

Device handbook

LINAX PQ5000-MOBILE

Operating instructions LINAX PQ5000-MOBILE (2019-05)



GMC INSTRUMENTS

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Legal information

Warning notices

In this document warning notices are used, which you have to observe to ensure personal safety and to prevent damage to property. Depending on the degree of danger the following symbols are used:



If the warning notice is not followed death or severe personal injury **will** result.



If the warning notice is not followed damage to property or severe personal injury **may** result.



If the warning notice is not followed the device **may** be damaged or **may** not fulfill the expected functionality.

Qualified personnel

The product described in this document may be handled by personnel only, which is qualified for the respective task. Qualified personnel have the training and experience to identify risks and potential hazards when working with the product. Qualified personnel are also able to understand and follow the given safety and warning notices.

Intended use

The product described in this document may be used only for the application specified. The maximum electrical supply data and ambient conditions specified in the technical data section must be adhered. For the perfect and safe operation of the device proper transport and storage as well as professional assembly, installation, handling and maintenance are required.

Disclaimer of liability

The content of this document has been reviewed to ensure correctness. Nevertheless it may contain errors or inconsistencies and we cannot guarantee completeness and correctness. This is especially true for different language versions of this document. This document is regularly reviewed and updated. Necessary corrections will be included in subsequent version and are available via our webpage <https://www.camillebauer.com>.

Feedback

If you detect errors in this document or if there is necessary information missing, please inform us via e-mail to: customer-support@camillebauer.com

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1. Purpose of this document

This document describes the universal measurement device for heavy-current quantities LINAX PQ5000-MOBILE. It is intended to be used by:

- Installation personnel and commissioning engineers
- Service and maintenance personnel
- Planners

Scope

This handbook is valid for all hardware versions of the LINAX PQ5000-MOBILE. Some of the functions described in this document are available only, if the necessary optional components are included in the device.

Required knowledge

A general knowledge in the field of electrical engineering is required. For assembly and installation of the device knowledge of applicable national safety regulations and installation standard is required.

2. Scope of supply

Upon receive of delivery check device and supplied accessories for completeness and integrity.

The scope of supply depends on the ordered variant.

Image	No.	Description	o.k.
	1	Power quality analyzer PQ5000-MOBILE with 5 test leads for voltage inputs including plug-on dolphin clamps	<input type="checkbox"/>
	1	Power adapter with plug kit	<input type="checkbox"/>
	1	WLAN Access Point Dongle	<input type="checkbox"/>
	1	Carrying bag	<input type="checkbox"/>
	1	Device handbook (German or English) including test report	<input type="checkbox"/>
	1	Optional: 4-phase current probe ACF 2004_1 2000 A	<input type="checkbox"/>
	4	Optional: Clamp-on probes 10A/1V	<input type="checkbox"/>
	4	Optional: Clamp-on probes 100A/1V	<input type="checkbox"/>
	4	Optional: Clamp-on probes 1000A/1V	<input type="checkbox"/>
	1	Optional: GPS receiver 16x-LVS	<input type="checkbox"/>
	..	Optional: IP67 protected Ethernet cable (RJ45), 5m	<input type="checkbox"/>

Leads for voltage measurement

For security reasons leads for voltage measurement are equipped with the following fuse:

SIBA, type 7017240, 6.3 x 32mm, very fast acting
FF 500mA / 1000V / 30kA



The fuse should only be replaced by a fuse of the same type.

To replace the fuse the probe can be screwed on.



Do not replace fuse again if failure is repeated. Repeated failure indicates a defective condition that will not clear with replacement of the fuse. Refer condition to a qualified technician.

3. Device overview

3.1 Short description

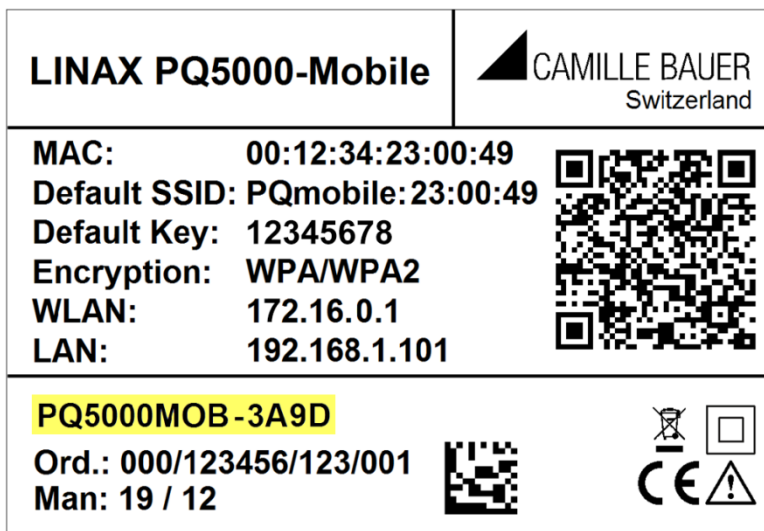
By means of the mobile measurement solution LINAX PQ5000-Mobile the operational aspects of the energy supply can be verified:

- Quality of supply
- Availability of supply
- Evaluation of changes or improvement measures
- Energy flow analysis

This measurement solution supports campaigns for repeated measurements at the same locations. For that, a configuration manager can handle up to 20 different device settings. The device can also have a WLAN access point for connecting mobile devices and provides all data for evaluation via its own website. In order to be able to validate the power quality at the measuring location, the duration of the measurement should be at least 7 full days.





A full parameterization of all device functions can be performed via a web browser. The PQ5000-Mobile fulfills all requirements of a class A device in accordance with the power quality standard IEC 61000-4-30 Ed.3.

The device is available in different variants. The nameplate on the device provides information about the given version.



Name plate of a device with

- **[3]**: Connector for Rogowski probe
- **[A]**: 4-phase Rogowski current probe 2000A
- **[9]**: GPS time synchronization (GPS receiver not in scope of supply)
- **[D]**: Device handbook German

Symbol	Meaning
	Device may only be disposed of in a professional manner!
	Double insulation, device of protection class 2
	CE conformity mark. The device fulfills the requirements of the applicable EU directives.
	Caution! General hazard point. Read the operating instructions.

3.2 Operation and evaluation

No software is required for the parameterization of the device or the evaluation of the measurement results. The WEB interface of the device provides all required functions. These can be used via mobile phone, tablet or laptop via the LAN or WLAN interface.

- Measurement data visualization
- Status bar for network LAN + WLAN, alarms, recording
- Service functions
- PQ Easy-Report for compliance reports
- Complete device parameterization
- Support for measurement campaigns (up to 20 configurations)
- Data export in CSV format (load profiles, waveform, event lists)

3.3 Measurement data

The device provides measurements in subcategories:

- Instantaneous values:** Present TRMS values and associated min/max values for the analysis of the present system state
- Energy:** Provides information about the current energy consumption (power mean-values with trend), the time-related energy consumption (load profiles) and the total energy consumption.
- Harmonics:** Total harmonic distortion THD/TDD, individual harmonics and their maximum values, phase angle of the harmonics
- Phasor diagram:** With the overview of all voltage and current phasors and the phase sequence check it can be clearly determined if the device is connected correctly.
- Waveform** of current and voltage inputs
- Events:** Provides chronological lists of all PQ events and the occurrence of monitored (user-defined) alarms and events. The operator list contains system events, such as configuration changes, power up/down, reset operations, firmware updates and much more, which may have an impact on the consistency of measurement data.
- PQ statistic:** Gives access to the result of the statistical power quality analysis. The user can directly perform conformity assessments to the standards EN 50160, IEC 61000-2-2 / 2-4 / 2-12, GB/T, IEEE 519 or other user-defined limit sets or directly create conformity reports (PQ-Easy Report).

3.4 Device usage

The planning of the device usage, performing the measurement and then evaluating the recorded data is described in the following chapters.

- [Preparation of the measurement application \(Chap. 4\)](#): Using the website the device functionality can be configured via LAN or WLAN interface
- [Connecting the device on-site \(Chap. 6\)](#)
- [Installation check \(Chap. 7.2\)](#)
- [Performing the measurement \(Chap. 7\)](#)
- [Evaluation of recorded data \(Chap. 8\)](#)

4. Preparation of the measurement application

4.1 Connecting to the measurement device

4.1.1 Connection via LAN interface

Before devices can be connected to an existing Ethernet network, you have to ensure that they will not disturb the normal network service. The rule is:



None of the devices to connect is allowed to have the same IP address than another device already installed

This also applies if the network only consists of a PC and the measuring device.

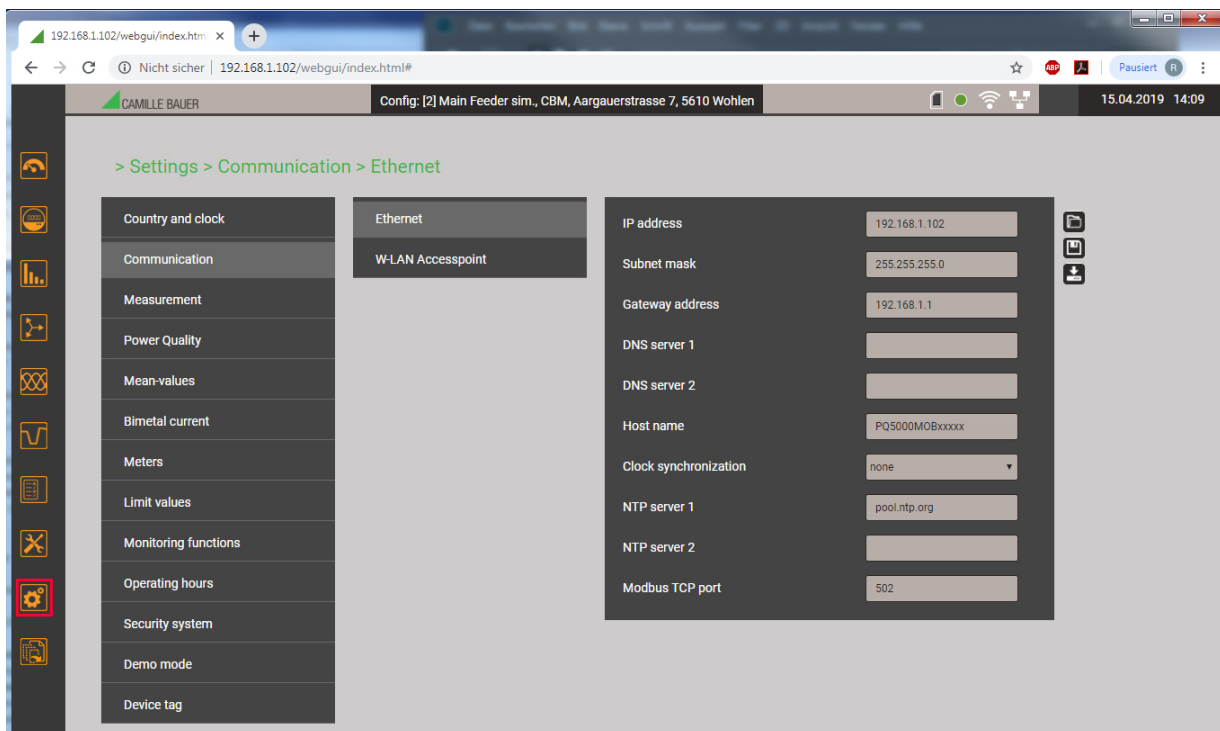
For a direct communication between PC and measurement device both devices need to be in the same network when the **subnet mask** is applied. The meaning of this is shown in the [example](#) on the next page. The assignment of the network settings is described in [Annex B](#).

As soon as PC and measurement device are in the same network, the website of the device may be accessed using a browser.



The recommended browsers are Google-Chrome and Firefox.

Call the device website via `http://<ip_addr>`. The default setting of the device IP address is 192.168.1.101.



If, for example, a device needs to be integrated into an existing network, the network settings can be modified via the menu Settings | Communication | Ethernet. The corresponding parameters are described on the next page.




If the IP address of the Ethernet interface is changed and the configuration stored in the device, the website of the device must be reloaded via the new IP address.

Hint: The device supports up to 20 different configurations, but the Ethernet settings are the same for all of them.

The following settings have to be arranged with the network administrator:

- **IP address:** This one must be **unique**, i.e. may be assigned in the network only once.
- **Subnet mask:** Defines how many devices are directly addressable in the network. This setting is equal for all the devices. [Example](#).
- **Gateway address:** Is used to resolve addresses during communication between different networks. It must contain a valid address within the directly addressable network.
- **DNS-Server x:** Is used to resolve a domain name into an address, if e.g. a name (pool.ntp.org) is used for the NTP server. [Further information](#).
- **Hostname:** Individual designation for each device. Via the hostname the device can be uniquely identified in the network. Therefore for each device a unique name should be assigned.
- **NTP-Server x:** NTP servers are used as base for [time synchronization](#)
- **Modbus/TCP Port:** Selection of the TCP port to be used for Modbus/TCP communication. Standard setting is 502. See also [TCP ports](#).

 If a USB to Ethernet adapter is used, the IP address of this local network can be assigned to an address in the network of the LAN interface of the measurement device, e.g. 192.168.1.100. This way the standard interface of the device does not need to be changed.



For a direct communication between device and PC both devices need to be in the same network when the **subnet mask** is applied:

Example	decimal	binary
IP address	192.168. 1.101	11000000 10101000 00000001 01100101
Subnet mask	255.255.255.0	11111111 11111111 11111111 00000000
	variable range	xxxxxxxx
First address	192.168. 1. 1	11000000 10101000 00000001 00000001 ^{a)}
		^{a)} Do not use address 0, as it is reserved for broadcast
Last address	192.168. 1.254	11000000 10101000 00000001 11111110 ^{b)}
		^{b)} Do not use address 255, as it is reserved for broadcast

► The device 192.168.1.101 can access directly the devices 192.168.1.1 ... 192.168.1.254

In private networks only reserved IP address ranges may be used, with subnets being most common in the 192.168.x.x/16 network (see examples above).

Alternative private networks are: 10.0.0.0/8 or 172.16.0.0/12 (used by the WLAN access point).

Time synchronization via NTP protocol

For the *time synchronization* of devices via Ethernet *NTP* (Network Time Protocol) is the standard. Corresponding time servers are used in computer networks, but are also available for free via Internet. Using NTP it's possible to hold all devices on a common time base.

Two different NTP servers may be defined. If the first server is not available the second server is used for trying to synchronize the time.

If a public NTP server is used, e.g. "pool.ntp.org", a name resolution is required. This normally happens via a **DNS server**. So, the IP address of the DNS server must be set in the communication settings of the Ethernet interface to make a communication with the NTP server, and thus time synchronization, possible. Your network administrator can provide you the necessary information.

The time synchronization of the standard interface can be performed via a [GPS receiver](#) (Chap. 6.2) as well.

TCP ports

The TCP communication is done via so-called ports. The number of the used port allows determining the type of communication. As a standard Modbus/TCP communication is performed via TCP port 502, NTP uses port 123. However, the port for the Modbus/TCP communication may be modified. You may provide a unique port to each of the devices, e.g. 503, 504, 505 etc., for an easier analysis of the communication traffic. Independent of these setting a communication via port 502 is always supported. The device allows at least 5 connections to different clients at the same time.

Firewall

Due to security reasons nowadays each network is protected by means of a firewall. When configuring the firewall you have to decide which communication is desired and which have to be blocked. The TCP port 502 for the Modbus/TCP communication normally is considered to be unsafe and is often disabled. This may lead to a situation where no communication between networks (e.g. via Internet) is possible.

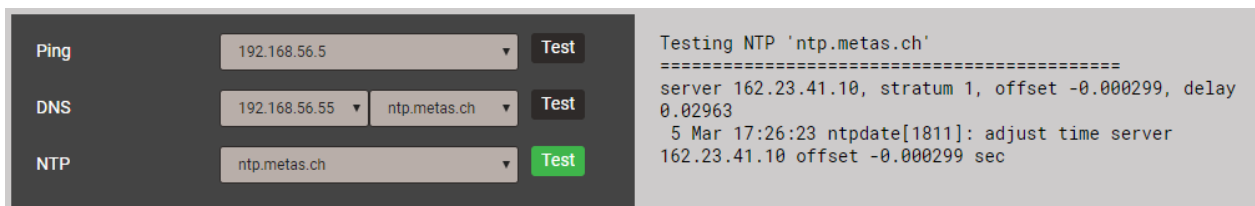
MAC address

For uniquely identifying Ethernet connections in a network, a unique MAC address is assigned to each connection. Compared to the IP address, which may be modified by the user at any time, the MAC address is static. The MAC address of the LAN interface is given on the nameplate.

Communication tests

Via the service menu on the device website you may check if the selected network structure is valid. The device must be able to reach the DNS server via gateway. The DNS server then allows resolving the URL of the NTP server to an IP address. The Standard Ethernet interface serves as interface for the communication tests.

- Ping: Connection test to any network device (initial: gateway address)
- DNS: Test, if the name resolution via DNS works (initial: URL of NTP server)
- NTP: Test, if the selected NTP-Server is in fact a time server (stratum x)



The screenshot shows a control panel for testing network connectivity. It has three rows: 'Ping' with a dropdown set to '192.168.56.5' and a 'Test' button; 'DNS' with a dropdown set to '192.168.56.55', another dropdown set to 'ntp.metas.ch', and a 'Test' button; and 'NTP' with a dropdown set to 'ntp.metas.ch' and a green 'Test' button. To the right, a terminal window displays the output of the NTP test: 'Testing NTP 'ntp.metas.ch'', followed by a separator line, 'server 162.23.41.10, stratum 1, offset -0.000299, delay 0.02963', and a timestamp '5 Mar 17:26:23 ntpdate[1811]: adjust time server 162.23.41.10 offset -0.000299 sec'.

NTP server test

4.1.2 Connection via WLAN interface

Via the WLAN dongle up to 10 devices (mobile phone, tablet, laptop or similar) can be connected wireless.

- For devices with camera the QR code on the nameplate can be used for joining directly the network of the measurement device. Depending on the mobile device used, an App for scanning the QR code may be required. Shown example: iPhone.
- All other devices can be connected to the measurement device by establishing a connection to the WLAN access point given on the nameplate (PQmobile:23:xx:xx).



Call the device website via `http://<ip_addr>`. The default setting of the device IP address is 172.16.0.1.

i If the IP address of the WLAN interface is changed and the configuration stored in the device, the website of the device must be reloaded via the new IP address.

Hint: The device supports up to 20 different configurations, but the WLAN settings are the same for all of them.

4.1.3 Resetting the network settings

If the communication settings of the communication interface are no longer known or an activated whitelist prevents access to the device, they can be reset to the default settings via the keys on the device.

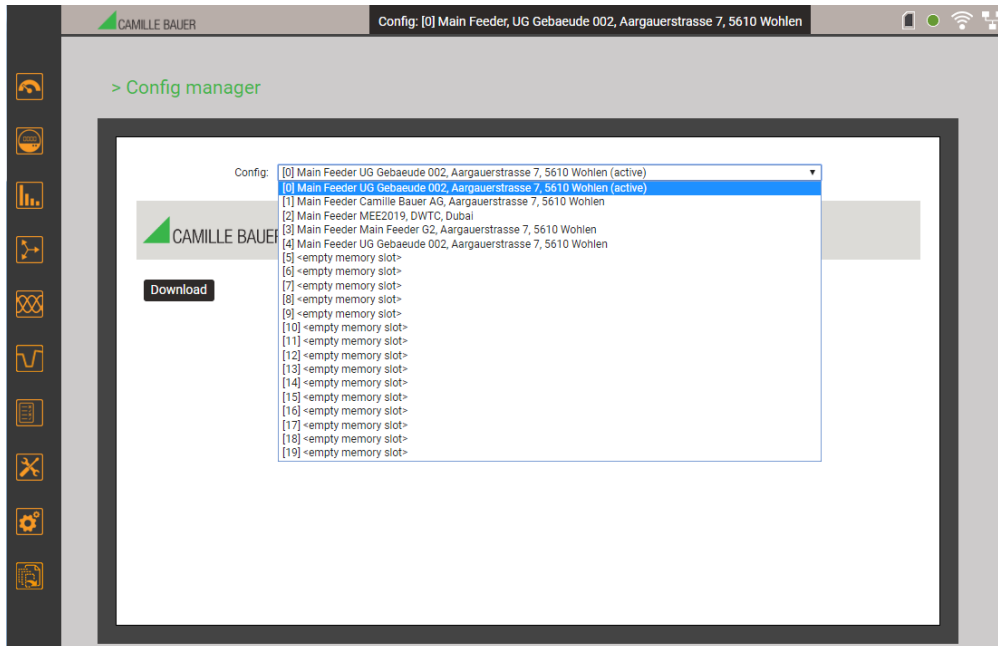


Function	Procedure and result
Resetting the WLAN interface to the default setting 172.16.0.1	Press <RESET> for at least 3 seconds: The assigned LED flashes. The reset is finished, as soon as the LED shows the state before the reset again.
Resetting the LAN interface to the default setting 192.168.1.101 Deactivating an active whitelist.	Press <RESET> and <RECORD> for at least 3 seconds: The assigned LEDs flash. The reset is finished, as soon as the LEDs show the state before the reset again.

