# Measuring devices for network operation

Measurement of voltage quality in the transfer and local substation. Detection and monitoring of overcurrents, leakage currents, voltage quality, operating hours and consumption peaks with alarm center. Avoidance of service interruptions and thus increase of availability.



# Aspects of the quality of care

## Quality of care includes the areas of:

- Supply reliability
- **Voltage quality**
- Quality of service

# Aspects of the quality of care

**Network operators make a significant contribution to voltage quality by taking appropriate measures, such as:**

- Network expansion with increasing network load
- **permanent network monitoring and management**
- use of high-performance equipment and control systems
- limitation of the feedback effect of interfering customer equipment on the supply voltage

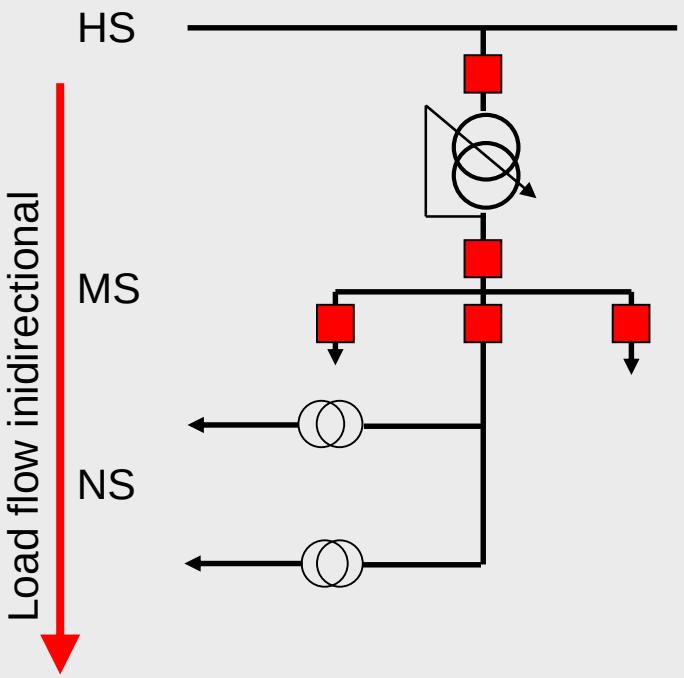
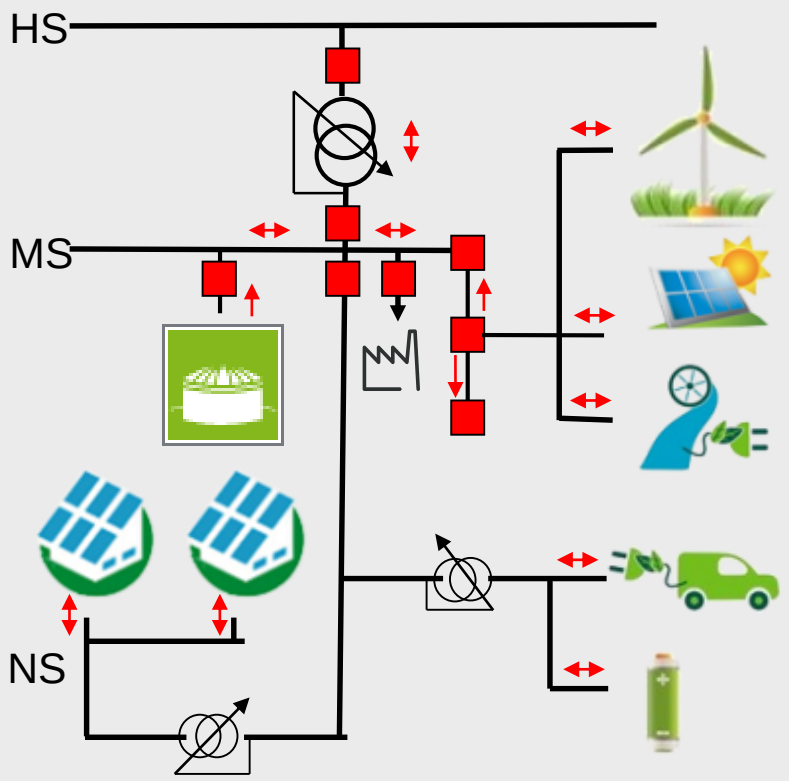
# Influencing the voltage quality

- Quality of generation
- Reactions (power electronics)
- Photovoltaics
- Wind power

The German Federal Office for the Environment, Nature Conservation, Building and Nuclear Safety writes on its homepage:

*"However, entering the age of renewables cannot work with yesterday's power grids - neither in terms of the length, capacity and location of the lines nor their technology." "The share of renewables in Germany's gross electricity consumption is expected to rise to around 80 percent by 2050. This will require a radical transformation of the entire energy infrastructure."*

