLT_w_2	Flicker range exceeded too frequently [week], line 2
93	DINSig_d_2	Signal voltage exceeded too frequently [day], line 2
94	DINSig_w_2	Signal voltage exceeded too frequently [week], line 2
95	DINSig_y_2	Maximum number of days exceeded on which the signal voltage is exceeded too frequently [year], line 2
96	Sig_2	Signal voltage exceeded, line 2
97	MSRRecS_2	New fault record in recorder S, line 2
98	MEMRecS_2	Maximum level of recorder S exceeded, line 2
99	DINSig_d_1	Signal voltage exceeded too frequently [day], line 1
100	DINSig_w_1	Signal voltage exceeded too frequently [week], line 1
101	DINSig_y_1	Maximum number of days exceeded on which the signal voltage is exceeded too frequently [year], line 1
102	Sig_1	Signal voltage exceeded, line 1

ID	Symbol	Description
103	MSRRecS_1	New fault record in recorder S, line 1
104	MEMRecS_1	Maximum level of recorder S exceeded, line 1
105	Eval_1	Status of event evaluation, line 1
106	ENs2_1	Status of recording for 10/12-period values, line 1
107	EN3s_1	Status of recording for 150/180-period values, line 1
108	EN10min_1	Status of recording for 10-min values, line 1
109	EN2h_1	Status of recording for 2-hour values, line 1
110	ENDay_1	Status of recording for daily values, line 1
111	ENRecA_1	Status of recording for fault record in recorder A, line 1
112	ENRecB_1	Status of recording for fault record in recorder B, line 1
113	ENRecC_1	Status of recording for fault record in recorder C, line 1
114	ENRecS_1	Status of recording for fault record in recorder S, line 1
115	ENEvnt_1	Status of recording for event, line 1
116	Eval_2	Status of event evaluation, line 2
117	ENs2_2	Status of recording for 10/12-period values, line 2
118	EN3s_2	Status of recording for 150/180-period values, line 2
119	EN10min_2	Status of recording for 10-min values, line 2
120	EN2h_2	Status of recording for 2-hour values, line 2
121	ENDay_2	Status of recording for daily values, line 2
122	ENRecA_2	Status of recording for fault record in recorder A, line 2
123	ENRecB_2	Status of recording for fault record in recorder B, line 2
124	ENRecC_2	Status of recording for fault record in recorder C, line 2
125	ENRecS_2	Status of recording for fault record in recorder S, line 2
126	ENEvnt_2	Status of recording for event, line 2
127	TIMESYNC	Status of external time synchronisation: 0 = not synchronised, 1 = synchronised
128	TIMESET	Time setting
129	BIN_1	Binary input 1
130	BIN_2	Binary input 2
131	BIN_3	Binary input 3
132	BIN_4	Binary input 4
133	BIN_5	Binary input 5
134	BIN_6	Binary input 6
135	BIN_7	Binary input 7
136	BIN_8	Binary input 8
137	BIN_9	Binary input 9
138	BIN_10	Binary input 10
139	BIN_11	Binary input 11
140	BIN_12	Binary input 12
141	BIN_13	Binary input 13
142	BIN_14	Binary input 14
143	BIN_15	Binary input 15

ID	Symbol	Description
144	BIN_16	Binary input 16
145	WDT2	Communication watchdog 2 : Timeout
146	TrgTx	External trigger signal sent
147	TrgRx	External trigger signal received
148	TrgLTF	Trigger signal: Lower limit for half-period frequency
149	TrgUTF	Trigger signal: Upper limit for half-period frequency
150	TrgSTF	Trigger signal: Half-period frequency jump
151	TrgSW_1	Trigger signal: Software trigger, line 1
152	TrgLT1_1	Trigger signal: Lower limit for half-period voltage U1, line 1
153	TrgLT2_1	Trigger signal: Lower limit for half-period voltage U2, line 1
154	TrgLT3_1	Trigger signal: Lower limit for half-period voltage U3, line 1
155	TrgLT12_1	Trigger signal: Lower limit for half-period voltage U12, line 1
156	TrgLT23_1	Trigger signal: Lower limit for half-period voltage U23, line 1
157	TrgLT31_1	Trigger signal: Lower limit for half-period voltage U3, line 1
158	TrgUT1_1	Trigger signal: Upper limit for half-period voltage U1, line 1
159	TrgUT2_1	Trigger signal: Upper limit for half-period voltage U2, line 1
160	TrgUT3_1	Trigger signal: Upper limit for half-period voltage U3, line 1
161	TrgUT12_1	Trigger signal: Upper limit for half-period voltage U12, line 1
162	TrgUT23_1	Trigger signal: Upper limit for half-period voltage U23, line 1
163	TrgUT31_1	Trigger signal: Upper limit for half-period voltage U3, line 1
164	TrgUTN_1	Trigger signal: Upper limit for half-period voltage UNE, line 1
165	TrgST1_1	Trigger signal: Half-period voltage jump U1, line 1
166	TrgST2_1	Trigger signal: Half-period voltage jump U2, line 1
167	TrgST3_1	Trigger signal: Half-period voltage jump U3, line 1
168	TrgST12_1	Trigger signal: Half-period voltage jump U12, line 1
169	TrgST23_1	Trigger signal: Half-period voltage jump U23, line 1
170	TrgST31_1	Trigger signal: Half-period voltage jump U31, line 1
171	TrgSTN_1	Trigger signal: Half-period voltage jump UNE, line 1
172	TrgSTP1_1	Trigger signal: Half-period voltage phase jump U1, line 1
173	TrgSTP2_1	Trigger signal: Half-period voltage phase jump U2, line 1
174	TrgSTP3_1	Trigger signal: Half-period voltage phase jump U3, line 1
175	TrgET1_1	Trigger signal: Envelope curve U1, line 1
176	TrgET2_1	Trigger signal: Envelope curve U2, line 1
177	TrgET3_1	Trigger signal: Envelope curve U3, line 1
178	TrgET12_1	Trigger signal: Envelope curve U12, line 1
179	TrgET23_1	Trigger signal: Envelope curve U23, line 1
180	TrgET31_1	Trigger signal: Envelope curve U31, line 1
181	TrgETN_1	Trigger signal: Envelope curve UNE, line 1
182	TrgLPS_1	Trigger signal: Lower limit for half-period voltage in a positive-sequence system, line 1
183	TrgUPS_1	Trigger signal: Upper limit for half-period voltage in a positive-sequence system, line 1

ID	Symbol	Description
184	TrgUNS_1	Trigger signal: Upper limit for half-period voltage in a negative-sequence system, line 1
185	TrgUZS_1	Trigger signal: Upper limit for half-period voltage in a zero-sequence system, line 1
186	TrgSW_2	Trigger signal: Software trigger, line 2
187	TrgLT1_2	Trigger signal: Lower limit for half-period voltage U1, line 2
188	TrgLT2_2	Trigger signal: Lower limit for half-period voltage U2, line 2
189	TrgLT3_2	Trigger signal: Lower limit for half-period voltage U3, line 2
190	TrgLT12_2	Trigger signal: Lower limit for half-period voltage U12, line 2
191	TrgLT23_2	Trigger signal: Lower limit for half-period voltage U23, line 2
192	TrgLT31_2	Trigger signal: Lower limit for half-period voltage U3, line 2
193	TrgUT1_2	Trigger signal: Upper limit for half-period voltage U1, line 2
194	TrgUT2_2	Trigger signal: Upper limit for half-period voltage U2, line 2
195	TrgUT3_2	Trigger signal: Upper limit for half-period voltage U3, line 2
196	TrgUT12_2	Trigger signal: Upper limit for half-period voltage U12, line 2
197	TrgUT23_2	Trigger signal: Upper limit for half-period voltage U23, line 2
198	TrgUT31_2	Trigger signal: Upper limit for half-period voltage U3, line 2
199	TrgUTN_2	Trigger signal: Upper limit for half-period voltage UNE, line 2
200	TrgST1_2	Trigger signal: Half-period voltage jump U1, line 2
201	TrgST2_2	Trigger signal: Half-period voltage jump U2, line 2
202	TrgST3_2	Trigger signal: Half-period voltage jump U3, line 2
203	TrgST12_2	Trigger signal: Half-period voltage jump U12, line 2
204	TrgST23_2	Trigger signal: Half-period voltage jump U23, line 2
205	TrgST31_2	Trigger signal: Half-period voltage jump U31, line 2
206	TrgSTN_2	Trigger signal: Half-period voltage jump UNE, line 2
207	TrgSTP1_2	Trigger signal: Half-period voltage phase jump U1, line 2
208	TrgSTP2_2	Trigger signal: Half-period voltage phase jump U2, line 2
209	TrgSTP3_2	Trigger signal: Half-period voltage phase jump U3, line 2
210	TrgET1_2	Trigger signal: Envelope curve U1, line 2
211	TrgET2_2	Trigger signal: Envelope curve U2, line 2
212	TrgET3_2	Trigger signal: Envelope curve U3, line 2
213	TrgET12_2	Trigger signal: Envelope curve U12, line 2
214	TrgET23_2	Trigger signal: Envelope curve U23, line 2
215	TrgET31_2	Trigger signal: Envelope curve U31, line 2
216	TrgETN_2	Trigger signal: Envelope curve UNE, line 2
217	TrgLPS_2	Trigger signal: Lower limit for half-period voltage in a positive-sequence system, line 2
218	TrgUPS_2	Trigger signal: Upper limit for half-period voltage in a positive-sequence system, line 2
219	TrgUNS_2	Trigger signal: Upper limit for half-period voltage in a negative-sequence system, line 2
220	TrgUZS_2	Trigger signal: Upper limit for half-period voltage in a zero-sequence system, line 2

Reference conditions

Reference temperature	23°C ± 1 K
Input parameters	$U = U_n$ ± 10% I= In ± 10%
Auxiliary voltage	$H = H_n$ ± 1 %
Frequency	= f_{nom} ± 1%
Other	IEC 60688 - Part 1

Measurement data acquisition

Sampling rate	10,240 Hz
ADC resolution	24-bit
Anti-aliasing filter	Analogue filter: 3rd order Butterworth filter Digital filter : sinc5 decimation filter (ADC)
Nominal frequency	f_{nom} = 50 Hz, 60 Hz
Frequency measurement range	f_{nom} ±15%

Data memory

Calibration parameter, hardware identification	Serial EEPROM, 256x16 bit
Firmware	FLASH (CPU), 4 MB
Non-volatile measurement data (4 MB), settings	NV RAM (CPU), 4 MB, battery backup (Li battery)
Volatile measurement data (64 MB, background memory)	SDRAM (DSP), 64 MB

Electromagnetic compatibility

CE conformity		
	Interference immunity	EN 61326 EN 61000-6-2
	Emitted interference	EN 61326 EN 61000-6-4
ESD		
	IEC 61000-4-2 IEC 60 255-22-2	8 kV / 16 kV
Electromagnetic fields		
	IEC 61000-4-3 IEC 60 255-22-3	10 V/m
Burst		
	IEC 61000-4-4 IEC 60 255-22-4	4 kV / 2 kV
Surge 1 MHz burst		
	IEC 61000-4-5 IEC 61000-4-12 IEC 60 255-22-1	4 kV / 2 kV 2.5 kV, Class III
Conducted high frequency magnetic fields		
	IEC 61000-4-6 IEC 61000-4-8 All layers	10 V, 150 kHz ... 80 MHz 100 A/m continuous 1000 A/m 1 s
Voltage dips		
	IEC 61000-4-11	30% 0.02s, 60% 1 s
Emitted interference		
	EN 61326 EN 61000-6-4	
	Housing at a distance of 10 m	30...230 MHz, 40 dB 230...1000 MHz, 47 dB
	AC power supply con-nection at a distance of 10 m	0.15...0.5 MHz, 79 dB 0.5...5 MHz, 73 d 5...30 MHz, 73 dB

Electrical safety

Degree of protection	1
Degree of pollution	2
Measurement category	CAT III / 300V
optional	CAT III / 500 V

Operating voltages

50 V	230 V
E-LAN, COM server COM1 ... COM2 time/trigger	Auxiliary voltage Binary inputs Relay outputs

Power supply

Feature	H0	H1
AC nominal range	100V ... 240V	-
AC operating range	90 ... 264 V	
DC nominal range	100 ... 300 V	20 ... 70 V
DC operating range	100 ... 300 V	18 ... 72 V
Power consumption	≤ 15 VA	≤ 15 Watts
Frequency	45 ... 400Hz	-
Microfuse	T2 250 V	T2 250 V

The following applies for all features:
Voltage interruptions of ≤ 80 ms do not cause a fault or loss of data.

Environmentalconditions

Temperature range

Function	-15 ... +55 °C
Transport and storage	-25 ... +65 °C

Humidity

No condensation on 30 days/year	95 % rel.

Dry, cold

IEC 60068-2-1	-15 °C / 16 h

Dry, hot

IEC 60068-2-2	+55 °C / 16 h

Constant humid heat

IEC 60068-2-3	+ 40 °C / 93 % / 2 days

Cyclical humid heat

IEC 60068-2-30	12+12h, 6 cycles, +55 °C/93%

Toppling

IEC 60068-2-31	100 mm drop, unwrapped

Vibration

IEC 60255-21-1	Class 1

Impact

IEC 60255-21-2	Class 1

Mechanical design

Measurement inputs

Feature	
C10	2 x 4 voltage inputs (100 V / 230 V) for double busbar system
C20 … C31	4 voltage inputs (100 V / 230 V), 4 current inputs (1 A / 5 A)

Design

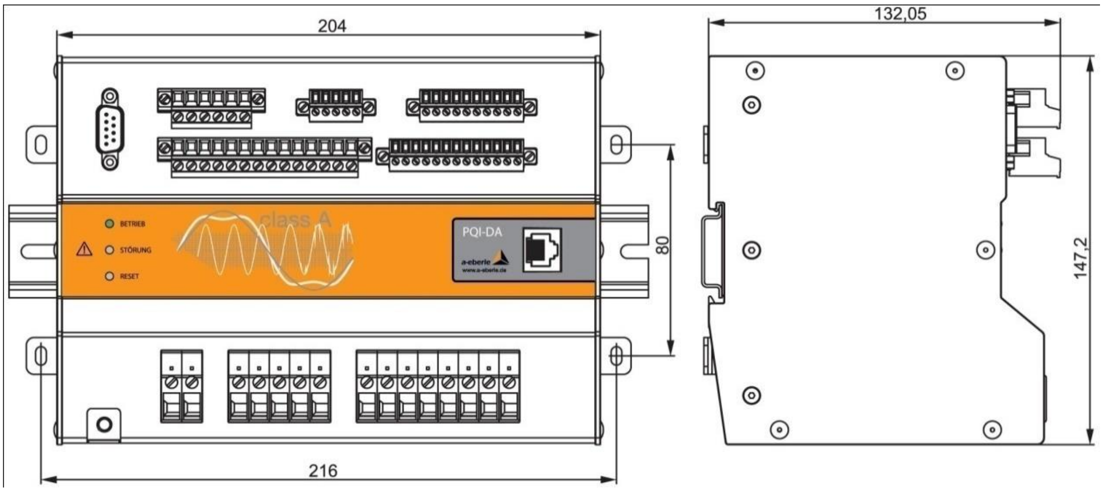
The PQI-DA Power Quality Interface has a robust stainless steel housing.

All connections are accessible via Phoenix terminals. All connections apart from the current and voltage inputs are plug/clamping connections.

If the COM server (feature T1) option is selected, an RJ 45 connection is available.