4.2 Parameterization of the device functionality

4.2.1 Configuration manager

This measurement solution supports campaigns for repeated measurements at the same locations. For that, a configuration manager can handle up to 20 different device settings.



The administration of the device configurations is done via the configuration manager.

- The active configuration is marked with (active) and also visible in the status bar
- <empty memory slot> means, that this configuration hasn't been used yet
- If the active configuration is selected, the menu **Download** is available
 - Download: Save the active configuration as XML file on the PC
- If a none active configuration is selected, the menu changes to **Activate configuration** **Delete** **Download**
 - Activate configuration: This configuration is activated in the device
 - Delete: The selected configuration will be deleted and then display as <empty memory slot>
Hint: The active configuration cannot be deleted
 - Download: Save the selected configuration as XML file on the PC
- If an empty configuration is selected, the menu changes to **Upload**
 - Upload: You may upload a configuration (XML file) from the PC

Each [device configuration](#) (chap. 4.2.2) is created via the Settings menu.

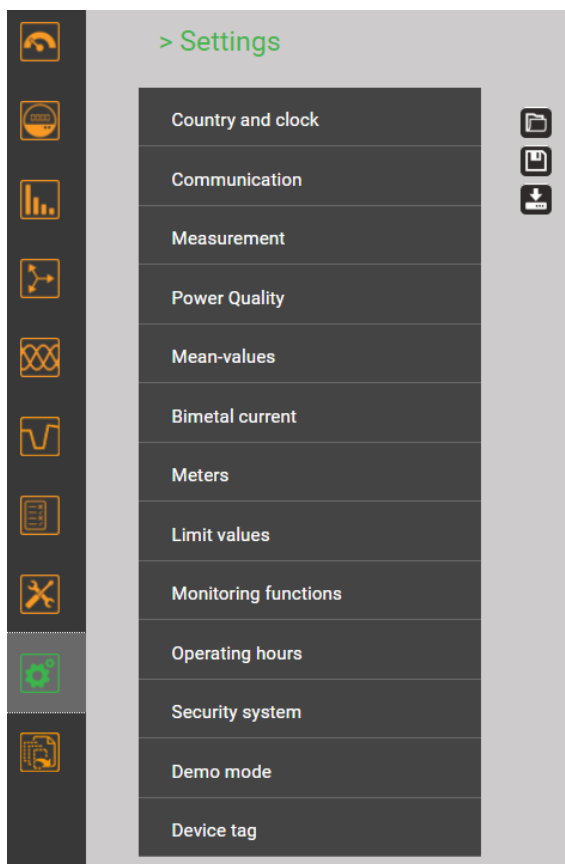


For the subsequent data analysis, the used configuration during data recording must be reactivated in the device

ATTENTION: If the configuration used during data recording has been changed or is no longer available, an evaluation of the data may no longer be possible.

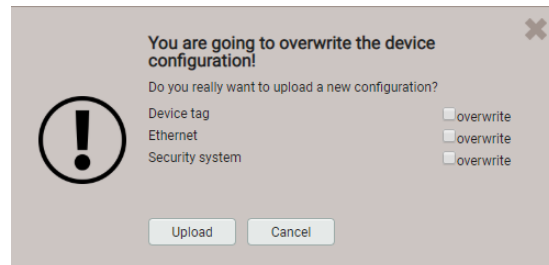
4.2.2 Device configuration

A full parameterization of all functions of the device can be performed via the settings menu on the website.



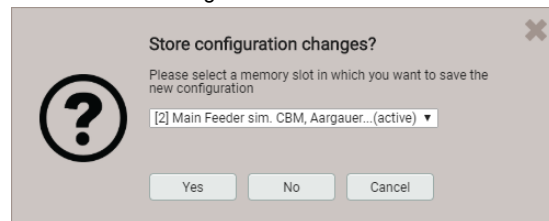
Upload a configuration from computer

The configuration data of the selected file will be directly loaded into the device. At the same time the active configuration in the configuration manager is updated. You can select, if the parameters shown in the below picture should be overwritten or retained by the values in the file to load.



Save current settings

You have to select the slot of the configuration manager to overwrite. The settings will be activated in the device as well.



Store configuration on computer

Subgroups of the settings menu

- **Country and clock:** display language, date format, time zone, clock synchronization, time/date (only if there is no time synchronization)

Hint: Although changing the language has immediate effect on the display, such a change must be saved in the device.

- **Communication:** Settings of the communication interfaces [Ethernet](#) (4.1.1) and [WLAN](#) (4.1.2)

Hint: The communication settings are valid for all configurations

- **Measurement:** System type, sense of rotation, nominal values of U / I / f, sampling, [reference arrow system](#) (annex A) etc.

Hints

- **U / I transformer:** The primary to secondary ratio is used only for converting the measured secondary to primary values, so e.g. 100 / 5 is equivalent to 20 / 1. The values do not have any influence on the display format of the measurements.
 - **Nominal voltage:** Is used as the 100% reference for monitoring power quality events and corresponds to the declared input voltage U_{dm} in accordance with IEC 61000-4-30
 - **Nominal current:** Used for scaling the harmonic content [TDD](#) of the currents
 - **Maximum primary values U/I:** These values are used only for fixing the display format of the measurements. This way the resolution of the displayed values can be optimized, because there is no dependency to installed transformers.
 - **Synchronous sampling:** yes=sampling is adjusted to the measured system frequency to have a constant number of samplings per cycle; no=constant sampling based on the selected system frequency
 - **Reference channel:** The measurement of the system frequency is done via the selected voltage input
- **Power quality** (Chap. 4.5): Definition of parameters for monitoring the PQ events voltage dip, voltage interruption, voltage swell, rapid voltage changes and mains signalling voltage. The default values of the trigger thresholds and hystereses are set to the common values of the EN50160 for a public low-voltage distribution system.


User-specific limits for the evaluation of the PQ statistic can also be set.

- **Mean-values | standard quantities:** The interval time for the predefined power mean values can be defined here; typical interval: 15 min
- **Mean-values | user defined quantities:** Selection of up to 12 quantities with a common averaging interval for determining their mean-values
- **Bimetal current:** Selection of the response time for determining [Bimetal currents](#) (annex A.4)
- **Meters | Standard meters:** [Meter resolution](#) (annex A.4)
- **Meters | User defined meters:** Up to 12 base quantities (Px,Qx,Q(H1)x,Sx,lx) can be selected for free definable meters; [Meter resolution](#) (annex A.4)
- **Meters | Meter logger:** Selection of the reading interval
- **Limit values:** Up to 12 upper or lower [limit values](#) (4.5.1) can be defined here
- **Monitoring functions:** Definition of up to 8 [monitoring functions](#) (4.5.2) with up to 3 inputs each, delay times for ON / OFF and description text
- **Operating hours:** Selection of the running condition for up to 3 operating hour counters
- **Security system:** Definition of password protection, https active/inactive, client whitelist
Hint: An activated security system is valid for all configurations
- **Demo mode:** Activation of a presentation mode; measurement data will be simulated. Demo mode is automatically stopped when rebooting the device.
- **Device tag:** In addition to the device tag, which is valid for all configurations, you may enter here specific information about the measurement location required for the PQ compliance report creation.

4.3 Security system

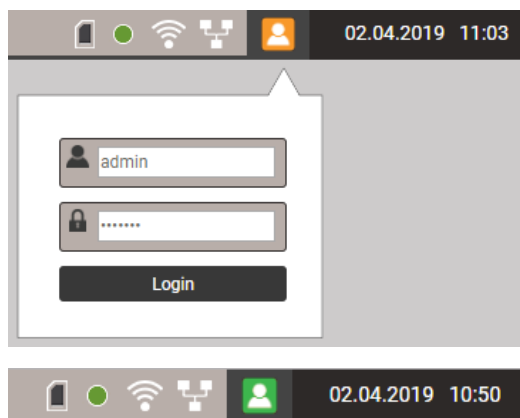
4.3.1 Protection against device data changing

Configuration or measurement data stored in the device may be modified via both service and settings menu. To protect these data a security system may be activated (default: not activated). If the security system is active the user has to enter a password before executing protected functions. Subsequent to a successful password input the access remains open until the user leaves the settings / service menu or an input timeout occurs.




The password can be modified by the user. Permitted characters are 'a'...'z', 'A'...'Z' and '0'...'9', length 4...12 characters.

ATTENTION: A reset to factory default will reset also the password (factory setting: „1234“). But for a factory reset the present password needs to be entered. If this password is no longer known the device must be sent back to the factory!



Release

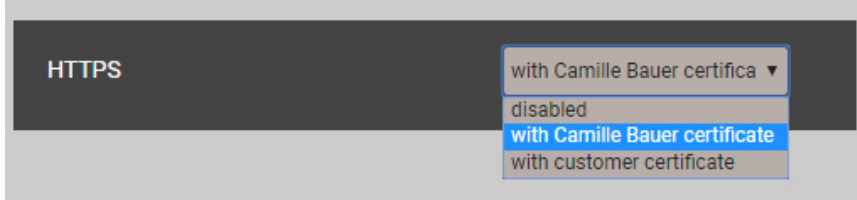
- Click on the symbol 
- Enter password
- Select Login

Protected functions can be used

4.3.2 Secure communication using HTTPS

HTTPS provides encrypted communication using TLS (Transport Layer Security). Such as bidirectional encryption of communications between a client and server protects against eavesdropping and tampering of the communication. HTTPS creates a secure channel over an insecure network.

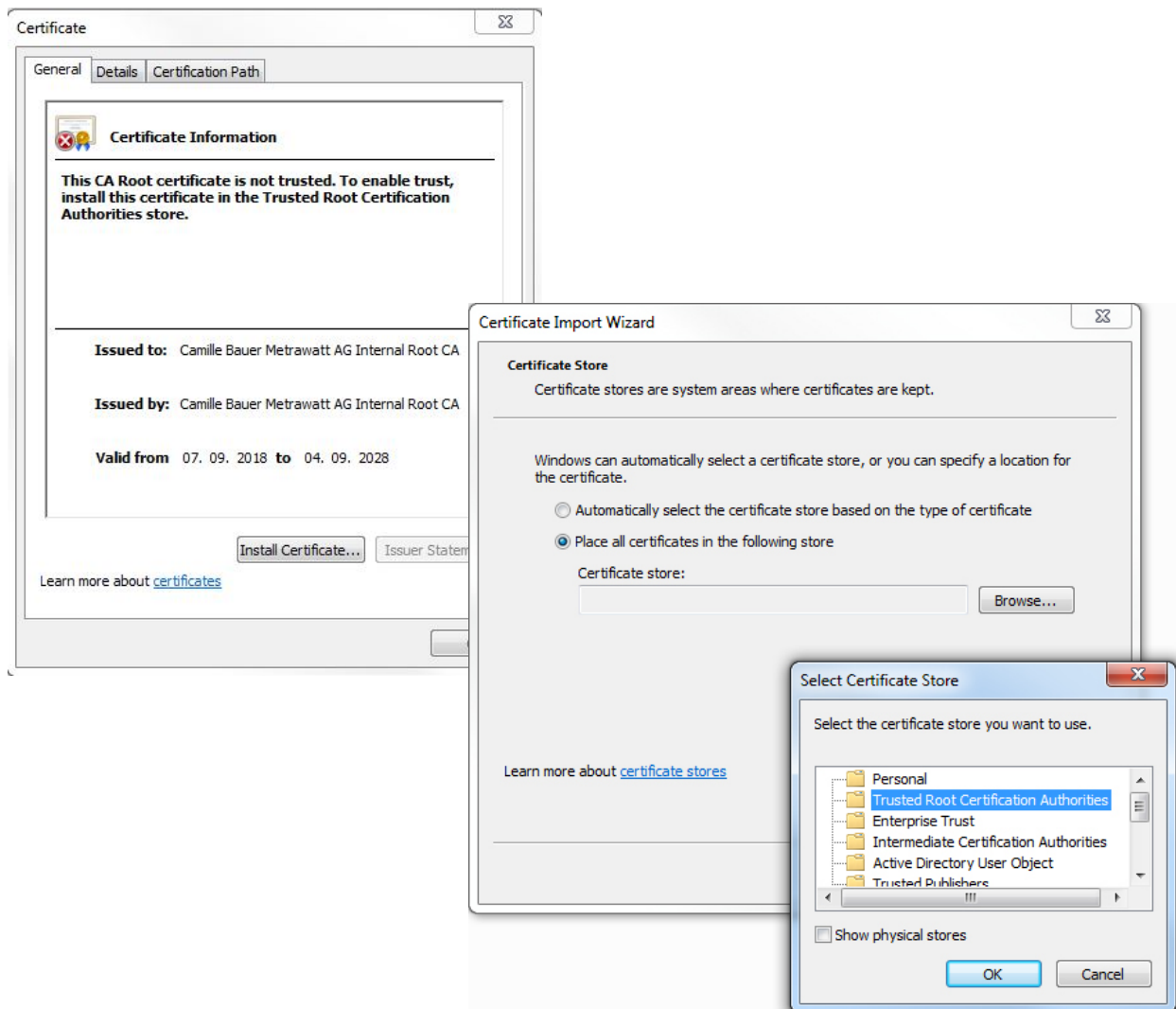
Before HTTPS communication can be used a root certificate needs to be installed. The user can either use a Camille Bauer certificate or its own customer certificate. This may be selected when activating https communication via the *Settings* of the *Security system* in the item *Web Security*.



Camille Bauer certificate

The certificate is provided via our webpage: <https://camillebauer.com/pg5000mob-en>

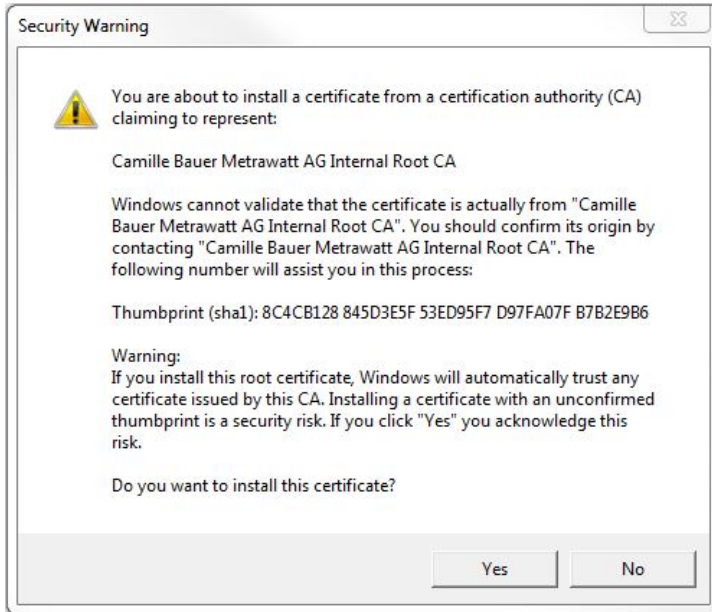
Once the certificate is downloaded to the local computer the certificate can be installed manually. Just double-click on the file.



Install certificate, then select **Place all certificates in the following store**, **Browse** and select **Trusted Root Certification Authorities**. **Finish** the Import Wizard.

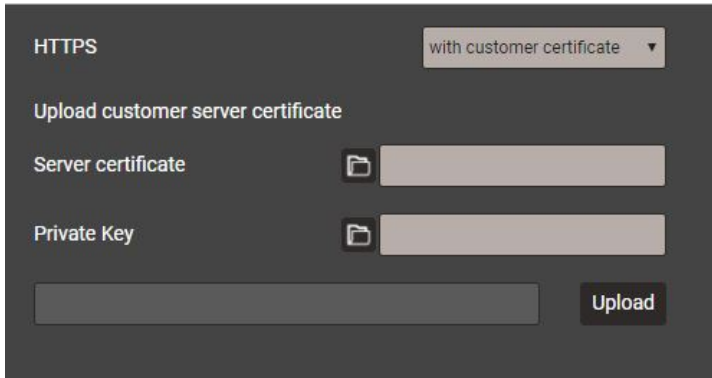
The imported certificate is valid for all devices of the PQ, AM, DM and CU series.

Agree to install the certificate when the below security warning appears:

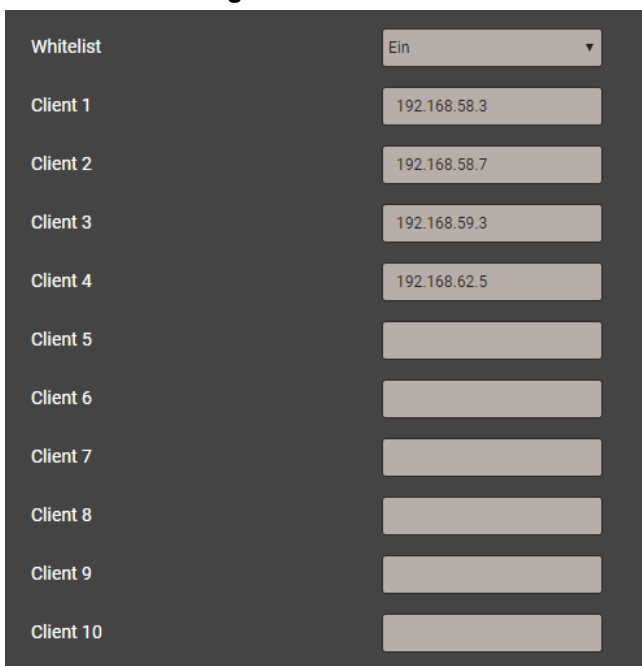


Customer certificate


Upload your certificate and private key via the *Settings* of the *Security system* in the item *Web Security*.



4.3.3 Whitelisting clients



It is possible to define an IP address list of up to 10 clients allowed to have access to the device. All other clients will be blocked. Enable the whitelist via the *Settings* of the *Security system* in the item *Whitelist*.

 *If a DHCP server is used in the system, clients may get different IP addresses on each startup, losing this way access to the device.*

If a device is no longer accessible you can reset its IP address (LAN), deactivating the whitelist at the same time. The whitelist may be switched off via WLAN interface as well.

4.4 PQ monitoring

Power quality monitoring provides both a statistical evaluation, allowing an assessment of compliance with standards (e.g. EN 50160) or supply contracts, as well as records of events in the grid (e.g. power voltage dips). This facilitates the analysis of causes and effects. Conformity reports may also be created directly via the website of the device.

4.4.1 PQ events

The device monitors the voltage events listed in the subsequent table. The default values of the trigger thresholds and hysteresis are set to the common values of the EN50160 for a public low-voltage distribution system. These values can be changed by the user to his individual needs. Recorded PQ events can be visualized either via the local display or the webpage of the device.

Monitored voltage events

Default values	Threshold	Hysteresis	Reference value
Voltage dip	90%	2%	Nominal voltage
Voltage interruption	10%	2%	
Voltage swell	110%	2%	
Rapid voltage changes	6%	50% ¹⁾	

¹⁾ Related to the respective threshold



The device does not verify the user-defined values. If these values are not plausible, events may be not recognized correctly or misclassified. In particular, the trigger threshold for RVC events should not be greater than half of the difference of the threshold values of voltage swell and voltage dip.

Mains signalling voltage

The device monitors mains signalling voltages, which are transmitted in the supply system for control purposes, and records them as [events](#) (8.1.3). Typically these are ripple control signals. The user can define the frequency of the signalling voltage, the threshold and hysteresis (related to the nominal voltage) as well as the recording duration in multiples of the measurement interval of 10/12 cycles. The recording duration must not exceed 120s. The ripple control frequency is typically below 3 kHz and can be requested from the local energy provider.

Reference channel		U1
Ripple control frequency	Hz	167
Trigger threshold	%	0.5
Trigger hysteresis	%	0.25
Rec. duration (10/12 cycles)	#	50

4.4.2 PQ statistic



Power quality (PQ) is assessed by a comparison between the PQ parameters measured by the device and the limits of a contract agreed upon. The assessment period is usually at least one week to take into account possible variations between weekdays and weekends.

