System handbook

LINAX PQ5000MOBCL MULTI-PQ

Operating instructions (2023-03)
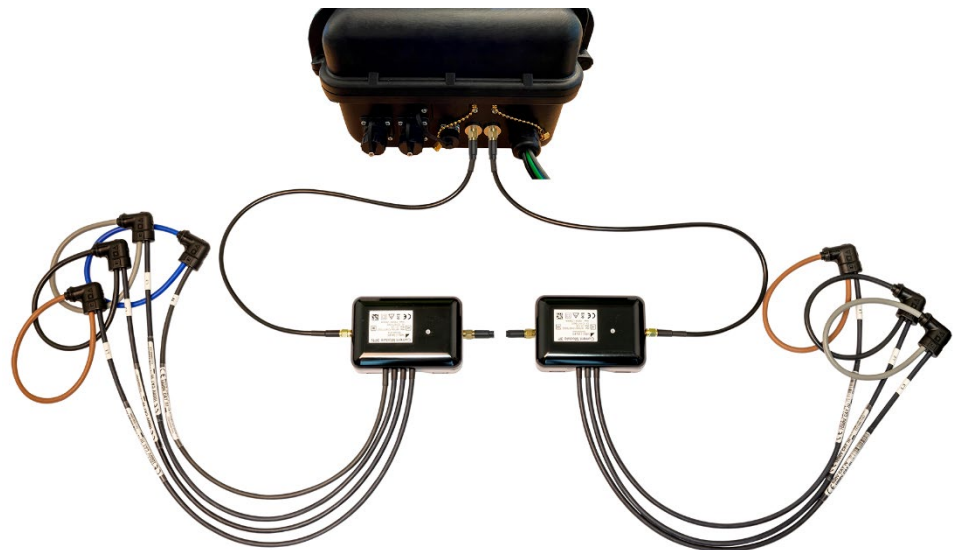
CAMILLE BAUER

Contents

0. 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

1. Purpose of this document

This document describes the universal power quality analysis device LINAX PQ5000MOBCLM (PQ5000-MOBILE CURRENT LINK MULTI-PQ) combined with the current modules 3P and 3PN. 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 devices. 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 PQ5000MOBCLM with 5 test leads for voltage inputs in carrying bag	☐
	1	Accessory bag inside the PQ5000MOBCLM with • 5 plug-on dolphin clamps • WLAN Access Point Dongle • System handbook • IP67 protected Ethernet cable (RJ45), 5m	☐
	1	Carrying bag with accessories in the ordered quantity • ≤ 9 Current modules 3P • ≤ 9 Current modules 3PN • ≤ 10 SMA connection cables • Power adapter 300V OVC IV	☐
	1	Optional: GPS receiver 16x-LVS	☐

3. Device overview

3.1 Short description

The system LINAX PQ5000-MOBILE CURRENT LINK Multi-PQ is designed for power quality and load flow analysis in power distribution systems. The voltage is measured centrally in the PQ5000MOBCLM base unit. The current measurement of up to 9 feeders with up to 36 current channels is done using Current Modules, which are arranged in a ring topology, the so-called Current Link, providing the current information for the 3 or 4 channel feeders. For each feeder the present status and load flow can be determined and power quality can be assessed. This current measurement is synchronized with the central voltage measurement to ensure that the power is correctly determined.

The functionality of the basic device can be parameterized directly via a web browser. 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.

The products of the LINAX PQ5000 series are independently certified Class A devices according to IEC 61000-4-30 Ed. 3. They provide reliable and comparable information for regulatory authorities, negotiations with energy suppliers or internal quality control.

By means of continuous monitoring, incidents can be analyzed immediately and their causes permanently eliminated. In addition, long-term acquisition permits the early recognition of changes in order to improve supply security and thus system availability.

The flexible approach without any software excels both in autarchy and flexible software integration options. It is based on standardized interfaces, generates power quality compliance reports directly via the device website and excels with a comprehensive cyber security concept.

3.2 System overview

The base unit LINAX PQ5000MOBCLM monitors centrally the power quality of the distribution system and collects, synchronized to the voltage, the current information of the current modules for state monitoring and load flow analysis of the individual feeders.

Using the current modules 3P and 3PN three or four currents of the feeders in a TNC or TNS low-voltage system are measured and transferred to the base unit via Current Link. The modules can measure normal operating currents and short-circuit currents up to a few kA.
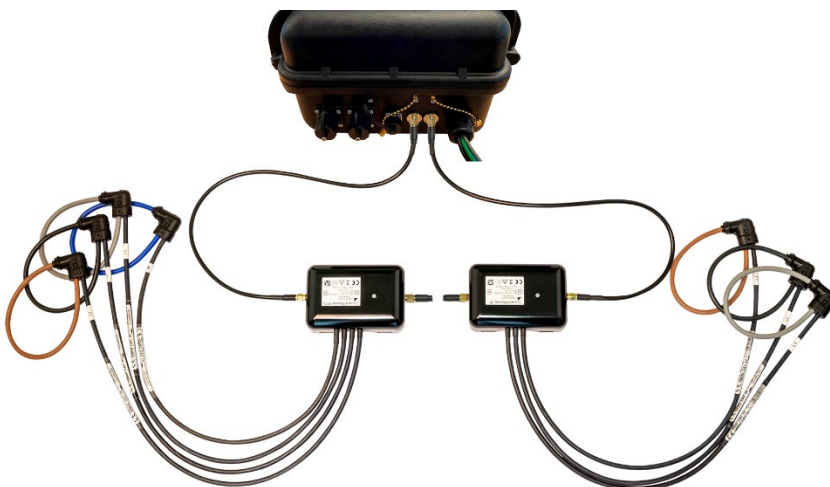
PQ5000MOBCLM with connected Current Modules 3PN and 3P

3.3 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, data 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)
- Data transfer to evaluation software (e.g. PQIS software) using CSV files

3.4 Measurement data

The device provides various measurement data via device website:

	Instantaneous values	Present TRMS values including phasor diagram, phase sequence check and evaluation of energy direction for each feeder monitored via a current module
	Energy	Provides data about the time-related energy consumption (load profile) and the total energy consumption per feeder
	Harmonics	Present data about harmonics, interharmonics, THD and TDD of all voltages as well as for the current of a selectable current module
	Waveform	Waveform of all voltages and the currents of a selectable current module
	Events	Chronological lists of all PQ and ripple control events
	PQ statistic	Data of the statistical power quality analysis, with which the user can create conformity reports, e.g. according to EN 50160, and visualize the chronological progression of the monitored variables

3.5 Device usage

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

A) **Preparation of the measurement application (Chap. 4)**: Using the website the device functionality can be configured via LAN or WLAN interface

B) **Connecting the device on-site (Chap. 6)**

C) **Installation check (Chap. 7.2)**

D) **Performing the measurement (Chap. 7)**

E) **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 IPv4/6 address than another device already installed**
>
> This also applies if the network only consists of a PC and the measuring device.

The device supports both IPv4 and IPv6 communication. IPv4 communication is activated by default; IPv6 can be activated additionaly via configuration.

As soon as PC and measurement device are in the same network, the website of the device may be accessed using a browser. The assignment of the network settings of a PC is shown in Annex B.

The recommended browsers are Google-Chrome and Firefox.

For configuring via Webbrowser you have to display the device website using:

- IPv4 communication: http://IPv4_addr,   e.g. http://192.168.1.101
- IPv6 communication: http://[IPv6_addr],   e.g. http://[fd2d:bb44:97f1:3976::1]

If the secure communication via https is activated and the root certificate installed, you have to use https instead of http for displaying the website
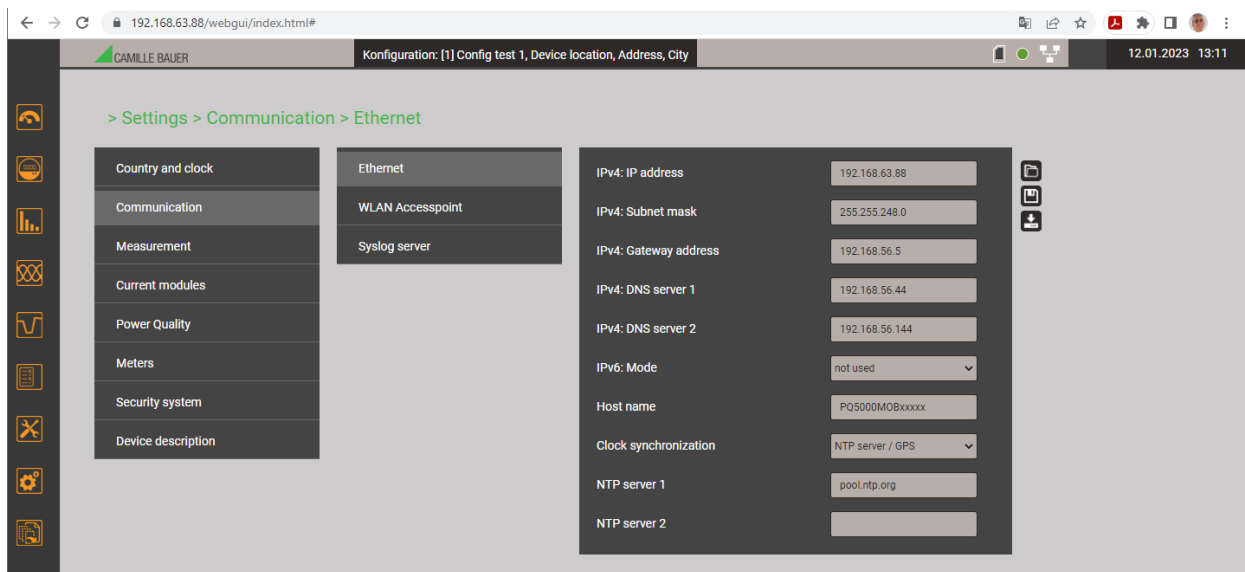
If, for example, a device needs to be integrated into an existing network, the network settings can be modified via the menu Settings | Communication | Ethernet. The corresponding parameters are described on the next page.

> ℹ️ 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.

Network settings (Communication | Ethernet)

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

• **IPv4/6: IP address**	Must be **unique**, i.e. may be assigned in the network only once
• **IPv4: Subnet mask**	Defines how many devices are directly addressable in the IPv4 network. This setting is equal for all the devices. Examples
• **IPv4/6: Gateway address**	Is used to resolve addresses during communication between different networks. It should contain a valid address within the directly addressable network
• **IPv4/6: 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
• **IPv6: Prefix length**	Is comparable to the subnet mask in IPv4 networks; it is the number of the leftmost bits of the site prefix which need to be identical for direct communication.
• **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

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.

IPv4: Subnet mask

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

Example 1	decimal	binary
IP address	192.168. 1.101	**11000000 10101000 00000001 011**00101
Subnet mask	255.255.255.224	**11111111 11111111 11111111 111**00000
	variable range	**xxxxx**
First address	192.168. 1. 96	**11000000 10101000 00000001 011**00000
Last address	192.168. 1.127	**11000000 10101000 00000001 011**11111

► *The device 192.168.1.101 can access directly the devices 192.168.1.96 … 192.168.1.127*

Example 2	decimal	binary
IP address	192.168. 57. 64	**11000000 10101000 001110**01 01000000
Subnet mask	255.255.252. 0	**11111111 11111111 111111**00 00000000
	variable range	**xx xxxxxxxx**
First address	192.168. 56. 0	**11000000 10101000 001110**00 00000000
Last address	192.168. 59.255	**11000000 10101000 001110**11 11111111

► *The device 192.168.57.64 can access directly the devices 192.168.56.0 ... 192.168.59.255*

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. 6.5) as well.

> Time synchronization via NTP or GPS is an elementary requirement for class A power quality measuring devices. Only with a correct time reference is it possible to evaluate the power quality and analyze disruptions in the network.

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.
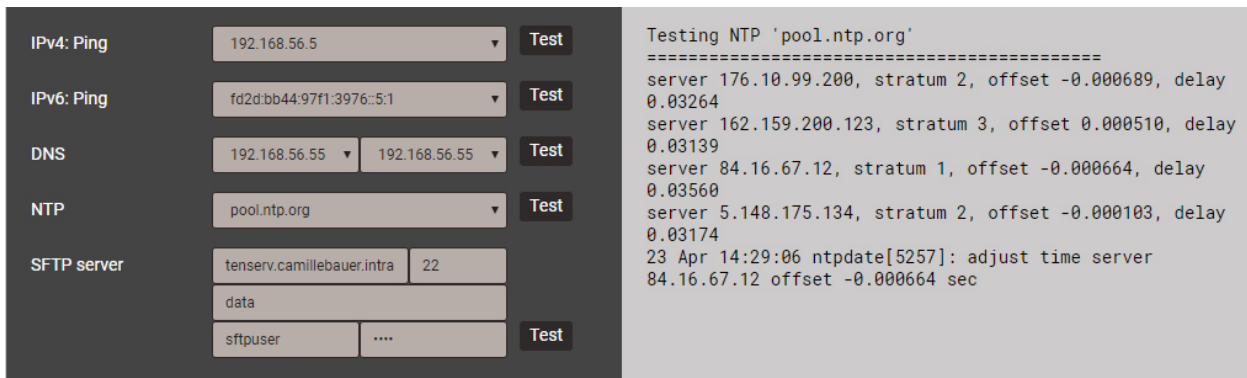
MAC address

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)
- SFTP: Test, if access to SFTP server works. A test file will be copied to the base directory of the server.