# Problems in networks

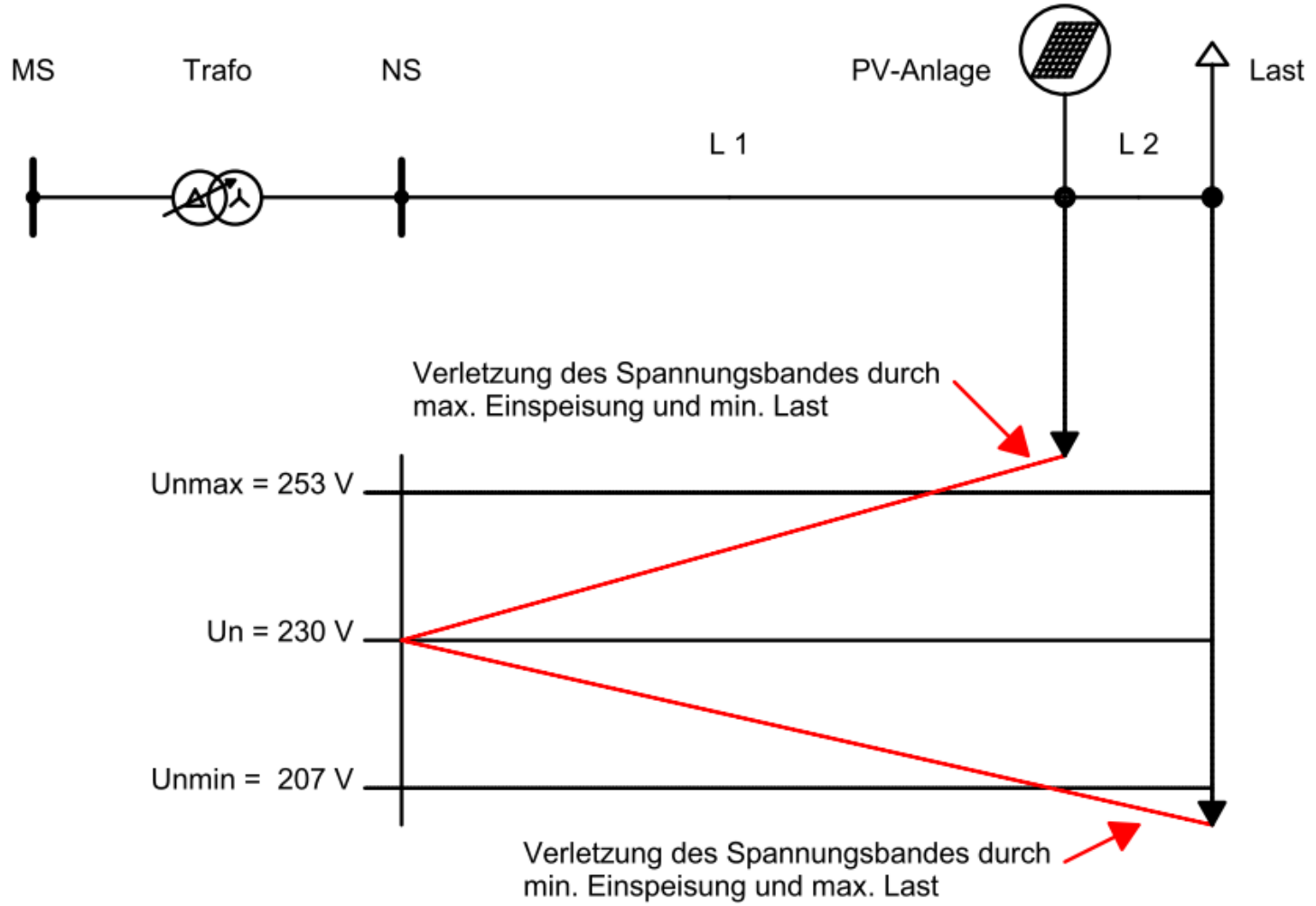
| former | today and in the future |
| --- | --- |
|  |  |