Via its website the device can perform an assessment of the measured PQ parameters in accordance with the following standards:

- EN 50160 (2010), low voltage, interconnected systems
- EN 50160 (2010), low voltage, island systems
- EN 50160 (2010), medium voltage, interconnected systems
- EN 50160 (2010), medium voltage, island systems
- EN 50160 (2010), high voltage, interconnected systems
- EN 50160 (2010), high voltage, island systems
- IEC 61000-2-2 (2002), public low voltage systems
- IEC 61000-2-4 (2002), industrial and non-public systems up to 35 kV, class 1
- IEC 61000-2-4 (2002), industrial and non-public systems up to 35 kV, class 2
- IEC 61000-2-4 (2002), industrial and non-public systems up to 35 kV, class 3
- IEC 61000-2-12 (2003), public medium voltage systems
- User specific limit sets

The assessment of the PQ statistic is shown in the chapter [Data recording | PQ statistic](#) (8.1.4), including the creation of conformity reports.

Recorded PQ parameter groups

Measurement	Averaging time	Applied limits
Power frequency	10 s	<p><i>The applied limits and time conditions of the preset standards can be seen via the device website.</i></p> <p><i>They can be displayed via the following menu:</i></p> <pre> Settings Power Quality Custom threshold limits (Standard) </pre> <p> <i>Within the same menu user data sets with specific limits and evaluation criteria can be defined</i></p> <p> <i>User specific data sets can also be deleted again.</i></p>
Voltage magnitude	10 min.	
Flicker P _{st}	10 min.	
Flicker P _{lt}	2 h	
Mains signalling voltage	3 s	
Supply voltage unbalance	10 min.	
THDS of voltages	10 min.	
Voltage harmonics	10 min.	
Voltage interharmonics	10 min.	
Current magnitude	10 min.	
Current unbalance	10 min.	
Current harmonics	10 min.	
Current interharmonics	10 min.	

4.4.3 Provision of PQ data

All recorded PQ data can be queried and visualized directly via the web interface of the device.

In addition, the device stores PQ related data, such as PQ events or PQ statistic, using the standard format PQDIF according IEEE 1159.3. The corresponding files will be created periodically after midnight for the past day and provided in a hierarchical time structure (year, month, day) for [download](#) (8.2).

4.5 Alarming

The device supports an alarming concept independent of power quality events. Depending on the user requirements, simple or more advanced monitoring tasks may be realized. The most important objects are limit values on base quantities, monitoring functions and the summary alarm.

4.5.1 Limit values on base quantities

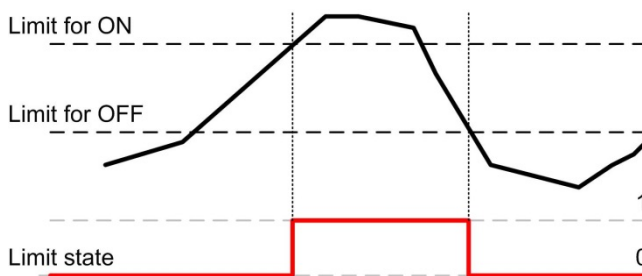
Monitored quantity	Active power system
Limit for ON	2500
Limit for OFF	2480
Event text	Power maximum
List entry	Alarms

Using limit values either the exceeding of a given value (upper limit) or the fall below a given value (lower limit) is monitored.

Limits values are defined by means of two parameters: Limit for ON / OFF. The hysteresis corresponds to the difference between these two values.

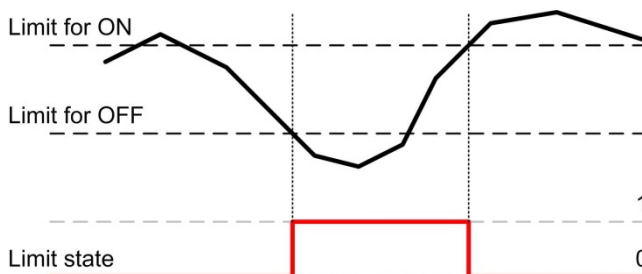
Both state transitions OFF→ON and ON→OFF can be recorded as event or alarm in the appropriate lists.

Upper limit: $\text{Limit for ON} \geq \text{Limit for OFF}$




- ▶ The limit value becomes active (1) as soon as the limit for ON state is exceeded. It remains active until the associated measured quantity falls below the limit for OFF state again.
- ▶ The limit value is inactive (0) if either the limit for ON is not yet reached or if, following the activation of the limit value, the associated measured quantity falls below the limit for OFF state again.

Lower limit: $\text{Limit for ON} < \text{Limit for OFF}$



- ▶ The limit value becomes active (1) as soon as the associated measured quantity falls below the limit for ON state. It remains active until the associated measured quantity exceeds the limit for OFF state again.
- ▶ The limit value is inactive (0) if either the associated measured quantity is higher than the limit for ON state or if, following the activation of the limit value, it exceeds the limit for OFF state again.

 If the limit for ON state and the limit for OFF state are configured to the same value, the limit value will be treated as an upper limit value without hysteresis.

Limit value states can:

- ... be used as logic input for a [monitoring function](#) (4.5.2)
- ... be recorded as event or alarm in the appropriate lists on each changing

4.5.2 Monitoring functions

By means of monitoring functions the user can define an extended condition monitoring, e.g. for triggering an over-current alarm, if one of the phase currents exceeds a certain limit value.

The states of all monitoring functions

...will be shown in the alarm or event list (via menu "Events")

...build a summary alarm state

The image shows a configuration interface for a monitoring function. At the top, there is a logic diagram with three input boxes labeled 'Limit state 1', 'Limit state 2', and 'Limit state 3'. These inputs are connected to a central logic block containing the symbol '≥ 1'. The output of this block is labeled 't1, t2'. Below the diagram, there are several configuration fields: 'Delay time on (t1)' with a value of 1.0, 'Delay time off (t2)' with a value of 1.0, 'Event text' set to 'Overcurrent', and 'List entry' set to 'Alarms'.

Logic inputs

Up to three states of limit values or other monitoring functions. Unused inputs will automatically be initialized in a way that they do not influence the output.

Logic function

For the logical combination of the inputs the function AND, NAND, OR, NOR, DIRECT and INVERT are available.

Delay time on

The time a condition must be present until it is forwarded

Delay time off

Time to be waited until a condition, which is no longer present, will be released again

Description

This text will be used for visualization in the alarm list

List entry

- *Alarm / event*: Each state transition will be recorded in the appropriate list
- *none*: No recording of state transitions

Possible follow-up actions

- Visualization of the present state in the alarm list
- Combining the states of all monitoring functions to create a [summary alarm](#) (4.5.3)
- Recording of state transitions as alarm or event in the appropriate lists

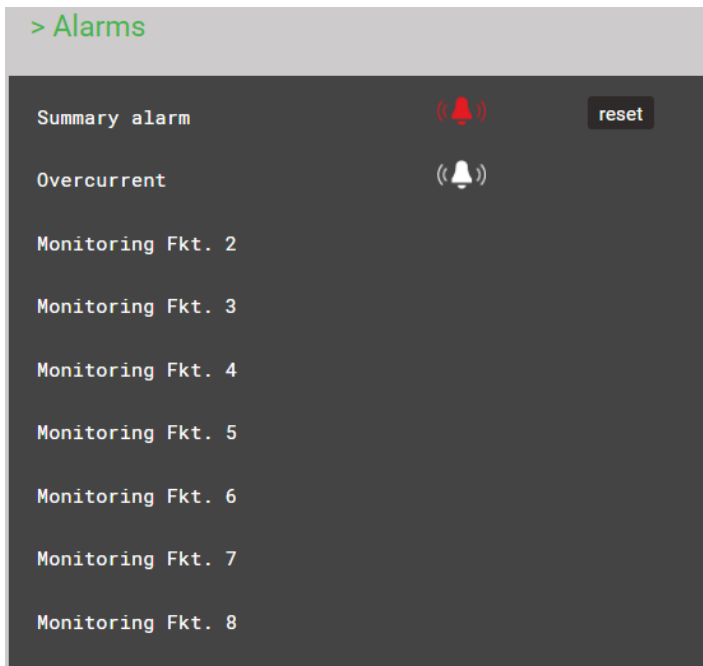
4.5.3 Summary alarm

The summary alarm combines the states of all [monitoring functions](#) (4.5.2) to a superior alarm-state of the overall unit. An alarm is signaled with a flashing bell:



Acknowledgment: By acknowledging the summary alarm, the user confirms that he has recognized that an alarm state occurred. The acknowledgment is done automatically as soon as the user displays the alarm overview. This can be done via the menu (Events | Alarms) or by clicking on the flashing bell symbol in the status bar. By acknowledging only the flashing of the alarm symbol stops, the symbol itself remains statically displayed until none of the monitoring functions is in the alarm state.

The **alarm overview** shows, which monitoring functions caused the summary alarm:



5. Safety instructions



Death, serious injury or fire hazard could result from improper connection of this instrument. Before connecting the instrument you have to read and understand this manual.

General



Connection of this instrument must be performed in compliance with all applicable national regulations on electricity and any additional safety requirements applicable to your installation.



Observe all valid and applicable safety regulations for work on electrical equipment.



Installation, operation, and maintenance of this instrument must be performed by qualified personnel only. The national regulations for electricity define a qualified person as “one who has the skills and knowledge related to the construction and operation of the electrical equipment and installations, and who has received safety training on the hazards involved.”



Qualified personnel who work on or near exposed energized electrical conductors must follow applicable safety related work practices and procedures including appropriate personal protective equipment in compliance with national standards for electrical safety requirements for employee workplaces and any additional workplace safety requirements applicable to your installation.



It is forbidden to open the device as live parts can be exposed. Any intervention in the device voids the warranty. Maintenance and repair work may only be carried out by our service center.

Before connecting



The instrument must be taken out of service if safe operation is no longer possible (e.g. visible damage). The instrument must be returned to the factory.



Check all test leads and current sensors for insulation defects before use. Replace defective current sensors immediately, voltage test leads can be replaced in the factory only.



Connection and operation of the device must only be carried out by trained personnel, who can recognize the danger of contact and can take the necessary safety precautions. Danger exists everywhere where voltages with a potential of greater than 30V against earth can occur.



Before connecting, make sure the device is switched off. Hint: The instrument is not equipped with an integrated circuit breaker; it is switched on as soon as the power adapter is connected to a live power outlet.



Before connecting, check that the maximum values of all connections of the measurement device are not exceeded.



Current sensors must be connected to the corresponding connectors of the instrument before connecting to the measuring points.



Use in humid ambient conditions is not permitted. The device must not be exposed to moisture.



Before use, check that the device is completely dry, outside and inside. A humid device must not be connected or supplied with auxiliary power.



When determining the place of installation, make sure that the [limits of the operating temperature](#) are not exceeded.

When connecting



If measurements are made which involve a risk of contact, a second person should be present on-site. This is typically the case during the connection of the current and voltage measurement inputs.



De-energize the electrical circuit to be monitored before connecting the test leads and current sensors. You always have to be aware that unforeseen voltages may be present on the test location, for example due to dangerously charged capacitors. Therefore check the absence of voltage and use the necessary protective equipment.



If it is not possible to switch off the system, the general safety instructions given above must be observed. In particular, the wearing of personal protective equipment is mandatory.



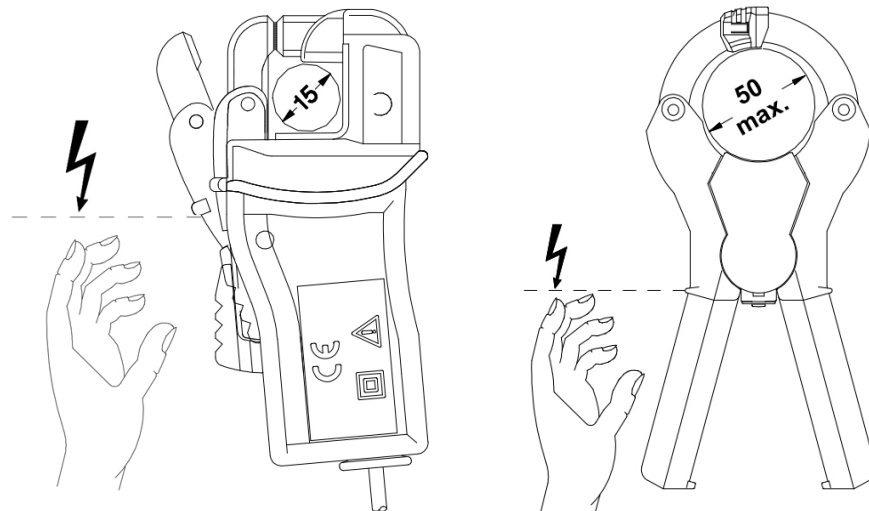
Do not touch exposed metal parts of unused voltage test leads.



When using Rogowski coils ACF 2004_1 refer to the operating instructions in [Annex C](#).



When connecting current clamps to live unisolated wires, the clamps may only be touched in the area given below.



When connecting the test leads and current sensors, pay attention to correct phase sequence and energy direction.

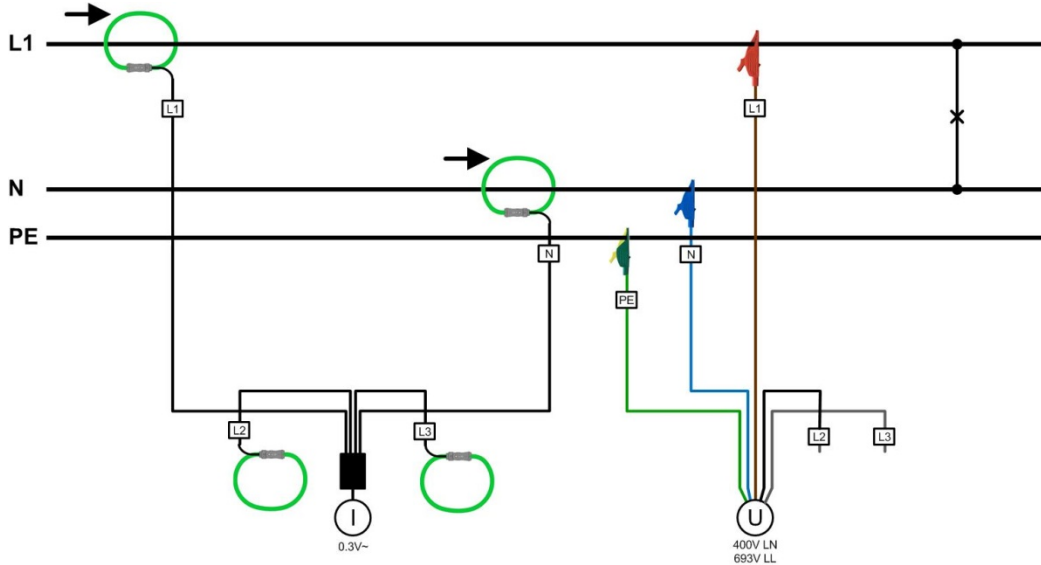


The positive current or energy direction is indicated on the current sensors with an arrow (marked in red for better visibility). This can be found either on the housing or on the nameplate.