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 (PQmobclm:29:xx:xx).
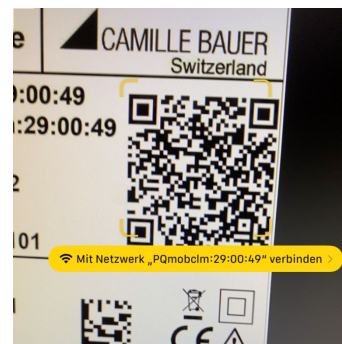
Call the device website via http://<ip_addr>. The default setting of the device IP address is 172.16.0.1.

> 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 settings of IPv4 and IPv6** • **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.
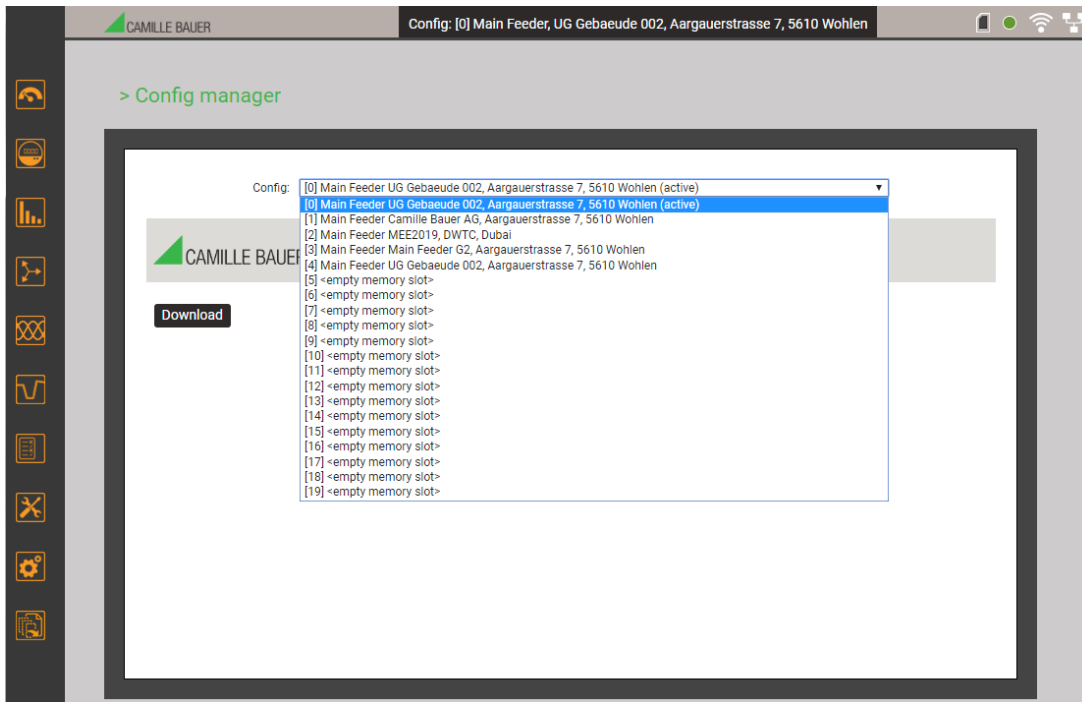
The administration of the device configurations is done via the configuration manager.

- 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.
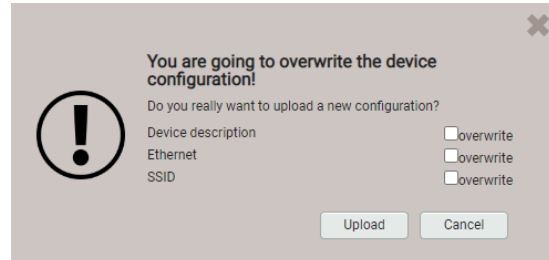
4.2.2 Device configuration

A full parameterization of all functions of the device can be performed via the settings menu on the website.
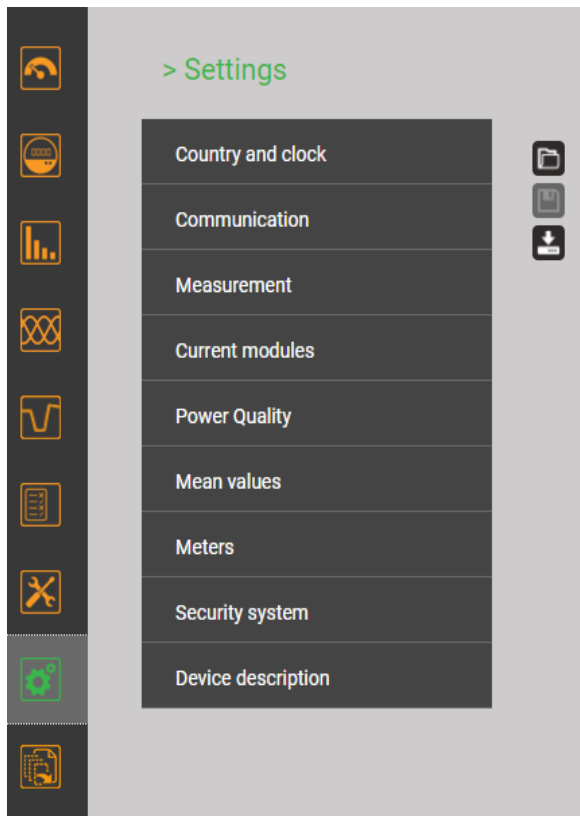
Upload a configuration from computer

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.
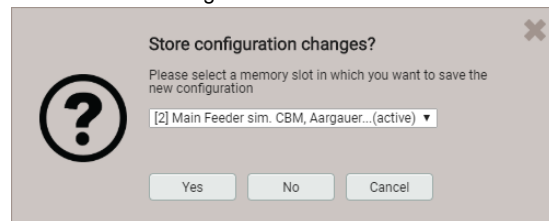
Store configuration on computer

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 via NTP or GPS)

  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).
  Further settings:
  - SFTP server to send user defined data files to.
  - Syslog server that collects security-realted messages
  Hint: The communication settings are valid for all configurations

- **Measurement**: Rated values of voltage / current / frequency
  Hints
  - *U / I transformer: The primary to secondary ratio is used only for converting the measured secondary to primary values, so e.g. 16'000 / 100 is equivalent to 160 / 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_{din} in accordance with IEC 61000-4-30*
  - *Maximum demand current: Reference value 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*

- **Current modules**: To each current module a description, a rated current, a system type and an amplification factor for both phase currents and neutral current can be assigned. The amplification factor allows the measured current to be scaled if, for example, only one of three parallel cables of a phase can be measured.

- **Power Quality** (Chap. 4.4): Definition of parameters for monitoring the PQ events and settings for the statistical power quality assessment. 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**: The interval time for the predefined power mean values can be defined here; typical interval: 15 min

- **Meters**: A resolution (displayed unit) can be assigned to the meters, see meter scaling (annex A.5), as well as a reading interval for the meter logger.

- **Security system**: Definition of the security system (RBAC, https, whitelist)
  Hint: An activated security system is valid for all configurations

- **Device description**: Definition of different texts[1] mainly used for report generation, such as device tag, document title, device location and others.

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[1] In user-defined event and description texts all Unicode characters (UTF8) are allowed with the exception of the following:
  - ASCII control characters (0x00 - 0x1F)
  - The quotation mark **"** (0x22)
  - The character **&** (0x26)
  - The apostrophe **'** (0x27)
  - The asterisk ***** (0x2A)
  - The slash **/** (0x2F)
  - The colon **:** (0x3A)
  - The «less than» character **<** (0x3C)
  - The «bigger than» character **>** (0x3E)
  - The question mark **?** (0x3F)
  - The backslash **** (0x5C)
  - The vertical line **|** (0x7C)

4.3 Security system

There are several security mechanisms implemented in the device which can be activated to provide a comprehensive access protection to all device data.

➢ The **role-based access control** (**RBAC**) system allows restricting the access to measured data, configuration settings and service functions to the rights granted to the present user. For access via website this is done by reducing the available menus and / or providing only read access rights to specific services. For accessing data via external applications an API (Application Programming Interface) key is required, which needs to be implemented as a special user.

➢ **HTTPS** provides encrypted communication using TLS (Transport Layer Security)

➢ Via **client whitelist** access to the device can be restricted to specific clients with definable IP addresses

➢ **Communication blocking:** Communication services, such as Modbus/RTU, Modbus/TCP or SYSLOG are blocked by default and must be actively enabled via configuration. This way unauthorized access may be prevented and possible intruding points eliminated.

➢ **Audit log**: The device stores all security related messages in a separate list accessible via the service menu. The content of this list can also be transferred to a central log-server using the **SYSLOG** protocol for security auditing.

If the device is equipped with a display, restrictions defined in the security system also take effect when operating the device via the local display. It is also possible to restrict users to local access only.

4.3.1 RBAC management

Each access to device data via website, local display or external software applications can be comprehensively protected using the role-based access control (RBAC) system. This way, access to measured value information, the change of configuration parameters or the resetting / deletion of measurement data can be individually adapted to the role of the active user.

Note: All settings of the security system are stored in the device in encrypted form only; login credentials are never transmitted in plain text.

A maximum of 8 users is supported

➢ **2 pre-defined standard users**

- *admin*: A user with administrator rights (Default setting password: „CBM_1234")

- *anonymous*: The standard user for access via device website. Its permissions determine what can be displayed or changed via the website without a user having to log in.

➢ **Up to 6 definable users or API keys**

Users or API keys may be created by each user with write access to the settings of the security system. In any case, each user with a web login can change the password of its own account.

Application programming interface (API) keys are used to allow applications to access device data via REST interface (communication via http/https protocol). Such keys are timely unlimited and have either read-only permissions, all permissions or all permissions except security.

The pre-defined administrator or any other user with full access rights to the settings of the security system can:

- Change its own credentials (user name and/or password)

- Change the credentials (user name and/or password) of any other user

- Freely define the permissions of the standard user *anonymous*

- Create new users up to a maximum of 6

- Restrict users to local operation only (no login via website)

Adding users / API keys

In addition to the 2 predefined users a maximum of 6 users or API keys may be created. To do so, use "Add user / API key" and select the type of user to be created.
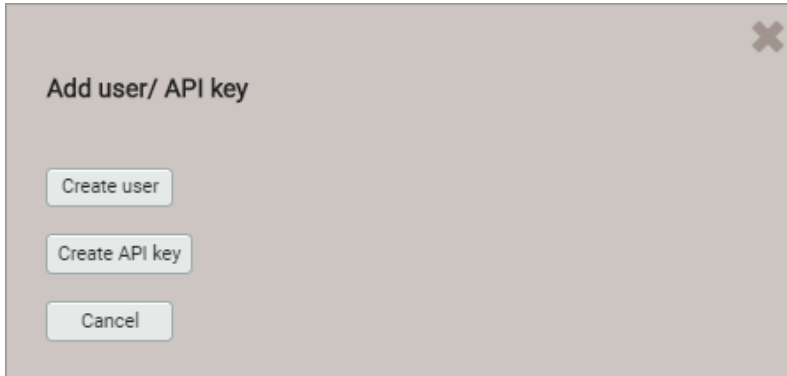
Users: During password definition the requirements for a secure password are checked and the result is displayed. Each new user can be created based on the permission template of an already existing user, but all of these permissions may be changed later.
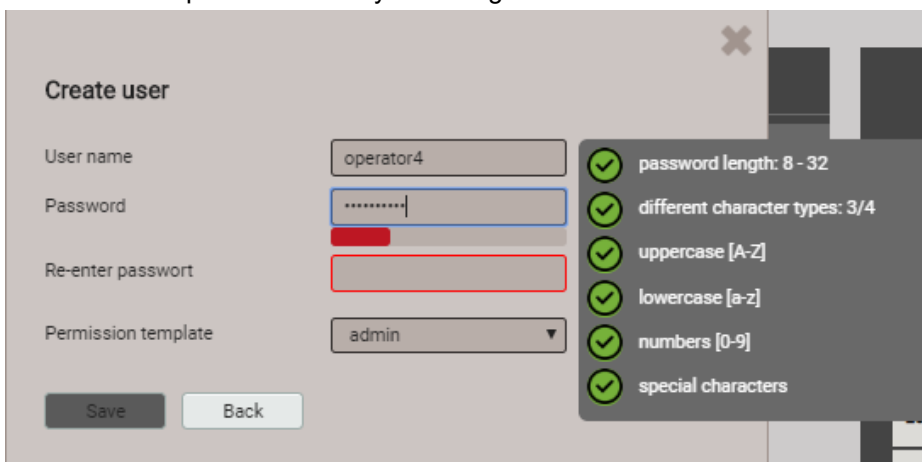
> When defining / changing passwords the following restrictions must be considered:
> - Password length 8 up to 32 characters
> - At least three different types of characters must be used (uppercase, lowercase, numbers, special characters)
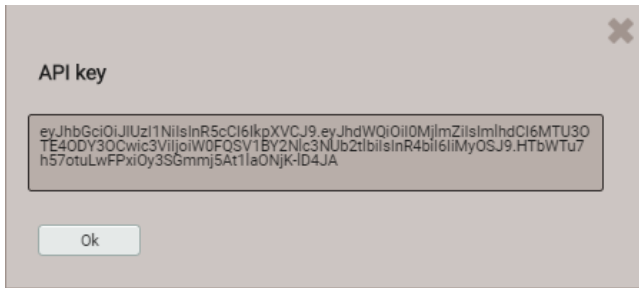
> **CAUTION**: If login credentials (user name and / or password) of users with write access to the security system are changed, this information must be kept safe. For security reasons resetting the RBAC system can only be done at the factory, no backdoor is implemented.