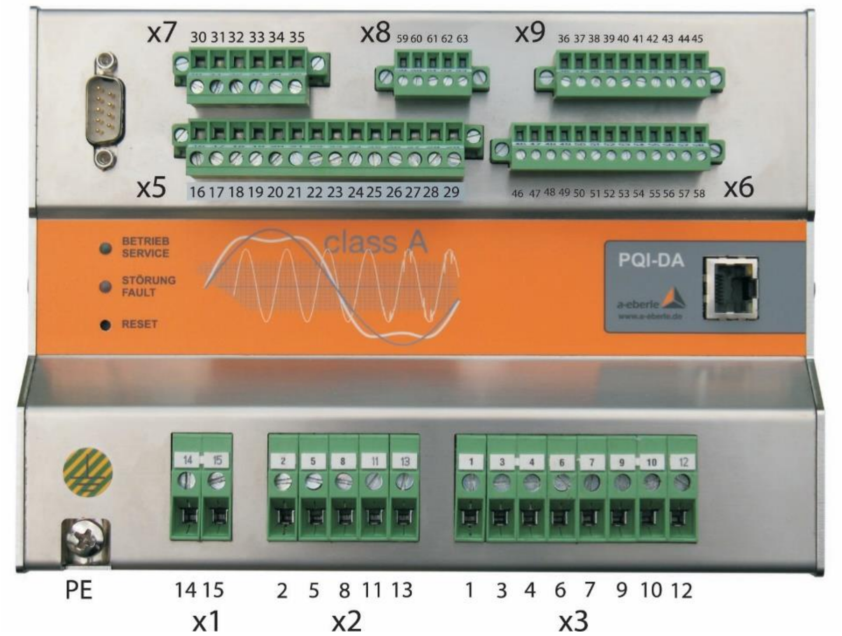
The device can be used for wall mounting as well as busbar mounting.

Material	Stainless steel
Degree of protection	
Housing	IP 40
Terminals	IP 20
Weight	≤ 2 kg
Dimensions	See figure below
Connection elements	Screw terminals

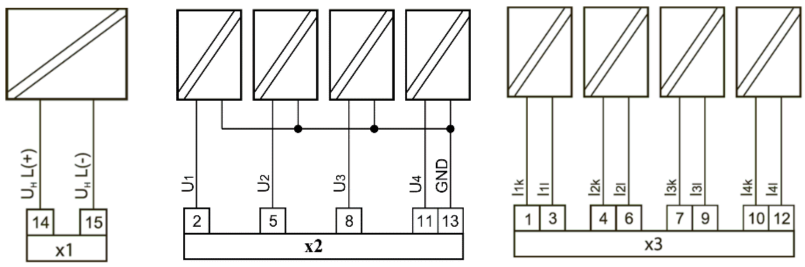


Dimensions

PQI-DA 4U / 4I

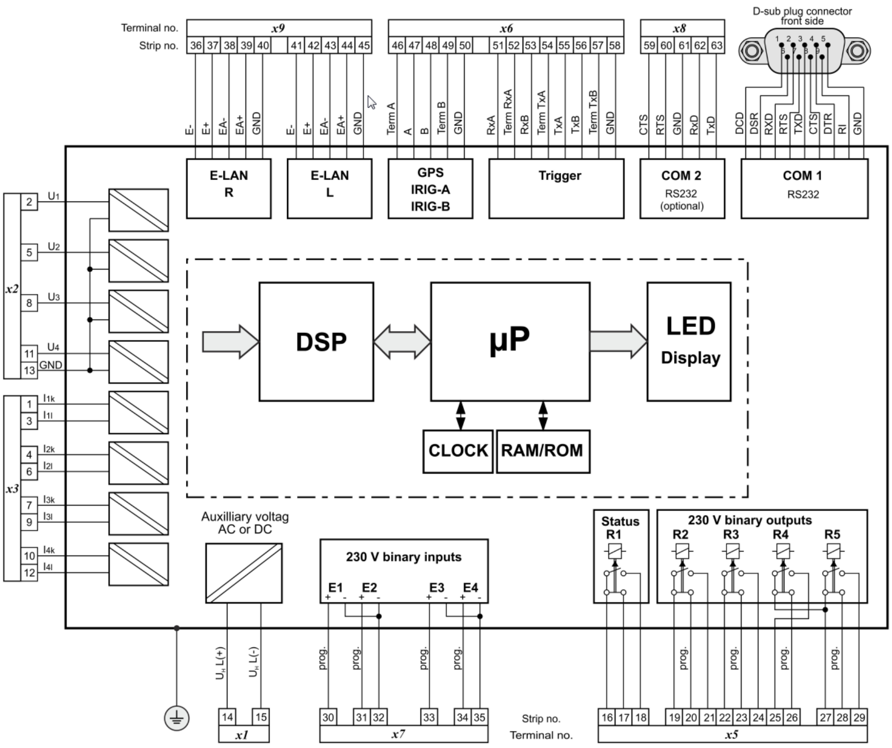


Assignment of the terminal strips x1 ... x3

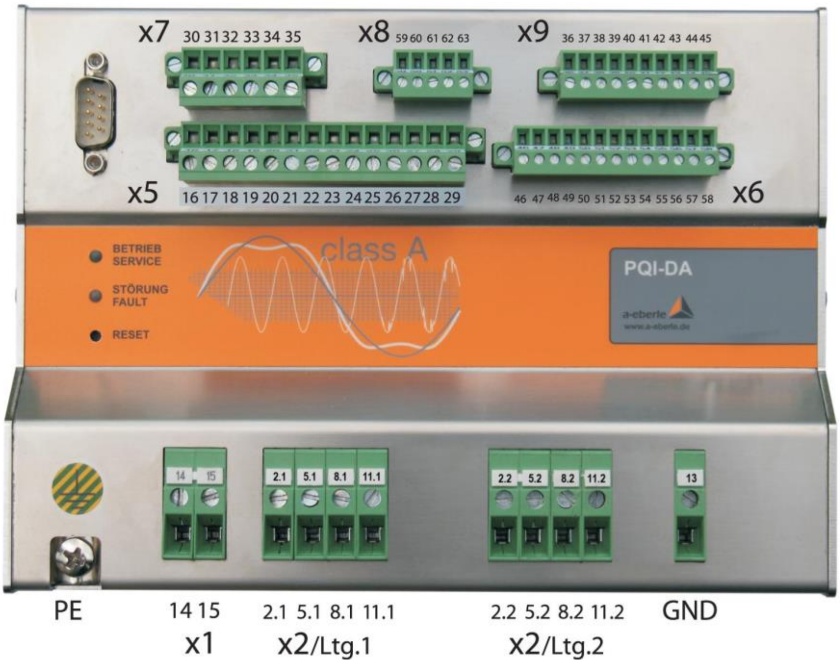


Terminal strip no.	Designation		Function	Terminal no.
X1	Auxiliary voltage	U_H	L (+) L (-)	14 15
X2	Phase voltage L1 (AC)	U_1	L1	2
	Phase voltage L2	U_2	L2	5
	Phase voltage L3	U_3	L3	8
	Neutral point voltage	U_4	N	11
	Ground	GND	E	13
X3	Phase current L1	I1	K l	1 3
	Phase current L2	I2	K l	4 6
	Phase current L3	I3	K l	7 9
	Neutral conductor / sum current	I4	K l	10 12

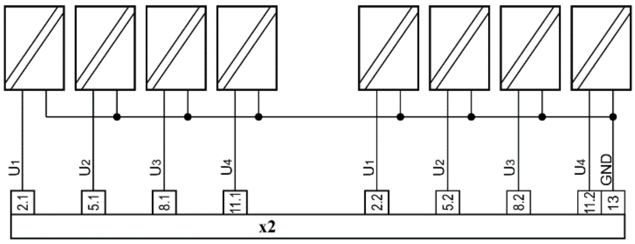
Block diagram:



PQI-DA 8U

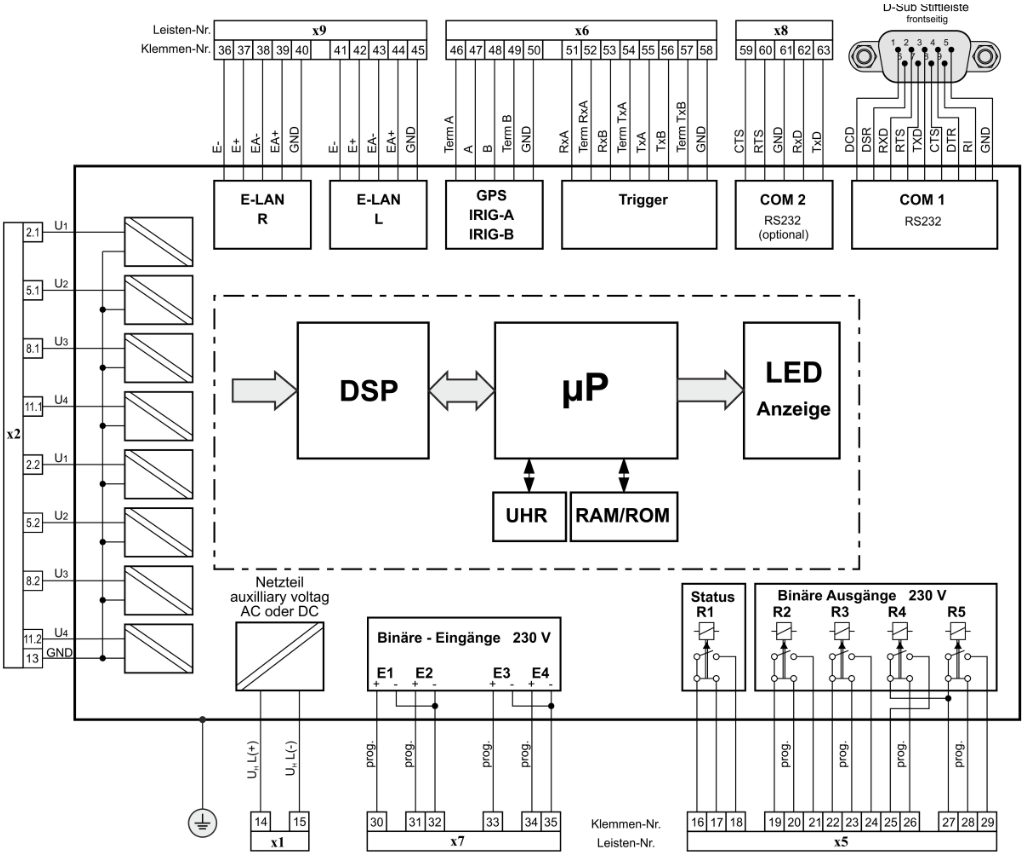


Assignment of the terminal strips x1 ... x2

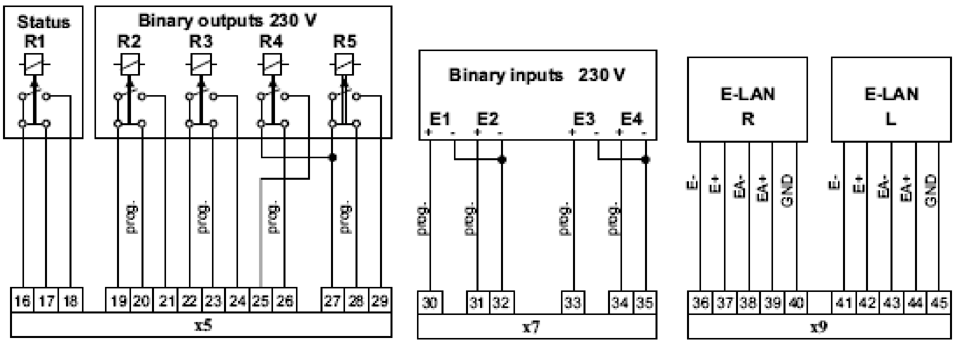


Terminal strip no.	Designation		Function	Terminal no.
X1	Auxiliary voltage	U_H	L (+)	14
			L (-)	15
X2 Line 1	Phase voltage	U_1	L1	2.1
	Phase voltage	U_2	L2	5.1
	Phase voltage	U_3	L3	8.1
	Neutral point voltage	U_4	N	11.1
X3	Ground	GND	E	13

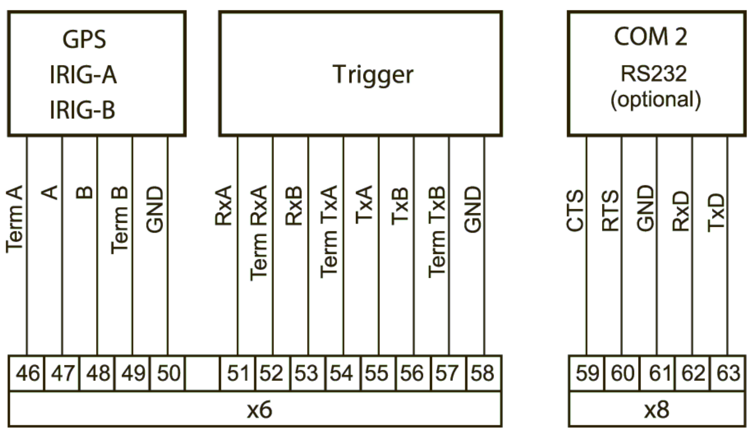
Block diagram:



Assignment of terminal strips x5..x9



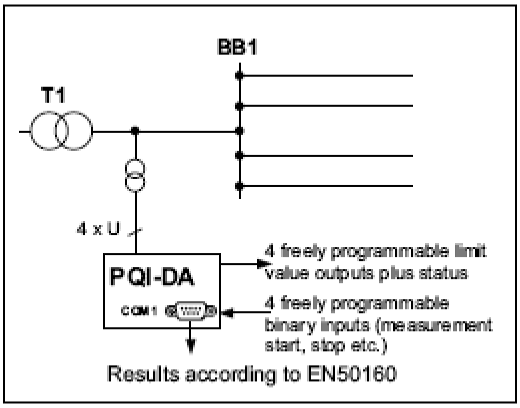
Terminal strip no.	Designation		Function	Terminal no.
X5	Status	R1	Pole NC contact NO contact	16 17 18
	Binary outputs 230 V	R2	Pole NC contact NO contact	19 20 21
		R3	Pole NC contact NO contact	22 23 24
		R4	Pole NC contact NO contact	27 26 25
		R5	Pole NC contact NO contact	27 28 29
X7	Binary inputs 230 V	E1	+	30
		E2	+	31
		E1 / E2	GND	32
		E3	+	33
		E4	+	34
		E3 / E4	GND	35
X9	E-LAN R (right)		E-	36
			E+	37
			EA-	38
			EA+	39
			GND	40
	E-LAN L (left)		E-	41
			E+	42
			EA-	43
			EA+	44
			GND	45

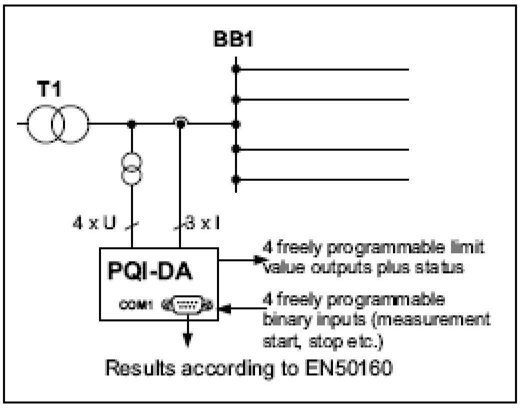


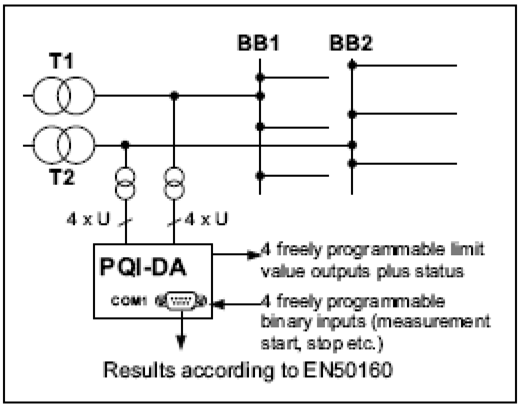
<table>
<tr><th>Terminal strip no.</th><th colspan="2">Designation</th><th>Function</th><th>Terminal no.</th></tr>
<tr><td rowspan="13">X6</td><td rowspan="5">GPS,
IRIG-A
IRIG-B adapter card</td><td></td><td>Term A</td><td>46</td></tr>
<tr><td></td><td>A</td><td>47</td></tr>
<tr><td></td><td>B</td><td>48</td></tr>
<tr><td></td><td>Term B</td><td>49</td></tr>
<tr><td></td><td>GND</td><td>50</td></tr>
<tr><td rowspan="8">Trigger</td><td></td><td>RxA</td><td>51</td></tr>
<tr><td></td><td>Term RxA</td><td>52</td></tr>
<tr><td></td><td>RxB</td><td>53</td></tr>
<tr><td></td><td>Term TxA</td><td>54</td></tr>
<tr><td></td><td>TxA</td><td>55</td></tr>
<tr><td></td><td>TxB</td><td>56</td></tr>
<tr><td></td><td>Term TxB</td><td>57</td></tr>
<tr><td></td><td>GND</td><td>58</td></tr>
<tr><td rowspan="5">X8</td><td rowspan="5">COM 2
RS 232</td><td></td><td>CTS</td><td>59</td></tr>
<tr><td></td><td>RTS</td><td>60</td></tr>
<tr><td></td><td>GND</td><td>61</td></tr>
<tr><td></td><td>RxD</td><td>62</td></tr>
<tr><td></td><td>TxD</td><td>63</td></tr>
</table>