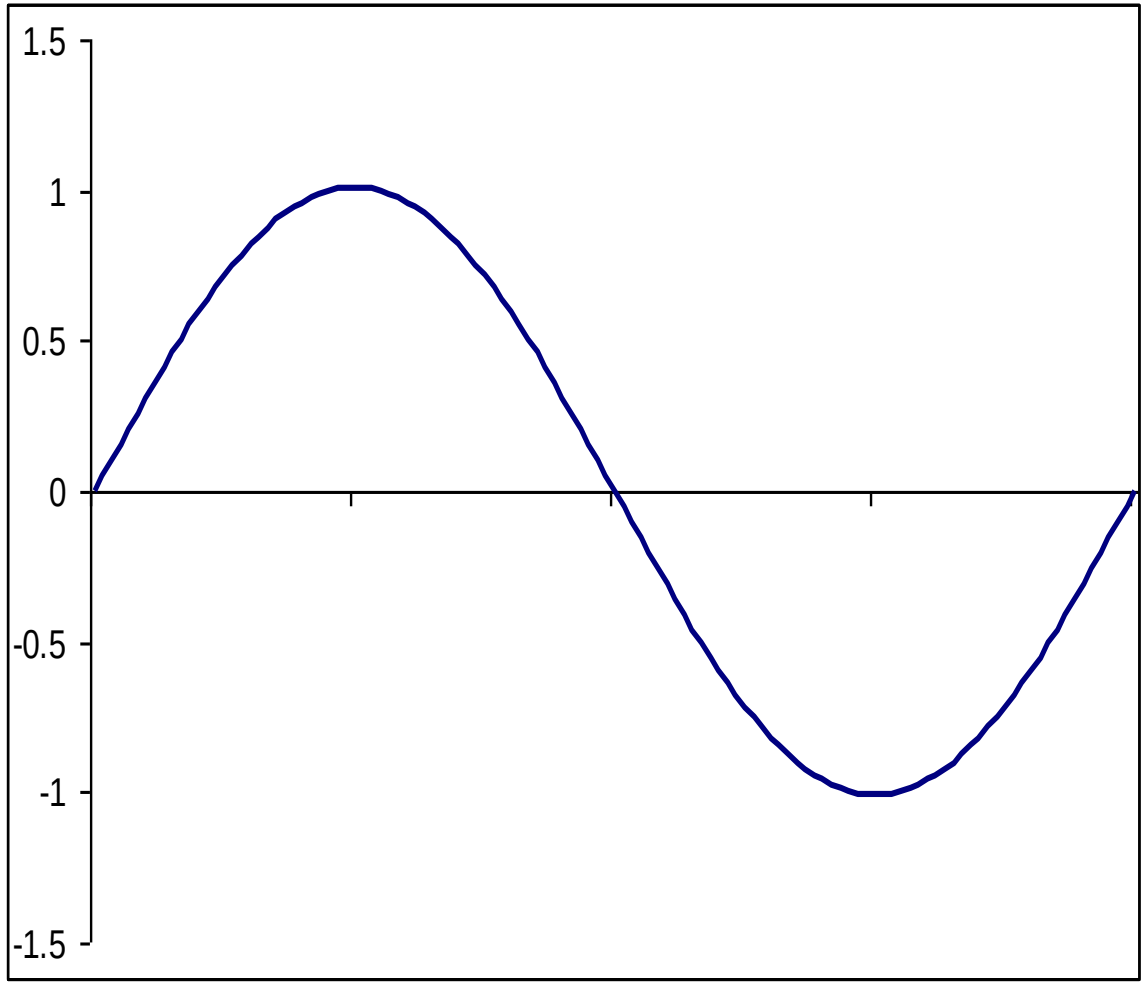


Quelle: Horstmann GmbH

# Feed-in vs. network load

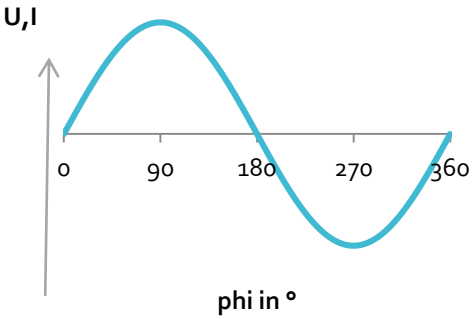


# Ideal mains voltage / sine



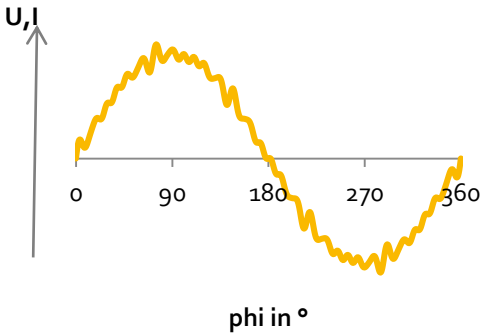
# Electric power systems in transition

Central power supply
**Linear behavior**



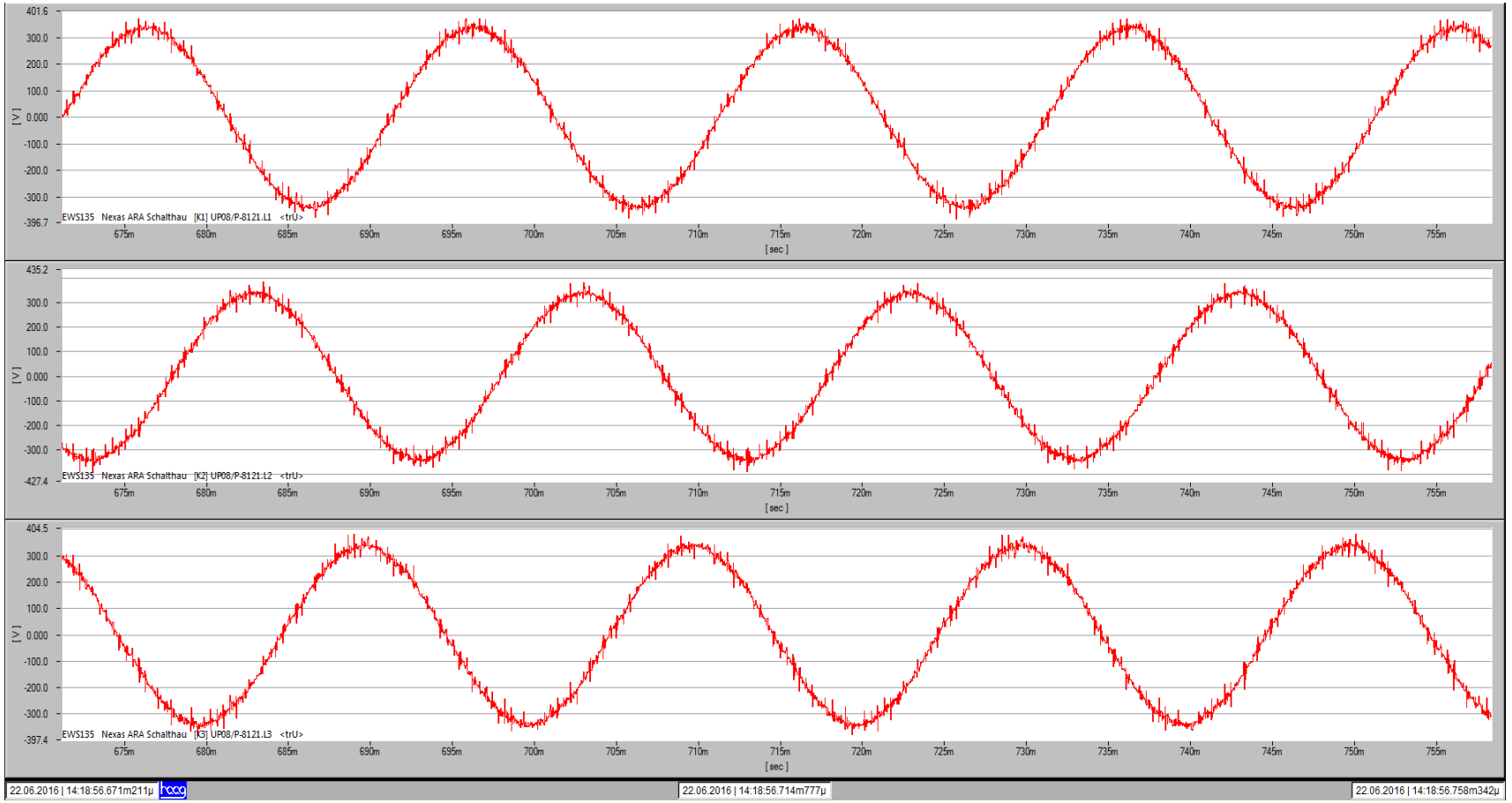