API key: Along with the key name you have to define the permissions to be granted to the application using the key via REST interface. The resulting access rights cannot be changed afterwards.
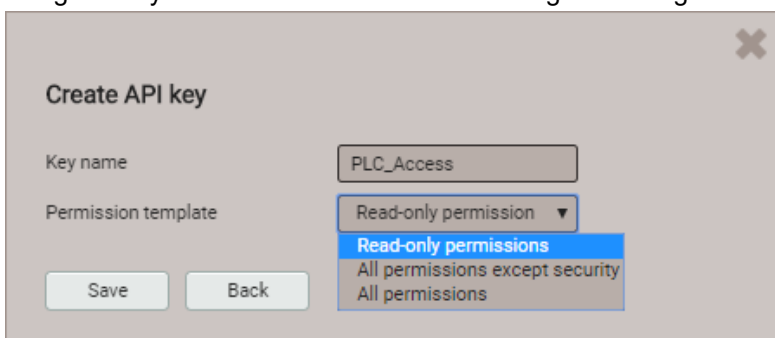
Once the API key is created it can be displayed using ⚙ "Show API key"

API key

eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJhdWQiOiI0MjlmZiIsImlhdCI6MTU3O
TE4ODY3OCwic3ViIjoiW0FQSV1BY2Nlc3NUb2tlbiIsInR4biI6IiMyOSJ9.HTbWTu7
h57otuLwFPxiOy3SGmmj5At1laONjK-lD4JA

Ok

When the application wants to communicate via REST interface with the device, it has to provide the API key and the session token via the cookie field in the request header, e.g.:

Cookie:
AccessToken=eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJhdWQiOiIxYjg4IiwiaWF0IjoxNTc5MTU4OTc4LCJzdWIiOi
Jhbm9ueW1vdXMiLCJ0eG4iOiIxOTIiMTY4LjU4LjExNCJ9.LiLjuJcs2bZAmYHlvdMXTAlr87gxUX-3kZ4cfz6jdMc;
sessionToken={5d1ca47c-8d38-4a08-85d5-fefbd941fa20}

Further information is provided in the document "http interface SINEAX PQx000"

Assignment of user rights

The assignment of the user rights granted for operation is done via the menu Settings | Security system | Users and permissions:
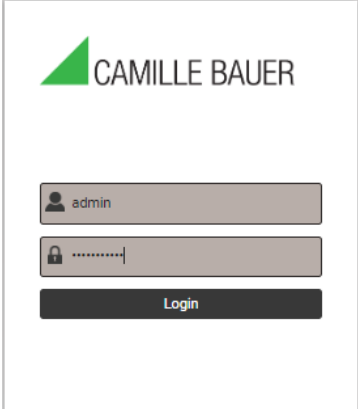
	admin	localgui	anonymous	operator1	operator2	operator3	[API]AccessToken
Local account (no weblogin)	☐	☑	☐	☐	☐	☐	☐
Instantaneous values	display	display	display	display	display	display	display
Energy	display	no display	no display	display	display	display	display
Harmonics	display	no display	no display	display	display	display	display
Phasor diagram	display	no display	no display	display	no display	no display	display
Waveform	display	no display	no display	display	no display	no display	display
Events	display	no display	no display	display	no display	no display	display
PQ statistic	display	no display	no display	display	display	no display	display
Service	display	display	display	display	display	no display	display
Reset values	change	no change	no change	change	no change	no change	change
Reset/Update device	change	no change	no change	change	no change	no change	change
Audit Log	display	display	display	no display	no display	no display	display
Use IO simulation	change	no change	no change	change	no change	no change	change
Settings	display	display	no display	display	no display	no display	display
Basic device settings	change	change	no change	no change	no change	no change	change
Measurement	change	no change	no change	no change	no change	no change	change
Communication	change	no change	no change	no change	no change	no change	change
Security system	change	change	no change	change	no change	no change	change

Legend:
- ◉ Measurements or settings can be displayed
- ⊘ Measurements or settings cannot be displayed
- ✎ Settings can be changed
- ⊠ Settings cannot be changed
- 🚫 Field not selectable
- ⚙ Change a user's login credentials

Overview of the access rights of each possible user

4.3.2 User log in / out via website

a) If "anonymous" has no granted permissions

Via website	Remarks
	1) Enter user name and password 2) Press <ENTER> or select "Login" If successful, depending on the permissions of the user logged in, the appropriate website is displayed

b) If "anonymous" has granted permissions

Via website	Remarks
	1) Click on the symbol 2) Enter user name and password. On first login use the default settings admin / CBM_1234. 3) Press <ENTER> or select "Login" If successful, depending on the permissions of the user logged in, the appropriate website is displayed

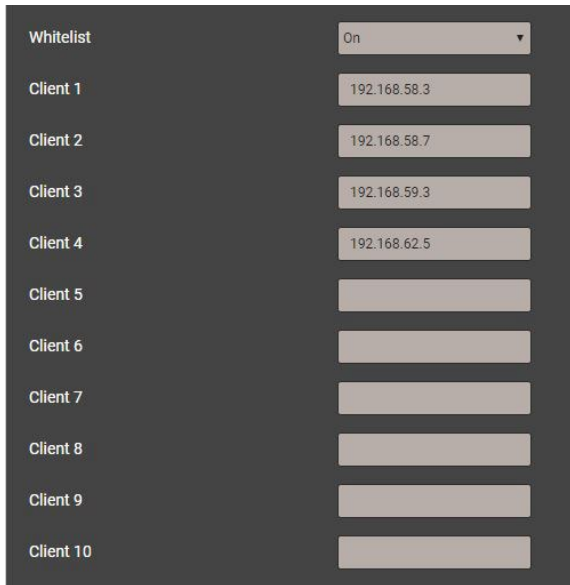**c) If another user is already logged in**

Via website	Remarks
	Log out the current user by selecting "Logout"
	1) Click on the symbol 2) Enter user name and password 3) Press <ENTER> or select "Login" If successful, depending on the permissions of the user logged in, the appropriate website is displayed

4.3.3 Whitelisting clients

It is possible to define a list of IPv4 and/or IPv6 addresses 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.*

4.3.4 Secure communication using https

According to Enel specifications https communication is activated by default. This protocol 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, by creating 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 (default setting) or its own customer certificate. This may be changed when defining the Settings of the Security system.
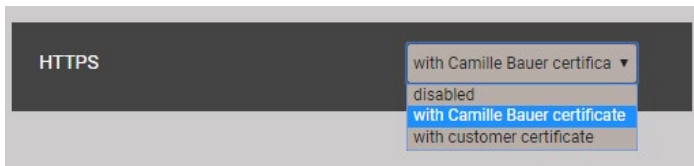

Camille Bauer certificate
Source: https://camillebauer.com/

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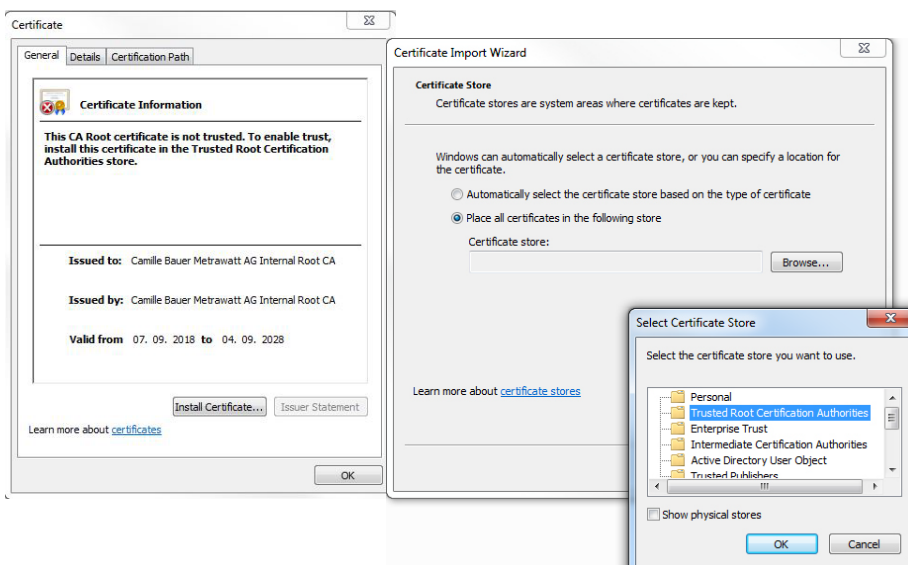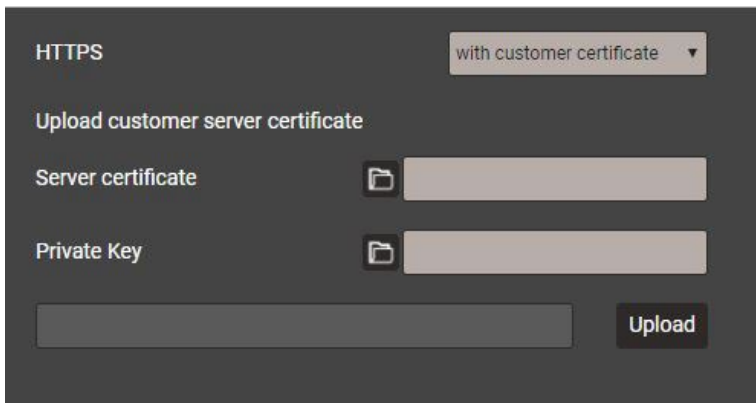
The imported certificate is valid for all devices of the PQ, AM, DM and CU series.

Agree to install the certificate if the below security warning appears:
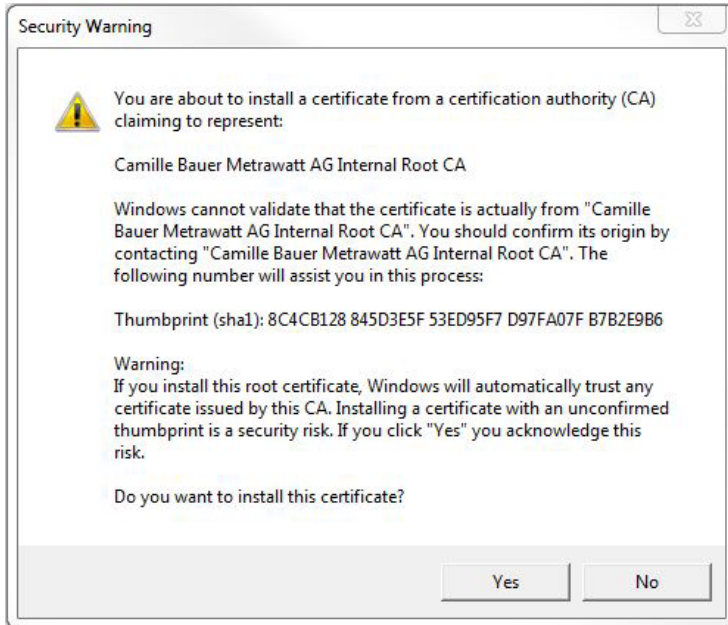
Customer certificate

You may also use a customer server certificate with a private key, but for that you first need to change the *Settings* of the *Security system* in the item *Web Security*.