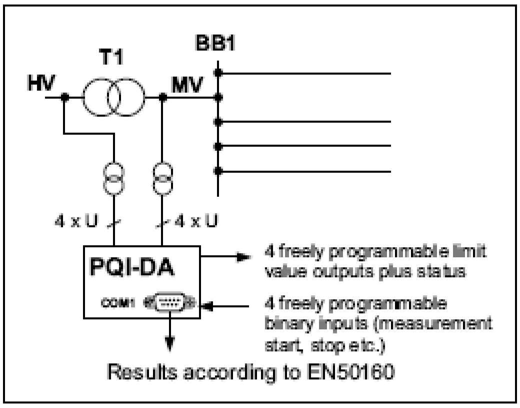
Connection examples

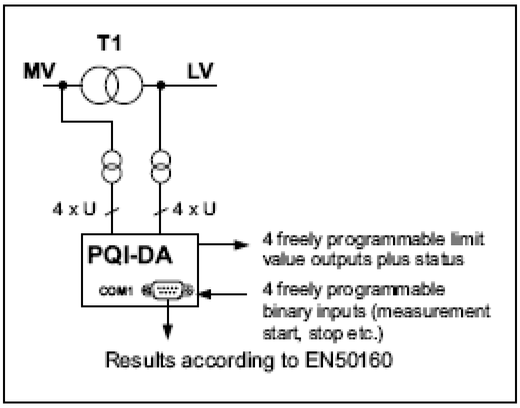
Feature group “C” has 5 typical applications.











Serial interfaces

RS232

Each PQI-DA has two RS 232 interfaces, designated COM 1 and COM 2.

COM 1 can be used as a parameterisation and programming interface via a 9-pole D-Sub plug. COM 2 can be wired via a plug-in terminal block.

If option T1 (COM server / TCP / IP) is selected, an RJ 45 connection is available instead of COM 2.

Connection elements

COM 1	Pin strip, Sub Min D on the front of the device, pin assignment the same as on PC
COM 2	Terminal strip x8
Connection possibilities	PC, terminal, modem, PLC
Number of data bits / protocol	Parity 8, even, off, odd
Transfer rate bit/s	1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200
Handshake	RTS / CTS or XON / XOFF

TCP/IP

The TCP/IP or COM server interface is galvanically isolated from

all other electrical circuits. Communication via this interface is possible with a baud rate of 100 MBaud.

Parameterisation of the IP address is carried out using the Reg-P Loader parameterisation software.

E-LAN (EnergyLocal Area Network)

The PQI-DA is equipped with a double E-LAN L, R interface as standard. It is used to provide a network connection to other PQI-DAs or other REGSys™ devices from **A. Eberle GmbH & Co. KG.**

Features

- 255 bus stations can be addressed
- Multimaster log based on SDLC/HDLC
- Repeater function between E-LAN interfaces L and R
- Adjustable transfer rate up to 375 kBaud
- 2-wire mode (multi-drop, RS485) or
  4-wire mode (peer-to-peer, RS422)
- Switchable termination

Operation

Up to 255 REGSys™ devices can communicate with each other on an E-LAN.

Access to the overall system network is possible from each RS232 or TCP/IP interface of the networked stations, for example to make settings on individual devices or to read out data.

Topology

The E-LAN can be set up from one linear bus segment or a tree structure made up of several linear bus segments. Data transfer between two bus segments usually takes place via the two E-LAN interfaces of a bus station (repeater function).

Closed loops are not permissible!

Bus segments

The length of each segment is limited to 1.2 km.

Termination must be activated in the stations at both ends of each bus segment

and deactivated in all the other stations.

Unused E-LAN interfaces must be terminated.

The operating mode (2-wire/4-wire) and the transfer rate must be specified for each bus segment. All E-LAN interfaces that are connected to this bus segment must be set to these parameters.

2-wire mode (multi-drop, RS485):

Up to 32 devices can be operated in parallel on a linear bus segment. The stations share the available transfer capacity.

Only one station can send at a given time, while all other stations receive (half-duplex mode).

If one of a number of stations is removed, data transfer between the remaining stations on this segment usually remains intact (bus termination!).

Spur lines must be avoided. The maximum baud rate is 125 kBaud.

4-wire mode (peer-to-peer, RS422):

2 devices are connected via one segment, where the wire pairs must be crossed for sending and receiving.

Both devices have the full transfer capacity and can send simultaneously (full-duplex mode).

If a station is removed, data transfer is interrupted.

The maximum baud rate is 375 kBaud.

Converter - booster

If distances > 1.2 km are spanned, or if existing transfer routes are to be used, a bus segment can be set up in 4-wire mode with the two intermediate bus amplifiers (e.g. RS422<->optical fibre) of the transfer route.

Bus IDs

Each E-LAN station must be assigned a unique address (A...A9, B...B9, C...C9.....Z...Z4)!

System planning

Topology planning becomes more and more important as the data quantity to be transferred and the number of stations increase and as the expected response times of the system decrease.

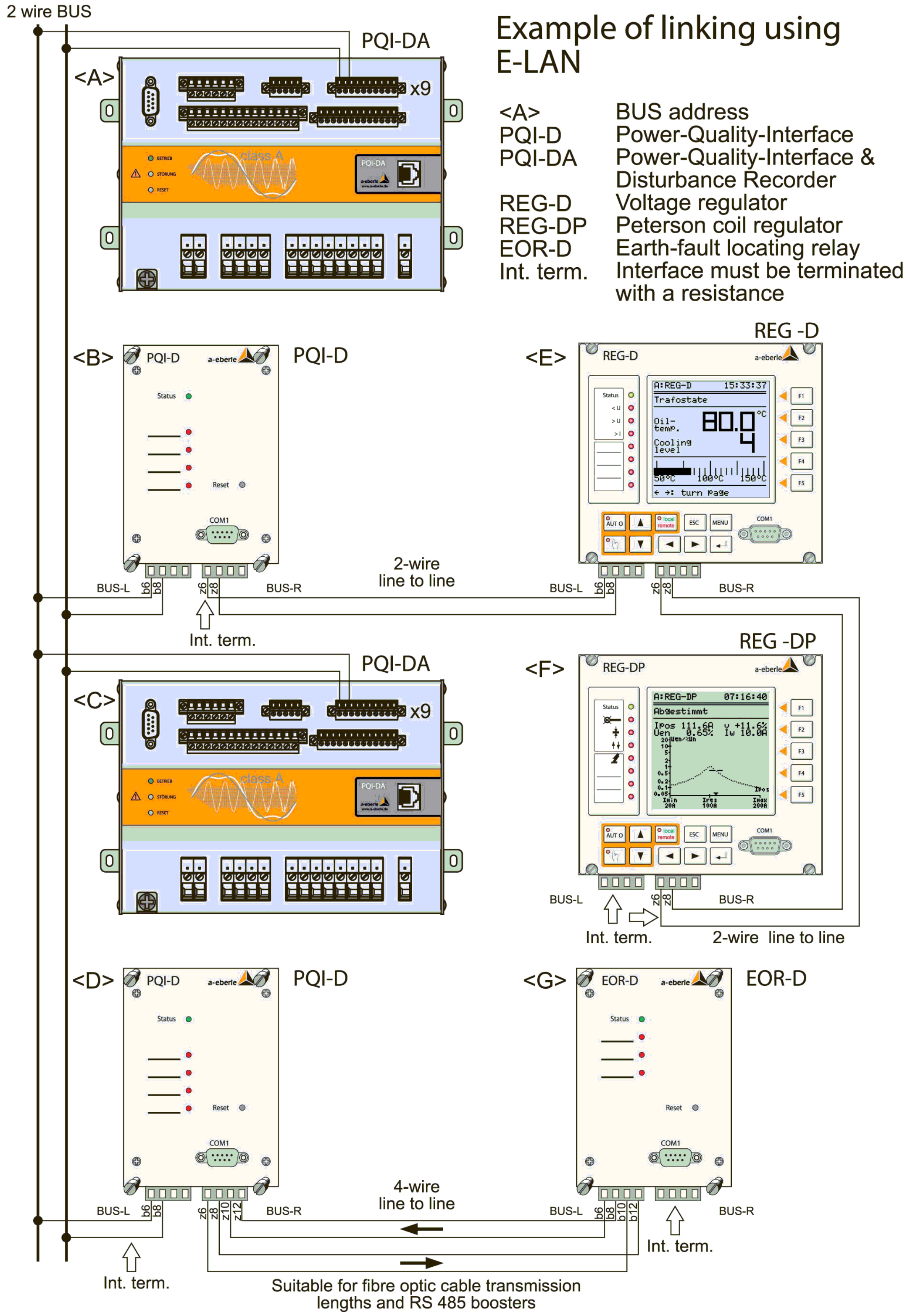
Please note that all stations that are connected to a bus segment or to be accessed via an RS232 or TCP/IP interface share the transfer capacity of the respective data channel.

Which data quantity of which devices is accessed at which devices is an important consideration.

The data quantity to be accessed via one interface should be restricted.

The maximum amount of data on one bus segment should not exceed the transfer capacity. In this regard, 4-wire mode is superior to 2-wire mode.

Schematic representation of E-LAN options



Time synchronisation

The PQI-DA has an accurate quartz real-time clock (RTC), which continues to run on a backup battery if the auxiliary voltage is interrupted. The synchronisation of multiple devices is achieved by linking the PQI-DAs via the time synchronisation bus (RS 485).

One device is configured as the time master and transfers its system time cyclically to the other PQI-DAs (time slaves). The real-time clocks of the synchronised PQI-DAs thus follow that of the PQI-DA master precisely. PQI-DAs that are not connected via the time synchronisation bus are configured as time masters.

- **Information on setting up the time synchronisation when setting up the software and hardware is given in the relevant sections of the commissioning instructions.**

External radio times signals must supply a DCF77 SPACE signal and can be connected to a PQsys system in one of two different ways:

RS232 interface of the time master (COM):

If a radio clock with a DCF77 output signal (DCF77 radio clock or GPS radio clock with DCF77 output signal) is connected to the RS232 interface, and if this is set to receive this signal, the time master sends the received signal to the time synchronisation bus, which synchronises all further PQI-DAs.

Time synchronisation bus (RS485):

The external GPS radio clock (NIS Time GPS) can be connected directly to the time bus and then functions as the time master, i.e. all PQI-DAs connected to the time synchronisation bus are configured as time slaves.

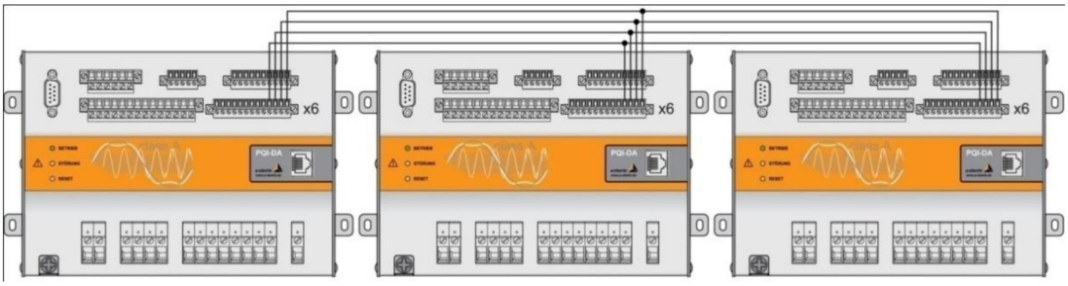
The time synchronisation bus is designed as a 2-wire bus (A, B with GND).

The identically named connections A, B and GND are looped through from device to device.

Active termination must be applied at the end of one bus (even when there is only one PQI-DA) by connecting the corresponding device A with Term_A and device B with Term_B.

If the bus length is > 1.5m, the termination should also be connected to the other

bus end.



Bus synchronisation, example of 3 PQI-DAs in 4-wire connection

Terminal strip no.	Function	Terminal no.	First/last PQI-DA	Other PQI-DA
x6	Term A	46	Line "A"	
	A	47	Line "A"	Line "A"
	B	48	Line "B"	Line "B"
	Term B	49	Line "B"	
	GND	50	Line "GND"	Line "GND"

External trigger

The PQI-DA can record fault records triggered by events. If several devices are interconnected via the trigger bus, each PQI-DA can send a pulse that triggers simultaneous recording of fault records on the other bus stations when a trigger event occurs. This function can be activated/deactivated during setup.

The external trigger should always be activated if the exact time sequence of events is required.

The maximum length of a bus segment is 1.2 km in accordance with RS 485 standard; up to 32 devices can be connected.

If the trigger bus is restricted to such a segment (within one wire), a 2-wire configuration (A, B and GND) is sufficient:

At each device, RxA is connected to TxA and RxB to TxB.

The identically named connections RxA, RxB and GND are looped through from device to device.

Active termination must be applied at the end of one bus (even when there is only one PQI-DA) by connecting the corresponding device RxA with Term_RxA and device RxB with Term_RxB.

If the bus cable length is > 1.5m, termination of the PQI-DA should also be connected at the other end of the bus.

Terminal strip no.	Function	Terminal no.	First/last PQI-DA	Other PQI-DA
x6	RxA	51	Line "A"	Line "A"
	Term RxA	52		
	RxB	53	Line "B"	Line "B"
	Term TxA	54	Line "A"	
	TxA	55	Line "A"	
	TxB	56	Line "B"	
	Term TxB	57	Line "B"	
	GND	58	Line "GND"	Line "GND"

If the trigger bus is made up of several segments that are connected via converters (e.g. FO star couplers), 4-wire operation (RxA, RxB, TxA, TxB with GND) is necessary:

The identically named connections xA, RxB, TxA, TxB and GND are looped through from device to device in each bus segment and connected to the corresponding

signals of the converter at one end of the bus (Rx->TxD, Tx->RxD).

The Tx bus must be terminated actively at the first PQI-DA.

Voltage quality monitor

Standard analysis

Sources: EN 50160, IEC 61000-4-30

- **Supply voltage (EN 50160):**

  R.m.s. value of the voltage at the transfer point.

- **Agreed supply voltage U_c (EN 50160):**

  Nominal voltage, unless an alternative is agreed upon between the power supply company and the customer.

- **Normal operating conditions (EN 50160):**

  Describes the operating status in a distribution network in which current supply requirements are met, switching operations are carried out and faults are rectified using automatic protection systems without any unusual circumstances arising due to external influences or large bottlenecks in the supply.

- **Slow voltage change (EN 50160):**

  Changes in the r.m.s. value of the voltage due to changes in the load.

- **Fast voltage change (EN 50160):**

  An individual fast change in the r.m.s. value of the voltage between two successive voltage levels that each have a definite but non-specific length (DIN EN 61000-3-3, DIN EN 61000-4-15).