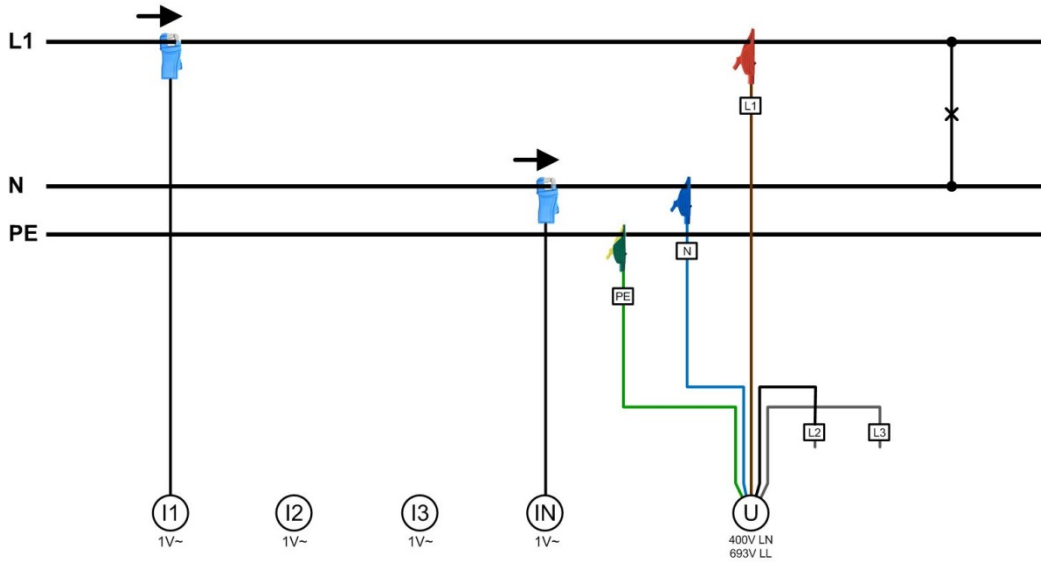


Single-phase AC mains

Current measurement via 4-phase Rogowski probe 2000 A

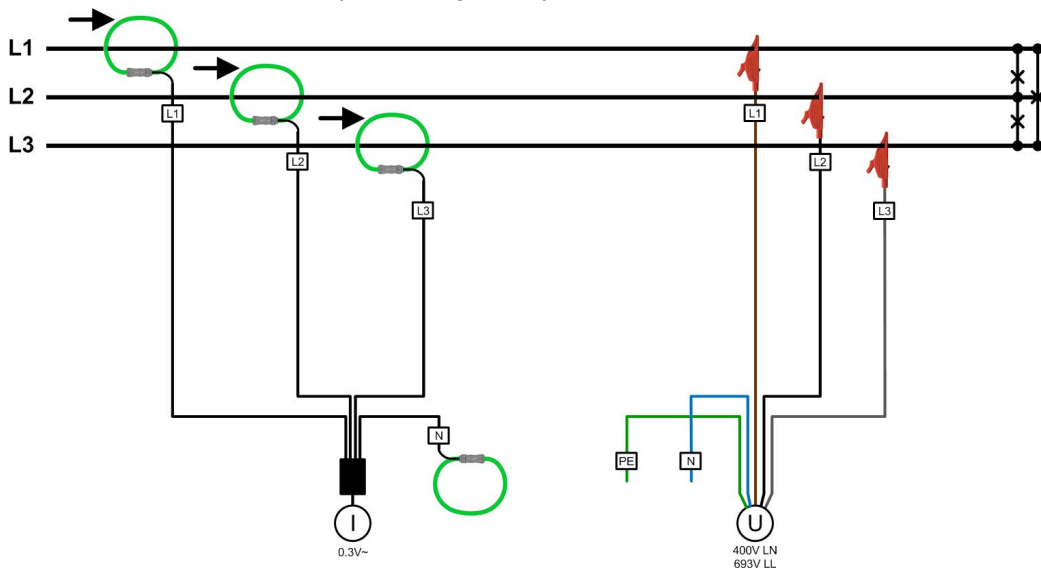


Current measurement via clamps xA/1V

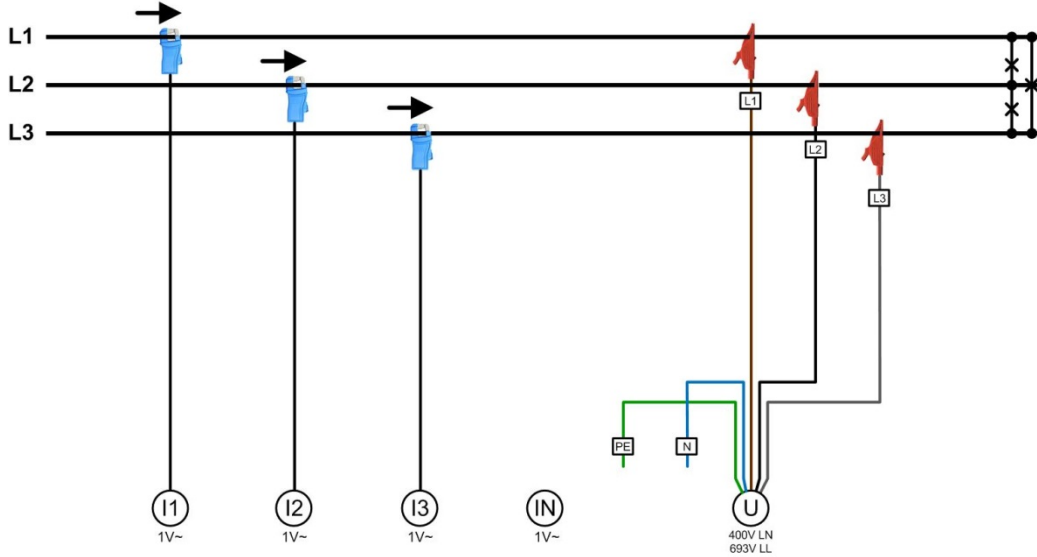


Three wire system, unbalanced load

Current measurement via 4-phase Rogowski probe 2000 A

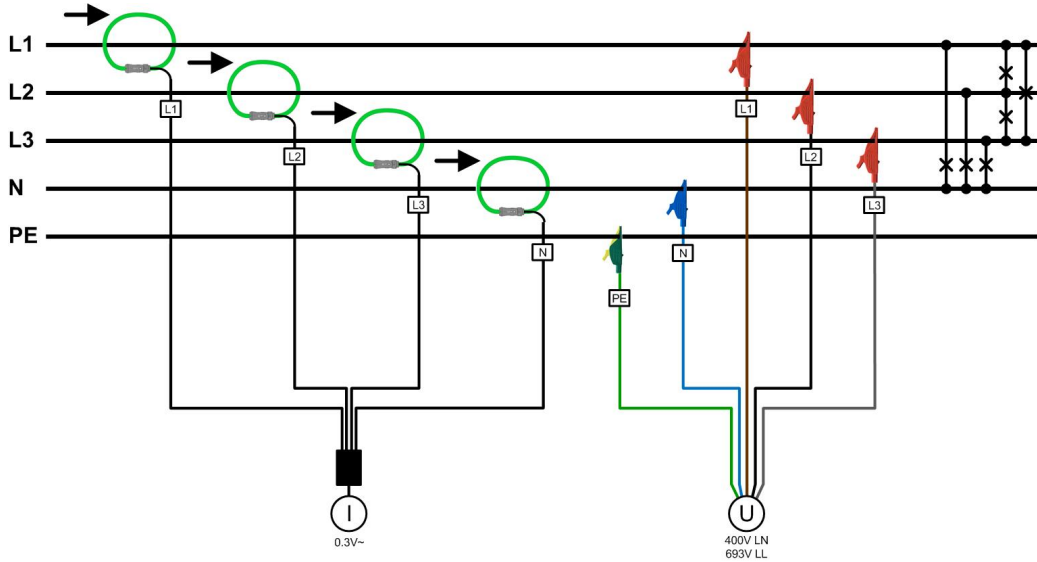


Current measurement via clamps xA/1V

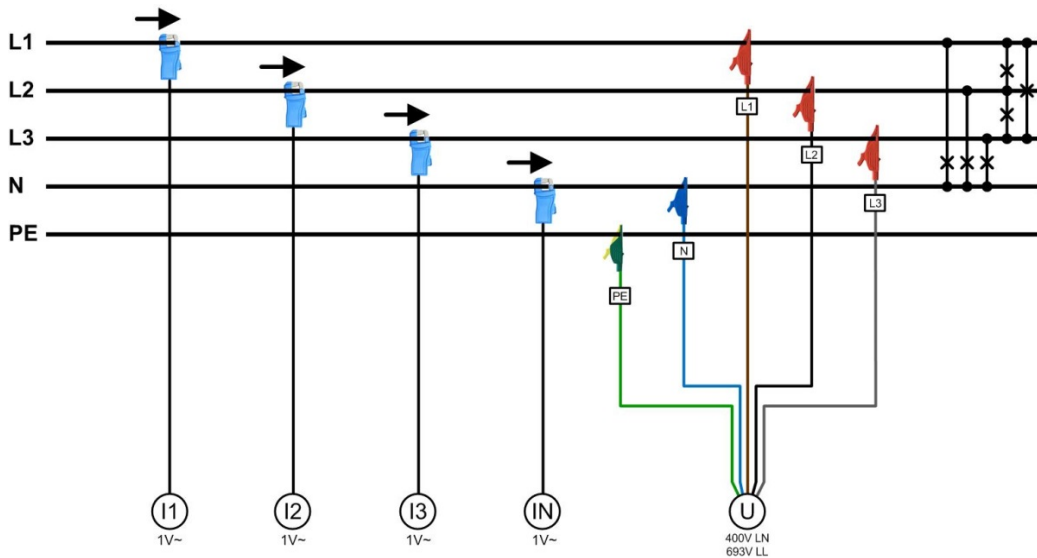


Four wire system, unbalanced load

Current measurement via 4-phase Rogowski probe 2000 A

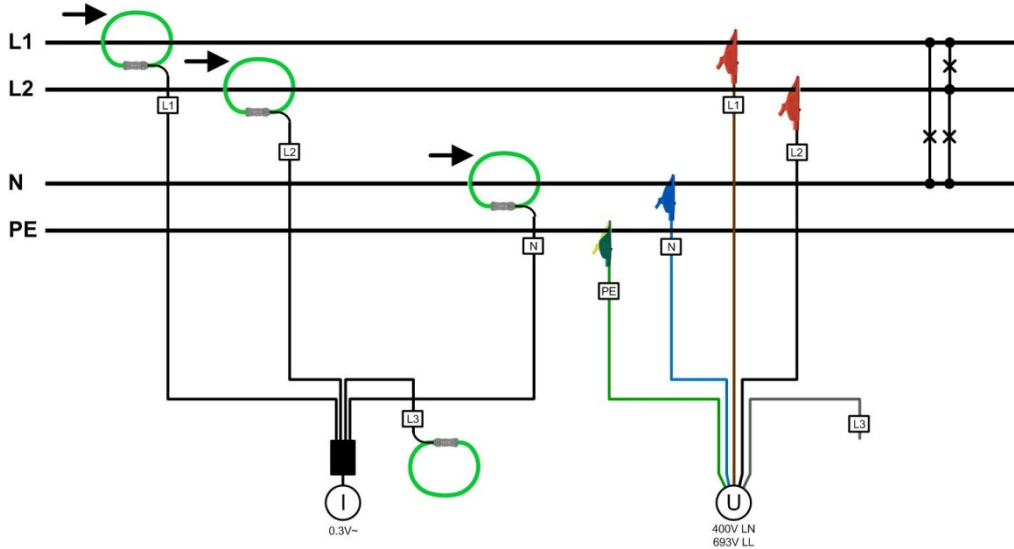


Current measurement via clamps xA/1V

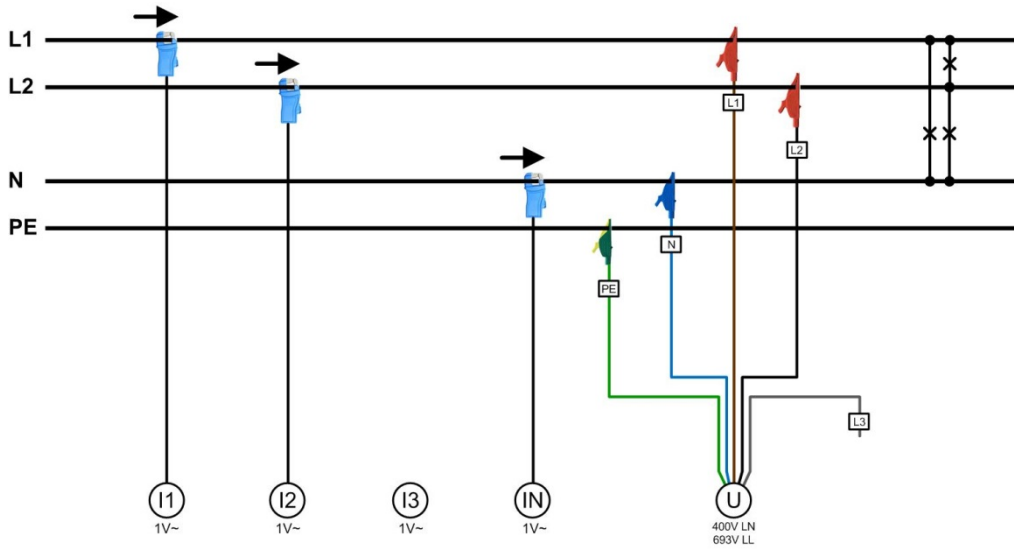


Split-phase ("two phase system"), unbalanced load

Current measurement via 4-phase Rogowski probe 2000 A

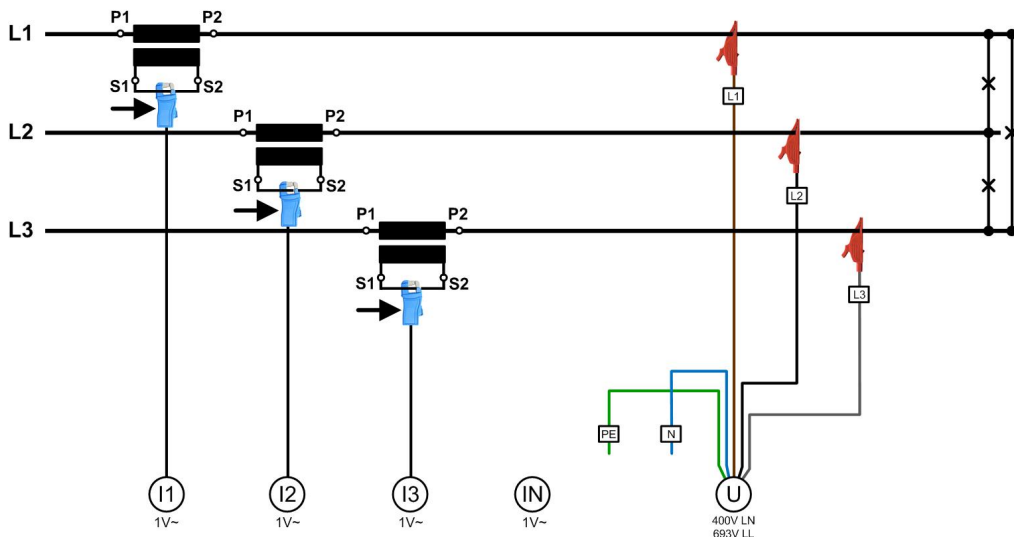


Current measurement via clamps xA/1V



Measurement in the secondary circuit of current transformers

Using current clamps 10A/1V a direct measurement in the secondary circuit of current transformers is possible. In order that measured values are scaled correctly, the current transformer ratio (CT: primary / CT: secondary) in the [configuration of the measurement](#) (4.2.2) must be set accordingly.



6.2 GPS time synchronization

The optional GPS connection module serves for connecting a GPS receiver as a very accurate time synchronization source for the measurement device. The GPS receiver, available as an accessory, is used as outdoor antenna to process data from multiple GPS satellites simultaneously.

GPS receiver

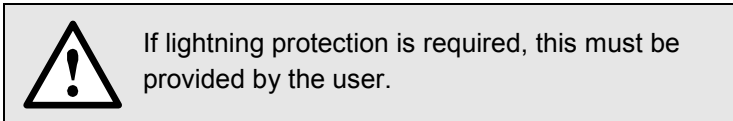
Only use the receiver **Garmin GPS 16x-LVS** (article no. 181'131), offered as an accessory. This device is preconfigured by us and provides the required time information (sentences) without further configuration effort.

- Protection: IPx7 (waterproof)
- Operating temperature: -30...80°C
- Storage temperature: -40...80°C
- 1Hz pulse accuracy: 1µs
- Connector: RJ45



Choosing a mounting location

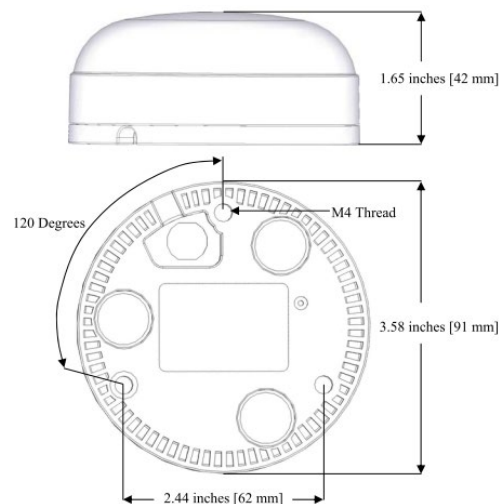
For a correct operation the GPS receiver requires data from at least 3 satellites at the same time. Therefore position the receiver so that the clearest possible view of the sky and horizon in all direction is obtained. This can be on the roof of a building, at best without reception being restricted by other buildings or obstacles. Avoid mounting the receiver next to large areas of conductible material, as this may cause poor signal reception. It should be also not closer than 1 meter away from any other antenna.



If lightning protection is required, this must be provided by the user.

Mounting the GPS receiver

- The GPS receiver **Garmin GPS 16x-LVS** can be flush mounted by means of 3 M4 screws.
- 120° distribution over a circle of $\varnothing 71.6\text{mm}$
- Thread length max. 8mm. Using longer screws may damage the GPS receiver.



Connecting the GPS receiver



Never connect the RJ45 socket of the connecting cable directly to a network device such as a router or switch. These devices could be damaged.

The GPS receiver is plugged directly into the GPS connection module. The connection cable has a length of 5m. It may be extended to up to 50m using an RJ45 coupling and an Ethernet cable. The connection cable should not be laid in parallel to live conductors. Twisting or sharp kinking of the cable should be avoided.

Commissioning

- In the settings menu change time synchronization to „NTP server / GPS“
- Check the time synchronization status

> Service > Device information > Device state

Min/max values reset	Device version
Meter contents set/reset	Device license
Operating hours	Device state
Device information	
Factory reset	
Firmware update	
Communication Tests	
Device reboot	

```
interfaces -----
1) eth0
MAC:          00:12:34:1A:00:05
State:        Up
Link:         Yes
Speed:        100Mb/s
IP address:   192.168.62.142   [static]
Broadcast addr.: 192.168.63.255 [static]
Subnet mask:  255.255.248.0   [static]
Gateway addr.: 192.168.56.4   [static]

Name servers -----
DNS server 1: 192.168.56.55   [static]

Time sources -----
Source 1:     pool.ntp.org
Source 2:     Local clock
Source 3:     GPS

Time Synchronisation -----
synchronised to GPS at stratum 1
time correct to within 1 ms
polling server every 16 s

GPS Status -----
Number of satellites: 04
GPS quality: Differential fix
```

- The time synchronization can be restarted by switching the time synchronization off and on again.
- Time synchronization via GPS and NTP server may work in parallel. If both synchronization sources are available, the system uses the more accurate time source, which is normally GPS.



When connecting a GPS receiver for the first time or when it has been out of operation for a long time, it may take up to 1 hour for finding enough satellites for GPS receiver operation and thus for a reliable time synchronization.

6.3 Power supply



The instrument is not equipped with an integrated circuit breaker; it is switched on as soon as the power adapter is connected to a live power outlet.



The power adapter must be connected to the device before it is plugged into the power outlet.

7. Commissioning

7.1 Device start



POWER

When the device is powered via the power adapter, the POWER-LED starts flashing. As soon as the POWER LED is permanently ON the startup procedure is finished.

Hint

It is recommended to start the data logging only if ...

- the correct connection of the device has been checked
- the configuration for the present measurement location is complete and correct
- this configuration has been stored and activated in the device
- Measurement data such as min/max values of a previous recording has been reset

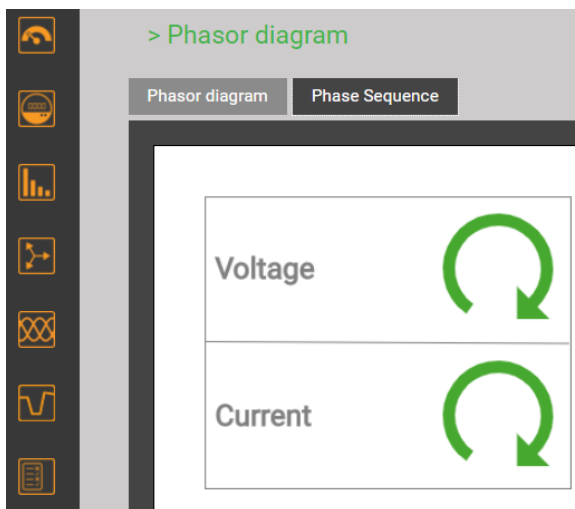
Otherwise the device could contain meaningless recordings that complicate the subsequent evaluation and conformity assessment.

7.2 Installation check




The correct connection of the current and voltage inputs can be checked in two ways.

- Sense of rotation check:** Using the sequence of the current and voltage phasors the sense of rotation is determined and compared to the configured one. The phase rotation indicator is arranged in the menu "Phasor diagram".


Test requirement: Magnitude of all connected voltages at least 5% of nominal, magnitude of all connected currents at least 0.2% of nominal.

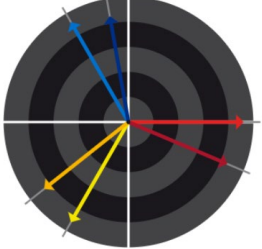

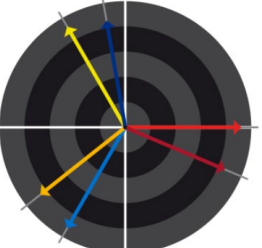
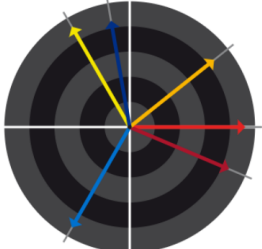



Possible results

-  Correct sense of rotation
-  Wrong sense of rotation
-  Missing phase or magnitude too small

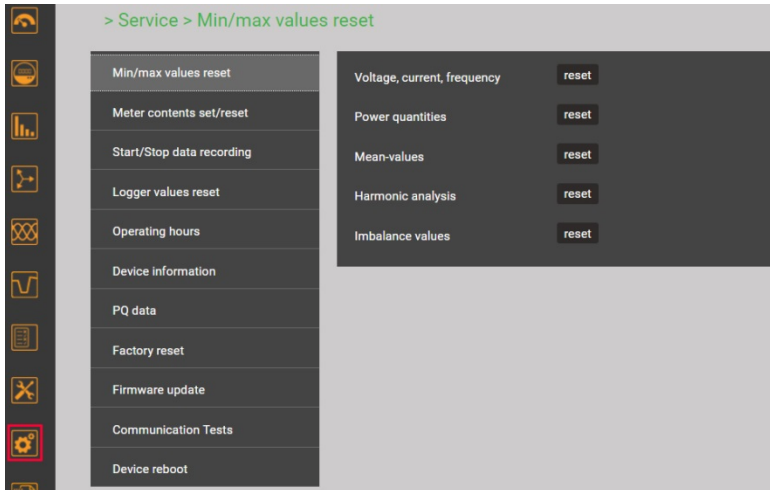
b) **Phasor verification:** The phasor diagram shows a technical visualization of the current and voltage phasors, using a counter-clockwise rotation, independent of the real sense of rotation.