> ℹ️ You may use https communication also by ignoring any browser warning and establishing an **unsecure** connection to the device. However, for security reasons you should not work like that in the intended network environment.

4.3.5   Audit log (SYSLOG)

Security related events, such as …

- a computer establishing a connection to the device
- a user logged in /out
- a failed login attempt
- each changing of the device configuration
- the view of the security log by a user
- etc.

are logged in a security log accessible via the service menu.

Time	PID	Priority	IP address	User name	Message
07.02.2020, 16:44:18	cb-gui[1523]	Notice	192.168.57.21:58824	admin	User logged in successfully
07.02.2020, 12:00:39	cb-pq3000[1516]	Notice	localhost	system	The device was power offFri Feb 7 09:41:26 2020
07.02.2020, 12:00:39	cb-pq3000[1516]	Notice	localhost	system	The device was power on Fri Feb 7 12:00:38 2020
06.02.2020, 14:25:02	cb-gui[2117]	Info	192.168.57.65:59614	admin	User logged out sucessfully
06.02.2020, 14:04:53	cb-gui[2117]	Notice	192.168.57.65:59378	admin	User logged in successfully
06.02.2020, 14:04:49	cb-gui[2117]	Warning	192.168.57.65:59378	admin	Failed login attempt# 1
06.02.2020, 13:55:14	cb-gui[2117]	Info	192.168.57.65:59256	admin	User logged out sucessfully
06.02.2020, 13:09:26	cb-gui[2117]	Notice	192.168.57.65:58678	admin	User logged in successfully
06.02.2020, 12:47:47	cb-gui[2117]	Info	192.168.57.65:58365	admin	User logged out sucessfully
06.02.2020, 12:21:37	cb-gui[2117]	Notice	192.168.57.65:57845	admin	User logged in successfully

Example of a security log: The severity of each message is shown in a color code, which may also serve as filter criteria.

Each entry into this list may, if activated, also be transferred to a central log-server using the **SYSLOG** protocol for security auditing. This transfer may be performed based on UDP, TCP or TLS. The settings of the Syslog server are available via Settings | Communication | Syslog server:

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 all voltage events in accordance with IEC 61000-4-30. The default values of the trigger thresholds correspond to the common values of the EN 50160 for a public low-voltage distribution system, but can be changed by the user to individual needs.

In addition to the requirements of IEC 61000-4-30 the device can monitor frequency anomalies and current swells in feeders monitored by current modules.

Monitored events	Threshold	Hysteresis	Reference value
Voltage dip	90%	2%	Nominal voltage
Voltage interruption	10%	2%	
Voltage swell	110%	2%	
Rapid voltage change	6%	50% [1]	
Current swell	120%	2%	Nominal current
Frequency anomaly	lower: 99% upper: 101%	0.5%	Nominal frequency

[1] *Related to the respective threshold*

> The device does not verify the user-defined event parameters. 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.

Recordings

If any of the above events occurs, the device records the half-cycle RMS values of all voltage and current channels. In addition, the samples (waveform) of the voltages are available. The event recording times can be configured using the menu *Settings | Power quality | Event recording:*

				Possible recording times
RMS(1/2): Pretrigger recording	s	1.000		*≤1.0s*
RMS(1/2): Event recording (max.)	s	180.000		*≤180.0s*
Samples: Pretrigger recording	s	1.000		*≤1.0s*
Samples: Event recording	s	4.000		*≤5.0s*

Note: The event recording time "RMS(1/2): After triggering" is a maximum recording time. It is reduced to the real event duration + 1s, if the event duration is shorter than the configured time. If there is a concurrent loss of the device supply, the recording time is limited to 5s.

Recorded PQ events can be visualized either via the local display or the webpage of the device.

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 specified in standards is normally at least one week to consider possible variations between weekdays and weekends. However, compliance reports may also be created for shorter or longer recording times; the user can freely select an assessment period as a multiple of 10 minutes.

> The standard to be evaluated needs to be preconfigured and only compliance to this standard can be assessed during PQ analysis.

The standard to be verified must be preset in the device and only this standard can be evaluated during the PQ analysis. The standard may be set via the menu *Settings | Power quality | General*. There also the lower limit for the no damage region of the ITIC curve may be defined.

Standard		EN50160 LV ⌄
Lower limit ITIC 'no damage'	ms	10

Limit ITIC

Possible choices for the standard are as follows:

- 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	*The applied limits and time conditions of the preset standards can be seen via the device website.* *They can be displayed via the following menu:* `Settings` `| Power Quality` `| Custom threshold limits` `| (Standard)` *Within the same menu user data sets with specific limits and evaluation criteria can be defined* *User specific data sets can also be deleted again.*
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

The device stores PQ related data, such as PQ events or PQ statistic, as CSV files in the internal memory. These files will be created and the end of the day and can be accessed at anytime via Ethernet interface without interrupting the measurement.

5. Safety instructions

	Death, serious injury or fire hazard could result from improper connection of this instrument. Before connecting the PQ5000MOBCLM and the current modules 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 PQ5000MOBCLM or the current modules 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

	Safe operation is no longer possible, if one of the components has visible damages. The affected component must be returned to the factory.
	Check all test leads, the connection cables of the power supply and the current sensors for insulation defects before use. Replace a defective power supply or current module immediately. Voltage test leads and connection cables of the power supply 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.
	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 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 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.

Ambient

⚠	The measurement system can be used indoors and in protected outdoor areas. The current modules must be protected against splashing water. In addition, in outdoor areas a suitable protection against direct sunlight is required.
⚠	Protection class IP65 of the base unit is only ensured if the cover of the case is closed and locked and the pressure release valve is closed.

6. Electrical connections

> **Be sure to observe the [Safety instructions](#) in chapter 5!**

6.1 Connecting the base unit

Symbol	Meaning
	Caution! General hazard point. Perfect and safe operation requires that this System handbook has been read and understood.

6.2 Voltage connections base unit
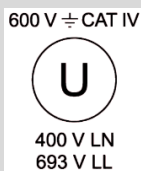
 For security reasons, the **leads for voltage measurement** (L1, L2, L3, N) are equipped with the following fuse:

SIBA, Typ 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.

 Maximum permissible rated voltage 400 VAC to ground (693V Ph-Ph)!
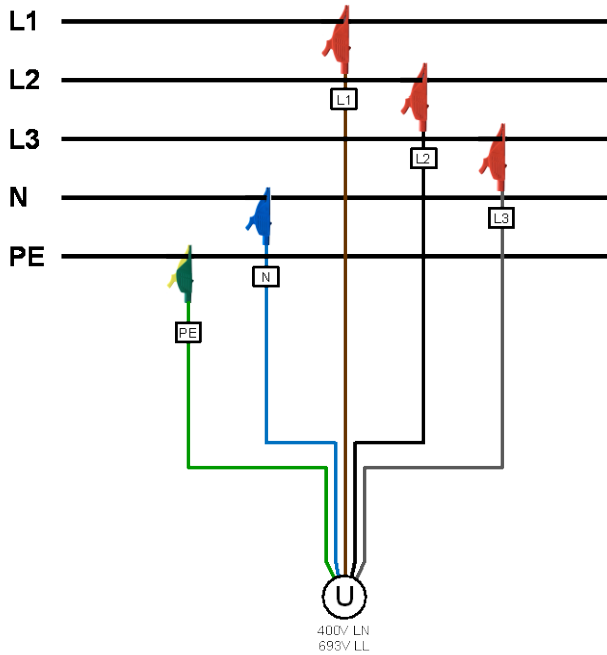
6.3 Current connection Current Link

The Current Link supports the current measurement of up to 9 feeders with up to 36 current channels. It consists of Current Modules, which are arranged in a ring structure and monitor 3 or 4 channel feeders. A typical connection of a PN-Moduls is shown below:
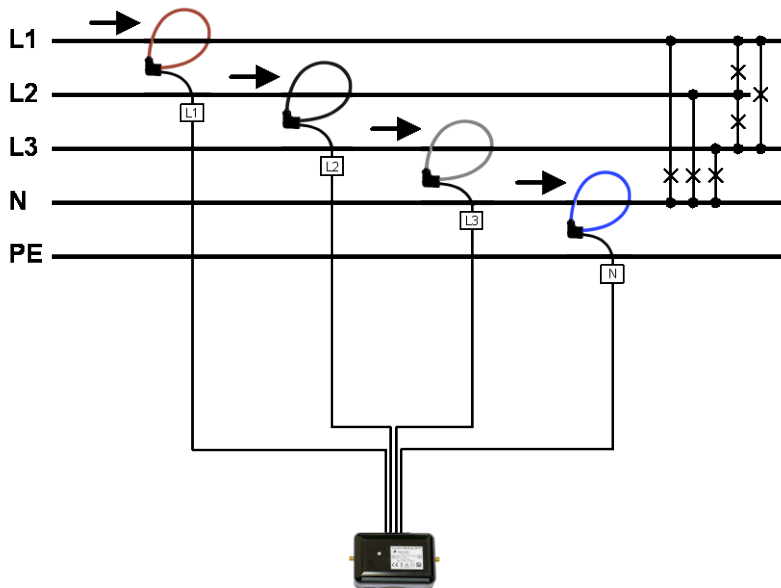
Rogowski coils

The Rogowski coils of the current modules are different in color and also marked: Brown – L1, Black – L2, Gray – L3, Blue – N.

The Rogowski coils are placed directly around the respective conductors. The current direction, which is indicated by an arrow on the measuring head, must be observed.

If not all conductors of a current can be encompassed with the coil, the measured current can be scaled using a configurable amplification factor.

The individual current modules in the ring are connected using SMA connection cables.

> ⚠️ The SMA connection cables must not be kinked during assembly, as the conductors could be damaged. The bending radius should be not smaller than 50mm.
>
> The fastening of the SMA cables to the corresponding connectors should be done with a torque wrench with a maximum torque of 1 Nm.
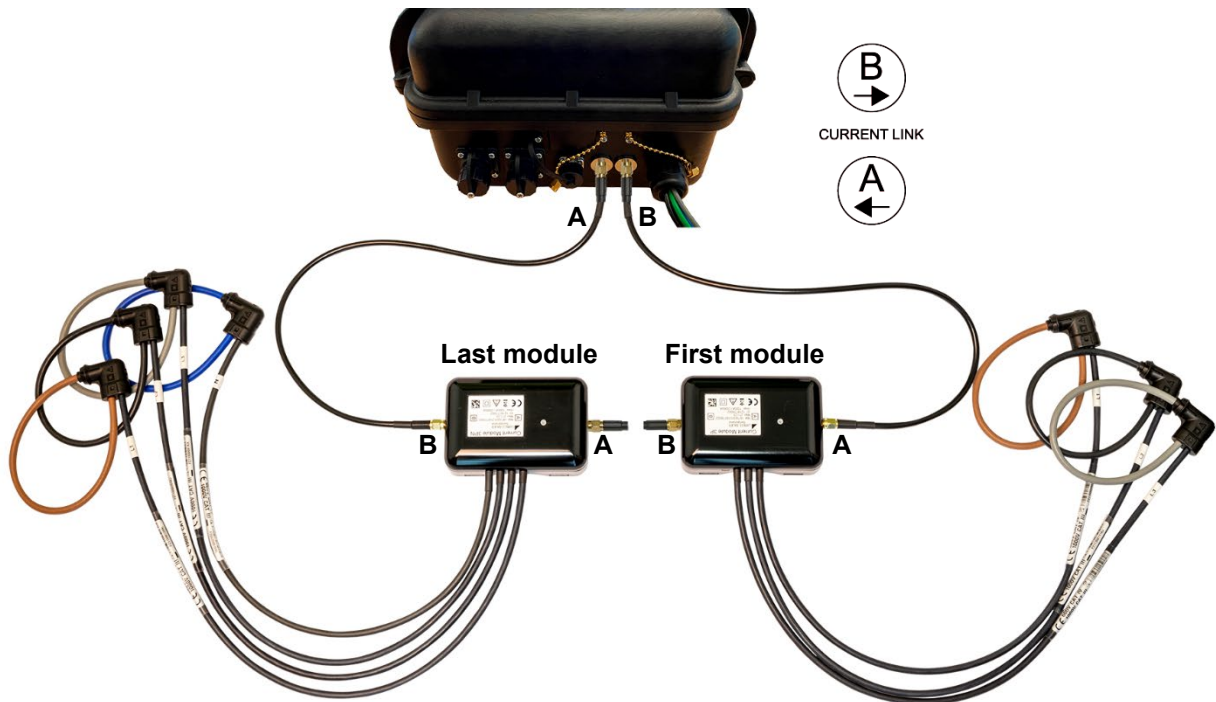
Connection of the modules to each other and to the base unit

Connector B is always connected *to connector A*. Starting from connector B of the base unit, connector A of the 1st module (CM1) is connected, then connector B of the 1st module is connected to connector A of the 2nd module (CM2) and so on, until finally connector B of the last module is connected back to connector A of the base unit.