- **Flicker (EN 50160):**

  This describes fluctuations in the supply voltage which cause the visual brightness of an attached lamp to change by a certain amount.

  Short-term flicker magnitude P_{st}: 10-minute interval value

  Long-term flicker magnitude P_{st}: 2-hour average value of 12 Pst values

- **Voltage dip (EN 50160):**

  Drop in the r.m.s. value of the voltage to 90%..1% of U_c.

- **Planned/random voltage interruption (EN 50160):**

  R.m.s. value of the voltage < 1% of U_c.

  Duration ≥ 3 minutes: Long-term interruption

  < 3 min: Short-term interruption

- **Intermittent overvoltage at the network frequency (EN 50160) :**

  R.m.s value of the voltage increases to > 170% of U_c.

- **nth order harmonic voltage :**

  Spectral components with a frequency n times the basic frequency of a periodic voltage.

- **THD (= Total Harmonic Distortion) :**

R.m.s. value of harmonic voltages n=2..40 based on the r.m.s. value of the fundamental oscillation.

- **Network signal transfer voltage (EN 50160):**

  R.m.s. value [%] of the ripple control signals of the audio frequency (110 Hz..3 kHz) or carrier frequency signals (3…148.5 kHz) based on U_c.

- **Voltage asymmetry:**

  The degree to which the voltage vectors of the the fundamental oscillation differ from the symmetrical state of the 3-phase network (two successive phases having the same amplitude and phase difference) is measured using the relationship between the positive-system and negative-system components.

- **Voltage dip (IEC 61000-4-30) :**

  Temporary drop in the voltage at a point in the electrical system below a threshold. An interruption is a special case of a voltage dip. Minimum voltage and the duration are essential characteristic values.

- **Voltage Swell (IEC 61000-4-30) :**

  Temporary increase in the voltage at a point in the electrical system above a threshold. Maximum voltage and the duration are important characteristic values.

Overview EN50160 (2010)

Characteristics of the voltage supply	Values / ranges of values		Measurement and evaluation parameters			
	Low voltage	Medium voltage	Basic quantity	Integration interval	Monitoring period	Required percentage
Frequency (when connected to an integrated network)	49.5 Hz to 50.5 Hz 47 Hz to 52 Hz		Average value	10 s	1 year	99,5% 100%
Slow voltage change	230 V +10% / - 10%	Uc +10% / - 10%	R.m.s. value	10 min	1 week	95% LV 99% MV
Fast voltage change	5%	4%	R.m.s. value	10 ms	1 day	100%
Flicker (specification only for long-term flicker)	P = 1		Flicker algorithm	2 h	1 week	95%
Voltage dips (< 1 min)	Tens to 1000 per year (under 85% Uc)		R.m.s. value	10 ms	1 year	100%
Short interruption to the supply (< 3 min)	Tens to several hundred per year		R.m.s. value	10 ms	1 year	100%
Random long interruptions to the supply (>3 min)	Tens to 50 per year (under 1% Uc)		R.m.s. value	10 ms	1 year	100%
Intermittent overvoltage at the network frequency (external conductor - earth)	Normally < 1.5 kV	1.7 to 2.0 Uc (dependent on neutral point connection)	R.m.s. value	10 ms	None	100%
Transient overvoltage (external conductor - earth)	Normally < 6 kV	depending on isolation coordination	Peak value	None	None	100%
Voltage asymmetry (ratio of negative-sequence system to positive-sequence system)	Normally 2 % Up to 3 % in special cases		R.m.s. value	10 min	1 week	95%
Harmonic voltage (reference value Un or Uc)	Total harmonic distortion (THD) = 8 %		R.m.s. value	10 min	1 week	95%
Interharmonic voltage	Values not yet available		Values not yet available			
Signal voltages (reference value U_n or U_c)	(MV: 9 to 95 kHz range not yet available)		R.m.s. value	3 s	1 day	99%

Characteristics of the voltage supply

Feature: Interruption to the supply

- Measurement quantities: Half-period r.m.s. voltage values
- Parameters: Threshold (EN 50160) = 0.01*U_C
  Maximum length of short interruptions to the supply (EN 50160) = 180 s
- Statistical quantities: Number and duration

Short interruptions to the supply :

Number per day, week and year
Integration over days, weeks and years
Long interruptions to the supply:
Number per day, week and year
Integration over days, weeks and years

- Reference values for number per year according to EN 50160:
  Short interruption to supply: “Tens to several hundred”, default value = 30
  Long interruption to supply: “Fewer than 10 to 50”, default value = 10

Feature: Slow voltage change

- Event: 10-minute interval with range exceeded
- Measurement quantities: 10-minute average values of the r.m.s. voltage values
- Parameters :
  Thresholds (EN 50160) = (1 ±0.1)*UC
  Default value of lower threshold: 0.9*UC
  Default value of upper threshold: 1.1*UC
- Statistical quantities:
  Number per day, week and year
- Max. relative frequency at each weekly interval
  according to EN 50160: 5%
  Default value: 5%

Feature: Voltage dip

- Measurement quantities: Half-period r.m.s. voltage values
- Parameter:
  Threshold (EN 50160) = 0.01..0.90*UC, default value = 0.90*UC
- Statistical quantities: Number and duration
  Number per day, week and year
  Integration over days, weeks and years
- Reference value for number per year according to EN 51060:
  "Tens to 1000", default value = 100

Feature: Intermittent overvoltage at the network frequency between the outer conductor and earth

- Measurement quantities: Half-period r.m.s. voltage values
- Parameters: Threshold (EN 50160) = 1.7..2.0*UC, default value = 1.7*UC
- Statistical quantities: Number and duration
  Number per day, week and year
  Integration over days, weeks and years
- Reference value for number per year according to EN 50160: None
  default value = 10

Feature: Fast voltage change

- Measurement quantities: Half-period r.m.s. voltage values
- Parameter:
  Threshold (EN 50160) = ±0.04..0.06*UC
  default threshold value = 0.06*UC

  Minimum duration of stationary status, default value = 1 s
- Statistical quantities: Number and duration
  Number per day, week and year
  Integration over days, weeks and years
- Reference value for number per day according to EN 51060:
  "Several possible", default = 10
  Number per year: Default value = 3650

Feature: Voltage asymmetry

- Event: 10-minute interval with range exceeded
- Measurement quantities: 10-minute average value for voltage asymmetry
- Parameters: Threshold (EN 50160) = 2..3%
  Default value: 2%
- Statistical quantities: Number per day, week and year
- Max. relative frequency at each weekly interval according to EN 50160: 5%
  Default value: 5%

Feature: Harmonic voltages, THD

- Event: 10-minute interval, range of at least one harmonic voltage or the THD is exceeded.
- Measurement quantities: 10-minute average values of harmonic voltages (r.m.s.), THD
- Parameters :
  Thresholds (EN 50160) = harmonic: See table 2 in EN 50160 THD: 8%
  Default value: According to EN 50160
- Statistical quantities: Number per day, week and year
- Max. relative frequency at each weekly interval according to EN 50160: 5%
  Default value: 5%

Feature: Network signal transfer voltages

- Measurement quantities: 3-second average values of network signal transfer voltages (%)
- Parameter:
  Thresholds (EN 50160) = see Figures 1 and 2 in EN 50160
  Carrier frequency
  Default value: Carrier frequency = 168 Hz, threshold = 9 %
- Statistical quantities: Number and duration
  Number per day, week and year
  Integration over days, weeks and years
- Max. relative frequency at each daily interval according to EN 50160: 1%
  Default value: 1%

Feature: Flicker

- Event: 2-hour interval with range exceeded
- Measurement quantities: Long-term flicker magnitude P_{lt} (2-hour average value)
- Parameters: Threshold (EN 50160) = 1.0
  Default value: 1.0
- Statistical quantities: Number per day, week and year
- Max. relative frequency at each weekly interval according to EN 50160: 5%
  Default value: 5%

Feature: Network frequency, narrow range

- Measurement quantities: 10-second average value
- Parameters:
  Thresholds (EN 50160, synchronised connection to the integrated network) = 50 Hz, ± 0.5 Hz
  Default value of lower threshold = 49.5 Hz
  Default value of upper threshold = 50.5 Hz
- Statistical quantities: Number and duration
  Number per day, week and year
  Integration over days, weeks and years
- Reference value for relative frequency per year according to EN 50160: 0.5%
  Default value: 0.5%

Feature: Network frequency, wide range

- Measurement quantities: 10-second average value
- Parameters:
  Thresholds (EN 50160, synchronised connection to the integrated network) = 47 Hz, 52 Hz
  Default value of lower threshold = 47.0 Hz
  Default value of upper threshold = 52.0 Hz
- Statistical quantities: Number and duration
  Number per day, week and year
  Integration over days, weeks and years
- Reference value for relative frequency according to EN 50160: 0%
  Default value: 0%

Network quality events

The features of the supply voltage are measured in the corresponding aggregation intervals and monitored with the (adjustable) network quality tolerance thresholds.

If the tolerance ranges are violated, network quality events are produced, recorded, and their duration and frequency accumulated at certain intervals.

The data acquired in this way are so compact that they can be recorded autonomously over longer periods. Event processing is a multi-level procedure that comprises the production, evaluation and recording of events.

In 3-conductor systems, only the voltage between the outer conductors are monitored according to EN50160.

In 4-conductor systems, the voltages between the outer conductors and the neutral conductor are also monitored. Limit value monitoring is carried out with hysteresis (exception: fast voltage change)

The events are first generated separately for each of the phase voltages being monitored ("phase events").

There are two basic types for aggregation of events over time

- Interval events
- Start/stop events

Evaluation of the network quality is based on network events that are produced by combining the phase events of a feature.

Depending on the type, events can be represented as one or several event entries with the same format:

Time stamp	: time at which the event was triggered
Identifier	: indicates type
Event value	: dependent on the type of event

Interval events

These events are generated at the end of the measurement interval when a limit violation occurs for the following supply voltage features measured as 10-minute or 2-hour values.

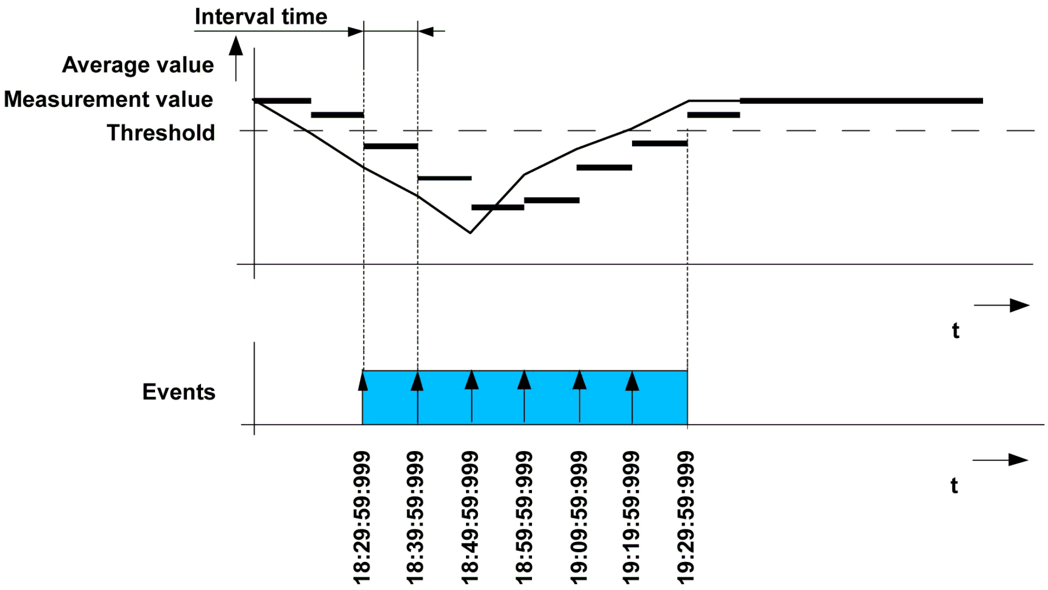
Slow voltage deviation (10-minute values)

Harmonics, THD (10-minute values)

Asymmetry (10-minute value)

Flicker (2-hour values)

If the limit value is continuously violated, the event is generated again each time the interval elapses. The event value corresponds to the interval measurement value.



The first phase event of the interval to be detected is interpreted as a network event.

Each network or phase event requires 1 event entry.

The network events are counted at daily, weekly and yearly intervals for each of these features.

Start / stop events

These events are generated for the following supply voltage features:

Fast voltage change (10-ms values)

Dip (10-ms values)

Swell (10-ms values)

Voltage dip (10-ms values)

Transient overvoltage at the network frequency (10-ms values):

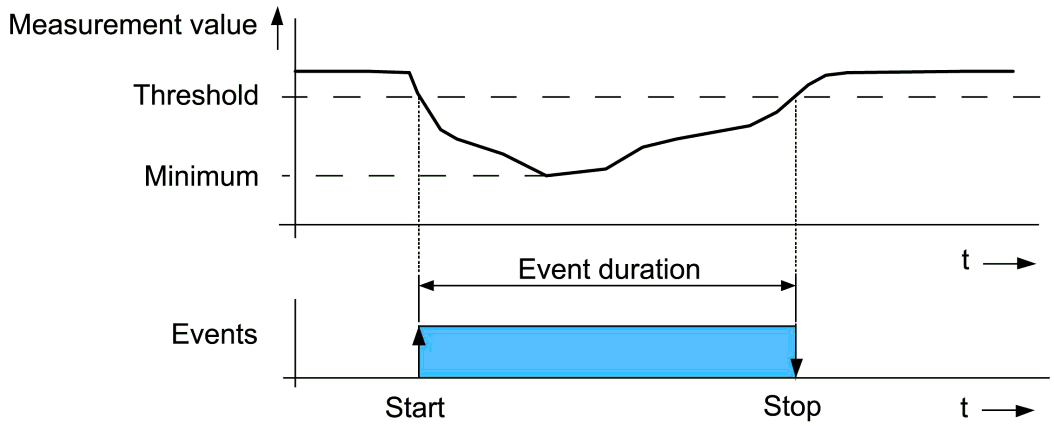
Voltage interruption (10-ms values)

Signal overvoltage (150/180-period values)

Frequency deviation, narrow tolerance (10-second values)

Frequency deviation, wide tolerance (10-second values)

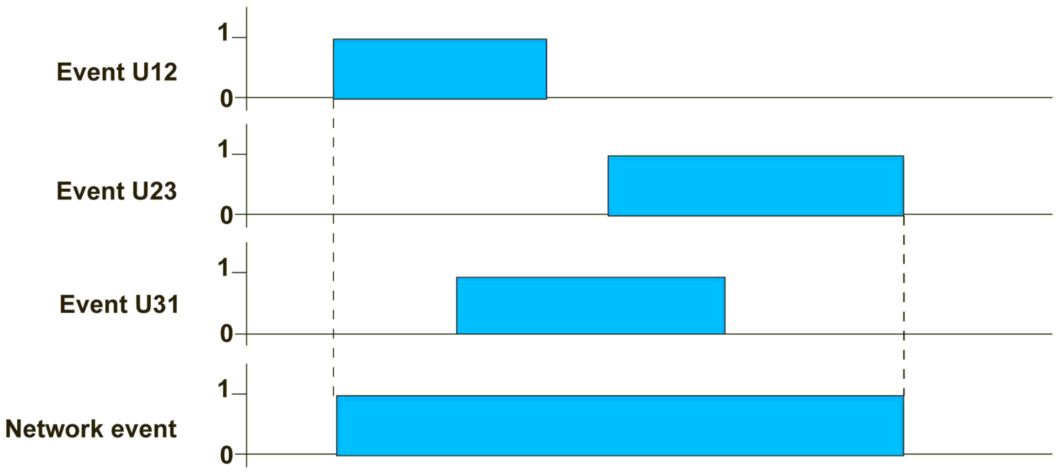
The event start entry is generated at the beginning of each limit violation, and the event stop entry at the end. The WinPQ evaluation software determines the time difference between the start and stop event, and displays the respective duration and extreme values for the event.