Low harmonic
Measured variables

Decentralized energy supply
**Nonlinear behavior**

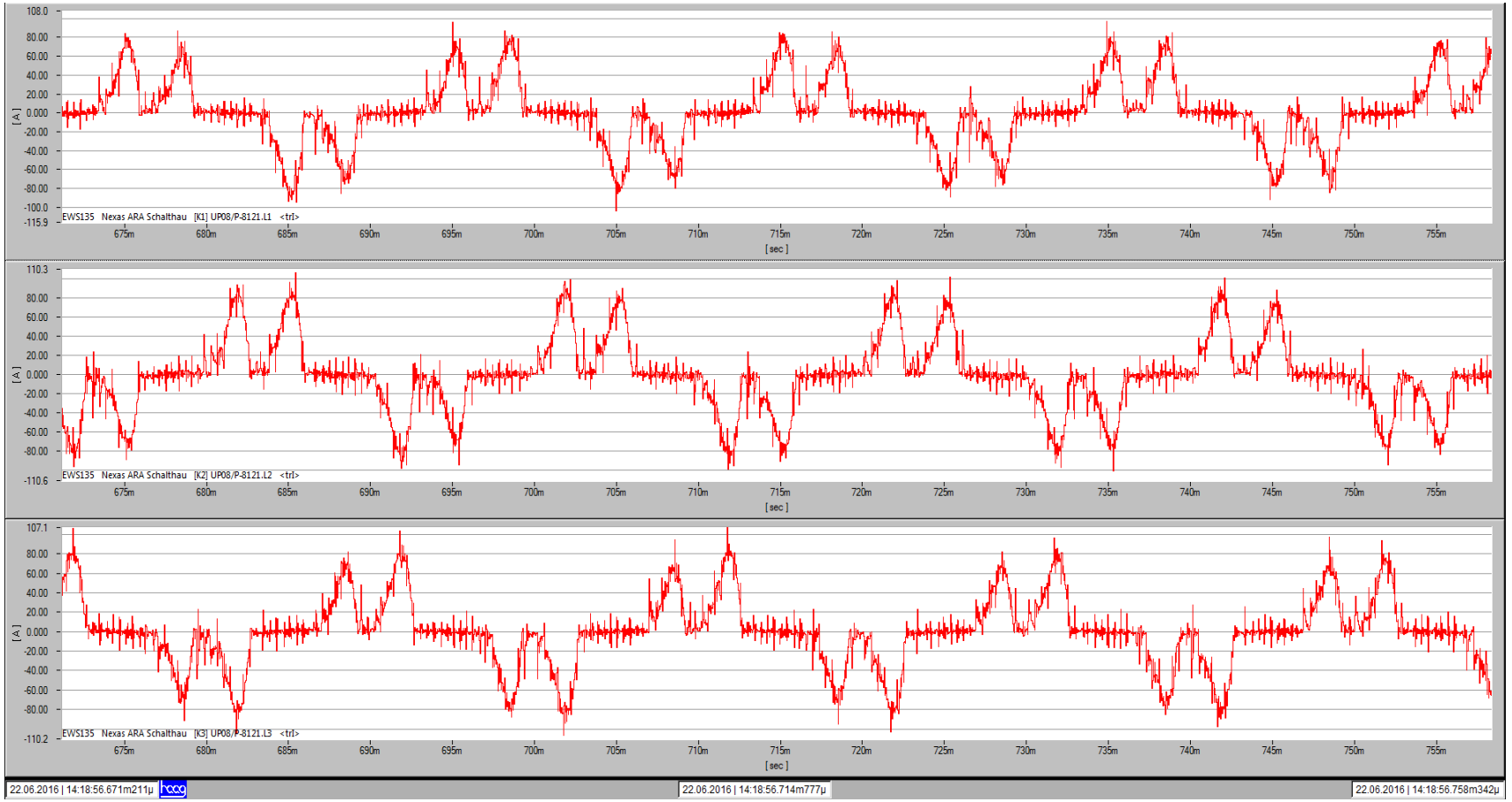



Harmonics
Measured variables

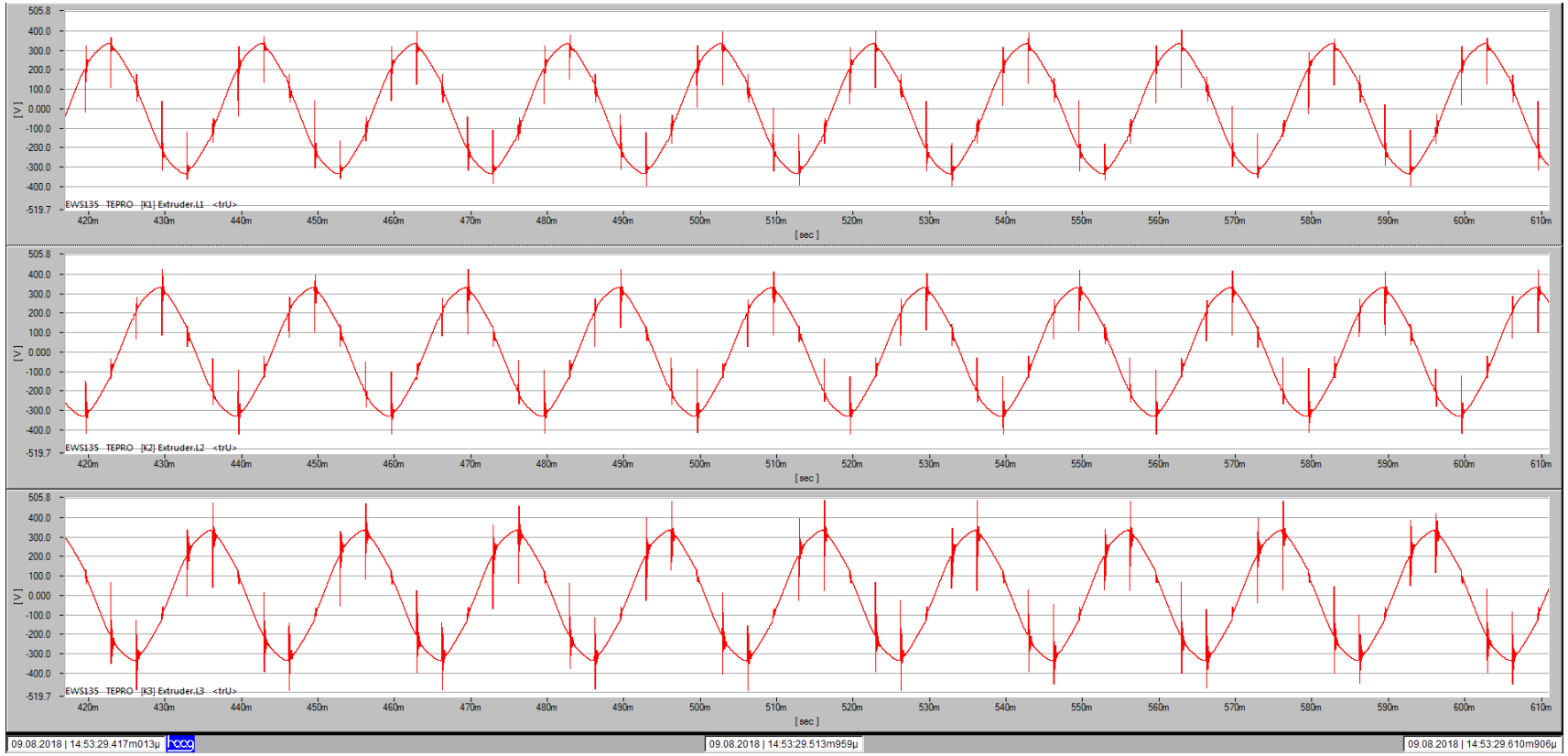
# 1. example: voltage quality today



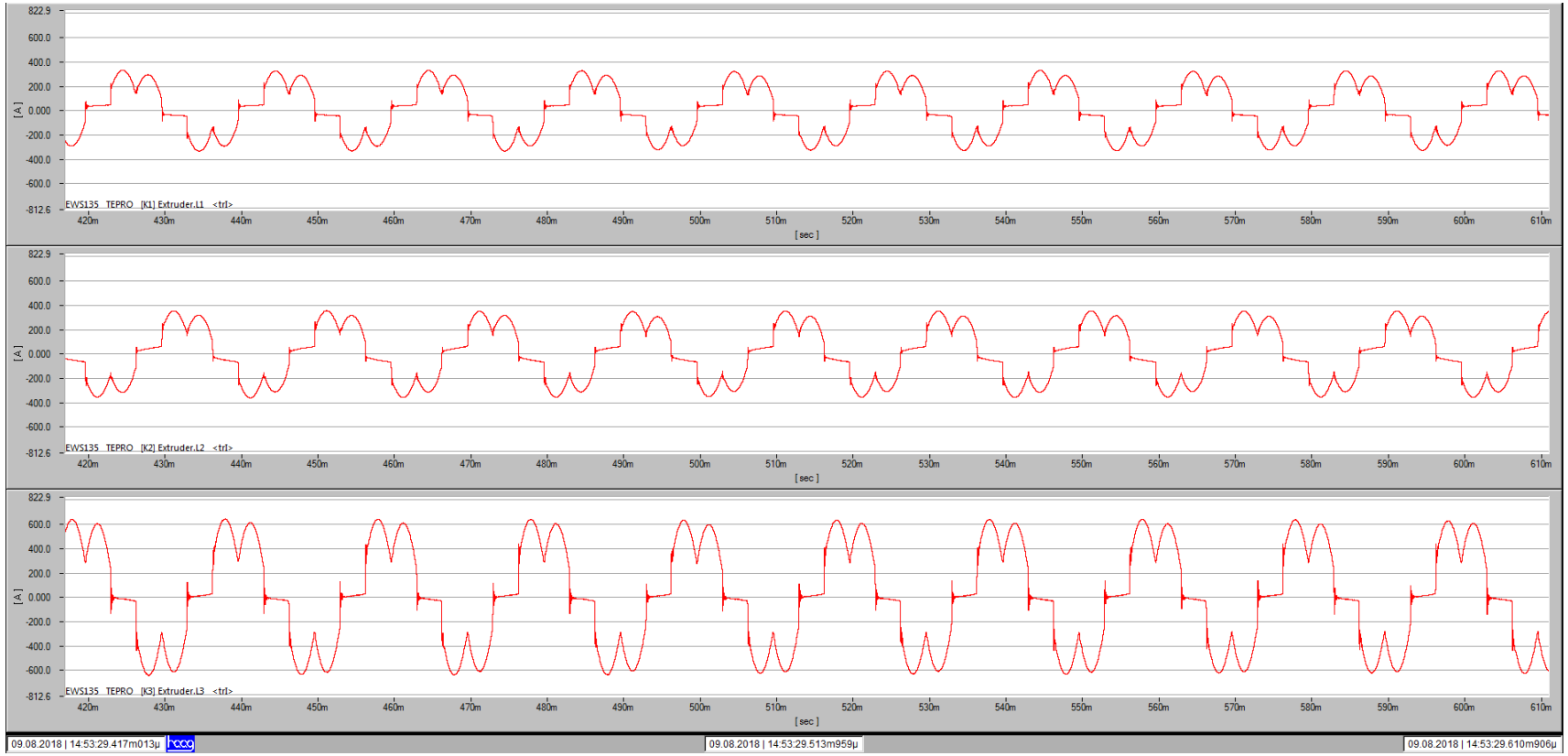
# 1. example: power quality today



# 2nd example: voltage quality today



# 2nd example: power quality today



# Power supply / voltage quality

## Avoidance of anything that deforms or shifts the sine:

- Reactive power
- Voltage dips
- Flicker
- harmonics
- high frequency disturbances

## Voltage quality means sinusoidal voltage with:

- constant frequency
- constant amplitude
- constant phase

# Problems in networks

**Example :**

- Tripping of circuit breakers or fuses
- Unusual heating of operating equipment
- Malfunctions of (electronic) equipment
- Damage to equipment
- ....

**Networks change:**

- loads & consumers
- decentralized energy supply
- standards & legal framework
- ....