Mounting of the junction box

The connection housing of a current module can be fixed directly to a cable using cable ties.

	The junction box of a current module must not be mounted on bare conductors, nor must connecting cables be routed over bare live conductors. If there are bare connections or busbars in the immediate vicinity, the junction box and connecting cables must be secured in such a way that their metal parts cannot touch live, bare parts in the event that the fixing of the junction box or a connecting cable becomes detached unexpectedly.

6.4 Operating LED of the Current Module 3P / 3PN
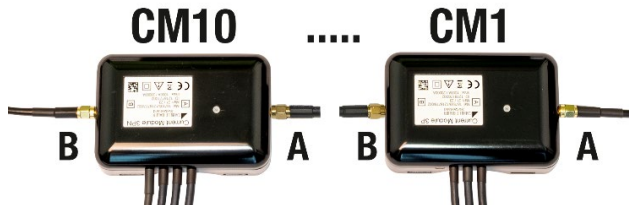
Each Current Module shows its state by means of a color status LED.

LED	Color	State
ON	Red	Error: FIFO overflow / underrun
	Yellow	Link not active, no error
	Green	Link active, no error
	Blue	Firmware update is running
OFF	-	Current Link not closed, missing supply

As long as the current module is not initialized, the LED is sequentially driven in a way that first the brightness is slowly increased and then abruptly switched dark. As soon as the module is initialized, the brightness is slowly increased and then slowly decreased.

6.5 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.

> ℹ️ Time synchronization via NTP or GPS is an elementary requirement for class A power quality measuring devices. Only with a correct time reference is it possible to evaluate the power quality and analyze disruptions in the network.

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 ø71.6mm

- Thread length max. 8mm. Using longer screws may damage the GPS receiver.
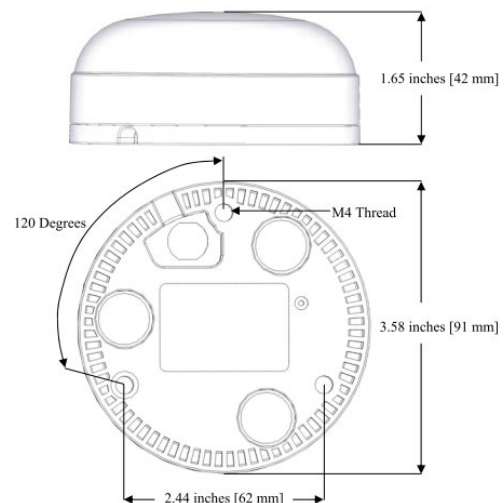
Connecting the GPS receiver

> ⚠ 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 5 m. It may be extended 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

- 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.

> ℹ 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.

6.6 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.

> ⚠ Connect the power adapter only to a power outlet with a professionally installed protective earth conductor.

7. Performing the measurement

To make the final evaluation and conformity assessment of the data much easier, the measurement should be carried out as follows:

a) Data recording should only be started when…

- The coorect connection of the device has been checked
- The configuration for the current measurement location and all measuring points is complete and correct
- This configuration has been saved and activated in the base unit
- Data of previous measurement campaigns (e.g. meter contents) are reset, if required

b) Data recording should be stopped at the end of the measurement

7.1 Device start

POWER

The device has no power switch. As soon as the device is powered via the power adapter, the POWER-LED starts flashing. When the POWER LED is permanently ON the startup procedure is finished.

7.2 Installation check

The correct connection of the current and voltage inputs can be checked via the menu "Instantaneous values" in two ways.

a) **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..

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

Stromschiene UG [1228613006]

	L1	L2	L3	PEN	SYS
ULN	235.74 V	234.93 V	236.00 V	0.140 V	-
φ(U)	0 °	240.06 °	120.16 °	-	-
ULL	407.48 V	407.61 V	408.67 V	-	-
I	0.480 A	0.920 A	0.900 A	0.870 A	-
φ(I)	21.3 °	4.2 °	27.2 °	-	-
P	0.070 kW	0.160 kW	0.180 kW	-	0.400 kW
Q	0.090 kvar	0.150 kvar	0.120 kvar	-	0.350 kvar
Q(H1)	0.030 kvar	0.010 kvar	0.090 kvar	-	0.130 kvar
S	0.110 kVA	0.220 kVA	0.210 kVA	-	0.540 kVA
F	-	-	-	-	50.007 Hz

Imbalance

	pos	neg	zero	neg/pos
U	0.601V	0.230V	0.065V	38.37%
I	46.314A	9.640A	0.724A	20.81%

Possible results

Correct sense of rotation
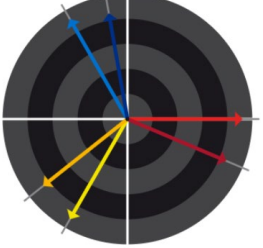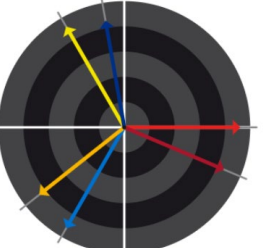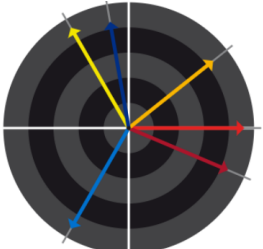
Wrong sense of rotation

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 colors of the phasors may differ from the colors shown below.

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

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

Correct installation (expectation)
- Voltage sequence in clock-wise order
  L1 → L2 → L3 (0° → -120° → 120°)
- Current sequence in clock-wise order
  L1 → L2 → L3
- Similar angle between voltage and current phasors in all phases (approx. -20°)

L1	L2	L3	
230.58	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

What's wrong?
- 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

Required correction
Reversing the polarity of current I_2

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

What's wrong?
- Voltage sequence: L1→ L3 → L2; L3 and L2 seems 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

Required correction
Exchanging the connections of the voltages L2 and L3

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

What's wrong?
- 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

Required correction
Exchanging the connections of the voltages L2 and L3 and reversing the polarity of the current input I_2

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

What's wrong?
- 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

Required correction
Cyclical exchange of the voltage connections: L1→L3, L2→L1, L3→L2. As an alternative the sequence of all currents may be changed as well (more effort required).

7.3 Measurement data reset

The device can store data of up to 20 measurement locations. If measurement locations are replaced, i.e. new configurations are loaded into the device, data belonging to the old configurationen can no longer be evaluated correctly and should therefore be deleted. However, data cannot be deleted for individual configurations, only as a whole.

The meter logger provides regular meter readings to analyze the energy consumption over time. It can make sense to delete the meter contents at the beginning of the measurement in order to be able to assume defined initial values.

- **Meter contents** can be individually set or reset via service menu

- **Recorded measurement data** can be deleted as a whole via service menu

> ⓘ **When deleting the logger data, all recorded data of previous measurement campaigns is deleted, there is no differentiation to individual configurations.**
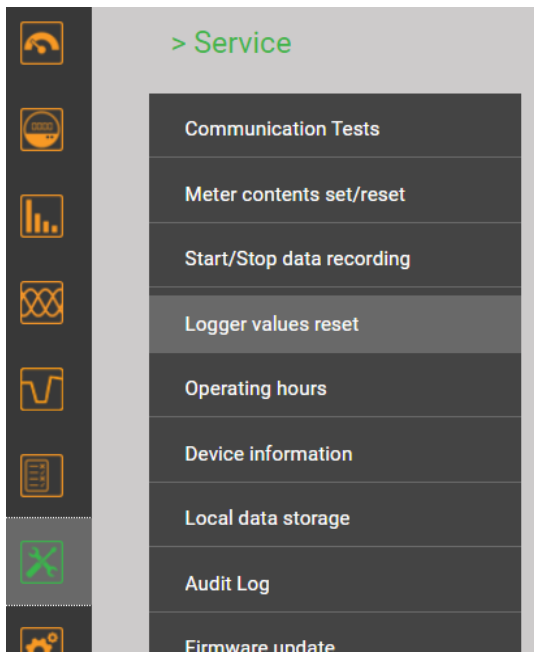
7.4 Start / stop data recording

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

> There is a delay when starting and stopping data recording until this state change completes. During this delay the local LED associated to the RECORD button flashes and a corresponding status window is displayed via device website.
>
> **Do not switch off the device during this change of the recording status to prevent data loss!**

RECORD
Using the button RECORD the recording can be started and stopped. Recording is active if the associated LED is ON and stopped if the LED is OFF.
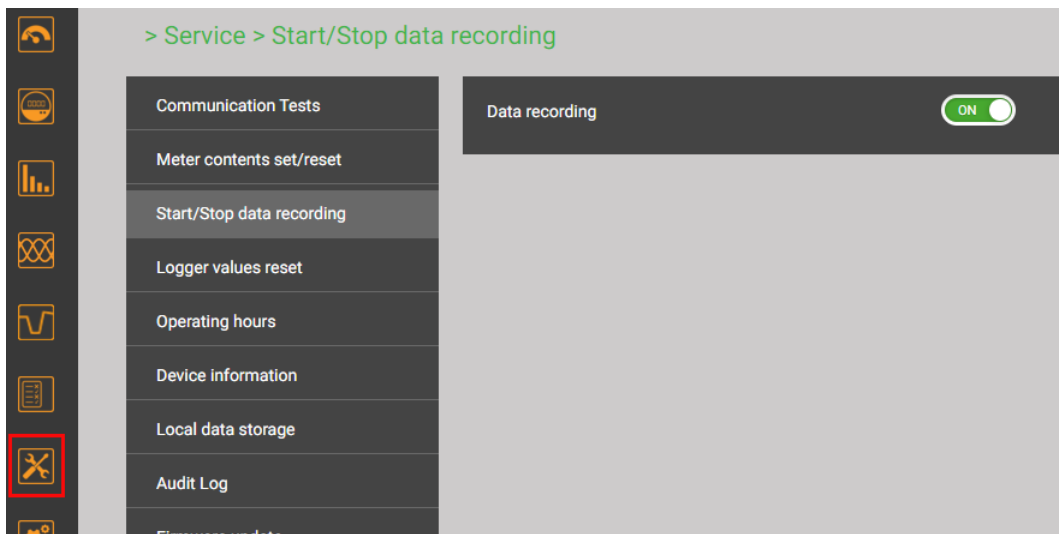
Start / Stop of data recording via the service menu

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 then be visible and can be assessed.
>
> **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

Via Configuration manager the recorded time ranges for each configuration may be displayed:

Group	Data type	Request	
Periodic data	• Time series of mean-values and meter readings	Energy	• Mean value logger • Meter logger
Security events	• Security log (Audit log)	Service	• Log of the security system
PQ events	The occurrence of PQ events will be registered in the PQ event list. By selecting the entries for voltage events: • the course of the RMS values of all U/I • the wave shape of the voltages during the disturbance will be displayed	Events	• PQ events and mains signalling
PQ statistic	For the active configuration a conformity assessment to the preset PQ standard can be made. In addition, daily trends of the monitored PQ variables can be displayed. By means of the PQ-Easy Report, conformity reports can be created directly via website.	Statistic	

Data export as CSV file

In some data visualizations an export as CSV file (Comma Separated Value) can be made.

For courses of measurements (e.g. meter contents) the time range of the data to export can be selected. For event lists the last 250 events are stored.

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

Data for all quantities of the corresponding group are stored in the same file.