It is possible to record either phase events or network events.

Network events are generated by combined evaluation of phase events (exception: frequency deviation). The OR connection applies when the above-mentioned phase events are combined, with the exception of voltage interruption, i.e. the network event

is active for as long as a phase event is active on at least one of the monitored phase voltages.



Linking Events:	*Recording events U12, U23, U31*
Network events mode:	*Recording events U12, U23*

Prioritising events

Faults in the supply voltage can affect a variety measurement quantities at the same time, and can trigger overlapping limit violations. In order to distinguish between dominant primary fault events and secondary effects at all times, the start/stop events are prioritised according to the scheme below. If an event occurs at any time while an event with higher priority is active, the event with the lower priority is rejected.

Event with higher priority	Voltage interruption	Voltage dip	Overvoltage	Voltage change	Frequency deviation
Event					
voltage change	✓	✓	✓		
Voltage dip	✓	✓			
Voltage swell	✓		✓		
Voltage dip	✓				
Overvoltage	✓				
Voltage interruption					
Signal voltage	✓			✓	
Frequency deviation, narrow range	✓			✓	✓
Frequency deviation, wide range	✓			✓	

Flagging

The PQI-DA network analyser flags measurement intervals in accordance with IEC 61000-4-30, Class A.

Flags are generated for events that are based on the 10-ms r.m.s. values of the voltage.

The events are classified according to 3 fault levels:

Level	**Event**
0	None
1	Fast voltage change, dip, swell
2	Voltage dip, overvoltage
3	Voltage interruption

For each phase voltage, the maximum fault level that occurs in each of the measurement intervals (10/12 periods, 150/180 periods, 10-minute, 2-hour) is recorded and stored in a status word in the interval data. By combining the maximum interval fault level with an adjustable

threshold, it is determined whether the events of the following features based on the interval measurement values are evaluated or rejected:

- Signal voltages (150/180-period values)
- Network frequency (10-second value)
- Slow voltage deviation (10-minute values)
- Harmonics, THD (10-minute values)
- Asymmetry (10-minute value)
- Flicker (2-hour values)

The setting "Flagging from…" (WinPQ) sets the fault level from which the events listed above are rejected. 10-minute and 2-hour events can only be rejected with the setting "Flagging from interruption" is selected (factory setting).

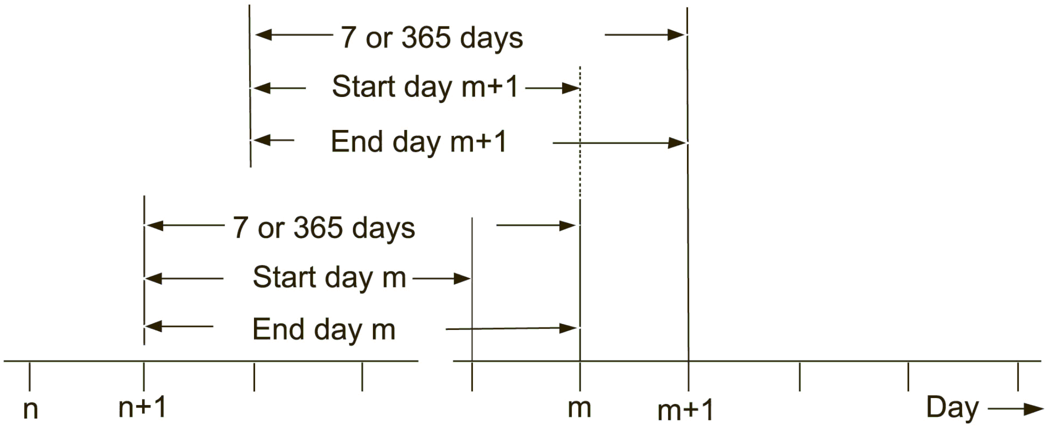
Binary event notification signals

The network events generate binary notification signals, which can be output via binary outputs, for example.

Aggregation of statistical values

The network events for the power supply feature are counted at daily, weekly and yearly intervals and the time sums calculated.

Events are assigned to the day on which they were completed.



At the end of the day, the weekly and yearly values from the last 7 or 365 days are calculated and stored.

Monitoring statistical values

The statistical values are monitored on the base of limit values (adjustable).

If these limit values are exceeded, corresponding binary notification signals are generated (see 4.10):

Narrow frequency tolerance range too frequently exceeded [week]

Narrow frequency tolerance range too frequently exceeded [year]

Maximum number of intermittent overvoltages at the network frequency exceeded [year]

Maximum number of fast voltage changes exceeded [day]

Maximum number of fast voltage changes exceeded [year]

Maximum number of voltage dips exceeded [year]

Maximum number of short supply interruptions exceeded [year]

Maximum number of long supply interruptions exceeded [year]

Slow voltage change range exceeded too frequently [week]

Harmonic distortion range exceeded too frequently [week]

Asymmetrical voltage range exceeded too frequently [week]

Flicker range exceeded too frequently [week]

Signal voltage exceeded too frequently [day]

Signal voltage exceeded too frequently [week]

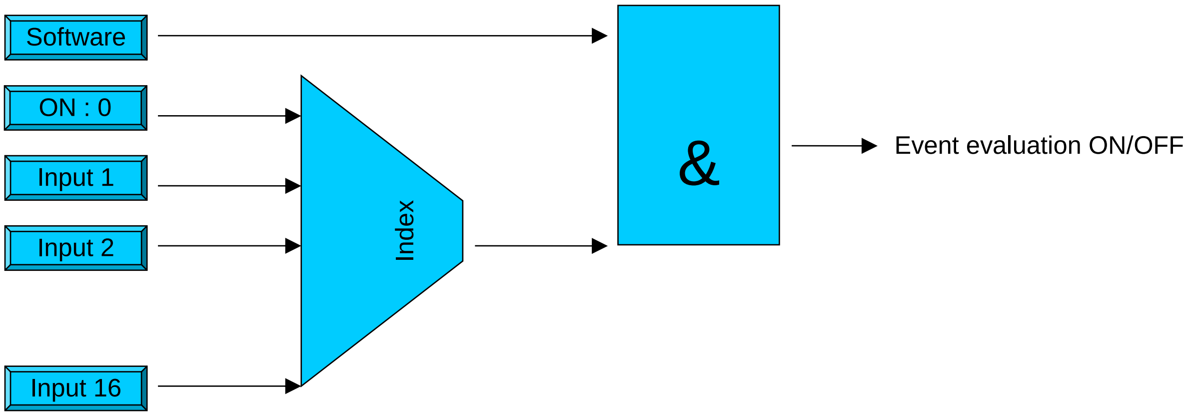
Maximum number of days with exceeded signal voltage exceeded [year]

Controlling the event evaluation

Evaluation is initially disabled at the factory. It is activated via software when all settings have been made and valid measurement signals are present.

When a binary input is selected (> 0) , the statistical evaluation of network quality events is interrupted during log "high".

The evaluation disable via software has a higher priority than the binary input.



Basic setting for PQI-DA

The factory settings have been selected in such a way that only a few parameters need be modified in most applications.

A PQI-DA with 400 V voltage inputs is configured for a typical low-voltage network. If the PQI-DA is equipped with 100 V inputs, it is preset at the factory for a typical medium-voltage network (EN50160 1kV-35kV.def).

Measurement circuits

Measurement inputs

A 3-conductor or 4-conductor system must first be selected for each line. This determines which transformer configurations are available for selection.

Primary and secondary values can be set individually for each measurement input. The transformer factor corresponds to the ratio of primary to secondary values. In delivery condition, the primary value corresponds to the secondary value, which means that secondary values are measured.

Voltage measurement inputs

The PQI-DA Power Quality Interface has four voltage inputs.
In delivery condition, inputs U1, U2, U3 are assigned to voltages U1E, U2E, U3E, and input U4 is assigned to voltage UNE (3-conductor system: neutral earth voltage of the neutral point, 4-conductor system: neutral conductor voltage).

The common reference earth connection (E) for all voltage inputs must be earthed.

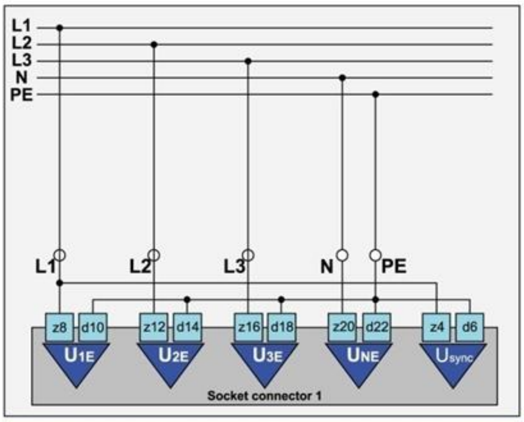
In 3-conductor systems, conductor-conductor voltages are usually indicated for primary and secondary voltages, even if a phase voltage is present at the relevant measurement input.

In 4-conductor systems, phase voltages are set for the primary and secondary values.

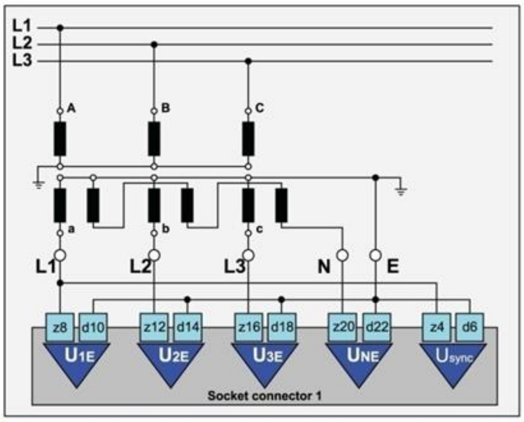
The agreed voltage is the reference value for all voltage limits and must be set for the optimum conductor-conductor voltage.

Normally, it only deviates a few percent from the nominal primary conductor-conductor voltage. An incorrect setting of the agreed voltage is a frequent cause of malfunctions.

Transformer configuration 1:



U-configuration 1, 4-phase

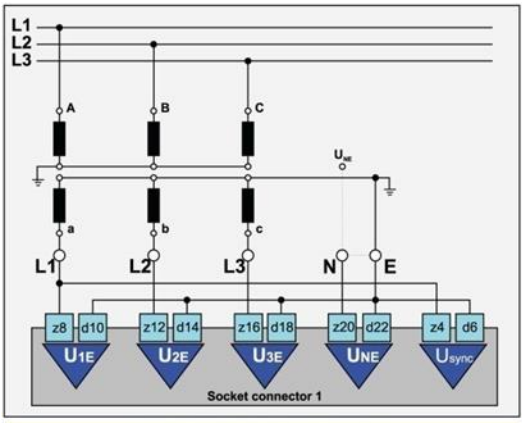


U-configuration 1, 3-phase

Voltages U1E, U2E, U3E and UNE are measured.
The measured voltages are used to calculate U12, U23 and U31.

This configuration is principally used in 4-conductor systems.

Transformer configuration 2:



U-configuration 2

Voltages U1E, U2E and U3E are measured.

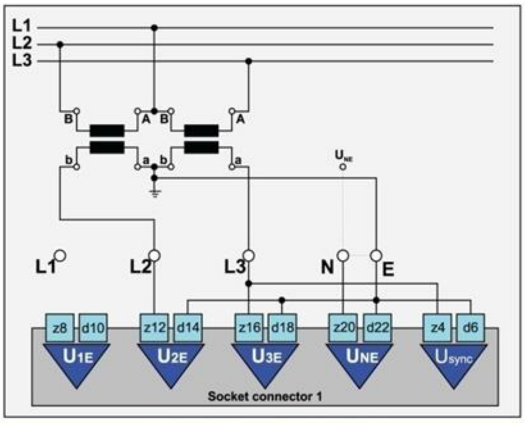
The measured voltages are used to calculate U12, U23 and U31.

UNE is calculated as the neutral earth voltage of the virtual neutral point to earth, i.e. as U0E from the measured voltages.

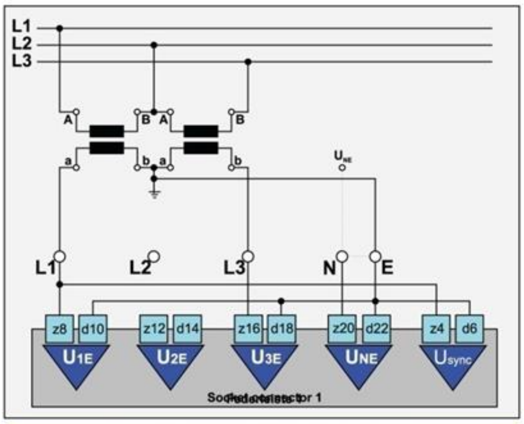
Transformer configuration 1 has advantages in 3-conductor systems when correspondingly accurate transformers are available for the neutral earth voltage or the voltage of a real neutral point is to be measured.

The transformer errors of L1, L2 and L3 do not affect the measured neutral earth voltage.

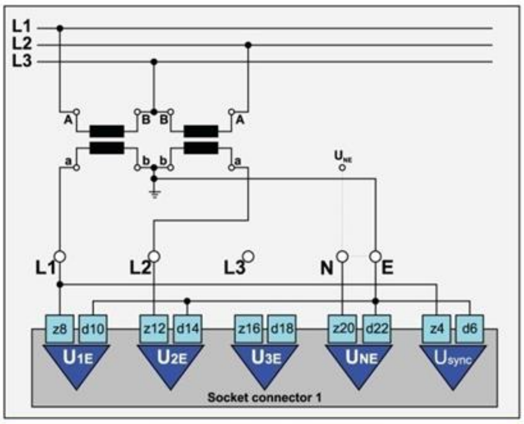
<u>Transformer configurations 3, 4 and 5 :</u>



U-configuration 3



U-configuration 4



U-configuration 5

Two of the three conductor-conductor voltages U12, U23, U31 and UNE to earth (E) are measured (V circuit). The third conductor-conductor voltage is calculated from the voltages that are measured.

A typical application is the Aron circuit with transformer configuration 4, i.e. U12 and U32 are measured and U31 calculated.

U1E, U2E and U3E are calculated from the measured voltages and calculated using UNE (!).

Since the input for UNE is always evaluated, the primary value must be set to zero if no transformer is connected so that this voltage is calculated with the value 0. The phase voltages are then based on the virtual neutral point.

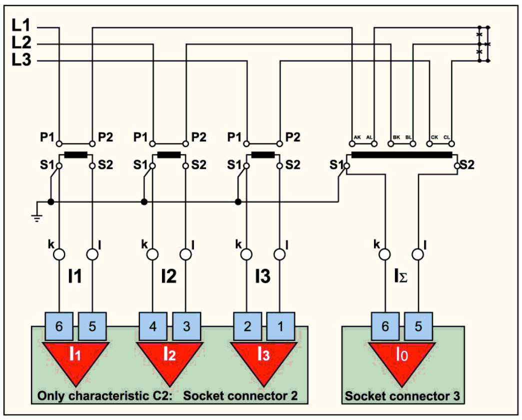
Currentmeasurement inputs

The PQI-DA Power Quality Interface has 4 galvanically isolated current inputs. In delivery condition, the inputs I1, I2 and I3 are assigned to the conductor currents of L1, L2, and L3, and I4 is assigned to the sum current (3-conductor system) or to the neutral conductor current (4-conductor system).

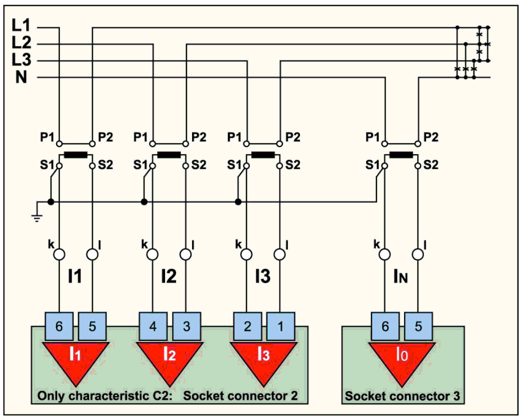
The reference current is the reference value for all current limit values and is usually set to the nominal primary conductor current.