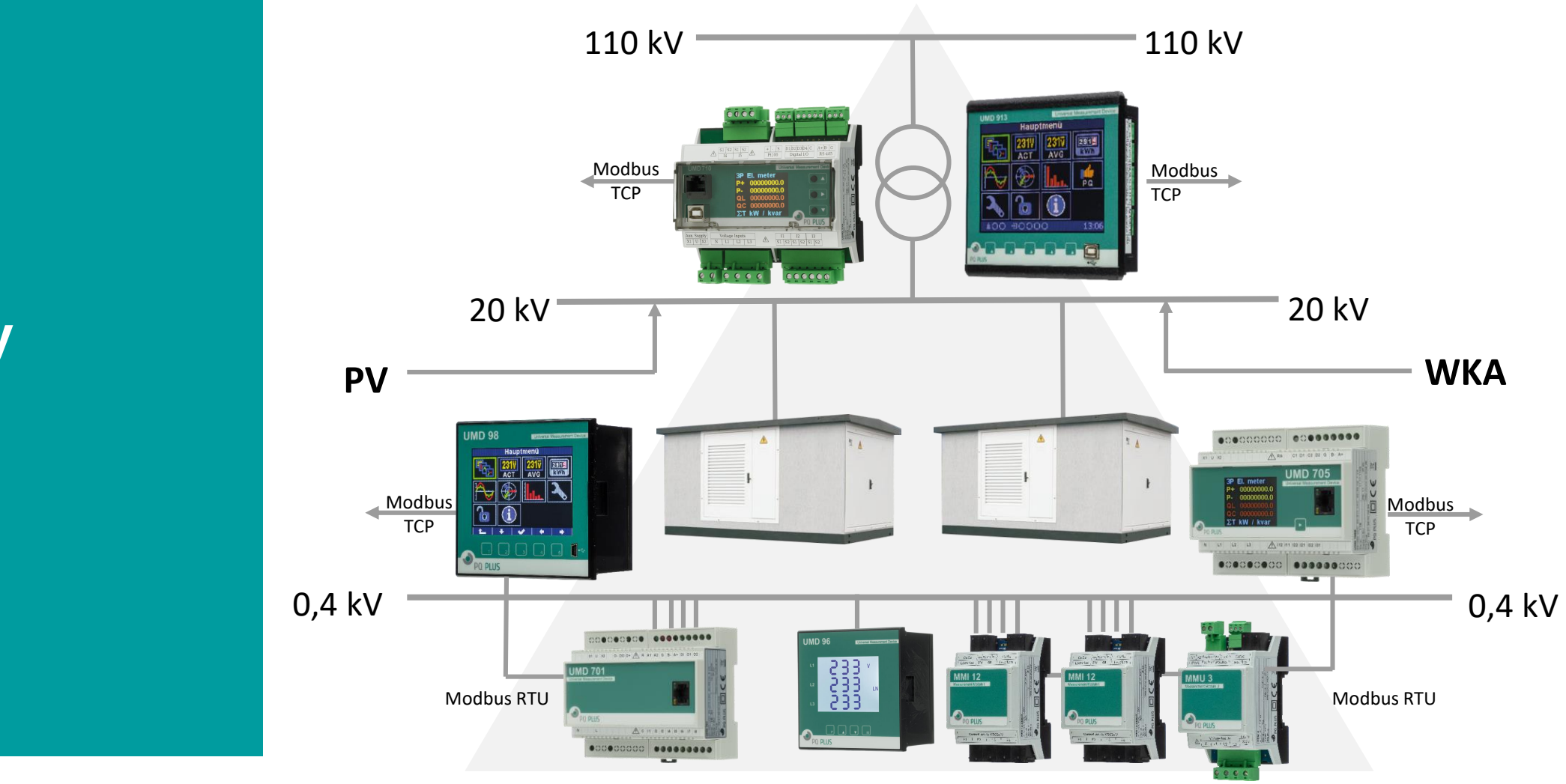
# Our solution:

- Measure
- Monitor
- Save
- Evaluate (e.g. according to EN 50160)

# EN 50160 - Features

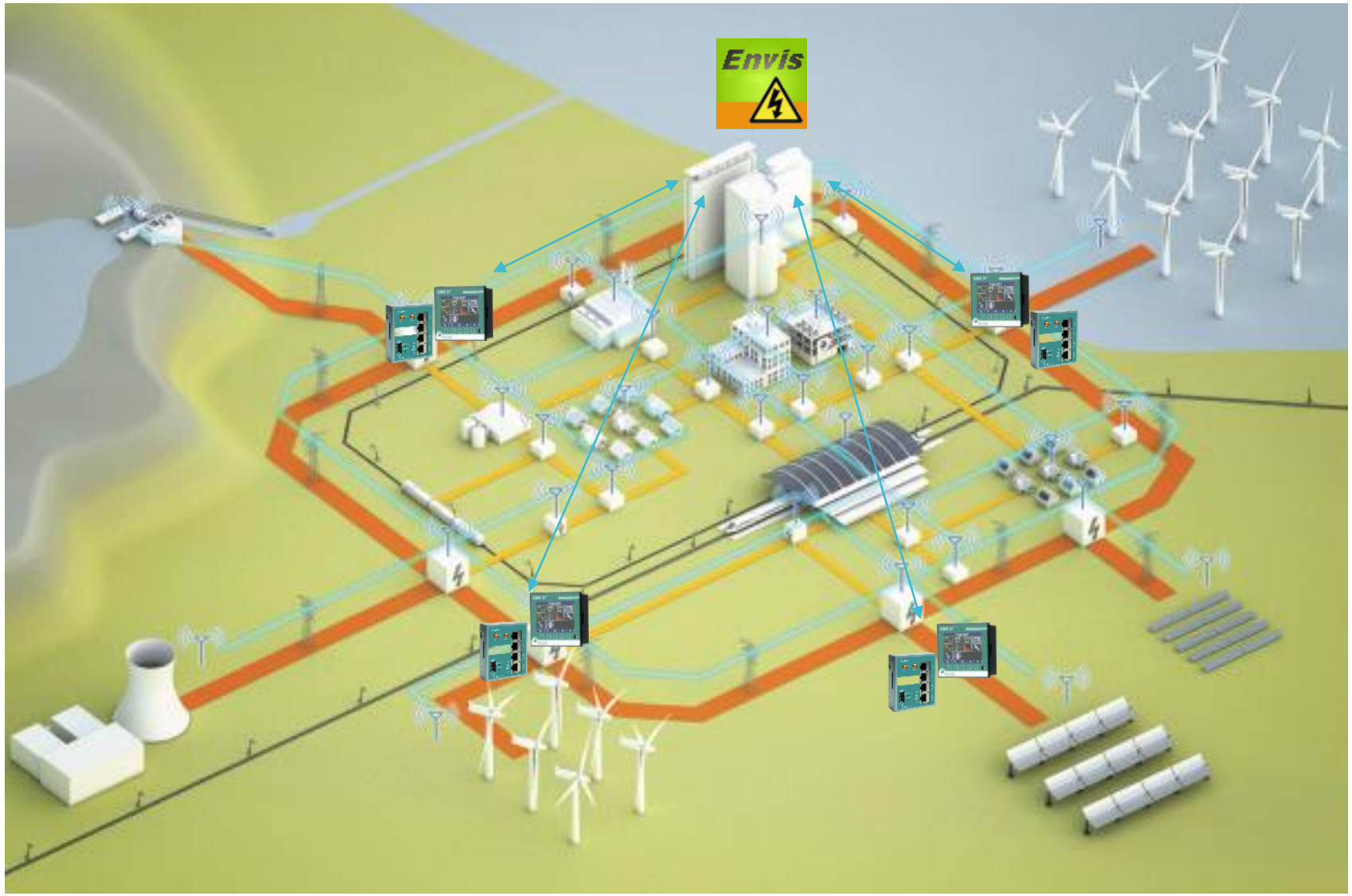
- Mains frequency
- Slow voltage changes
- Fast voltage changes
- Short interruptions
- Flicker strength
- Unbalance
- Harmonics