8.1.1 Periodical data

Display of mean-value time series
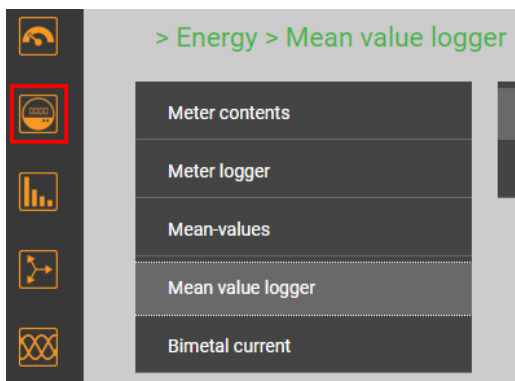
Selection of the mean value group
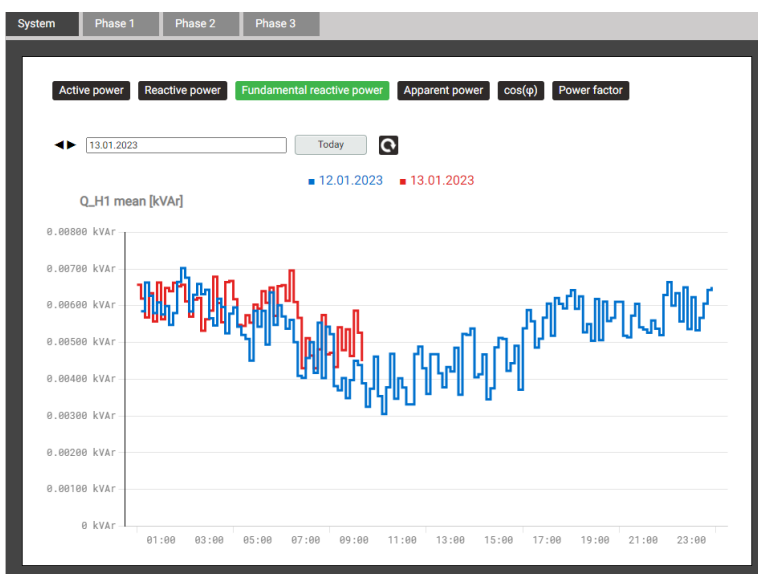
The measured quantity to display can be selected via the corresponding register.

The graphical representation allows a direct comparision with the values of the previous day.

The representation supports time zoom and curve readings.

Displaying the chronology of meter contents

Meter readings are available via the menu **Energy**

Meter content readings in table form

8.1.2 PQ events

Power quality events are entered in the PQ event list with time of occurrence, event duration and further characteristical values (such as the remaining voltage). Mains signaling events are saved in a separate list. By selecting a list entry, the graphical display of the measured values during this event is entered. The following represntations are available:

- Half-cycle RMS values of all voltages and the currents of a selectable current module
- Waveform (samples) of all voltages

List of PQ events

Graphical display of a PQ event (half cycle values), Current module may be selected

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.
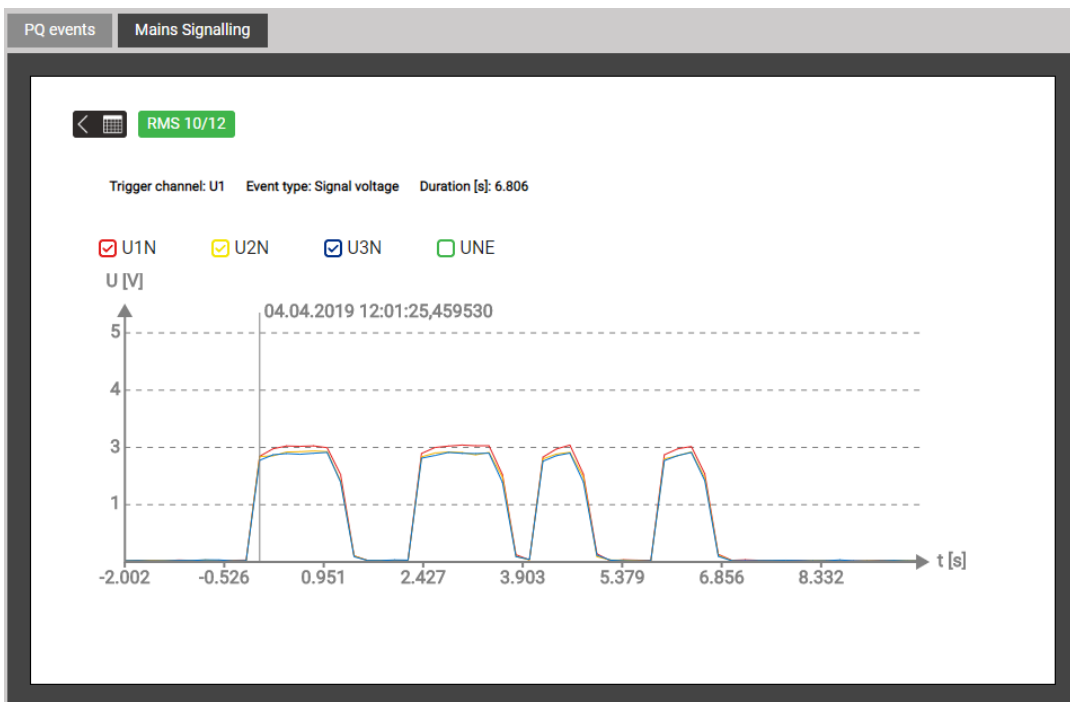
Recognized sequence on the ripple control frequency

8.1.3 PQ statistic

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

- PQ statistic overview of the monitored criteria (4.4.2)
- 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:
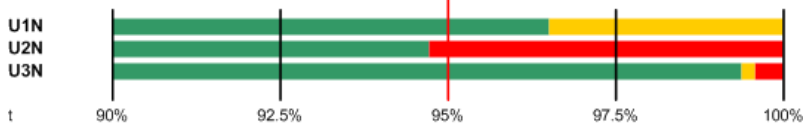
- Limit to be respected is marked with a red line (95% of the time range)
- U1N: Requirement fulfilled, because green bar > 95%
- U2N: Requirement not fulfilled, because green bar < 95%
- U3N: Requirement fulfilled, because green bar > 95%
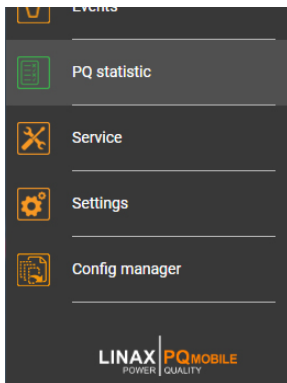
The PQ statistic overview is shown for the duration of the selected campaign, with the end time being reduced to the last full 10-min interval.
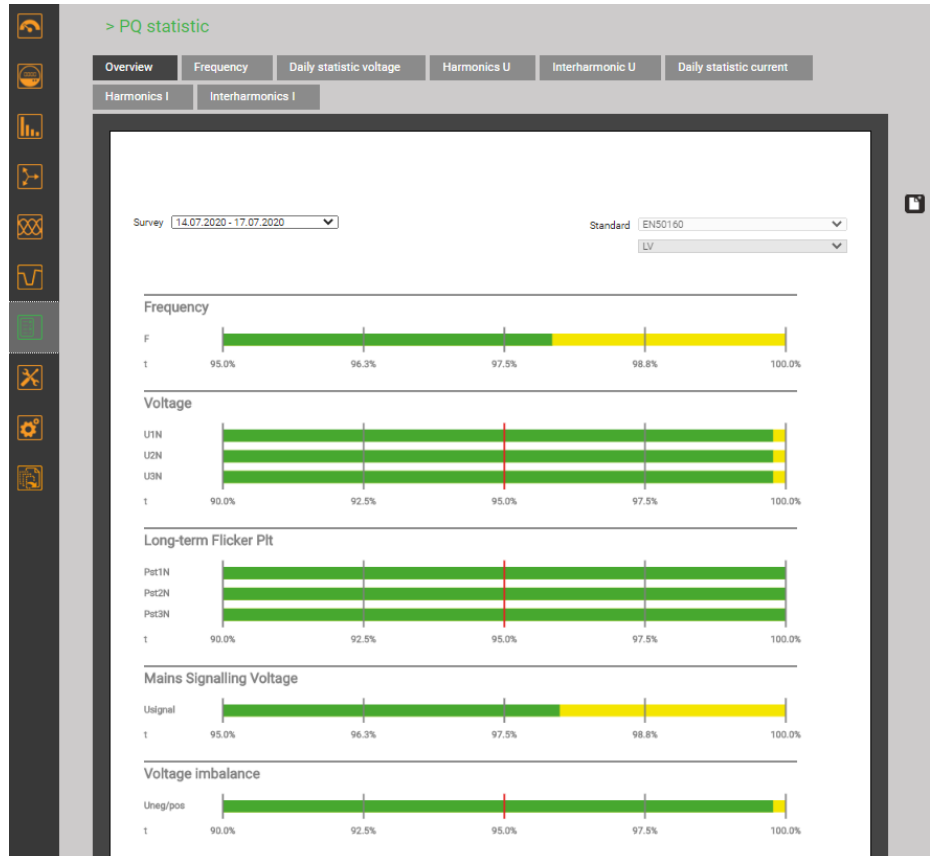
Daily trends of monitored PQ variables

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:
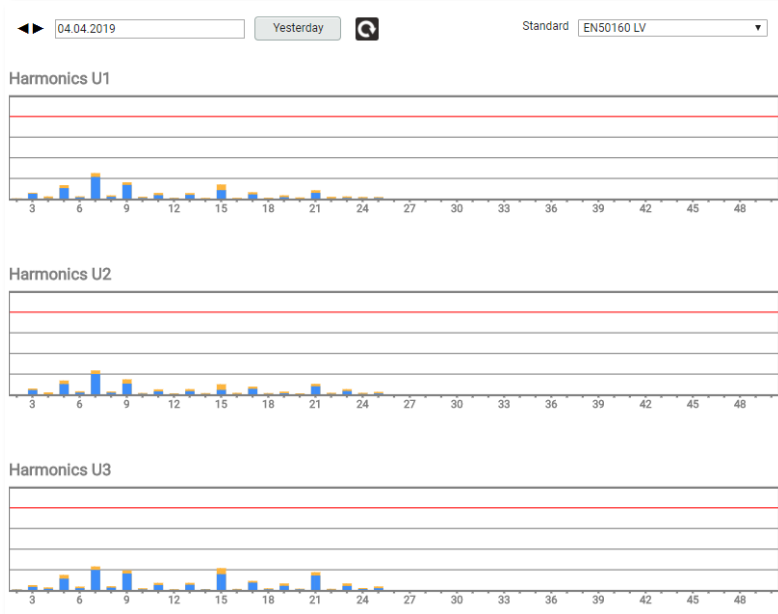
Voltage harmonics

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.
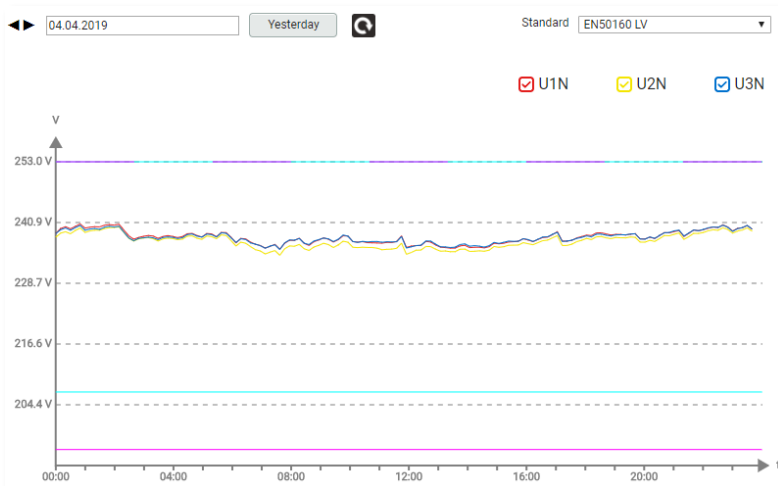
Voltage trends

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 (±10%)
- for 95% of time (+10 / -15%)
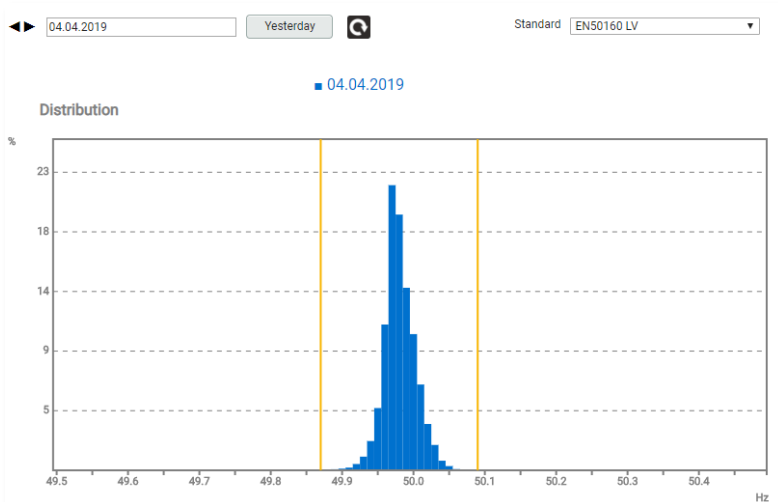
Distribution of 10-s frequency values

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.