Reversing the polarity of the current converter connection and incorrect setting of the reference current is a frequent cause of malfunctions.

<u>Transformer configuration 1:</u>



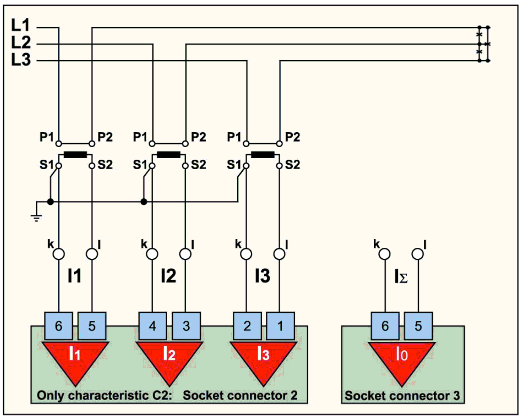
I-configuration 1, 3-phase



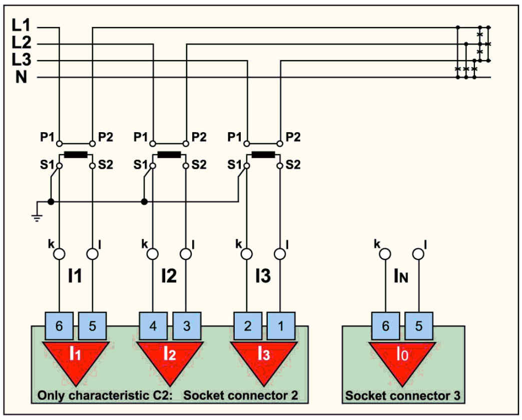
I-configuration 1, 4-phase

All four currents are measured.

<u>Transformer configuration 2:</u>



I-configuration 2, 3-phase



I-configuration 2, 4-phase

Only the currents of L1, L2 and L3 are measured.

The sum current or neutral conductor current is calculated from the currents that are measured.

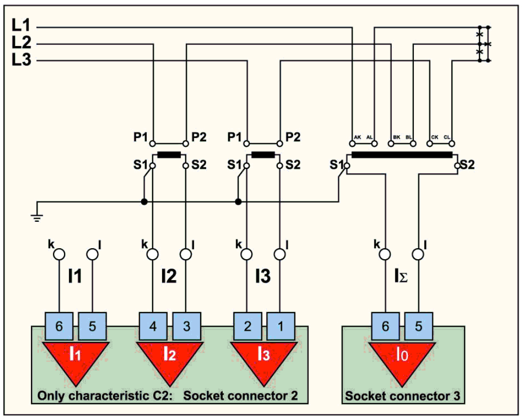
Transformer configuration 1 has advantages in 3-conductor systems when the sum current is measured via a core balance transformer or a sum current transformer. The transformer errors of L1, L2 and L3

do not affect the sum current.

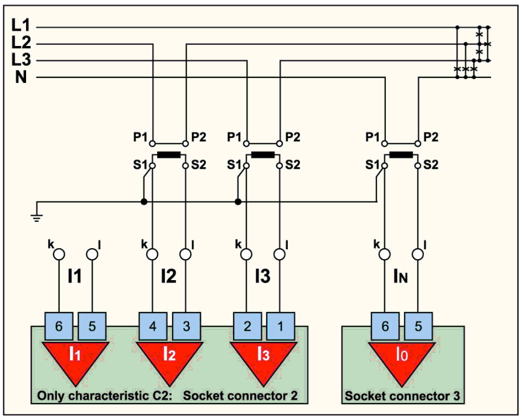
Transformer configuration 1 has advantages in 4-conductor systems when the earth current can be neglected.

The earth current does not affect the measured neutral conductor current.

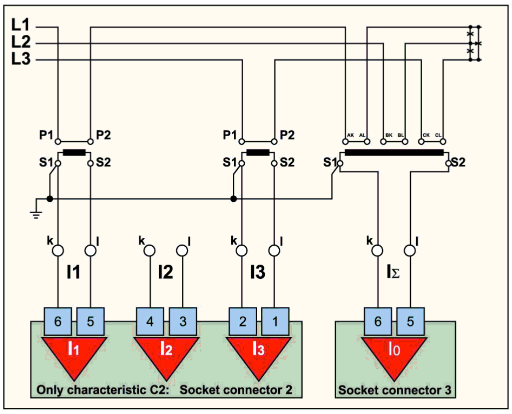
Transformer configurations 3, 4 and 5 :



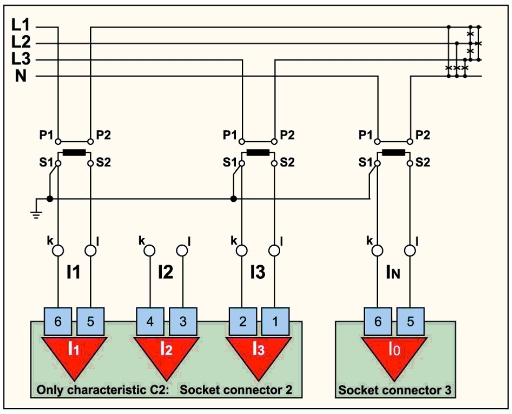
I-configuration 3, 3-phase



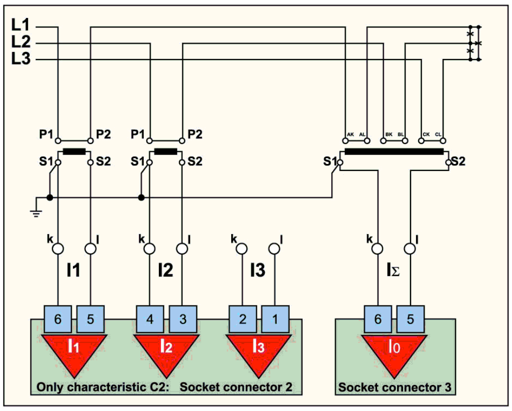
I-configuration 3, 4-phase



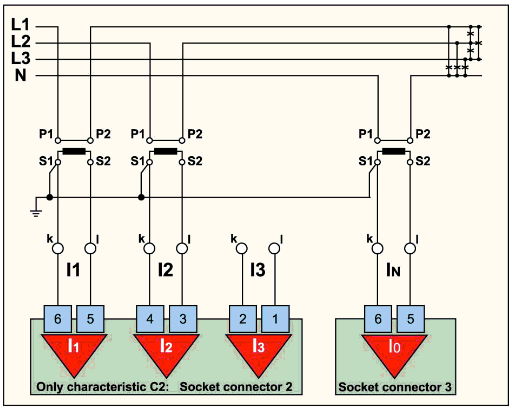
I-configuration 4, 3-phase



I-configuration 4, 4-phase



I-configuration 5, 3-phase



I-configuration 5, 4-phase

Only 2 of the 3 currents of L1, L2, L3 and the sum current and/or neutral conductor current are measured. The outer conductor current that is not measured is calculated from the currents that are measured.

A typical application is the Aron circuit with transformer configuration 4, i.e. the currents in L1 and L3 are measured and are used to calculate the current in L2.

Since the input for the sum and neutral conductor currents is always evaluated, the primary value must be set to zero if no transformer is connected so that this current is calculated with the value 0. It is assumed that the sum of the outer conductor currents is equal to zero.

Reference voltage

U12 is set as the reference voltage at the factory. Any other voltage can also be defined as the reference voltage. All absolute phase angles are based on this voltage.

The reference voltage is also used for frequency measurement.

In the 8xU version, the reference voltage is monitored and, if it fails, automatically switched to the corresponding voltage of the other line, if one is available.

Network frequency

The nominal network frequency can be set to 50 Hz or 60 Hz.

The factory setting is 50 Hz.

Changes do not become effective until the device is restarted.

System time

The system time is set at the factory and is protected against unintentional adjustment; the time zone is CET and summer/winter switching for CEST is activated.

If the local time zone does not match the one set at the factory, the setting can be changed at any time.

Adapting the time to the local time zone must never be carried out manually!

The maximum time deviation in non-synchronised mode is 1 minute/month. When the time setting is protected, the device accepts only changes within +/-250ppm based on the time elapsed since the last correction. The time accuracy of ±20ms required by DIN IEC 61000-4-30, Class A dictates the need for synchronisation by an external real-time clock with DCF77 output (SPACE format) (refer to 6.4). In synchronised mode, the manual time setting is blocked.

Binary inputs

One use of the bipolar binary inputs is to control recording, statistical evaluation and synchronisation of average values in the power intervals.

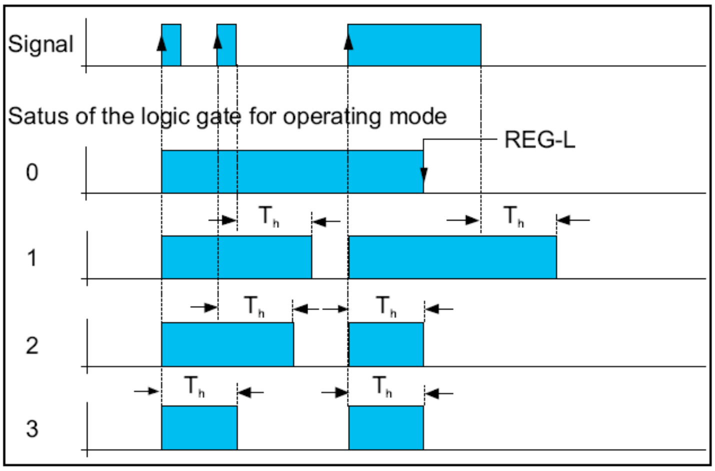
The number of debounce cylces (4 ms) can be set. The factory setting of 5 debounce cycles ensures trouble-free operation at 50 Hz/60 Hz AC.

The associated logic state can be configured for passive and active voltage levels.

Binary outputs

Each binary output (relay) can be controlled by an output function that can be assigned up to 32 binary notification signals.

The logic level of the OR connection of these signals is debounced using the adjustable delay time (Th) and the operating mode, and output with a configured switching state.



Operating mode	Designation
0	Bistable, edge trigger, set/delete via REG-L
1	Monostable, level re-trigger
2	Monostable, edge re-trigger
3	Monostable, no re-trigger

The status relay is always preassigned the corresponding system error notification signals at the factory.

Without notification signals assigned, the binary outputs can be triggered

directly in mode 0 using REG-L commands.

Synchronisation of interval average power values

In order to record the 15-minute power interval synchronously with a counter, for example, you can choose between internally generated time intervals and a trigger binary input.

Factor setting : internal 15-minute interval

Data management

When the PQI-D is operating, it generates a large amount of continuous and event-triggered data, of which only a certain proportion can be measured and saved within a limited time period. The length of the saving process is dependent on the amount to be saved, as well as on how often the data are transferred to the PC database.

The selection and the method of displaying the measurement data must be configurable so that the **device memory** and **transfer capacity** resources can be used as flexibly and efficiently as possible. All the configuration parameters are stored in the device and can be read, so that the measurement data are uniquely identifiable at all times when accessed using a PC.

The following distinctions must be made:

- Settings (configuration parameters)
- System data
- Interval measurement data
- Event-triggered measurement data (fault recorder)
- Statistical measurement data
- Binary messages (signals)

Measurement data classes

Interval	Data class	Maximum number of channels	Data types	Data quantity [bytes]/ (day * measurement channel)
10/12 periods ≈200 ms	C_s2_1	8	Average values	1.73 M
	C_s2_2			
150/180 periods ≈3s	C_3s_1	256	Average values	115 k
	C_3s_2			
10 minutes	C_10m_1	1024	Average values	576 bytes
	C_10m_2		Extreme values	1728 bytes
2 hours	C_2h_1	256	Average values	48 bytes
	C_2h_2			

Each data class is made up of an adjustable number of recording points,

the memory requirement being proportional to the number of recording points.

One of two operating modes for recording may be selected:

Linear:

When the set number of recording points is reached, further entries are rejected.

Circular:

When the set number of recording points is reached, the oldest recording point is overwritten with the newest one.

Memory configuration

For optimum utilisation of the measurement data memory, it can be

fully or partially re-configured by the user.

The following basic rules then apply:

Each allocated data class occupies a contiguous block of memory (no segmentation). Utilisation of free memory outside the allocated block is not possible.

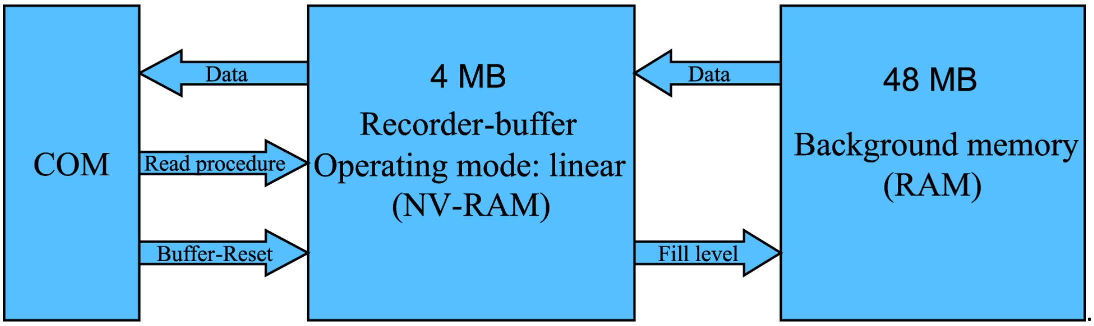
Data classes can only be allocated or removed individually and consecutively.

Allocation is carried out according to the "first-fit" procedure, in which a new data class is inserted at the beginning of the first sufficiently large, contiguous segment of free memory (starting at the lowest memory address).

If only single data classes are newly allocated or removed, fragmentation of free memory will usually result.

Contiguous memory allocation can only be forced by first deleting all data classes and then re-allocating them individually.

The memory contents of a data class (including the recorder background memory) can be deleted while upholding the allocation, or the recording can be interrupted.



Besides the non-volatile NV RAM, a volatile background memory is also available in the considerably larger SDRAM for the recording of fault records. All fault records are initially recorded in the background memory. In order for them to be accessed from the device via the communication interface, they must be shifted to the NV RAM.

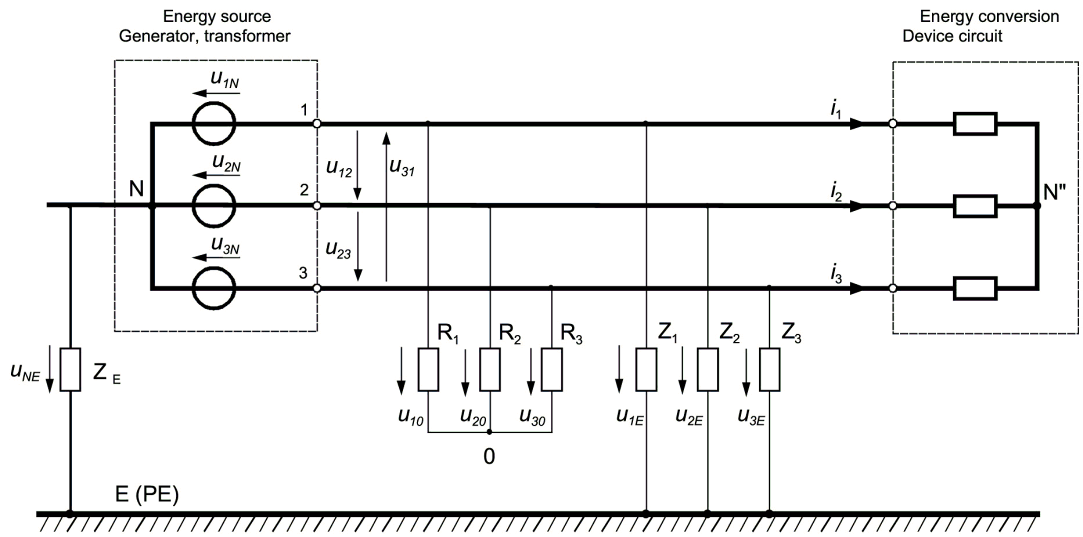
In circular buffer mode, new fault records are shifted to the NV RAM buffer immediately, since the oldest entry is always overwritten by the newest one, irrespective of whether it could be read via the communication interface beforehand.