 **The diagram is always built basing on the voltage of the reference channel (direction 3 o'clock)**

 <p>50V/div 20A/div</p>	<table border="1"> <thead> <tr> <th>L1</th> <th>L2</th> <th>L3</th> <th></th> </tr> </thead> <tbody> <tr> <td>230.60</td> <td>230.64</td> <td>230.54</td> <td>V</td> </tr> <tr> <td>0.00</td> <td>-119.97</td> <td>120.03</td> <td>*</td> </tr> <tr> <td>85.97</td> <td>86.03</td> <td>85.86</td> <td>A</td> </tr> <tr> <td>-22.9</td> <td>-21.7</td> <td>-20.0</td> <td>*</td> </tr> <tr> <td>0.921</td> <td>0.929</td> <td>0.940</td> <td>PF</td> </tr> </tbody> </table>	L1	L2	L3		230.60	230.64	230.54	V	0.00	-119.97	120.03	*	85.97	86.03	85.86	A	-22.9	-21.7	-20.0	*	0.921	0.929	0.940	PF	<p>Correct installation (expectation)</p> <ul style="list-style-type: none"> • Voltage sequence in clock-wise order L1 → L2 → L3 ($0^\circ \rightarrow -120^\circ \rightarrow 120^\circ$) • Current sequence in clock-wise order L1 → L2 → L3 • Similar angle between voltage and current phasors in all phases (approx. -20°)
L1	L2	L3																								
230.60	230.64	230.54	V																							
0.00	-119.97	120.03	*																							
85.97	86.03	85.86	A																							
-22.9	-21.7	-20.0	*																							
0.921	0.929	0.940	PF																							
 <p>50V/div 20A/div</p>	<table border="1"> <thead> <tr> <th>L1</th> <th>L2</th> <th>L3</th> <th></th> </tr> </thead> <tbody> <tr> <td>230.58</td> <td>230.63</td> <td>230.53</td> <td>V</td> </tr> <tr> <td>0.00</td> <td>-119.97</td> <td>120.03</td> <td>*</td> </tr> <tr> <td>85.96</td> <td>86.04</td> <td>85.87</td> <td>A</td> </tr> <tr> <td>-22.9</td> <td>158.4</td> <td>-20.0</td> <td>*</td> </tr> <tr> <td>0.921</td> <td>-0.930</td> <td>0.940</td> <td>PF</td> </tr> </tbody> </table>	L1	L2	L3		230.58	230.63	230.53	V	0.00	-119.97	120.03	*	85.96	86.04	85.87	A	-22.9	158.4	-20.0	*	0.921	-0.930	0.940	PF	<p>What's wrong?</p> <ul style="list-style-type: none"> • Voltage sequence: L1 → L2 → L3 • Current sequence: L1 → L3 → L2; Current L2 is out of the expected sequence • Angle U-I: Angle between U_{L2} and I_{L2} is approx. 180° wrong <p>Required correction Reversing the polarity of current I_2</p>
L1	L2	L3																								
230.58	230.63	230.53	V																							
0.00	-119.97	120.03	*																							
85.96	86.04	85.87	A																							
-22.9	158.4	-20.0	*																							
0.921	-0.930	0.940	PF																							
 <p>50V/div 20A/div</p>	<table border="1"> <thead> <tr> <th>L1</th> <th>L2</th> <th>L3</th> <th></th> </tr> </thead> <tbody> <tr> <td>230.59</td> <td>230.49</td> <td>230.70</td> <td>V</td> </tr> <tr> <td>0.00</td> <td>120.04</td> <td>-119.99</td> <td>*</td> </tr> <tr> <td>85.97</td> <td>86.02</td> <td>85.86</td> <td>A</td> </tr> <tr> <td>-22.9</td> <td>98.3</td> <td>-140.0</td> <td>*</td> </tr> <tr> <td>0.921</td> <td>-0.145</td> <td>-0.766</td> <td>PF</td> </tr> </tbody> </table>	L1	L2	L3		230.59	230.49	230.70	V	0.00	120.04	-119.99	*	85.97	86.02	85.86	A	-22.9	98.3	-140.0	*	0.921	-0.145	-0.766	PF	<p>What's wrong?</p> <ul style="list-style-type: none"> • Voltage sequence: L1 → L3 → L2; L3 and L2 seem to be interchanged • Current sequence: L1 → L2 → L3 • Angle U-I: Angles between U_{L2} / I_{L2} and U_{L3} / I_{L3} do not correspond to the expectations <p>Required correction Exchanging the connections of the voltages L2 and L3</p>
L1	L2	L3																								
230.59	230.49	230.70	V																							
0.00	120.04	-119.99	*																							
85.97	86.02	85.86	A																							
-22.9	98.3	-140.0	*																							
0.921	-0.145	-0.766	PF																							
 <p>50V/div 20A/div</p>	<table border="1"> <thead> <tr> <th>L1</th> <th>L2</th> <th>L3</th> <th></th> </tr> </thead> <tbody> <tr> <td>230.58</td> <td>230.49</td> <td>230.68</td> <td>V</td> </tr> <tr> <td>0.00</td> <td>120.04</td> <td>-119.99</td> <td>*</td> </tr> <tr> <td>85.97</td> <td>86.04</td> <td>85.86</td> <td>A</td> </tr> <tr> <td>-22.9</td> <td>-81.6</td> <td>-140.0</td> <td>*</td> </tr> <tr> <td>0.921</td> <td>0.145</td> <td>-0.766</td> <td>PF</td> </tr> </tbody> </table>	L1	L2	L3		230.58	230.49	230.68	V	0.00	120.04	-119.99	*	85.97	86.04	85.86	A	-22.9	-81.6	-140.0	*	0.921	0.145	-0.766	PF	<p>What's wrong?</p> <ul style="list-style-type: none"> • Voltage sequence: L1 → L3 → L2; L3 and L2 seems to be exchanged • Current sequence: L1 → L3 → L2; Current L2 is out of the expected sequence • Angle U-I: Angles between U_{L2} / I_{L2} and U_{L3} / I_{L3} do not correspond to the expectations <p>Required correction Exchanging the connections of the voltages L2 and L3 and reversing the polarity of the current input I_2</p>
L1	L2	L3																								
230.58	230.49	230.68	V																							
0.00	120.04	-119.99	*																							
85.97	86.04	85.86	A																							
-22.9	-81.6	-140.0	*																							
0.921	0.145	-0.766	PF																							
 <p>50V/div 20A/div</p>	<table border="1"> <thead> <tr> <th>L1</th> <th>L2</th> <th>L3</th> <th></th> </tr> </thead> <tbody> <tr> <td>230.45</td> <td>230.48</td> <td>230.58</td> <td>V</td> </tr> <tr> <td>0.00</td> <td>-120.02</td> <td>119.98</td> <td>*</td> </tr> <tr> <td>85.96</td> <td>86.00</td> <td>85.86</td> <td>A</td> </tr> <tr> <td>-143.0</td> <td>-141.6</td> <td>-140.0</td> <td>*</td> </tr> <tr> <td>-0.798</td> <td>-0.784</td> <td>-0.766</td> <td>PF</td> </tr> </tbody> </table>	L1	L2	L3		230.45	230.48	230.58	V	0.00	-120.02	119.98	*	85.96	86.00	85.86	A	-143.0	-141.6	-140.0	*	-0.798	-0.784	-0.766	PF	<p>What's wrong?</p> <ul style="list-style-type: none"> • Voltage sequence: L1 → L2 → L3 • Current sequence: L3 → L1 → L2 • Angle U-I: The U-I angles do not correspond to the expectation, but are similar <p>Required correction Cyclical exchange of the voltage connections: $L1 \rightarrow L3, L2 \rightarrow L1, L3 \rightarrow L2$. As an alternative the sequence of all currents may be changed as well (more effort required).</p>
L1	L2	L3																								
230.45	230.48	230.58	V																							
0.00	-120.02	119.98	*																							
85.96	86.00	85.86	A																							
-143.0	-141.6	-140.0	*																							
-0.798	-0.784	-0.766	PF																							


7.3 Measurement data reset

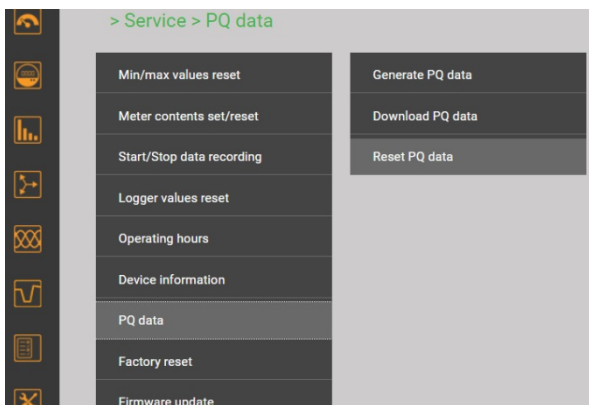
- **Minimum and maximum values** may be reset in groups via the service menu:



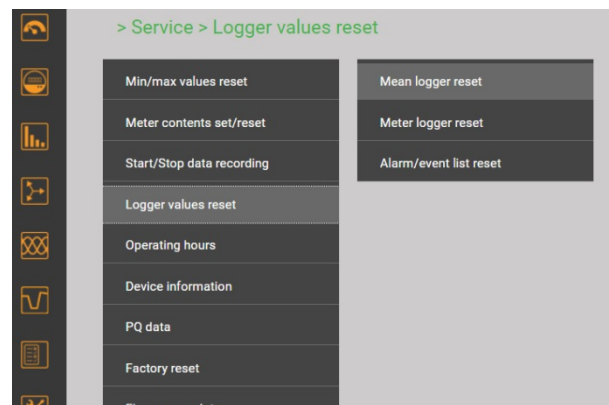
Group	Values to be reset
1	Min/max values of voltages, currents and frequency
2	Min/max values of Power quantities (P,Q,Q(H1),D,S); min. load factors
3	Min/max values of power mean-values, bimetal slave pointers and free selectable mean-values
4	Maximum values of harmonic analysis: THD U/I, TDD I, individual harmonics U/I
5	All imbalance maximum values of voltage and current

- **Meter contents** may be individually set or reset during operation using the service menu.
- **Recorded logger data** can be individually reset via the service menu.

 **When deleting logger data, always the complete content of the selected group is deleted, it is not differentiated according to configurations.**



PQ data recordings



Mean values / meter logger and lists

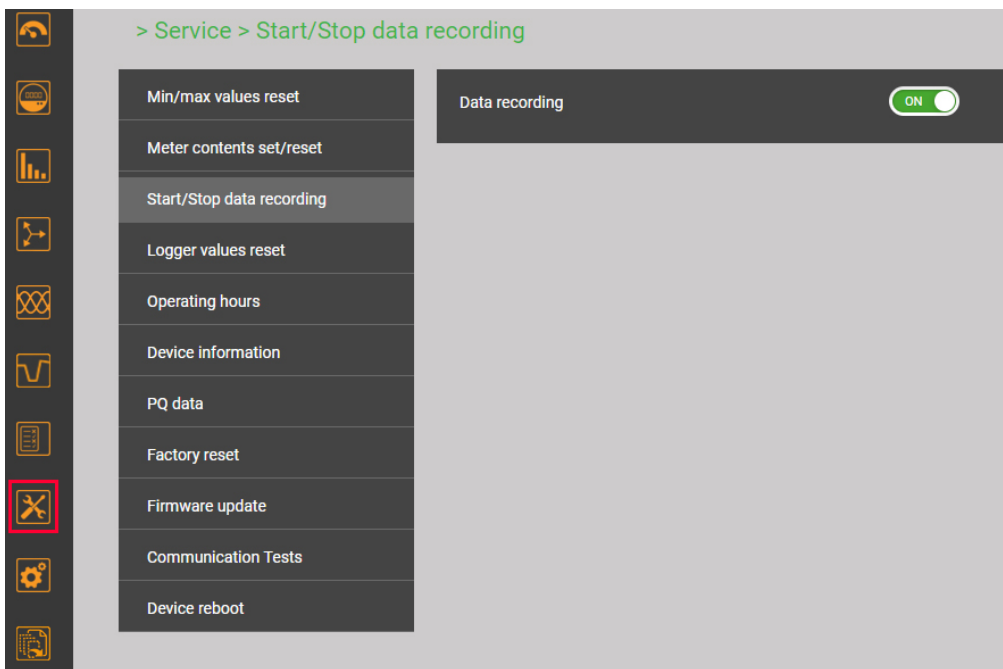
7.4 Start data recording

The data recording can be started directly at the device or via the website.



RECORD

Using the button RECORD recording can be started and stopped. If the associated LED is ON, recording is started.



Start / Stop of data recording via the service menu

The state of the data recording is displayed in the status bar

Data recording	Status bar
Started	
Stopped	

Tip: By selecting the status symbol you can go directly to the corresponding menu





8. Evaluation of recorded data



For the evaluation of recorded data you first have to activate the configuration used during data recording. Only data recorded with the active configuration will be shown.

ATTENTION: If the configuration used during data recording has been changed or is no longer available, an evaluation of the data may no longer be possible.

8.1 Available long-term recordings

Group	Data type	Request	
Periodic data	<ul style="list-style-type: none"> • Mean-values versus time • Periodic meter readings 	 Energy	<ul style="list-style-type: none"> • Mean value logger • Meter logger
Events	In Form of a logbook with time information: <ul style="list-style-type: none"> • Event list: Every state transition of monitoring functions or limit values, classified as event • Alarm list: Every state transition of monitoring functions or limit values, classified as alarm • Operator list: The occurrence of system events, such as configuration changes, power failures or reset operations and much more 	 Events	<ul style="list-style-type: none"> • Event and alarm list • Operator list
PQ events	The occurrence of voltage events will be registered in the PQ event list. By selecting the entries: <ul style="list-style-type: none"> • the course of the RMS values of all U/I • the curve shape of all U/I during the disturbance will be recorded	 Events	<ul style="list-style-type: none"> • PQ events and Mains Signalling
PQ statistic	For a selectable weekly interval the evaluation of the PQ statistic is displayed, depending on the selected standard. In addition, daily trend of the monitored PQ variables can be displayed. By means of PQ-Easy Report, conformity reports can also be created directly via website.		


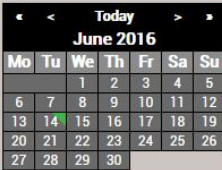
Data export as CSV file



With the exception of the PQ statistic data, all information shown above can be exported as CSV file (Comma Separated Value).

Download data ✕

Time domain

Start:  End: 

7.6.2016 14.6.2016

For courses of measurement (e.g. mean values) the time range of the data to export can be selected. For event lists the last 250 events can be stored.

The created CSV file can be imported as a text file to Excel, with comma as a separator.

8.1.1 Periodic data

Displaying the chronology of the mean values

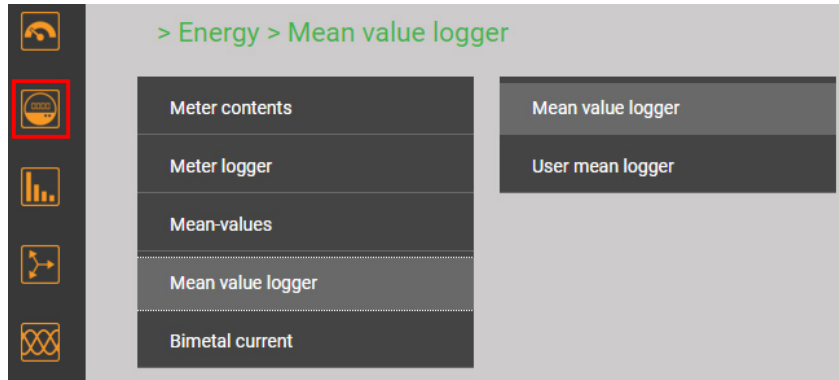
The chronology of the mean values is available via the menu **Energy** and is divided in two groups:

- Pre-defined power mean values
- User-defined mean values

Power mean values can easily be converted into energy values:

$$\text{Energy} = \text{Averaging_interval} * \text{Power_mean_value}$$

By summing these individual values, energy consumption can be calculated with high resolution. This can be done very easily via the exported CSV data in Excel.



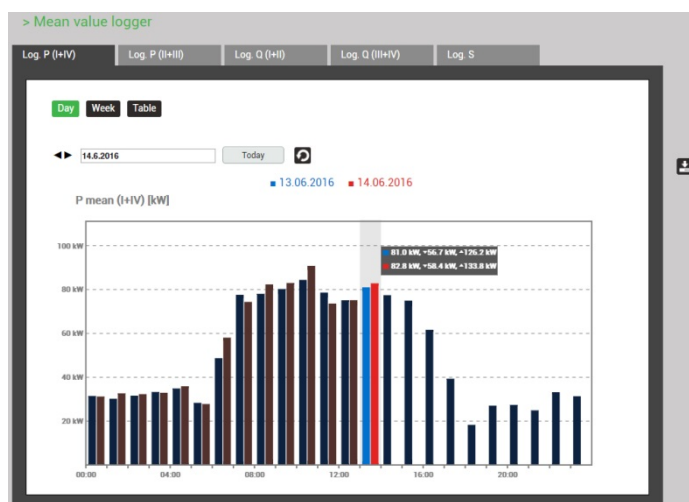
Selection of the mean value group



The selection of the mean-value quantity to display can be performed via choosing the corresponding register. Three different kind of displays are supported:

- Daily profile: Hourly mean-values will be shown, independently of the real averaging time
- Weekly profile
- Table: Listing of all acquired mean-values in the sequence of the real averaging interval

The graphical representation allows comparing directly the values of the previous day respectively week.



By selecting the bars you may read the associated values:

- Mean-value
- Min. RMS value within the interval
- Max. RMS value within the interval



Weekly display



Weekly display: Reading

#	time	mean	min(interval)	max(interval)
1	14.06.2016, 14.33:00.000	78.89 kW	65.75 kW	109.42 kW
2	14.06.2016, 14.32:00.000	93.65 kW	74.96 kW	125.97 kW
3	14.06.2016, 14.31:00.000	86.42 kW	74.48 kW	104.69 kW
4	14.06.2016, 14.30:00.000	80.17 kW	67.36 kW	106.59 kW
5	14.06.2016, 14.29:00.000	88.62 kW	75.01 kW	111.77 kW
6	14.06.2016, 14.28:00.000	80.96 kW	69.96 kW	116.12 kW
7	14.06.2016, 14.27:00.000	81.96 kW	68.81 kW	108.47 kW
8	14.06.2016, 14.26:00.000	80.98 kW	69.05 kW	102.54 kW
9	14.06.2016, 14.25:00.000	88.52 kW	68.12 kW	123.43 kW
10	14.06.2016, 14.24:00.000	87.96 kW	70.66 kW	104.96 kW

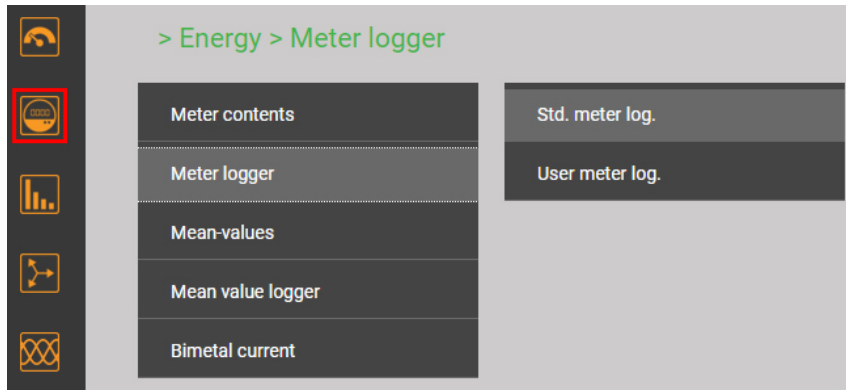
Mean values in table format

Displaying the chronology of meter contents

The chronology of meters is available via the menu **Energy** and is divided in two groups:

- Pre-defined meters
- User-defined meters

From the difference of two successive meter readings the energy consumption for the dedicated time range can be determined.



Selection of the meter logger group

> Std. meter log.