8.1.4 PQ-Easy compliance report

Via a compliance report in PDF format can be created.
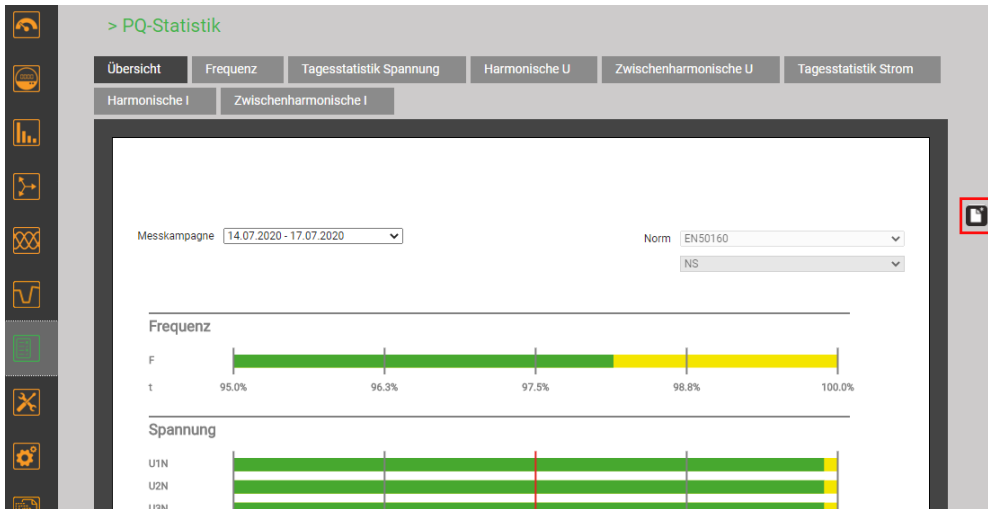
1. Select survey. Hint: Start and end time are reduced to 10-min intervals.

2. Start and end time may be modified in 10-min steps.

3. Select content of report (3 levels)

4. Optional: Enter a comment, which needs to be shown on the first page of the report

5. 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 Measurement files

Periodically, at the end of each day, the device generates CSV files with all information about the power quality, occurred events and the determined load profiles. These files can be opened and visualized directly via the website or downloaded compressed in a ZIP file for a selectable time period.

The following files will be generated:

- 10 minutes mean-values for PQ assessment
- 2 hours flicker values for PQ assessment
- 10 minutes mean-values of each current module for PQ statistic
- Mean-values (configurable interval) of power quantities of each current module for load profile analysis
- PQ event list
- Data for each PQ event:
    - Half-cycle values of voltages
    - Half-cycle values of each current module
    - Waveform (samples) of voltages
- Signalling voltage event list
- Half-cycle voltages for all signalling voltage events

Accessing file information via webpage

You can access files stored in the device using **Download csv data | Data within a range** in the service menu.
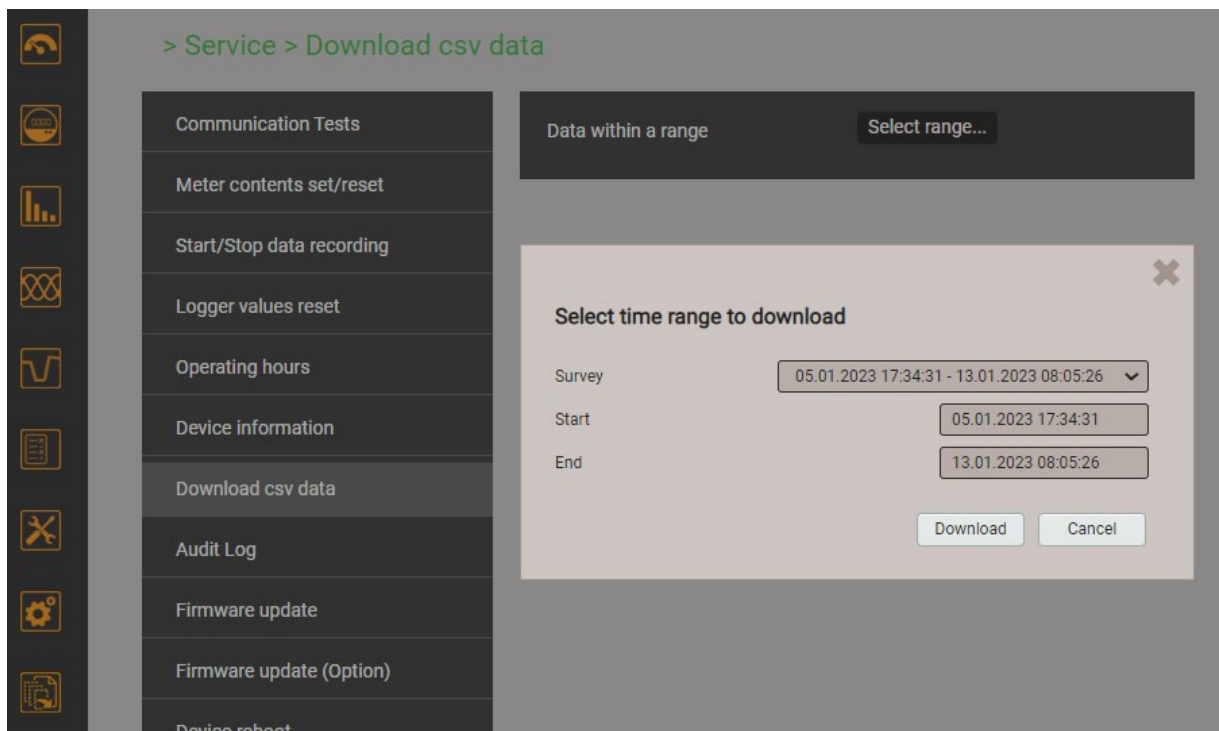
By selecting a measurement campaign, all information for the entire merasurement period can be downloaded to the local computer as a compressed ZIP file. The start and end times are automatically set, but can be changed.

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 may damage parts of 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.

A maintenance-free capacity module is installed to bridge power failures.

9.4 Disposal

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

> ⚠ Potential for Fire or Burning. Do not disassemble, crush, heat or burn the removed batteries.

10. Technical data

Measurement inputs

Voltage base unit PQ5000MOBCLM

Nominal voltage:	57,7…400 V_{LN} (UL: 347 V_{LN}), 100...693 V_{LL} (UL: 600 V_{LL});
Range maximum:	520 V_{LN}, 900 V_{LL} (sinusoidal)
Measurement category:	600V CAT III
Uncertainty:	± 0,1%
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}

Current measurement with Current Module 3P / 3PN

Nominal current range 1:	400 A (typ.), 1000 A (max.)
Nominal current range 2:	8 kA (typ.), 20 kA (max.)
Measurement category:	600V CAT IV
Uncertainty:	± 0,5% (with centered conductors and no external field)
Angle error:	± 1,0°
Design:	3 or 4 Rogowski coils
Diameter Rogowski coils:	75 or 100mm

Measurement uncertainty

Reference conditions: Acc. IEC 62586-1, ambient 23°C±1K, sinusoidal input signals, Rogowski current measurement with centered conductors and no external field

Voltage	± 0,1 %
Current	± 0,5 %
Power	± 2,0 % (typical)
Power factor	± 1,0°
Frequency	± 0,01 Hz
Active energy	Class 3 (typical)
Reactive energy	Class 3 (typical)

System:	4-wire, unbalanced
Nominal frequency:	42...<u>50</u>...58Hz
Sampling rate:	18 kHz (U), 54 kHz (I)
Internal data memory:	64 GB

Power Quality

Type of device:	(IEC 62586-1) **PQI-A FI1**: **P**ower **Q**uality **I**nstrument – Class **A**; **F**ixed installation; **I**ndoor environment with uncontrolled temperature variations (**1**)
Measurement cycle:	10 cycles at 50Hz, approx. 200ms
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

Conformity assessment against IEC 62586-2:2017

Clause	PQ parameter	Compliance 120 V- 60 Hz	Compliance 230 V – 50 Hz
6.1	Power frequency	Yes	Yes
6.2	Magnitude of the supply voltage	Yes	Yes
6.3	Flicker	Yes (class F1)	Yes (class F1)
6.4	Supply voltage interruptions, dips and swells	Yes	Yes
6.5	Supply voltage unbalance	Yes	Yes
6.6	Voltage harmonics	Yes	Yes
6.7	Voltage Interharmonics	Yes	Yes
6.8	Mains signalling voltage of the supply voltage	Yes	Yes
6.10	Flagging	Yes	Yes
6.11	Clock uncertainty testing	Yes	Yes
6.12	Variations due to external influence quantities	Yes	Yes
6.13	Rapid voltage changes (RVC)	Yes	Yes

Zero suppression, range limitations

For the current inputs a start-up current can be defined. If the measured current is below this value, it is suppressed, i.e. set to zero. Any derived quantity, like e.g. power, is then set to zero as well.

Power supply	via power adapter
Rated voltage:	100 … 240V AC, 300V OVC IV
Secondary:	24V DC, 1.2 A
Frequency:	47 … 63 Hz

Uninterruptible power supply (UPS)	
Bridge time:	≥30s
Technology:	Maintenance-free double layer capacitors

Communication

Ethernet	via RJ45 socket
Protocol:	Modbus/TCP, NTP, http, https, IPv4, IPv6
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 AT BE CY CZ DK EE FI FR RU
DE GR HU IE IT LV LT LU MT NL PL PT UA
SK SI ES SE GB IS LI NO CH BG RO TR

C€ FC ☑ N20379 PCT AЯ46

Internal clock (RTC)

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

> ℹ️ Time synchronization via NTP or GPS is an elementary requirement for class A power quality measuring devices. Only with a correct time reference is it possible to evaluate the power quality and analyze disruptions in the network.

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

The current inputs are galvanically isolated from each other

Protection class:	II (protective insulation, voltage inputs via protective impedance)
Pollution degree:	2
Protection base unit:	IP65 (with housing cover closed)
Protection Rogoski:	IP67
Protection Current Module:	IP43

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
EN 50160	Voltage characteristics of electricity supplied by public distribution systems
DIN 40110	AC quantities
IEC/EN 60068-2-1/	Ambient tests
-2/-3/-6/-27:	-1 Cold, -2 Dry heat, -3 Damp heat, -6 Vibration, -27 Shock
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
IEC/EN 60529	Protection type by case
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

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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-0003.

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.

# 11. Dimensional drawings

L x B x H: 360 x 304 x 194 [mm]

Annex

A Description of measured quantities

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 been 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.
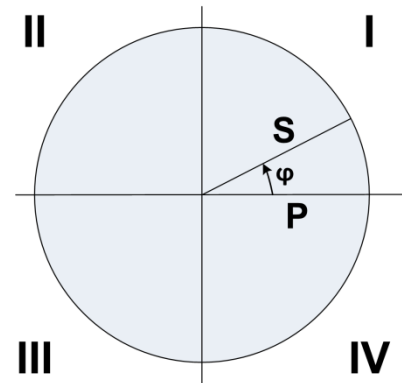
A1 Basic measurements

The basic measured quantities are calculated each 200ms by determining an average over 10 cycles at 50Hz.

Voltages of the base unit

Measurement
Voltage U_{1N}
Voltage U_{2N}
Voltage U_{3N}
Voltage U_{12}
Voltage U_{23}
Voltage U_{31}
Voltage U_{NE}
Phase angle between U1 and U2
Phase angle between U2 and U3
Phase angle between U3 and U1

In addition for each current module

Measurement
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
Total reactive power Q
Total reactive power Q1
Total reactive power Q2
Total reactive power Q3
Fundamental reactive power Q(H1)
Fundamental reactive power Q(H1) L1
Fundamental reactive power Q(H1) L2
Fundamental reactive power Q(H1) L3
Apparent power S
Apparent power S1
Apparent power S2
Apparent power S3
Frequency F
Power factor PF
Power factor PF1
Power factor PF2
Power factor PF3
cosφ (H1)
cosφ (H1) L1
cosφ (H1) L2
cosφ (H1) L3
Angle between U1 and I1
Angle between U2 and I2
Angle between U3 and I3

A2 Harmonics and interharmonics

The harmonic analysis is performed according IEC 61000-4-7 over 10 cycles at 50Hz. The voltages of the base unit and the currents of the selectable reference channels are calculated.

Voltages of the base unit

Measurement
THD voltage U1N
THD voltage U2N
THD voltage U3N
THD voltage UNE
THD voltage U12
THD voltage U23
THD voltage U31
Harmonic contents U1N up to 50th
Harmonic contents U2N up to 50th
Harmonic contents U3N up to 50th
Harmonic contents UNE up to 50th

Measurement
Harmonic contents U12 up to 50th
Harmonic contents U23 up to 50th
Harmonic contents U31 up to 50th
Interharmonics U1N up to 50th
Interharmonics U2N up to 50th
Interharmonics U3N up to 50th
Interharmonics UNE up to 50th
Interharmonics U12 up to 50th
Interharmonics U23 up to 50th
Interharmonics U31 up to 50th

In addition for each current module

Measurement
Harmonic contents I1 up to 50th
Harmonic contents I2 up to 50th
Harmonic contents I3 up to 50th
Harmonic contents IN up to 50th
Interharmonics I1 up to 50th
Interharmonics I2 up to 50th
Interharmonics I3 up to 50th
Interharmonics IN up to 50th

Measurement
THD current I1
THD current I2
THD current I3
THD current IN
TDD current I1
TDD current I2
TDD current I3
TDD current IN

Harmonics

Harmonics are multiples of the fundamental or 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.