For this reason, the buffer for recorders A, B and S is set to linear mode at the

factory. Fault records are shifted from the background memory to the NV RAM buffer until the latter is full. Further fault records are initially stored in the background memory. As soon as the NV RAM buffer has been accessed, the corresponding memory is released and the next fault records are shifted from background memory to NV RAM buffer. This ensures that no fault record can be overwritten before it has been accessed.

Definition of the measurement quantities

The figure below illustrates the basic quantities for measurements in 3-conductor, three-phase current systems; the designations are based on DIN 40110-2 "Quantities used in alternating current theory - Part 2: Multi-line circuits".



Sampling values

The measurement signals are first filtered through anti-aliasing low pass filters.

The signals, now limited to a measurement bandwidth of roughly 4 kHz, are

sampled by an A/D converter (ADC) with a 24-bit resolution and a constant frequency of 10.24 kHz.

The ADC sampling values are recorded in the oscilloscope recorder.

Half-period values

The half-period values are formed at every half-period from the last two half-wave values.

R.m.s. values

Half-wave r.m.s. values:

$$X_{rms(T/2)} = \sqrt{\frac{\sum_{n=1}^{N} w_n \cdot x_a^2(n)}{\sum_{n=1}^{N} w_n}}$$

Half-period r.m.s. value:

$$X_{rms(1/2)} = \sqrt{\frac{\sum_{n=1}^{2} X_{rms(T/2)}^2(n)}{2}}$$

Arithmetic average values

Arithmetic half-wave average value:

$$X_{(T/2)} = \frac{\sum_{n=1}^{N} w_n \cdot x_a(n)}{\sum_{n=1}^{N} w_n}$$

Arithmetic half-period average value:

$$X_{(1/2)} = \frac{\sum_{n=1}^{2} X_{(T/2)}(n)}{2}$$

Synchronised sampling values

From the ADC sampling values, 2048 equidistant synchronised sampling values are computed for each 10/12-period interval.

10/12-period values

The 10/12-period values are calculated from the synchronised sampling values $x_s(n)$.

R.m.s. values

$$X_{rms-10/12} = \sqrt{\frac{\sum_{n=1}^{2048} x_s^2(n)}{2048}}$$

Arithmetic average values

$$X_{10/12} = \frac{\sum_{n=1}^{2048} x_s(n)}{2048}$$

150/180-period values

The 150/180-period values are calculated from the N 10/12-period values of a 150/180-period interval.

R.m.s. values

$$X_{rms-150/180} = \sqrt{\frac{\sum_{n=1}^{N} X_{rms-10/12}^2(n)}{N}}$$

Arithmetic average values

$$X_{150/180} = \frac{\sum_{n=1}^{N} X_{10/12}(n)}{N}$$

10-minute values

The 10 minute values are calculated from the N 10/12-period values of each 10-minute interval, and are calculated synchronously with the 10-minute limits of the system time. Each 10/12-period value is included exactly once in a 10-minute value calculation.

R.m.s. values

$$X_{rms-10\min} = \sqrt{\frac{\sum_{n=1}^{N} X_{rms-10/12}^{2}(n)}{N}}$$

Arithmetic average values

$$X_{10\min} = \frac{\sum_{n=1}^{N} X_{10/12}(n)}{N}$$

2-hour values

The 2-hour values are calculated from the N 10-minute values of each 2-hour interval, and are calculated synchronously with the 2-hour limits of the system time. Each 10-minute value is included exactly once in a 2-hour value calculation.

R.m.s. values

$$X_{rms-2h} = \sqrt{\frac{\sum_{n=1}^{N} X_{rms-10\min}^{2}(n)}{N}}$$

Arithmetic average values

$$X_{2h} = \frac{\sum_{n=1}^{N} X_{10\min}(n)}{N}$$

Sampling values

Primary sampling values

With the exception of the V circuit, the measurement signals from the conductor-ground voltages and conductor currents are sampled.

Phase-to-phase sampling values

The phase-to-phase sampling values are calculated from the primary values of the following relationships.

External conductor voltages

$$u_{12}(n) = u_{1E}(n) - u_{2E}(n) = -\left(u_{23}(n) + u_{31}(n)\right)$$

$$u_{23}(n) = u_{2E}(n) - u_{3E}(n) = -\left(u_{31}(n) + u_{12}(n)\right)$$

$$u_{31}(n) = u_{3E}(n) - u_{1E}(n) = -\left(u_{12}(n) + u_{23}(n)\right)$$

Neutral earth voltage of the virtual neutral point to earth (3-conductor system)

$$u_{0E}(n) = \frac{u_{1E}(n) + u_{2E}(n) + u_{3E}(n)}{3}$$

Phase voltages to the virtual neutral point (3-conductor system)

$$u_{10}(n) = \frac{u_{12}(n) - u_{31}(n)}{3}$$

$$u_{20}(n) = \frac{u_{23}(n) - u_{12}(n)}{3}$$

$$u_{30}(n) = \frac{u_{31}(n) - u_{23}(n)}{3}$$

Outer conductor-neutral conductor voltages (4-conductor system)

$$u_{1N}(n) = u_{1E}(n) - u_{NE}(n)$$

$$u_{2N}(n) = u_{2E}(n) - u_{NE}(n)$$

$$u_{3N}(n) = u_{3E}(n) - u_{NE}(n)$$

Sum current, conductor currents (3-conductor system)

$$i_E(n) = i_1(n) + i_2(n) + i_3(n)$$

$$i_1(n) = i_E(n) - \left(i_2(n) + i_3(n)\right)$$

$$i_2(n) = i_E(n) - \left(i_3(n) + i_1(n)\right)$$

$$i_3(n) = i_E(n) - \left(i_1(n) + i_2(n)\right)$$

Neutral conductor current, external conductor currents (4-conductor system)

$$i_N(n) = -\left(i_1(n) + i_2(n) + i_3(n)\right)$$

$$i_1(n) = -\left(i_N(n) + i_2(n) + i_3(n)\right)$$

$$i_2(n) = -\left(i_N(n) + i_3(n) + i_1(n)\right)$$

$$i_3(n) = -\left(i_N(n) + i_1(n) + i_2(n)\right)$$

R.m.s. voltage values

All sampling values are included in the same way when calculating the r.m.s. values. Measurement value aggregation is carried out according to (10.1).

Negative deviation, positive deviation

Negative deviation and positive deviation are calculated from the corresponding r.m.s. voltage values in [%] of the agreed voltage in accordance with DIN EN 61000-4-30.

R.m.s. current values

All sampling values are included in the same way when calculating the r.m.s. values. Measurement value aggregation is carried out according to (10.1).

Network frequency

The network frequency is calculated from the duration T of N of the periods that are fully contained in a 10-second interval.

$$f_{10s} = \frac{N}{T}$$

The 10-minute and 2-hour values of the network frequency are calculated as arithmetic average values according to (9.1).

Spectral analysis

Please also refer to: EN 61000-4-7

The spectral components of all voltages and currents are calculated from the 2048 sampling values of each 10/12-period interval using an FFT algorithm.

R.m.s. values of the harmonic subgroups

The r.m.s. values of the harmonic subgroups are calculated
from the spectral components in accordance with EN 61000-4-7.

The r.m.s. values of the harmonic subgroups of the voltages are normalised to the r.m.s. value fundamental oscillation and transferred in [%], i.e. multiplied by 100.

The r.m.s. value of harmonic subgroup 1 consequently always has
the value 100%.

The r.m.s. values of the harmonic subgroups are transferred
in [A].

The aggregation of the 150/180-period, 10-minute and 2-hour r.m.s. values is carried out according to (10.1).

R.m.s. values of the interharmonic subgroups

The r.m.s. values of the interharmonic subgroups are calculated
from the spectral components in accordance with EN 61000-4-7.

The r.m.s. values of the interharmonic subgroups of the voltages are normalised to the r.m.s. value fundamental oscillation and transferred in [%], i.e. multiplied by 100.

The r.m.s. values of the interharmonic subgroups are transferred in [A] .

The aggregation of the 150/180-period, 10-minute and 2-hour r.m.s. values is carried out according to (10.1).

Harmonic distortions

The measurement quantities for distortion are calculated from the r.m.s. values U_n, I_n of the harmonic subgroups.

The 150/180-period, 10-minute and 2-hour values are calculated from the corresponding r.m.s. values of the harmonic subgroups.

Total Harmonic Distortion (THDS)

Voltages:

$$THDS = \sqrt{\sum_{n=2}^{40} U_n^2}$$

Currents:

$$THDS = \frac{\sqrt{\sum_{n=2}^{40} I_n^2}}{I_1}$$

The values are transferred in [%], i.e. multiplied by 100.

Partial Weighted Harmonic Distortion (PWHD)

Voltages:

$$PWHD = \sqrt{\sum_{n=14}^{40} n \cdot U_n^2}$$

Currents:

The values are transferred in [%], i.e. multiplied by 100.

$$PWHD = \frac{\sqrt{\sum_{n=14}^{40} n \cdot I_n^2}}{I_1}$$

K factor

The values are transferred in [%], i.e. multiplied by 100.

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

Total Harmonic Current (THC)

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

Partial Odd Harmonic Current (PHC)

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

Signal voltage

The 10/12-period r.m.s. value of the signal voltage based on the reference voltage is calculated from the spectral components of the 10/12-period FFT using either one of the two methods in DIN EN 61000-4-30.

The signal frequency can be selected within the measurement bandwidth.

The output is in [%].

The 10/12-period r.m.s. value is stored event-triggered in recorder S in accordance with DIN EN 61000-4-30.

The 150/180-period r.m.s. value is formed according to (10.1) and is

a feature of the supply voltage (DIN 50160).

Phase of the voltages, currents to reference voltage (fundamental oscillation)

The 10/12-period value of the phase of the fundamental oscillations of the voltages and currents based on the reference voltage is calculated from the phase angles of the corresponding spectral components.

The phase angle of the reference voltage is consequently always 0°.

The 150/180-period, 10-minute and 2-hour values are calculated as arithmetic average values according to (10.1).

Phase of the phase voltages to associated conductor currents (fundamental oscillation)

The 10/12-period value of the phase of the fundamental oscillations of the phase voltages based on the associated conductor currents is calculated from the phase angles of the corresponding spectral components.

The 150/180-period, 10-minute and 2-hour values are calculated as arithmetic average values according to (10.1).

Phase of the current harmonics to the phase voltage fundamental oscillation

For the 2nd..40th harmonics of the conductor currents, the phase shift (+/- 180°) of the zero point is calculated based on the zero point of the fundamental oscillation of the associated phase voltage (10/12-period value). The 150/180-period, 10-minute and 2-hour values are calculated as arithmetic average values according to (10.1).

Symmetrical components, asymmetries, phase sequence

The value and phase of the positive, negative and zero-sequence system component for voltages and currents are calculated from the corresponding spectral components of the fundamental oscillation.

Positive-sequence system:

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

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

Negative-sequence system:

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

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

Zero-sequence system:

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

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

where

Rotation operator:

$$\underline{a} = e^{j \cdot 120^{\circ} \cdot ROT}$$

The phase differences between the corresponding symmetrical components of voltage and current are also calculated.

The 150/180-period, 10-minute and 2-hour values of the amounts are calculated as r.m.s. values, and those of the phases are calculated as arithmetic average values according to (10.1).

The negative-sequence system asymmetry is calculated from the negative-sequence and positive-sequence system components.

Voltage:

$$u_2 = \frac{\left|\underline{U}_{1\_NS}\right|}{\left|\underline{U}_{1\_PS}\right|}$$

Current:

$$u_2 = \frac{\left|\underline{I}_{1\_NS}\right|}{\left|\underline{I}_{1\_PS}\right|}$$

The zero-sequence system asymmetry is calculated from the zero-sequence and positive-sequence system components.

Voltage

$$u_0 = \frac{\left|\underline{U}_{ZS}\right|}{\left|\underline{U}_{1\_PS}\right|}$$

Current

$$u_0 = \frac{\left|\underline{I}_{ZS}\right|}{\left|\underline{I}_{1\_PS}\right|}$$

All asymmetry values are transferred in [%], i.e. multiplied by 100.

The 150/180-period, 10-minute and 2-hour values are calculated as arithmetic average values according to (10.1).

When calculating the symmetrical components, the direction of rotation *ROT* is selected in such a way that the positive-sequence component of the voltage is larger than the negative-sequence system component.

ROT = +1 : phase sequence 123 ROT = -1 : phase sequence 321

Power measurement quantities

Active powers

The 150/180-period, 10-minute and 2-hour values of the active powers are calculated as arithmetic average values according to (10.1).

Collective half-period active power

The collective half-period active power $P\sum_{(1/2)}$ is calculated as an arithmetic half-period average value of the collective present power $p\sum(n)$ according to (10.1.2.2)and recorded in recorder B.

$$p_{\Sigma}(n) = u_{1E/N}(n) \cdot i_1(n) + u_{2E/N}(n) \cdot i_2(n) + u_{3E/N}(n) \cdot i_3(n)$$

In 3-conductor systems, the phase voltages correspond to the conductor-earth voltages; in 4-conductor systems, they correspond to the voltages of the external conductors to the neutral conductor.

10/12-period active powers

The 10/12-period values of the active powers of the phases $P_{L-10/12}$ are calculated as arithmetic average values from the present powers $p_L(n)$ of the phase voltages and the corresponding conductor currents according to (10.1.4.2).

$$p_L(n) = u_{L0/N}(n) \cdot i_L(n)$$

with L = phase index

In 4-conductor systems, the voltage between the external conductor and the neutral conductor is used as the phase voltage.

The collective active power is then:

$$P_{\Sigma-10/12} = P_{1-10/12} + P_{2-10/12} + P_{3-10/12}$$

In 3-conductor systems, the voltage between the conductor and the
virtual neutral point is used as the phase voltage, so that the neutral earth voltage has no effect on the active power of the phase.

The "earth active power"
$P_{E-10/12}$ produced by the neutral earth voltage and earth current is calculated separately as an arithmetic average value from the present powers $p_E(n)$ of the neutral earth voltage and the earth current according to (10.1.4.2).

$$p_E(n) = u_{0E}(n) \cdot i_E(n)$$

The collective active power is then calculated as

$$P_{\Sigma-10/12} = P_{1-10/12} + P_{2-10/12} + P_{3-10/12} + P_{E-10/12}$$

The fundamental oscillation active power is calculated from the apparent power of the geometrical fundamental oscillation (refer to 10.9.2) as

$$P_{G-10/12} = \mathrm{Re}\{\underline{S}_{G-10/12}\}$$

Interval average values of the active powers

The average values of the active powers of the phases and the collective active power are based on a definable time interval and transferred as events. The time interval can be triggered either externally (binary input/trigger command) or internally as a fixed cycle time.

Apparent power

Collective apparent power according to DIN 40110-2:

$$S_\Sigma = U_\Sigma \cdot I_\Sigma$$

$$U_\Sigma = \frac{1}{2} \cdot \sqrt{U_{12}^2 + U_{23}^2 + U_{31}^2 + U_{1E/N}^2 + U_{2E/N}^2 + U_{3E/N}^2}$$

$$I_\Sigma = \sqrt{I_1^2 + I_2^2 + I_3^2 + I_{E/N}^2}$$

where

E = earth (3-conductor system)

N = neutral conductor (4-conductor system)

The collective apparent power according to DIN 40110-2 only corresponds to the sum of the apparent powers of the phases when perfect symmetry is given. It is greater under real asymmetrical conditions, since it also includes the coupling between the phases.

The 150/180-period, 10-minute and 2-hour values of the apparent power are calculated from the corresponding values of the input quantities.