Log. $\Sigma P(I+IV)$ | Log. $\Sigma P(II+III)$ | Log. $\Sigma Q(I+II)$ | Log. $\Sigma Q(III+IV)$

«Previous 1 2 3 4 5 Next» Results per page 25

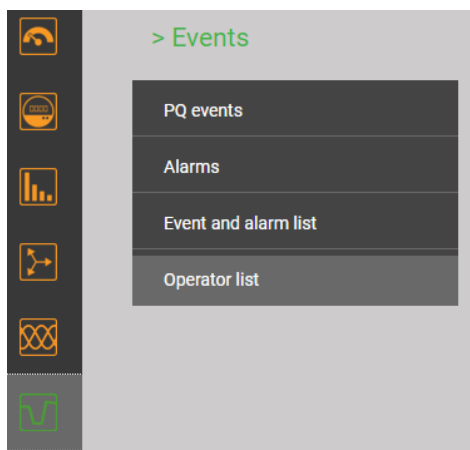
#	time	$\Sigma P(I+IV), \Sigma IT$		$\Sigma P(I+IV), \Sigma HT$	
1	15.06.2016, 14:00:00.000	0	kWh	33276.80	kWh
2	15.06.2016, 13:00:00.000	0	kWh	33203.10	kWh
3	15.06.2016, 12:00:00.000	0	kWh	33137.40	kWh
4	15.06.2016, 11:00:00.000	0	kWh	33069.10	kWh
5	15.06.2016, 10:00:00.000	0	kWh	32996	kWh
6	15.06.2016, 09:00:00.000	0	kWh	32919.70	kWh
7	15.06.2016, 08:00:00.000	0	kWh	32849.90	kWh
8	15.06.2016, 07:00:00.000	0	kWh	32784	kWh
9	15.06.2016, 06:00:00.000	0	kWh	32735.30	kWh
10	15.06.2016, 05:00:00.000	0	kWh	32719.10	kWh
11	15.06.2016, 04:00:00.000	0	kWh	32687.10	kWh

Meter content readings in table form

8.1.2 Events

Event lists are a kind of logbook. The occurrence of monitored events is recorded in the appropriate list with the time of its occurrence. There are the following lists:

- Alarm and event list (based on [user-defined monitorings](#), chap. 4.2)
- Operator list
- [PQ events](#) (8.1.3)



Operator list

Navigation: |< < 1 2 3 4 5 > +5>> Results per page 25

#	time	Action	User
1	10.04.2019, 14:50:46,815	Config File: Change	device
2	04.04.2019, 14:05:03,937	Config File: Change	device
3	03.04.2019, 11:27:40,985	Config File: Change	device
4	02.04.2019, 11:14:47,522	Config File: Change	device
5	15.03.2019, 11:33:37,836	Config File: Change	device
6	15.03.2019, 11:30:28,377	Config File: Change	device
7	15.03.2019, 09:48:48,644	Device: On	device
8	15.03.2019, 09:45:55,000	Device: Firmware update	device
9	15.03.2019, 09:43:19,148	Device: Off	device
10	12.03.2019, 14:52:26,647	Alarm: Reset	device
11	07.03.2019, 10:44:51,577	Alarm: Reset	device
12	05.03.2019, 09:18:36,748	Alarm: Reset	device
13	04.03.2019, 17:32:23,245	Config File: Change	device

Example of an operator list

8.1.3 PQ events

Recorded events are available in the form of a logbook, mains signalling events are stored in a separated list. Each detected event is entered into the PQ event list with the time of its occurrence, the remaining voltage and the duration of the event. By selecting a list entry the graphical display of the measured values during this event is entered. The following presentations are available:

- Half cycle RMS curves of all voltages, all currents, all voltages and currents
- Curve shapes of all voltages, all currents, all voltages and currents

> PQ events

PQ events Mains Signalling

Navigation: |< < 1 2 3 4 5 > +5>> Results per page 25

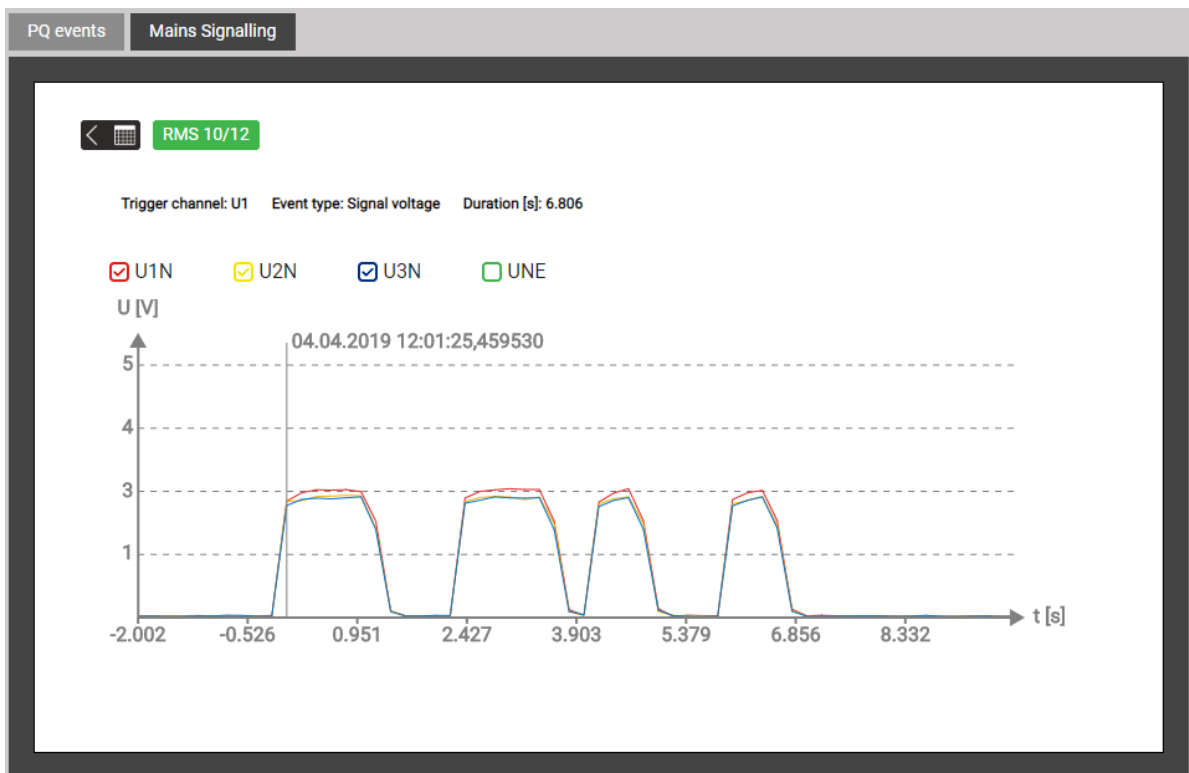
#	time	Trigger channel	Event type	Event value	Event value	Duration [s]
51	22.11.2018, 06:04:54,061	U1	Voltage dip	Residual voltage: 177.59 V	Depth: 52.41 V	0.070
52	15.11.2018, 06:19:34,599	U1, U3	Rapid voltage change	ΔU_{max} : 30.34 V	ΔU_{ss} : 0.08 V	0.093
53	30.10.2018, 01:32:59,765	U3	Rapid voltage change	ΔU_{max} : 13.78 V	ΔU_{ss} : 0.12 V	0.340
54	30.10.2018, 01:31:01,378	U2	Rapid voltage change	ΔU_{max} : 19.83 V	ΔU_{ss} : 0.32 V	0.070
55	30.10.2018, 01:29:14,032	U3	Rapid voltage change	ΔU_{max} : 21.22 V	ΔU_{ss} : 0.60 V	0.650
56	29.10.2018, 20:06:17,128	U1, U2, U3	Rapid voltage change	ΔU_{max} : 23.78 V	ΔU_{ss} : 0.95 V	0.117
57	28.10.2018, 06:04:04,247	U1	Rapid voltage change	ΔU_{max} : 18.62 V	ΔU_{ss} : 0.14 V	0.060
58	25.10.2018, 15:57:16,387	U3	Voltage dip	Residual voltage: 187.26 V	Depth: 42.74 V	0.040
59	25.10.2018, 13:25:06,893	U1, U2	Rapid voltage change	ΔU_{max} : 19.32 V	ΔU_{ss} : 0.18 V	0.027

List of PQ events



Graphical display of a PQ event (RMS 1/2)

The recorded data in the mains signalling area allow checking, if the magnitude of the ripple control signal at the receiver complies with the expectations and if the pulse sequences arrive correctly.



Recognized sequence on the ripple control frequency

8.1.4 PQ statistic

Via the menu PQ statistic all recorded power quality data can be visualized and assessed.

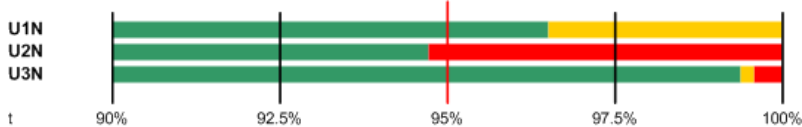
- PQ statistic overview of the [monitored criteria](#) (4.5.2)
- Daily trends of the recorded PQ variables
- PQ-Easy compliance report

PQ statistic overview

The overview is loaded and displayed for the duration of the selected survey period, applying the selected standard. From that it is very easy to see whether the limits of the monitored criteria are respected or not. Each criterion to be monitored by the selected standard is represented by a bar, which itself may be composed of multiple color components:

- Requirement fulfilled**
- Missing data**
- Requirement not fulfilled**

Example for monitoring voltage variations:



- Limit to be respected is marked with a red line (95% of the time range)
- U1N: Requirement fulfilled, because green bar > 95%
- U2N: Requirement not fulfilled, because green bar < 95%
- U3N: Requirement fulfilled, because green bar > 95%

- Events
- PQ statistic**
- Service
- Settings
- Config manager

LINAX | PQMOBILE
POWER | QUALITY

> PQ statistic
Overview
Frequency
Daily statistic voltage
Harmonics U
Interharmonic U
Daily statistic current
Harmonics I

Interharmonics I

Survey: 17.05.2019 - 20.05.2019
Standard: ENS0160

Frequency

LV
 LV island system
 MV
 MV island system
 HV
 HV island system

Voltage

Criterion	Compliance
U12	~98%
U23	~98%
U31	~98%

Long-term Flicker Pit

Criterion	Compliance
Pst12	~98%
Pst23	~98%
Pst31	~98%

Mains Signalling Voltage

Criterion	Compliance
Usignal	~98%

Voltage imbalance

Criterion	Compliance
Uneg/pos	~98%

The PQ statistic overview is shown for the duration of the selected campaign, with the end time being reduced to the last full hour.

The standard to be used for assessment can be directly selected.

Daily trends of monitored PQ variables

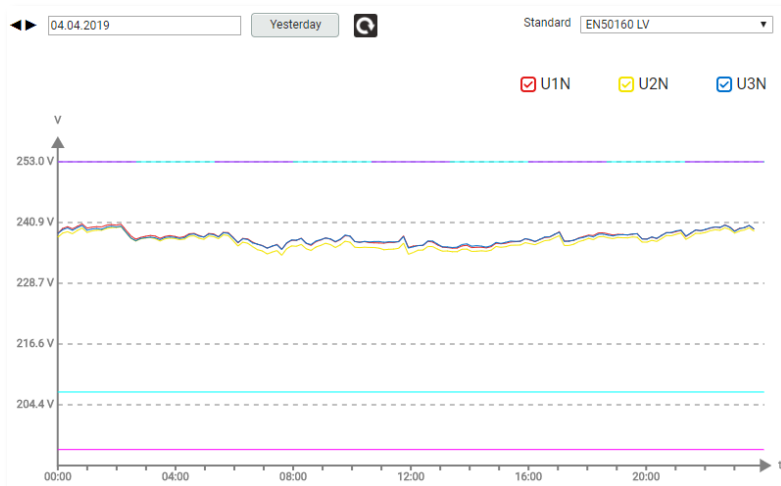
For all recorded PQ variables details can be displayed on daily basis. As far as the selected standard defines limits for the visualized quantity, these will be inserted in the graphic. Some examples are shown below:



Voltage harmonics

For each phase and each harmonic it is shown, how close the determined values are to the **limit value**.

For each value the **mean value** of the 144 daily values and the **maximum** 10-min value is displayed.

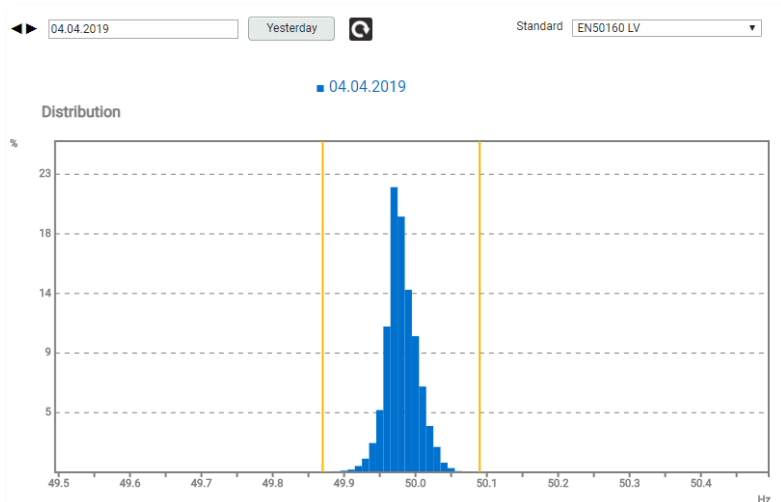


Voltage trends

For each individual voltage the daily trend of the 10-min values is shown.

For the selected standard the following ranges may not be left:

- for 100% of time ($\pm 10\%$)
- for 95% of time (+10 / -15%)




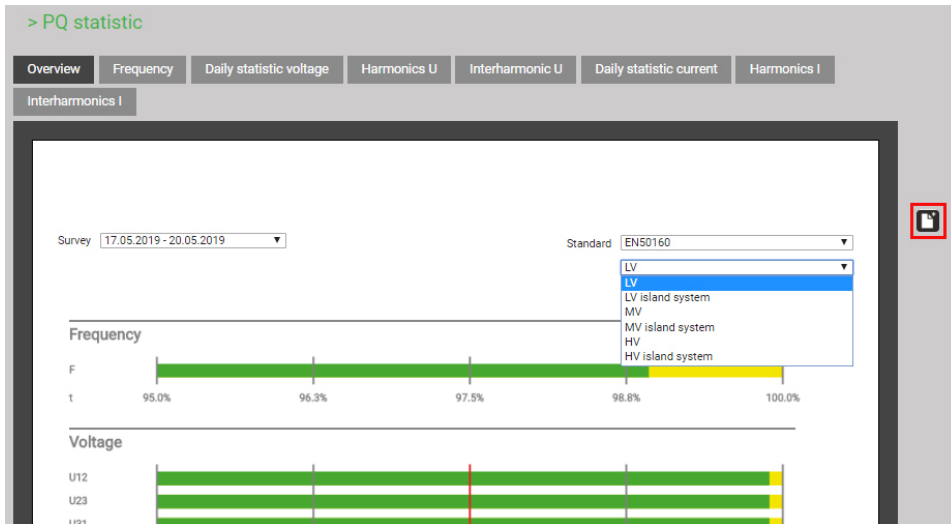
Distribution of 10-s frequency values

The **lines** mark the detected minimum and maximum frequency values.

The limit values are here not visible, because they are outside of the displayed range.

8.1.5 PQ-Easy compliance report

Via  a compliance report in PDF format can be created.



1. Select survey. Hint: The end time is reduced to the last full hour.
2. If dates are modified in the measuring period always 00:00 is assigned
3. Select standard for which compliance needs to be proven
4. Select content of report (3 levels)
5. Enter a comment, which needs to be shown on the first page of the report
6. Start report generation...

During report generation a progress bar is shown at the upper side of the screen. The duration of the report generation depends on the selected content, the assessment period and the number of recorded PQ events.

The generated report can be downloaded.

Depending on the browser and its settings, you can either choose where to save the file or the report will be saved in the default download directory.

Example of a compliance report

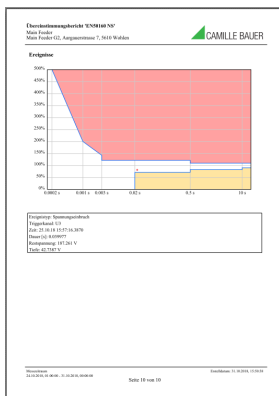
a) Overview



b) Details



c) Events



8.2 Data export of PQDIF files

8.2.1 Provision of PQ data

The PQDIF files will be created periodically after midnight for the past day and provided in a hierarchical time structure (year, month, day), shown below for 2017/October /3rd.

Index of /download/data/pqdif/y2017/m10/d03/

Name	Last Modified	Size
Parent Directory		-
PQ3000-1182195001_20171003_Events.pqd	2017-10-03 22:12	1.7M
PQ3000-1182195001_20171003_Histograms.pqd	2017-10-03 22:12	47.5K
PQ3000-1182195001_20171003_Statistics.pqd	2017-10-03 22:12	346.8K

PQDIF files may also be generated manually via web interface. This is possible for the present day (data since midnight) or for days in the past. The date can be selected:

> Service > PQ data > Generate PQ data

Min/max values reset
Meter contents set/reset
Start/Stop data recording
Logger values reset
Operating hours
Device information
PQ data
Factory reset
Firmware update
Communication Tests
Device reboot

Generate PQ data
Download PQ data
Reset PQ data

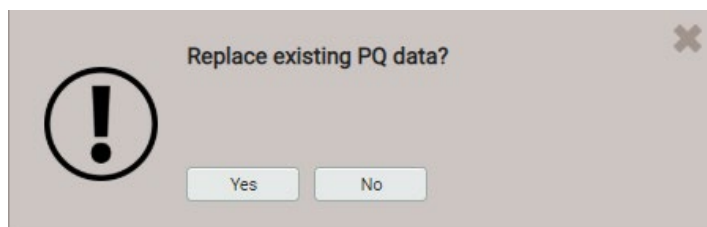
Today
May 2019

Mo	Tu	We	Th	Fr	Sa	Su
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

22.5.2019 Generate PQ data

```
> Start PQ data generation
> Event 'Voltage dip' at 2019-05-22T13:12:45.631+02:00
> Event 'Voltage dip' at 2019-05-22T13:12:57.778+02:00
> Event 'Voltage dip' at 2019-05-22T13:13:09.764+02:00
> Event 'Rapid voltage change' at 2019-05-22T13:13:28.633+02:00
> Found 4 events
> PQ data stored in file 'PQ5000MOB-1201847001_20190522_Events.pqd'
> PQ data stored in file 'PQ5000MOB-1201847001_20190522_Statistics.pqd'
> PQ data stored in file 'PQ5000MOB-1201847001_20190522_Histograms.pqd'
> PQ data generation done
```

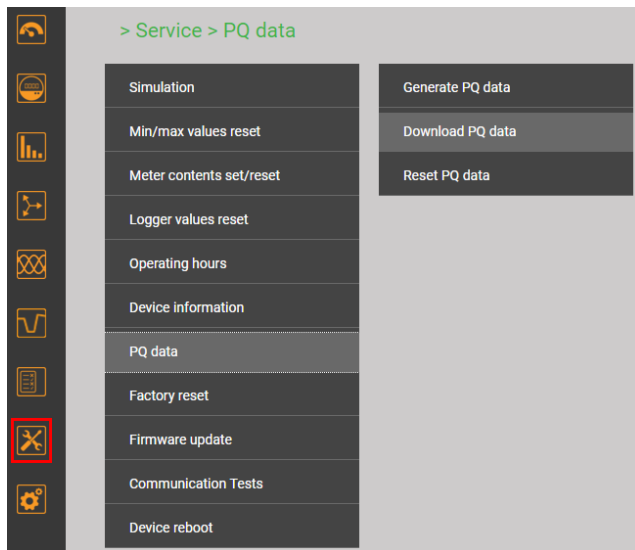
If there are already PQDIF files stored in the device for the selected past day the below warning will be displayed.



8.2.2 Accessing PQDIF files

You may access PQDIF files in two ways:

- a) **Manual download** via the **Service | PQ data | Download PQ data**: The desired file can be selected from the file structure according to chapter 8.2.1.

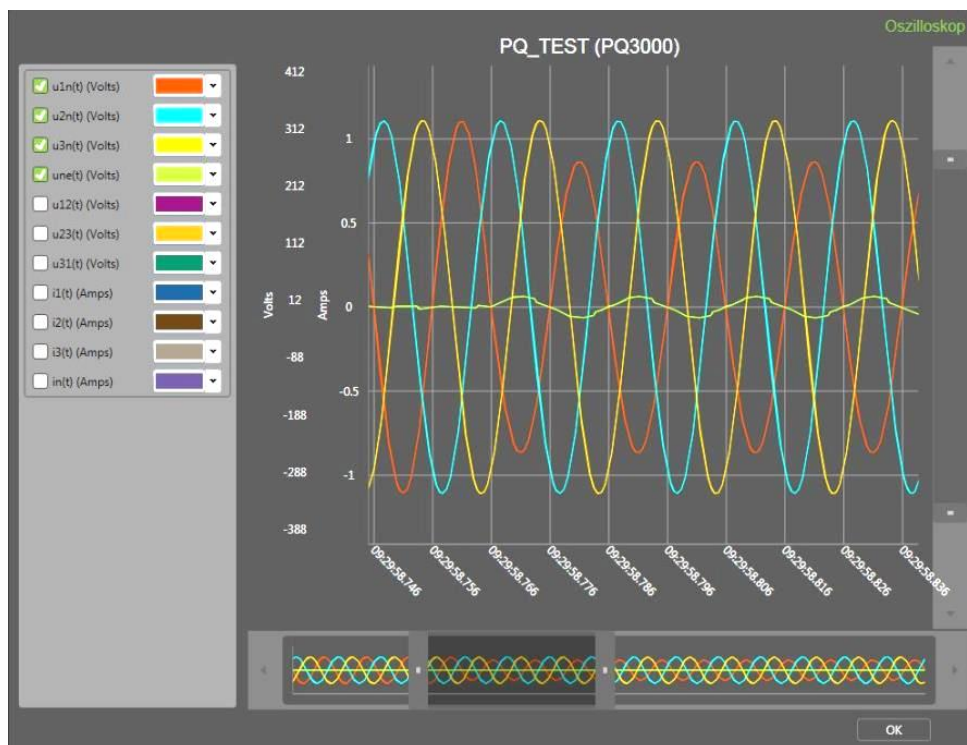


- b) **Automatic download** using the SmartCollect PM20 software (not included in the scope of delivery)

8.2.3 Evaluation of the PQDIF files

For the analysis of the data of the PQDIF files either the SmartCollect PM20 software (not included in the scope of delivery) or a free tool with limited functionality, such as the PQDiffactor from Electrotek Concepts (<http://www.pqview.com/pqdiffactor/>; registration required), can be used.

The **SmartCollect PM20** allows a more detailed analysis of the PQ data. Events can be graphically analyzed or displayed in an ITIC curve, which contains all PQ events with their residual voltage and event duration. You may also create conformity reports, e.g. according to EN50150.



Representation of a voltage dip, using the SmartCollect PM20 software

9. Service, maintenance and disposal

9.1 Calibration and new adjustment

Each device is adjusted and checked before delivery. The condition as supplied to the customer is measured and stored in electronic form.

The uncertainty of measurement devices may be altered during normal operation if, for example, the specified ambient conditions are not met. If desired, in our factory a calibration can be performed, including a new adjustment if necessary, to assure the accuracy of the device.

9.2 Cleaning

The operating keys should be cleaned in regular intervals. Use a dry or slightly moist cloth for this.



Damage due to detergents

Detergents can damage the device. Therefore, do not use detergents.