TDD (Total Demand Distortion)

The complete harmonic content of the currents is calculated additionally as Total Demand Distortion, briefly TDD. This value is scaled to the (configurable) maximum demand current. Only this way it's possible to estimate the influence of the current harmonics on the connected equipment correctly.

A3 System imbalance

Voltages of the base unit

Measurement	
Positive sequence UR1	[V]
Negative sequence UR2	[V]
Zero sequence U0	[V]
Imbalance UR2/UR1	[%]
Imbalance U0/UR1	[%]

In addition for each current module

Measurement	
Positive sequence IR1	[A]
Negative sequence IR2	[A]
Zero sequence I0	[A]
Imbalance IR2/IR1	[%]
Imbalance I0/IR1	[%]

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.

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%.

A4 Mean-values

The mean value calculation is performed via integration of the measured instantaneous values over a averaging interval.

Power mean-values

The avergaing interval of this group is configurable. The following mean-values will be provided for each feeder monitored via current module:

Measurement
Active power Σ
Reactive power Σ
Apparent power Σ
Power factor Σ
cosφ Σ
Active power L1
Active power L2
Active power L3
Reactive power L1
Reactive power L2

Measurement
Reactive power L3
Apparent power L1
Apparent power L2
Apparent power L3
Power factor L1
Power factor L2
Power factor L3
cosφ L1
cosφ L2
cosφ L3

10-min mean-values of the voltages of the base unit

Measurement
Voltage U_{1N}
Voltage U_{2N}
Voltage U_{3N}
Voltage U_{12}
Voltage U_{23}
Voltage U_{31}
Voltage U_{NE}

Measurement
THD U_{1N}
THD U_{2N}
THD U_{3N}
THD U_{12}
THD U_{23}
THD U_{31}
THD U_{NE}

10-min mean-values of the currents of each current module

Measurement
Current I1
Current I2
Current I3
Neutral current I_N
THD I1
THD I2

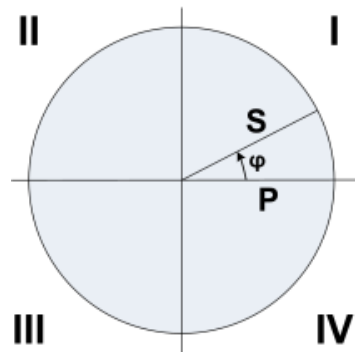| Measurement |
| --- |
| THD I3 |
| THD IN |
| TDD I1 |
| TDD I2 |
| TDD I3 |
| TDD IN |

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.

A5 Meters

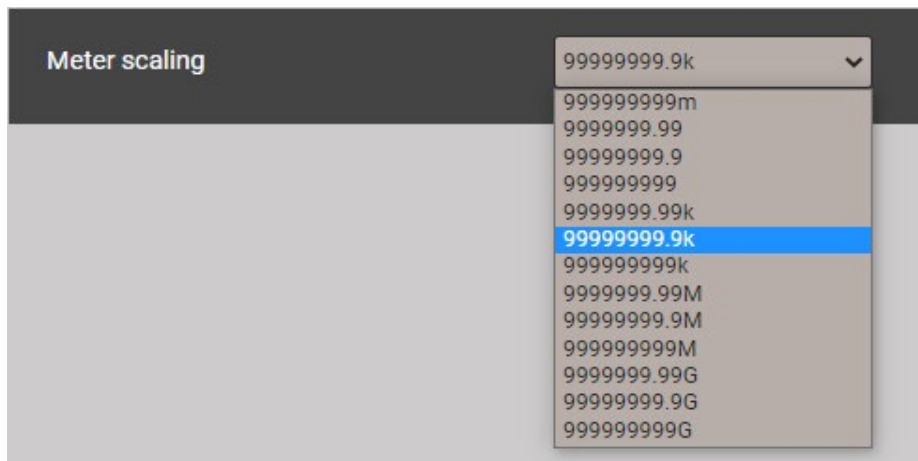The subsequent listed meter values are available for each feeder monitored by a Current Module.

Measurement	
Active energy I+IV	Σ
Active energy II+III	Σ
Reactive energy I+II	Σ
Reactive energy III+IV	Σ
Active energy I+IV	L1
Active energy I+IV	L2
Active energy I+IV	L3
Active energy II+III	L1
Active energy II+III	L2
Active energy II+III	L3
Reactive energy I+II	L1
Reactive energy I+II	L2
Reactive energy I+II	L3
Reactive energy III+IV	L1
Reactive energy III+IV	L2
Reactive energy III+IV	L3

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.

Meter scaling	99999999.9k ▾
	999999999m
	9999999.99
	99999999.9
	999999999
	9999999.99k
	99999999.9k
	999999999k
	9999999.99M
	99999999.9M
	999999999M
	9999999.99G
	99999999.9G
	999999999G

Meter readings

Meter contents are written to the meter logger in a configurable reading interval. The difference of meter readings represents the energy consumption for the associated time range.
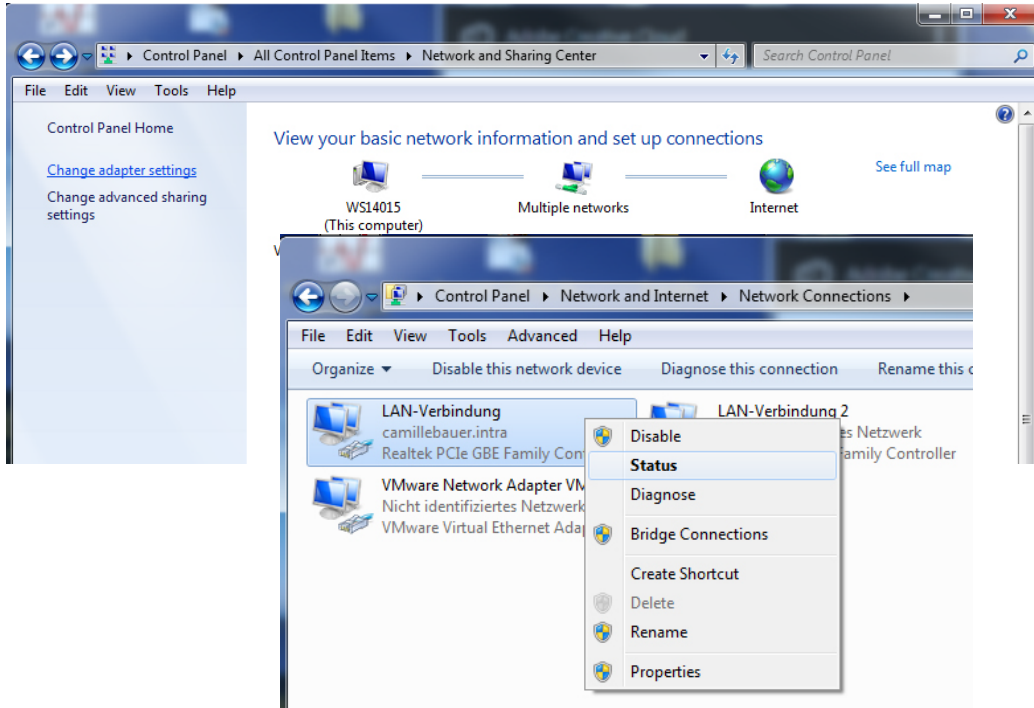
B   Network settings in Windows

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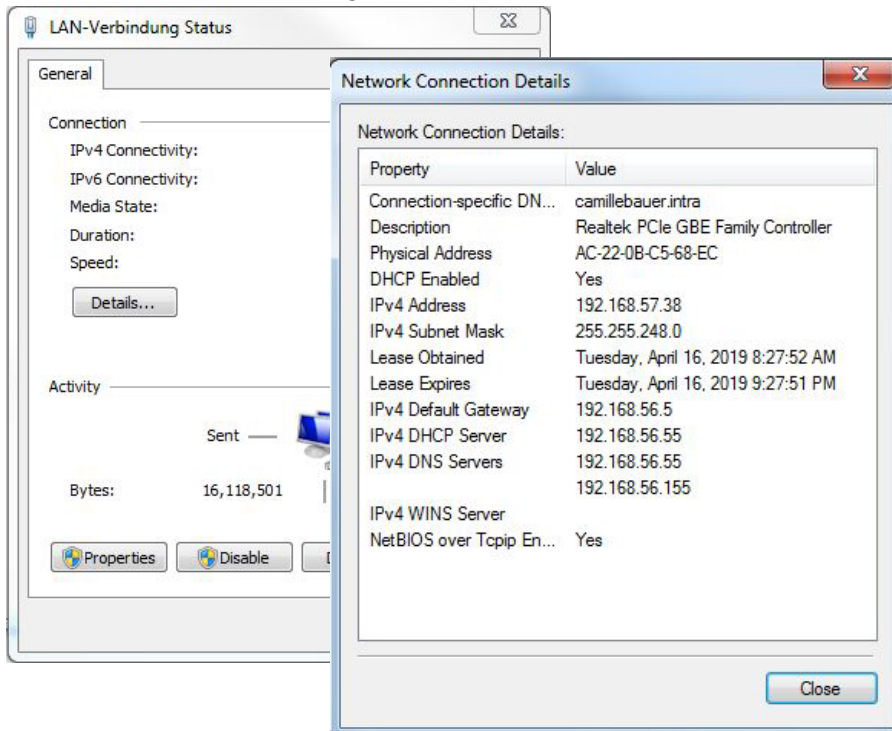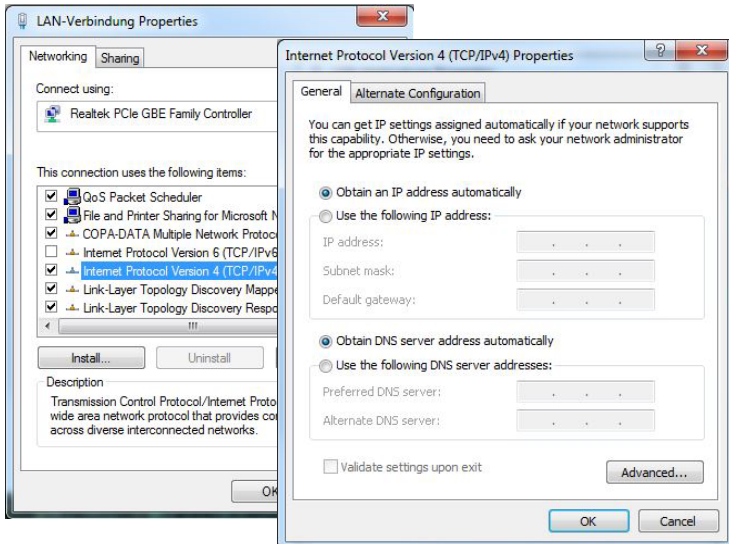
Display / change network settings

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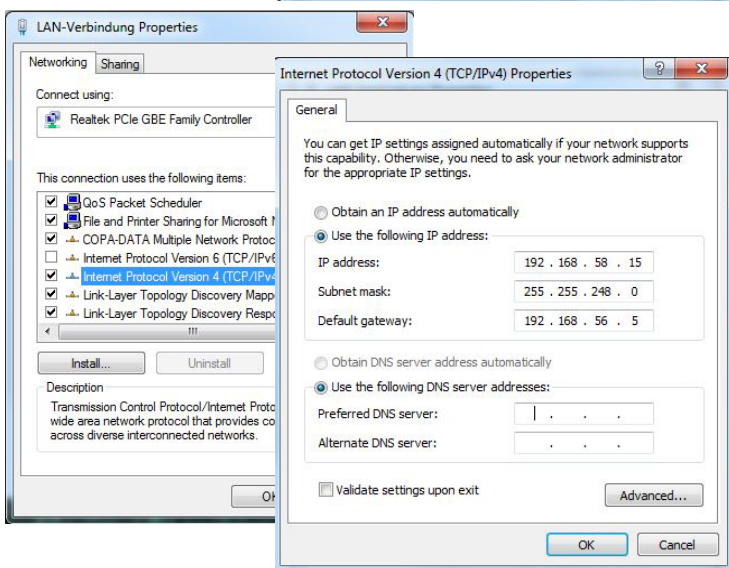
The network settings may be specified manually. Entered settings are activated after confirmation with <OK>.

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.**

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