Apparent power of the geometrical fundamental oscillation:

Calculation from the symmetrical components where

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

Angle of the apparent power of the geometrical fundamental oscillation:

$$\varphi_G = arc\{\underline{S}_G\}$$

Collective half-period apparent power

The collective apparent power according to DIN40110-2 is calculated from the half-period r.m.s. values of the voltages and currents and recorded in recorder B.

$$S_{\Sigma(1/2)} = U_{\Sigma(1/2)} \cdot I_{\Sigma(1/2)}$$

10/12 period apparent powers

The apparent powers of the phases are calculated from the corresponding 10/12-period r.m.s. values of the phase voltages and currents as

$$S_{L-10/12} = U_{L-10/12} \cdot I_{L-10/12}$$

In 3-conductor systems, the voltage between the conductor and the virtual neutral point is used as the phase voltage; in 4-conductor systems, the voltage between the external conductor and the neutral conductor is used.

The collective apparent power according to DIN40110-2 is calculated from the 10/12-period r.m.s. values of the voltages and currents.

$$S_{\Sigma(10/12)} = U_{\Sigma(10/12)} \cdot I_{\Sigma(10/12)}$$

The apparent power of the geometrical fundamental oscillation $\underline{S}_{G-10/12}$ is calculated from the 10/12-period values of the symmetrical components.

Reactive power

Given sufficiently sinusoidal voltages, the following applies for the collective overall reactive power:

$$Q_{tot,\Sigma} \approx \sqrt{Q_{1,\Sigma}^2 + D_\Sigma^2 + Q_u^2}$$

Given sufficiently sinusoidal voltages, the following applies for the total reactive powers of the phases:

$$Q_{tot,L} \approx \sqrt{Q_{1,L}^2 + D_L^2}$$

where

Q_1 : displacement reactive power of the fundamental oscillation

D: current distortion reactive power

Q_u : asymmetry reactive power

The collective total reactive power only corresponds to the sum of the total reactive powers of the phases when perfect symmetry is given. It is greater under real asymmetrical conditions, since it also contains the asymmetry reactive power.

The sign of the displacement reactive power of the fundamental oscillation is applied to the reactive powers. The reactive power of the phases is
φ_L : Phase difference between the phase voltage and the conductor current (fundamental oscillation)

for collective reactive powers

φ_G : Angle of the apparent power for the geometrical fundamental oscillation.

The 150/180-period, 10-minute and 2-hour values of the reactive power are calculated from the corresponding values of the input quantities.

Collective half-period total reactive power

The collective reactive power is calculated from the half-period values of the collective apparent power and the collective active power and recorded in recorder B.

$$Q_{tot,\Sigma(1/2)} = Sgn(\varphi_G)\cdot\sqrt{S^2_{\Sigma(1/2)} - P^2_{\Sigma(1/2)}}$$

Total reactive power

Phase:

$$Q_{tot,L-10/12} = Sgn(\varphi_{L-10712})\cdot\sqrt{S^2_{L-10/12} - P^2_{L-10/12}}$$

Collective:

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

Collective displacement reactive power of the fundamental oscillation

$$Q_{1,\Sigma-10/12} = \mathrm{Im}\{\underline{S}_{G-10/12}\}$$

current distortion reactive power

Phase:

$$D_L = U_{L0/N-1}\cdot I_{D\_L}$$

$U_{L0/N-1}$: r.m.s. value of the fundamental oscillation of the phase voltage
of external conductor L = {1, 2, 3} where
0 = virtual neutral point (3-conductor system)
N = neutral conductor (4-conductor system)

I_{D_L} : distortion current of conductor L

$$I_{D\_L} = \sqrt{I_L^2 - I_{L-1}^2}$$

I_L : r.m.s. value of the conductor current

I_{L-1} : r.m.s. value of the fundamental oscillation of the conductor current

Since the distortion current also contains the non-harmonic components, these are are also included in the current distortion reactive power.

Collective:

$$D_{\Sigma} = U_{\Sigma-1} \cdot \sqrt{I_{D\_1}^2 + I_{D\_2}^2 + I_{D\_3}^2 + I_{D\_E/N}^2}$$

where

$$U_{\Sigma-1} = \frac{1}{2} \cdot \sqrt{U_{12-1}^2 + U_{23-1}^2 + U_{31-1}^2 + U_{1E/N-1}^2 + U_{2E/N-1}^2 + U_{3E/N-1}^2}$$

$U_{LE/N-1}$: r.m.s. value of the fundamental oscillation of the phase voltage of outer conductor L = {1, 2, 3} to earth/neutral conductor

$I_{D\_E/N}$: distortion current earth/neutral conductor

where

E = earth (3-conductor system)

N = neutral conductor (4-conductor system)

Dimensionless power measurement quantities

In general:

φ_L : phase difference between the phase voltage and the conductor current (fundamental oscillation)

φ_G : phase angle of the apparent power of the geometrical fundamental oscillation

The 150/180-period, 10-minute and 2-hour values are calculated from the corresponding values of the input quantities.

Active factor

Phase:

$$PF_L = \frac{P_L}{S_L}$$

Collective:

$$PF_{\Sigma} = \frac{P_{\Sigma}}{S_{\Sigma}}$$

COSPHI

Phase:

$$COS\varphi_L = \cos(\varphi_L)$$

Collective:

$$COS\varphi = \cos(\varphi_G)$$

Output of the COSPHI for analogue display devices:

The COSφ is mapped linearly in the range 0(cap.)...+1...0(ind.) or 0(cap.)...- 1...0(ind.) to Y = -1(cap.)...0...+1(ind.) irrespective of the draw/supply.

Phase:

$$Y_L = Sgn(\varphi_L) \cdot (Sgn(COS\varphi_L) - COS\varphi_L)$$

Collective:

$$Y = Sgn(\varphi_G) \cdot (Sgn(COS\varphi) - COS\varphi)$$

COSφ with sign of displacement angle (capacitive: -, inductive: +) ,

irrespective of draw/supply :

Phase:

$$COSPHV_L = Sgn(\varphi_L) \cdot COS\varphi_L$$

Collective:

$$COSPHV = Sgn(\varphi_G) \cdot COS\varphi$$

Reactive factor

Phase:

$$QF_L = \frac{Q_L}{S_L}$$

Collective:

$$QF_\Sigma = \frac{Q_\Sigma}{S_\Sigma}$$

SINPHI

Phase:

$$SIN\varphi_L = \sin(\varphi_L)$$

Collective:

$$SIN\varphi = \sin(\varphi_G)$$

TANPHI

Phase:

$$TAN\varphi_L = \tan(\varphi_L)$$

Collective:

$$TAN\varphi = \tan(\varphi_G)$$

Active energies

The active energies of the phases in a time interval defined by t_0 (reset point) and t_m (measurement point) are calculated by summation of the products of the 10/12-period values of the active power and the associated 10/12-period time.

The 150/180-period, 10-minute and 2-hour values are taken from the corresponding accumulator

at the relevant intervals and transferred in kWh.

$$W_L(t_0, t_m) = \sum_{n=0}^{m} P_{L-10/12}(n) \cdot T_{10/12}(n)$$

The relevant sum of the corresponding phase active energies is output as network active energy.

Total active energy

All 10/12-period values of the active power of the phases are included in the summation, retaining their signs.

Supplied active energy

Only the 10/12-period values of the active power of the phases with a positive sign are included in the summation.

Drawn active energy

Only the 10/12-period values of the active power of the phases with a negative sign are included with a positive sign in the summation.

Reactive energies

The reactive energies of the phases in a time interval defined by t_0 (reset point) and t_m (measurement point) are calculated by summation of the products of the 10/12-period values of the reactive power and the associated 10/12-period time.

The 150/180-period, 10-minute and 2-hour values are taken from the corresponding accumulator at the relevant intervals and transferred in kVArh.

$$W_{r-L}(t_0, t_m) = \sum_{n=0}^{m} Q_{L-10/12}(n) \cdot T_{10/12}(n)$$

The relevant sum of the corresponding phase reactive energies is output as network reactive energy.

Total reactive energy

All 10/12-period values of the reactive power of the phases are included in the summation, retaining their signs.

Supplied reactive energy

Only the 10/12-period values of the reactive power of the phases with a positive sign are included in the summation.

Drawn reactive energy

Only the 10/12-period values of the reactive power of the phases with a negative sign are included with a positive sign in the summation.

Flicker magnitude

The short-term flicker magnitudes P_{st} (10 minutes) and long-term flicker magnitudes P_{lt} (2 hours) are calculated for the phase and delta voltages. P_{st} and P_{lt} are defined in EN 61000-4-15.

Transnostic

If voltage dips or overvoltages occur, the PQI-DA generates events that allow conclusions to be drawn about the cause of the error (error type).

The trigger thresholds can be set.

Event value	Error type	Phase	Direction
1	Short-circuit	L1-E	behind measurement point (own network)
2	Short-circuit	L2-E	behind measurement point (own network)
3	Short-circuit	L1-L2	behind measurement point (own network)
4	Short-circuit	L3-E	behind measurement point (own network)
5	Short-circuit	L3-L1	behind measurement point (own network)
6	Short-circuit	L2-L3	behind measurement point (own network)
7	Short-circuit	L1-L2-L3	behind measurement point (own network)
9	Overvoltage	L1-E	behind measurement point (own network)
10	Overvoltage	L2-E	behind measurement point (own network)
11	Overvoltage	L1-L2	behind measurement point (own network)
12	Overvoltage	L3-E	behind measurement point (own network)
13	Overvoltage	L3-L1	behind measurement point (own network)
14	Overvoltage	L2-L3	behind measurement point (own network)
15	Overvoltage	L1-L2-L3	before measurement point
17	Short-circuit	L1-E	before measurement point
18	Short-circuit	L2-E	before measurement point
19	Short-circuit	L1-L2	before measurement point
20	Short-circuit	L3-E	before measurement point
21	Short-circuit	L3-L1	before measurement point
22	Short-circuit	L2-L3	before measurement point
23	Short-circuit	L1-L2-L3	before measurement point
25	Overvoltage	L1-E	before measurement point

26	Overvoltage	L2-E	before measurement point
27	Overvoltage	L1-L2	before measurement point
28	Overvoltage	L3-E	before measurement point
29	Overvoltage	L3-L1	before measurement point
30	Overvoltage	L2-L3	before measurement point
31	Overvoltage	L1-L2-L3	before measurement point

Updating the firmware

Firmware updates can only be carried out via the COM1 interface of the device. The following steps are necessary:

- Establish a physical connection between the PC and the PQI-DA via zero modem cable.
- The program “COMM.EXE” can be found in the “Firmware” subfolder, which is located in the WinPQ folder. To upload the new firmware, select a transfer speed of 115 baud at the RS232 interface of the PC and set the hardware protocol to “RTS/CTS”.
- Then switch the station to firmware upload mode by pressing and holding the reset button for at least 5 seconds. The status LEDs "Operation" (green) and "Fault" (red) continue to light up when the button is released.
- In the program “COMM.EXE” menu: Select “Send terminal/firmware with reset”.
- The familiar Windows “Open file dialog” is shown. The valid firmware file (e.g. PQI_UU.MOT) must be opened.

  The "Operation" LED flashes once per second during data transfer.

  The status of the upload can be followed in the program status line.
- Then (transfer takes approx. 3 to 5 minutes), the device restarts. As soon as the "Operation" LED lights up again, it is possible to query the version at the terminal using the “VER” command. The response must contain the new firmware version with the associated date, e.g.
  "PQI-DA: Version 5.0.09 from 13.01.11“
- You can use the terminal command "SYSRESET=590" to load the current factory settings. The station is then restarted. The station parameterisations are then restored via one of the communication interfaces using the “PQPara” program components.

Information:

A detailed description for firmware updates is given in the section "Firmware update" in the commissioning instructions.

Scope of delivery

- PQI-D corresponding to the design features
- PQI-DA operating manual
- RS232 interface cable

Storage information

The devices should be stored in clean, dry rooms. The devices and their respective replacement modules can be stored between -25°C and +65°C.

The relative humidity must not lead to the formation of either condensation or ice.

We recommend that the storage temperature be kept between +0°C and +55°C to ensure that the built-in electrolytic capacitors do not age prematurely.

We also recommend that the device be connected to an auxiliary voltage every two years to reform the electrolytic capacitors. This procedure should also be carried out before the device is put into operation. Under extreme climatic conditions (tropics), this also ensures "preheating" at the same time and helps to avoid the formation of condensation.

The device should be stored in the service room for at least two hours prior to being connected to the voltage for the first time, so that it can become accustomed to the ambient temperature and to avoid the formation of moisture and condensation.

Guarantee

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

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

Ordering information

Please note the following when ordering:

- Only one code with the same capital letter is possible.
- If the capital letter is followed by the number 9, additional details in plain text are required.
- If capital letters are followed only by zeros, the code can be omitted.

FEATURE	CODE
Power Quality Interface for medium-voltage and high-voltage networks according to DIN EN-50160 and IEC 61000-4-30 (Class A) with 4 binary inputs and outputs plus status relay (life contact) with two E-LAN interfaces for communication with the REGSys components REG-D(A), PAN-D, REG-DP(A), MMU-D, EOR-D, CPR-D and DMR-D. Equipped with COM 1 and COM 2 as standard in transformer design or standard mounting rail enclosure 204 x 142 x 132 mm (W x H x D)	PQI-DA
supply voltage AC 100V ... 110V ... 240V / DC 100V..220V..300V DC 20V...60V...70V	 H0 H1
Input configuration 1 x 4 voltage transformers 2 x 4 voltage transformers 4 voltage transformers, 4 current transformers In =1A (Imax < 2 x In) 4 voltage transformers, 4 current transformers In=1A (Imax < 20 x In) 4 voltage transformers, 4 current transformers In=5A (Imax < 2 x In) 4 voltage transformers, 4 current transformers In=5A (Imax < 20 x In)	 C00 C10 C20 C21 C30 C31
Additional interface: as RS 232 as COM server (RJ 45) **Note**: If T1 is selected, the COM2 interface is omitted; RS 232 is only a service interface	 T0 T1
Rated value of the input voltage 100 V / 110 V 230 V / 400 V 4 x 100 V and 4 x 400 V **Note**: E9 can only be selected together with C10	 E1 E2 E9

Inputs 4 programmable binary inputs (48…250 V AC/DC) 4 programmable binary inputs (10…48 V DC)	 M1 M2
Operating manual German English French	 G1 G2 G3

FEATURE	CODE
WinPQ software For parameterising, archiving and evaluating PQI-D/DA measurement data with the following basic functions: • 32-bit Windows program interface • SQL database for storage of measurement values for each measurement point • Data access via TCP/IP network • Option of displaying all measurement quantities that can be accessed by a PQI-D/DA as a function of time and as a statistical quantity • An additional workplace license is included in the price	**WinPQ**
Licenses As a single license for up to 2 PQI-D/DAs As a single license for 2 to 10 PQI-D/DAs As a single license for > 10 PQI-D/DAs	 L0 L1 L2
Language German English	 A1 A2
WinPQ Para Express	
WinPQ Para Express software For the parameterisation of PQI-DAs and PQI-DA measurement data	**ParaPQ**

Additions to PQI-DA	CODE
100 MBit TCP/IP adaptor	A90
DCF 77 radio clock	111.9024
RS 232 extension cable (10 m)	582.2040.10
USB adaptor for zero modem cable	111.9046
Industrial modem can be used as a dial-up line or dedicated line modem (Uh: 20 V ... 260 V AC / 14 V ... 280 V DC) with mounting rail adapter for PC and device side!	111.9030.17
IRIG-DCF77 - converter (10 TE)	IRIG-DCF
AC 100V ... 110V ... 240V / DC 100V..220V..300V DC 20V...60V...70V	H1 H2
as a 20TE wall mounting housing	B1
Operating manual German English	 G1 G2

Notes

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Software version:

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Version: _130117
Version: 16.02.2023 11:15