9.3 Battery

The device contains a battery for buffering the internal clock. It cannot be changed by the user. The replacement can be done at the factory only.

9.4 Disposal

The product must be disposed in compliance with local regulations. This particularly applies to the built-in battery.

10. Technical data

Inputs

Nominal voltage:	57.7...400 V _{LN} , 100...693 V _{LL} ;
Measurement max.:	520 V _{LN} , 900 V _{LL} (Sinus)
Measurement category:	600V CAT III
Consumption:	≤ U ² / 1.54 MΩ per phase
Impedance:	1.54 MΩ per phase
Overload capacity:	continuous: 520 V _{LN} , 900 V _{LL} 10 x 1 s, interval 10s: 800 V _{LN} , 1386 V _{LL}
Measurement uncertainty:	0.1%

Current

a) Rogowski probe ACF 2004_1

Current range CR:	2000A AC
Measurement category:	1000V CAT III, 600V CAT IV
Accuracy (25°C, 50Hz):	± 0.5% of reading
Interchangeability:	± 0.5% of reading
Linearity (10-100% MB):	± 0.2% of reading
Phase error (45-65 Hz):	<± 1°
Temperature coefficient:	± 0.05% of reading /°C
Position sensitivity:	± 2% of reading
External field:	± 0.25% CR
Frequency range:	10Hz up to 20kHz (-1dB)

b) Current clamps

Measurement category:	600V CAT III
Frequency range:	30Hz up to 10kHz

10A / 1V

Current range CR:	10mA up to 10A AC
Output sensitivity:	100mV / A
Uncertainty:	

Primary current	10...50mA	50...100mA	0,1...10A
Accuracy (of reading)	±5%	±2%	±1%
Phase error (typically)	undefined	5°	3°

100A / 1V

Current range CR:	1A up to 120A AC
Output sensitivity:	10mV / A
Uncertainty:	

Primary current	1...10A	10...25A	25...100A
Accuracy (of reading)	±2%	±1.5%	±1%
Phase error (typically)	undefined	2.2°	2°

1000A / 1V

Current range CR:	1A up to 1200A AC
Output sensitivity:	1mV / A
Uncertainty:	

Primary current	1...10A	10...100A	100...1200A
Accuracy (of reading)	±3%+0.1mV	±1.5%	±1%
Phase error (typically)	undefined	0.5°	0.3°

Nominal frequency: 42...50...58Hz or 50.5...60...69.5Hz, configurable

Sampling rate: 18 kHz

Systems: Single phase
 Split phase (2-phase system)
 3-wire, balanced load
 3-wire, unbalanced load
 3-wire, unbalanced load, Aron connection
 4-wire, unbalanced load

Power supply via power adapter
 Rated voltage: 100 ... 240V AC
 Secondary: 12V DC, 1A
 Frequency: 47 ... 63 Hz

Zero suppression, range limitations

The measurement of specific quantities is related to a pre-condition which must be fulfilled, that the corresponding value can be determined and sent via interface or displayed. If this condition is not fulfilled, a default value is used for the measurement.

Quantity	Condition	Default
Voltage	$U_x < 1\% U_{x_{nom}}$	0.00
Current	$I_x < 0,1\% I_{x_{nom}}$	0.00
PF	$S_x < 1\% S_{x_{nom}}$	1.00
QF, LF, $\tan\phi$	$S_x < 1\% S_{x_{nom}}$	0.00
Frequency	voltage and/or current input too low ¹⁾	Nominal frequency
Voltage unbalance	$U_x < 5\% U_{x_{nom}}$	0.00
Current unbalance	mean value of phase currents $< 5\% I_{x_{nom}}$	0.00
Phase angle U	at least one voltage $U_x < 5\% U_{x_{nom}}$	120°
Harmonics U, THD-U	fundamental $< 5\% U_{x_{nom}}$	0.00

¹⁾ Specific levels depend on the device configuration

Communication

Ethernet via RJ45 socket
 Protocol: Modbus/TCP, NTP, http, https
 Physics: Ethernet 100BaseTX
 Mode: 10/100 Mbit/s, full/half duplex, auto-negotiation

WLAN via USB socket
 Protocol: Modbus/TCP, http
 Access Point: up to 10 clients

The EDIMAX N150 Wireless LAN USB Adapter is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC, 2009/125/EC.

FOR USE IN

Internal clock (RTC)

Uncertainty: ± 2 minutes / month (15 up to 30°C)
 Synchronization: none, via Ethernet ([NTP protocol](#)) or [GPS](#)
 Running reserve: > 10 years

Ambient conditions, general information

Operating temperature: -10 up to 15 up to 30 up to +55°C
Storage temperature: -25 up to +70°C;
Temperature influence: 0.5 x measurement uncertainty per 10 K
Long term drift: 0.5 x measurement uncertainty per year
Usage group: II (acc. EN 60 688)
Relative humidity: < 95% no condensation
Altitude: ≤ 2000 m max.

Safety

Protection class: II (protective insulation, voltage inputs via protective impedance)
Pollution degree: 2
Protection: IP65 (closed housing)

Power Quality

Type of device: (IEC 62586-1) **PQI-A F12: Power Quality Instrument – Class A; Fixed installation; Indoor environment with controlled temperature variations (2)**
Measurement cycle: 200ms (50Hz: 10 cycles; 60Hz: 12 cycles)
Flagging concept: Multiphase approach in accordance with IEC 61000-4-30
Certification: According to IEC62586-2 (standard for verifying compliance with IEC 61000-4-30)
Certification body: Federal Institute of Metrology METAS, an independent and accredited laboratory
Test records: Conformity was proven at 230V / 50Hz and 120V / 60Hz

PQ functionality acc. IEC 61000-4-30 Ed.3

Chap.	PQ parameter	Class	Remarks
5.1	Power frequency	A	
5.2	Magnitude of the supply voltage	A	
5.3	Flicker	A	Flicker meter class F1
5.4	Supply voltage dips and swells	A	
5.5	Supply voltage interruptions	A	
5.7	Supply voltage unbalance	A	
5.8	Voltage harmonics	A	
5.9	Voltage inter-harmonics	A	
5.10	Mains signalling voltage	A	
5.11	Rapid voltage change (RVC)	A	
5.12	Underdeviation and overdeviation	A	
5.13	Current (magnitude, harmonics, inter-harmonics, unbalance)	A	

Applied regulations, standards and directives

IEC/EN 61010-1	Safety regulations for electrical measuring, control and laboratory equipment
IEC/EN 61000-4-30 Ed.3	Power quality measurement methods
IEC/EN 61000-4-7	General guide on harmonics and interharmonics measurements
IEC/EN 61000-4-15	Flickermeter - Functional and design specifications
IEEE 1159.3	Recommended Practice for the Transfer of Power Quality Data
IEC 62586-1 Ed.2	Power quality measurement in power supply systems – Power quality instruments (PQI)
IEC 62586-2 Ed.2	Power quality measurement in power supply systems – Functional tests and uncertainty requirements
EN50160	Voltage characteristics of electricity supplied by public distribution systems
DIN 40 110	AC quantities
IEC/EN 60068-2-1/ -2/-3/-6/-27:	Ambient tests -1 Cold, -2 Dry heat, -3 Damp heat, -6 Vibration, -27 Shock
IEC/EN 60529	Protection type by case
IEC/EN 61000-6-4	Electromagnetic compatibility (EMC): Emission standard for industrial environments
IEC/EN 61000-6-5	Electromagnetic compatibility (EMC): Immunity for equipment used in power station and substation environment
UL94	Tests for flammability of plastic materials for parts in devices and appliances
2011/65/EU (RoHS)	EU directive on the restriction of the use of certain hazardous substances

Warning

This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

This device complies with part 15 of the FCC:

Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This Class A digital apparatus complies with Canadian ICES-003.

FCC statement

The following statement applies to the products covered in this manual, unless otherwise specified herein. The statement for other products will appear in the accompanying documentation.

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules and meets all requirements of the Canadian Interference-Causing Equipment Standard ICES-003 for digital apparatus. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/T.V. technician for help.

Camille Bauer Metrawatt AG is not responsible for any radio television interference caused by unauthorized modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by Camille Bauer Metrawatt AG. The correction of interference caused by such unauthorized modification, substitution or attachment will be the responsibility of the user.

Annex

A Description of measured quantities

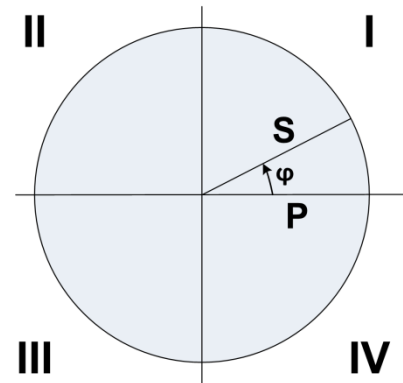
Used abbreviations

1L	Single phase system
2L	Split phase; system with 2 phases and center tap
3Lb	3-wire system with balanced load
3Lu	3-wire system with unbalanced load
3Lu.A	3-wire system with unbalanced load, Aron connection (only 2 currents connected)
4Lu	4-wire system with unbalanced load

Incoming / outgoing / inductive / capacitive

The device provides information for all four quadrants. Quadrants are normally identified using the roman numbers I, II, III and IV, as shown in the adjacent graphic. Depending on whether the system is viewed from the producer or consumer side, the interpretation of the quadrants is changing: The energy built from the active power in the quadrants I+IV can either be seen as delivered or consumed active energy.

By avoiding terms like incoming / outgoing energy and inductive or capacitive load when displaying data, an independent interpretation of the 4-quadrant information becomes possible. Instead the quadrant numbers I, II, III or IV, a combination of them or an appropriate graphical representation is used. You can select your own point of view by selecting the reference arrow system (load or generator) in the settings of the measurement.



A1 Basic measurements

The basic measured quantities are calculated each 200ms by determining an average over 10 cycles at 50Hz resp. 12 cycles at 60Hz. If a measurement is available depends on the selected system.

Depending on the measured quantity also minimum and maximum values are determined and non-volatile stored with timestamp. These values may be reset by the user via display, see [resetting of measurements](#) (7.3).

Measurement	present	max	min	1L	2L	3Lb	3Lu	3Lu.A	4Lu
Voltage U	•	•	•	√	√				
Voltage U _{1N}	•	•	•		√				√
Voltage U _{2N}	•	•	•		√				√
Voltage U _{3N}	•	•	•						√
Voltage U ₁₂	•	•	•			√	√	√	√
Voltage U ₂₃	•	•	•			√	√	√	√
Voltage U ₃₁	•	•	•			√	√	√	√
Zero displacement voltage U _{NE}	•	•		√	√				√
Current I	•	•		√		√			
Current I1	•	•			√		√	√	√
Current I2	•	•			√		√	√	√
Current I3	•	•					√	√	√
Neutral current I _N	•	•		√	√				√
Earth current I _{PE} (calculated)	•	•							√
Active power P	•	•		√	√	√	√	√	√
Active power P1	•	•			√				√
Active power P2	•	•			√				√
Active power P3	•	•							√
Fundamental active power P(H1)	•	•		√	√	√	√	√	√
Fundamental active power P1(H1)	•	•			√				√
Fundamental active power P2(H1)	•	•			√				√
Fundamental active power P3(H1)	•	•							√
Total reactive power Q	•	•		√	√	√	√	√	√
Total reactive power Q1	•	•			√				√
Total reactive power Q2	•	•			√				√
Total reactive power Q3	•	•							√
Distortion reactive power D	•	•		√	√	√	√	√	√
Distortion reactive power D1	•	•			√				√
Distortion reactive power D2	•	•			√				√
Distortion reactive power D3	•	•							√
Fundamental reactive power Q(H1)	•	•		√	√	√	√	√	√
Fundamental reactive power Q1(H1)	•	•			√				√
Fundamental reactive power Q2(H1)	•	•			√				√
Fundamental reactive power Q3(H1)	•	•							√
Apparent power S	•	•		√	√	√	√	√	√
Apparent power S1	•	•			√				√
Apparent power S2	•	•			√				√
Apparent power S3	•	•							√
Fundamental apparent power S(H1)	•	•		√	√	√	√	√	√
Fundamental apparent power S1(H1)	•	•			√				√
Fundamental apparent power S2(H1)	•	•			√				√
Fundamental apparent power S3(H1)	•	•							√
Frequency F	•	•	•	√	√	√	√	√	√
Power factor PF	•			√	√	√	√	√	√
Power factor PF1	•				√				√
Power factor PF2	•				√				√
Power factor PF3	•								√
PF quadrant I			•	√	√	√	√	√	√
PF quadrant II			•	√	√	√	√	√	√
PF quadrant III			•	√	√	√	√	√	√
PF quadrant IV			•	√	√	√	√	√	√

Measurement	prese	max	min	1L	2L	3Lb	3Lu	3Lu.A	4Lu
Reactive power factor QF	•			√	√	√	√	√	√
Reactive power factor QF1	•				√				√
Reactive power factor QF2	•				√				√
Reactive power factor QF3	•								√
Load factor LF	•			√	√	√	√	√	√
Load factor LF1	•				√				√
Load factor LF2	•				√				√
Load factor LF3	•								√
cosφ (H1)	•			√	√	√	√	√	√
cosφ L1 (H1)	•				√				√
cosφ L2 (H1)	•				√				√
cosφ L3 (H1)	•								√
cosφ (H1) quadrant I			•	√	√	√	√	√	√
cosφ (H1) quadrant II			•	√	√	√	√	√	√
cosφ (H1) quadrant III			•	√	√	√	√	√	√
cosφ (H1) quadrant IV			•	√	√	√	√	√	√
tanφ (H1)	•			√	√	√	√	√	√
tanφ L1 (H1)	•				√				√
tanφ L2 (H1)	•				√				√
tanφ L3 (H1)	•								√
$U_{mean}=(U1N+U2N)/2$	•				√				
$U_{mean}=(U1N+U2N+U3N)/3$	•								√
$U_{mean}=(U12+U23+U31)/3$	•					√	√	√	
$I_{mean}=(I1+I2)/2$	•				√				
$I_{mean}=(I1+I2+I3)/3$	•						√		√
IMS, Average current with sign of P	•			√	√	√	√	√	√
Phase angle between U1 and U2	•					√	√	√	√
Phase angle between U2 and U3	•					√	√	√	√
Phase angle between U3 and U1	•					√	√	√	√
Angle between U and I	•			√		√	√	√	
Angle between U1 and I1	•				√				√
Angle between U2 and I2	•				√				√
Angle between U3 and I3	•								√
Maximum $\Delta U \ll U_m^{1)}$	•	•			√	√	√	√	√
Maximum $\Delta I \ll I_m^{2)}$	•	•			√		√		√

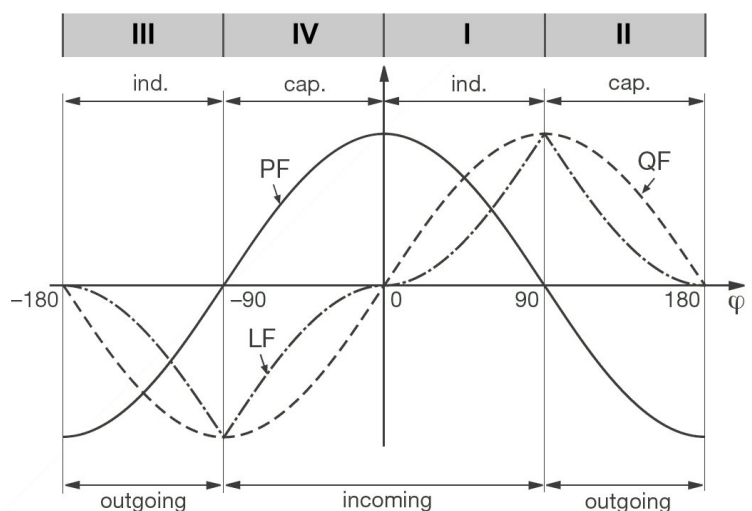
• Available via communication interface only

Power factors

The **power factor PF** gives the relation between active and apparent power. If there are no harmonics present in the system, it corresponds to the $\cos\phi$ or displacement power factor. The PF has a range of $-1...0...+1$, where the sign gives the direction of energy flow.

The **load factor LF** is a quantity derived from the PF, which allows making a statement about the load type. Only this way it's possible to measure a range like 0.5 capacitive ... 1 ... 0.5 inductive in a non-ambiguous way.

The **reactive power factor QF** gives the relation between reactive and apparent power.

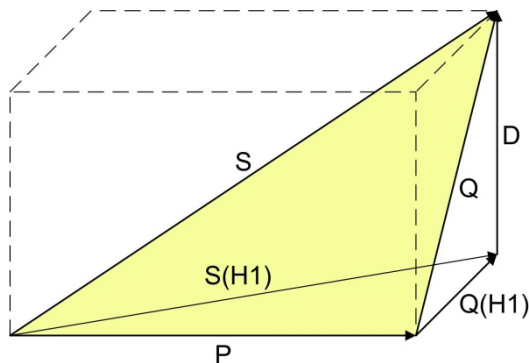


Example from the perspective of an energy consumer

Reactive power

Most of the loads consume a combination of ohmic and inductive current from the power system. Reactive power arises by means of the inductive load. But the number of non-linear loads, such as RPM regulated drives, rectifiers, thyristor controlled systems or fluorescent lamps, is increasing. They cause non-sinusoidal AC currents, which may be represented as a sum of harmonics. Thus the reactive power to transmit increases and leads to higher transmission losses and higher energy costs. This part of the reactive power is called distortion reactive power.

Normally reactive power is unwanted, because there is no usable active component in it. Because the transmission of reactive power over long distances is uneconomic, it makes sense to install compensation systems close to the consumers. So transmission capacities may be used better and losses and voltage drops by means of harmonic currents can be avoided.



- P: Active power
- S: Apparent power including harmonic components
- S1: Fundamental apparent power
- Q: Total reactive power
- Q(H1): Fundamental reactive power
- D: Distortion reactive power

The reactive power may be divided in a fundamental and a distortion component. Only the fundamental reactive power may be compensated directly by means of the classical capacitive method. The distortion components have to be combated using inductors or active harmonic conditioners.

The **load factor PF** is the relation between active power P and apparent power S, including all possibly existing harmonic parts. This factor is often called $\cos\phi$, which is only partly correct. The PF corresponds to the $\cos\phi$ only, if there is no harmonic content present in the system. So the $\cos\phi$ represents the relation between the active power P and the fundamental apparent power S(H1).

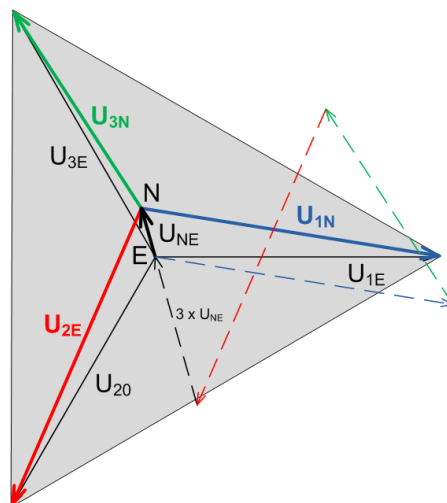
The **tanφ** is often used as a target quantity for the capacitive reactive power compensation. It corresponds to the relation of the fundamental reactive power Q(H1) and the active power P.

Zero displacement voltage U_{NE}

Starting from the generating system with star point E (which is normally earthed), the star point (N) on load side is shifted in case of unbalanced load. The zero displacement voltage between E and N may be determined by a vectorial addition of the voltage vectors of the three phases:

$$\underline{U}_{NE} = - (\underline{U}_{1N} + \underline{U}_{2N} + \underline{U}_{3N}) / 3$$

A displacement voltage may also occur due to harmonics of order 3, 9, 15, 21 etc., because the dedicated currents add in the neutral wire.



A2 Harmonic analysis

The harmonic analysis is performed according IEC 61000-4-7 over 10 cycles at 50Hz resp. 12 cycles at 60Hz. If a measured quantity is available depends on the selected system.

Measurement	prese	max	1L	2L	3Lb	3Lu	3Lu.A	4Lu
THD Voltage U1N/U	•	•	√	√				√
THD Voltage U2N	•	•		√				√
THD Voltage U3N	•	•						√
THD Voltage U12	•	•			√	√	√	
THD Voltage U23	•	•			√	√	√	
THD Voltage U31	•	•			√	√	√	
THD Current I1/I	•	•	√	√	√	√	√	√
THD Current I2	•	•		√		√	√	√
THD Current I3	•	•				√	√	√
TDD Current I1/I	•	•	√	√	√	√	√	√
TDD Current I2	•	•		√		√	√	√
TDD Current I3	•	•				√	√	√
Harmonic contents 2 nd ...50 th U1N/U	•	•	√	√				√
Harmonic contents 2 nd ...50 th U2N	•	•		√				√
Harmonic contents 2 nd ...50 th U3N	•	•						√
Harmonic contents 2 nd ...50 th U12	•	•			√	√	√	
Harmonic contents 2 nd ...50 th U23	•	•			√	√	√	
Harmonic contents 2 nd ...50 th U31	•	•			√	√	√	
Harmonic contents 2 nd ...50 th I1/I	•	•	√	√	√	√	√	√
Harmonic contents 2 nd ...50 th I2	•	•		√		√	√	√
Harmonic contents 2 nd ...50 th I3	•	•				√	√	√

Harmonic contents are available up to the 89th (50Hz) or 75th (60Hz) on the Modbus interface

• Available via communication interface only

Harmonics

Harmonics are multiples of the fundamental resp. system frequency. They arise if non-linear loads, such as RPM regulated drives, rectifiers, thyristor controlled systems or fluorescent lamps are present in the power system. Thus undesired side effects occur, such as additional thermal stress to operational resources or electrical mains, which lead to an advanced aging or even damage. Also the reliability of sensitive loads can be affected and unexplainable disturbances may occur. In industrial networks the image of the harmonics gives good information about the kind of loads connected. See also:

► [Increase of reactive power due to harmonic currents](#) (annex A1)

TDD (Total Demand Distortion)

The complete harmonic content of the currents is calculated additionally as Total Demand Distortion, briefly TDD. It is related to the maximum load current in accordance with IEEE 519. Only this way it's possible to estimate the influence of the current harmonics on the connected equipment correctly. The TDD value is especially used for conformity assessment in accordance with IEEE 519.

Maximum values

The maximum values of the harmonic analysis arise from the monitoring of THD and TDD. The maximum values of individual harmonics are not monitored separately, but are stored if a maximum value of THD or TDD is detected. The image of the maximum harmonics therefore always corresponds to the dedicated THD resp. TDD.

A3 System imbalance

Measured quantity	prese	max	min	1L	2L	3Lb	3Lu	3Lu.A	4Lu
UR1: Positive sequence [V]	•					√	√	√	√
UR2: Negative sequence [V]	•					√	√	√	√
U0: Zero sequence [V]	•								√
U: Imbalance UR2/UR1	•	•				√	√	√	√
U: Imbalance U0/UR1	•	•							√
IR1: Positive sequence [A]	•						√		√
IR2: Negative sequence [A]	•						√		√
I0: Zero sequence [A]	•								√
I: Imbalance IR2/IR1	•	•					√		√
I: Imbalance I0/IR1	•	•							√

• Available via communication interface only

Imbalance in three-phase systems may occur due to single-phase loads, but also due to failures, such as e.g. the blowing of a fuse, an earth fault, a phase failure or an isolation defect. Also harmonics of the 3rd, 9th, 15th, 21st etc. order, which add in the neutral wire, may lead to imbalance. Operating resources dimensioned to rated values, such as three-phase generators, transformers or motors on load side, may be excessively stressed by imbalance. So a shorter life cycle, a damage or failure due to thermal stress can result. Therefore monitoring imbalance helps to reduce the costs for maintenance and extends the undisturbed operating time of the used resources.

Imbalance or unbalanced load relays use different measurement principles. One of them is the approach of the symmetrical components, the other one calculates the maximum deviation from the mean-value of the three phase values. The results of these methods are not equal and don't have the same intention. Both of these principles are implemented in the device.

Symmetrical components (acc. Fortescue)

The imbalance calculation method by means of the symmetrical components is ambitious and intensive to calculate. The results may be used for disturbance analysis and for protection purposes in three-phase systems. The real existing system is divided in symmetrical system parts: A positive sequence, a negative sequence and (for systems with neutral conductor) a zero sequence system. The approach is easiest to understand for rotating machines. The positive sequence represents a positive rotating field, the negative sequence a negative (braking) rotating field with opposite sense of direction. Therefore the negative sequence prevents that the machine can generate the full turning moment. For e.g. generators the maximum permissible current imbalance is typically limited to a value of 8...12%.

Maximum deviation from the mean value

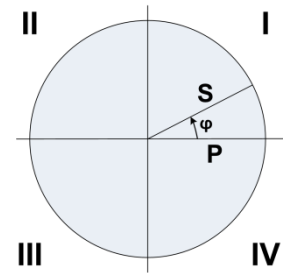
The calculation of the maximum deviation from the mean value of the phase currents resp. phase voltages gives the information if a grid or substation is imbalanced loaded. The results are independent of rated values and the present load situation. So a more symmetrical system can be aspired, e.g. by changing loads from one phase to another.

Also failure detection is possible. The capacitors used in compensation systems are wear parts, which fail quite often and then have to be replaced. When using three phase power capacitors all phases will be compensated equally which leads to almost identical currents flowing through the capacitors, if the system load is comparable. By monitoring the current imbalance it's then possible to estimate if a capacitor failure is present.

The maximum deviations are calculated in the same steps as the instantaneous values and therefore are arranged there ([see A1](#)).

A4 Mean values and trend

Measured quantity		Present	Trend	max	min	History
Active power I+IV	10s...60min. ¹⁾	•	•	•	•	5
Active power II+III	10s...60min. ¹⁾	•	•	•	•	5
Reactive power I+II	10s...60min. ¹⁾	•	•	•	•	5
Reactive power III+IV	10s...60min. ¹⁾	•	•	•	•	5
Apparent power	10s...60min. ¹⁾	•	•	•	•	5
Mean value quantity 1	10s...60min. ²⁾	•	•	•	•	1
....						
Mean value quantity 12	10s...60min. ²⁾	•	•	•	•	1



¹⁾ Interval time t1 ²⁾ Interval time t2

The device calculates automatically the mean values of all system power quantities. In addition up to 12 further mean value quantities can be freely selected.

Calculating the mean-values

The mean value calculation is performed via integration of the measured instantaneous values over a configurable averaging interval. The interval time may be selected in the range from 10 seconds up to one hour. Possible interim values are set the way that a multiple of it is equal to a minute or an hour. Mean values of power quantities (interval time t1) and free quantities (interval time t2) may have different averaging intervals.

Synchronization

For the synchronization of the averaging intervals the internal clock is used. It should be synchronized via GPS or NTP to avoid drifting of the intervals.

Trend

The estimated final value (trend) of mean values is determined by weighted addition of measurements of the past and the present interval. It serves for early detection of a possible exceeding of a given maximum value. This can then be avoided, e.g. by switching off an active load.

History

For mean values of system powers the last 5 interval values may be displayed on the device or read via interface. For configurable quantities the value of the last interval is provided via communication interface.

Bimetal current

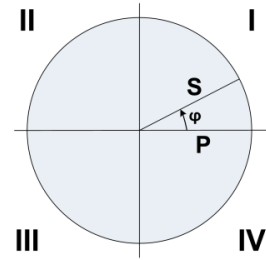
This measured quantity serves for measuring the long-term effect of the current, e.g. for monitoring the warming of a current-carrying line. To do so, an exponential function is used, similar to the charging curve of a capacitor. The response time of the bimetal function can be freely selected, but normally it corresponds to the interval for determining the power mean-values.

Measured quantity	Present	max	min	1L	2L	3Lb	3Lu	3Lu.A	4Lu
Bimetal current IB, 1...60min. ³⁾	•	•		√		√			
Bimetal current IB1, 1...60min. ³⁾	•	•			√		√	√	√
Bimetal current IB2, 1...60min. ³⁾	•	•			√		√	√	√
Bimetal current IB3, 1...60min. ³⁾	•	•					√	√	√

³⁾ Interval time t3

A5 Meters

Measured quantity		1L	2L	3Lb	3Lu	3Lu.A	4Lu
Active energy I+IV, high tariff		•	•	•	•	•	•
Active energy II+III, high tariff		•	•	•	•	•	•
Reactive energy I+II, high tariff		•	•	•	•	•	•
Reactive energy III+IV, high tariff		•	•	•	•	•	•
User configured meter 1	Only basic quantities can be selected which are supported in the present system.						
User configured meter 2							
User configured meter 3							
User configured meter 4							
User configured meter 5							
User configured meter 6							
User configured meter 7							
User configured meter 8							
User configured meter 9							
User configured meter 10							
User configured meter 11							
User configured meter 12							



Standard meters

The meters for active and reactive energy of the system are always active.

User configured meters

To each of these meters the user can freely assign a basic quantity.

Programmable meter resolution



For all meters the resolution (displayed unit) can be selected almost freely. This way, applications with short measurement times, e.g. energy consumption of a working day or shift, can be realized. The smaller the basic unit is selected, the faster the meter overflow is reached.

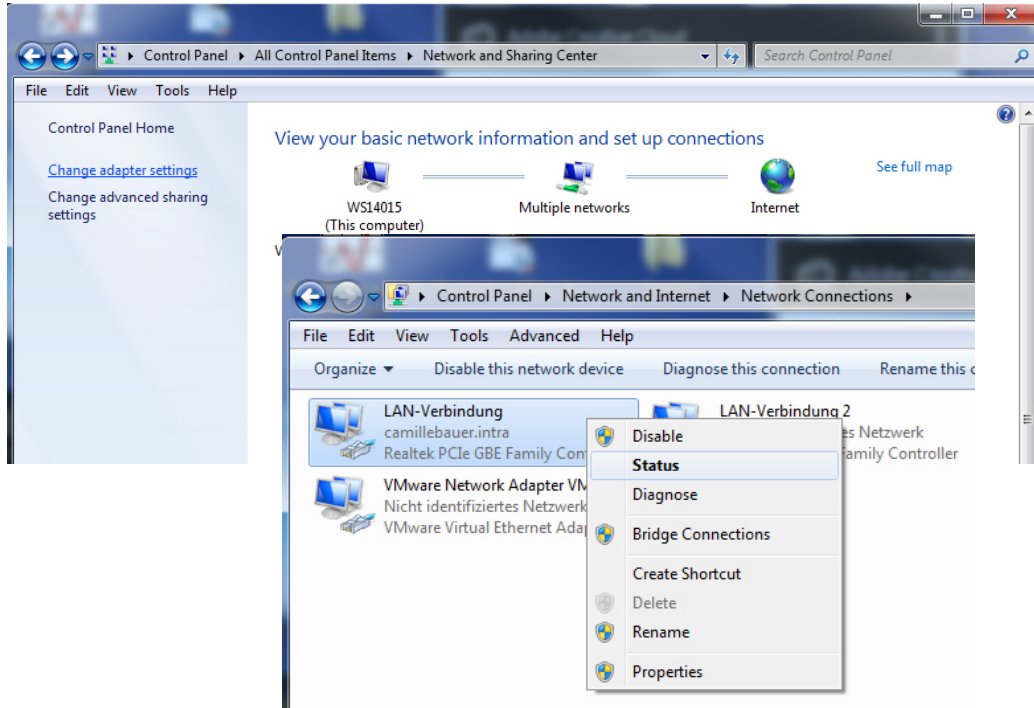
B Network settings in Windows

Depending on the Windows version used network settings and network status are arranged differently. The below images are created using Windows 7.

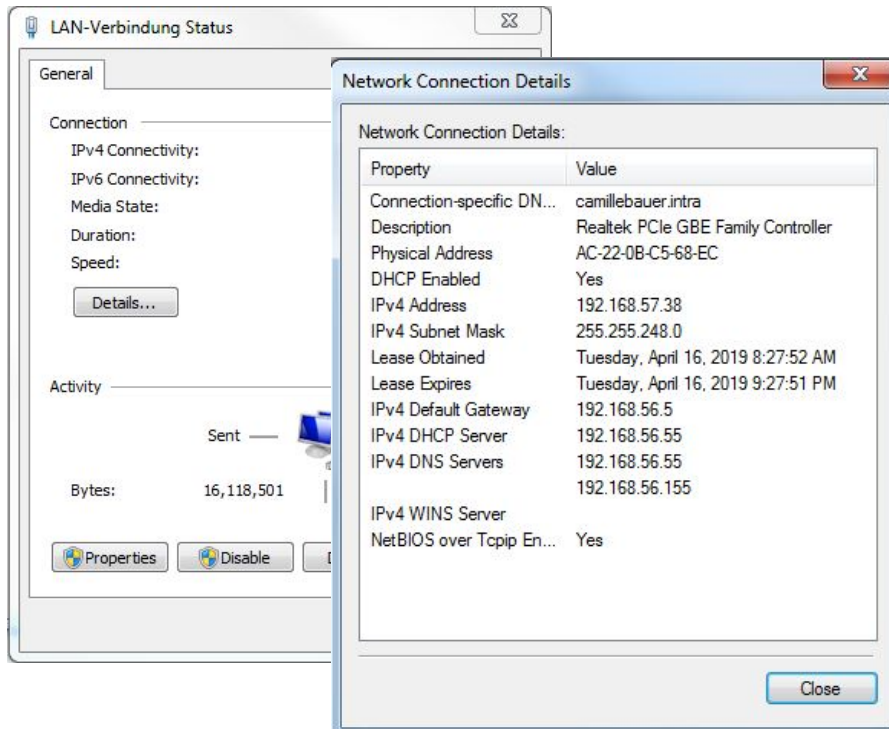
Display / change network settings



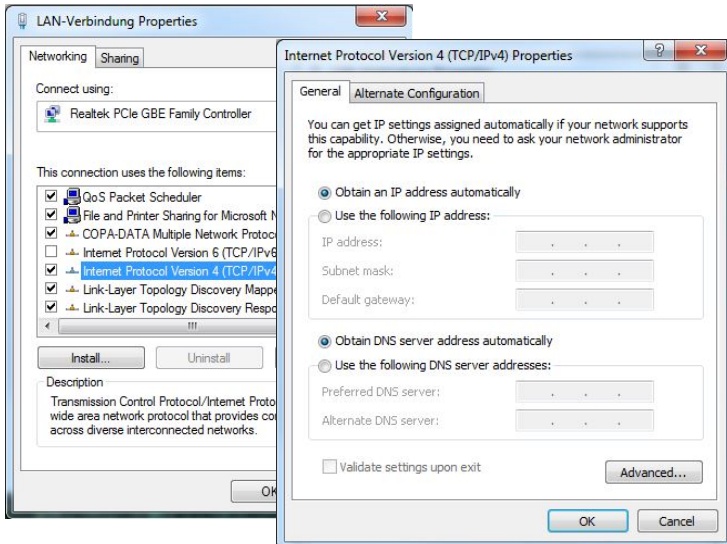
Via control panel select **Network and Sharing Center**



Via **Status** the active settings of the selected LAN interface can be displayed:

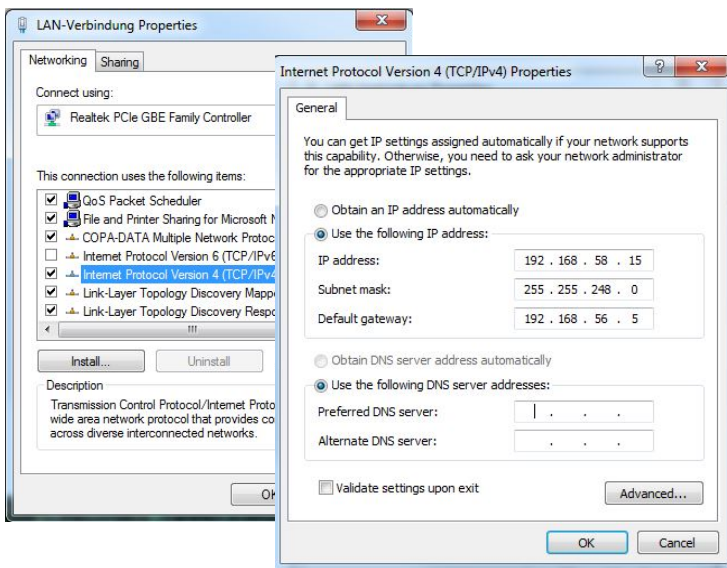


For changing the settings of the LAN interface, display the settings of the selected LAN interface via **Properties** first:



The setting **Obtain IP address automatically** indicates that the network settings are obtained from a DHCP server on the network.

If the PC is connected directly to the measurement device or the network does not have a DHCP server, the network settings are undefined.

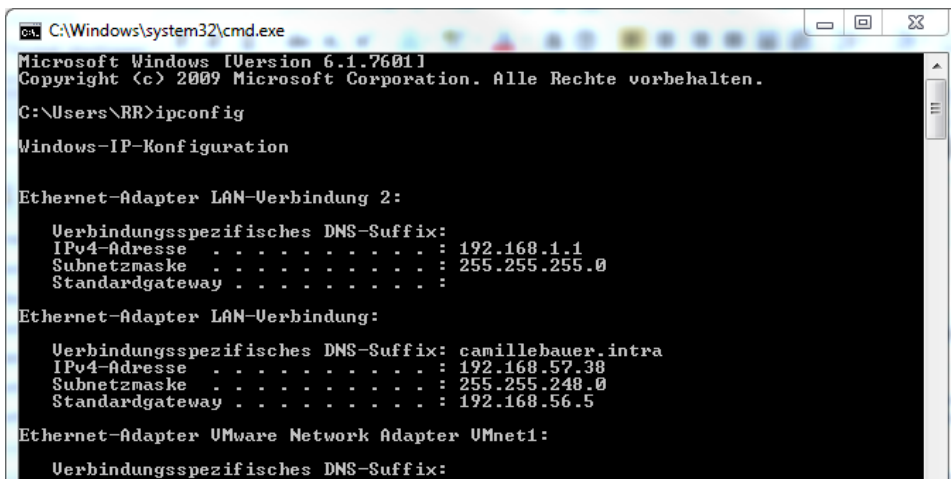


The network settings may be specified manually. Entered settings are activated after confirmation with **<OK>**.

The current settings of all LAN connections of a computer can also be queried via the DOS command prompt. A DOS window can be opened in two ways:

- a) **Start | Execute**, type **cmd** as command
- b) **Start | All programs | Accessories | command prompt**

In the DOS windows enter the command **ipconfig**.









ACF 2004_1

IP65 rated 2000A FLEXIBLE AC CURRENT PROBE







SAFETY

The following symbols appear on the product:

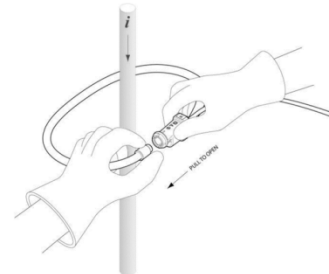
-  Attention! Refer to Manual.
-  Do not apply around or remove from HAZARDOUS LIVE conductors without additional protective means. "Additional protective means" can be de-energizing the circuit or wearing protective clothing suitable for high voltage work.
-  Double/Reinforced Insulation.
-  Complies with the relevant European standards.
-  Do not dispose of this product as unsorted municipal waste. Contact a qualified recycler for disposal.
-  Read all instructions completely before using this product.

OPERATION

-  Read safety section of instructions before operating this product.
-  Ensure conductor to be tested is de-energized
- Connect the output of the probe to the input of a measurement device.
-  The flexible current probe is not for use on conductors with a potential of over 1000V (CAT III) or 600V (CAT IV).
- Wrap the flexible probe around the conductor to be tested, close coupling. Energize the circuit under test. Locate the coupling away from nearby conductors.
-  Always use appropriate equipment for personal protection. Do not use the flexible current probe to measure bare conductors unless wearing protective clothing suitable for high voltage work.

To avoid electric shock:

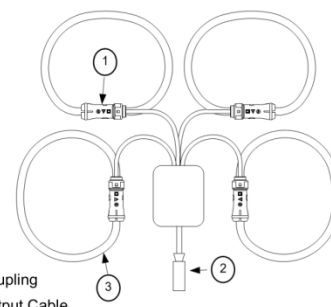
- Use caution during installation and use of this product. High voltages and currents may be present in circuit under test.
- This product must be used only by qualified personnel practicing applicable safety precautions.
- Do not install this product on live conductors.
- Always de-energize circuit under test before installing flexible measuring head. Always inspect connecting cable and flexible probe for damage before using this product.
- Do not use product if damaged.
- Always connect electronics unit to display device before installing the flexible measuring head.
- Always wear protective clothing and gloves if hazardous live parts are present in the installation where the measurement is carried out.
- If the probe is used in a manner not specified by the manufacturer the protection provided by the equipment may be impaired.



MAINTENANCE

-  Do not use ACF 2004_1 if damaged

- Always inspect connecting cable and flexible probe for damage before use.
- To avoid electric shock, keep the ACF clean and free of surface contamination.
- Use Isopropyl alcohol to clean the probe.
- Make sure the flexible probe and the connecting cable are dry before further use.



1. Probe Coupling
2. Probe Output Cable
3. Flexible Current Probe

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