# Topology


110 kV
110 kV
Modbus
TCP
Modbus
TCP
20 kV
20 kV
PV
WKA
UMD 98
Modbus
TCP
UMD 705
Modbus
TCP
0,4 kV
0,4 kV
UMD 701
Modbus RTU
UMD 96
MMI 12
MMI 12
MMU 3
Modbus RTU

# Telecontrol

# Remote connection / communication



# UMD 913

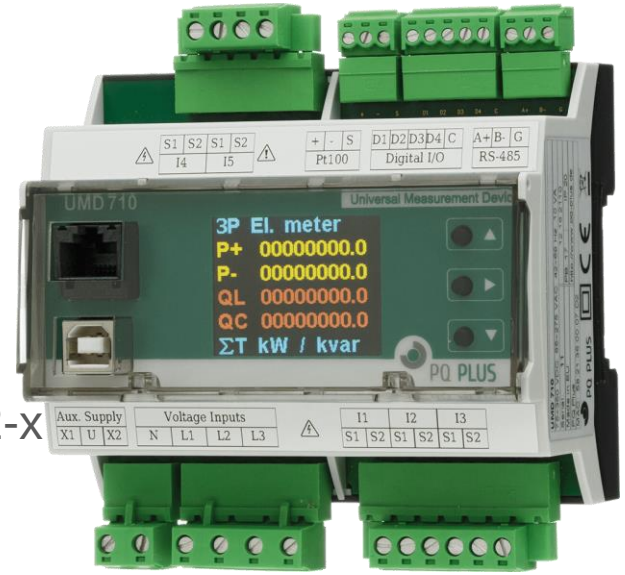
## Key Features

- 4U, 4I, 1xRCM, 1xPt100, CATIV/300V
- 4 quadrant measurement
- sampling 28.8 kHz
- UI class 0.05
- 128th harmonic / opt.: 9 kHz
- Evaluation according to EN 50160 / 61000-2-x
- 512 MB Data logger
- Ethernet, RS485, Opt.: IEC 60870-5-104

# UMD 709 / 710A

## Key Features

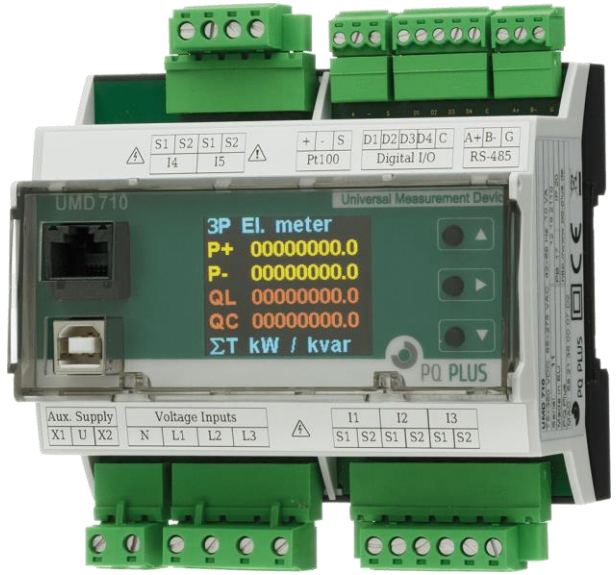
- 3U, 4I, 1xRCM, 1xPt100; CATIII/300V
- 4 quadrant measurement
- sampling 28,8 kHz
- UI class 0.05
- 128th harmonic / opt.: 9 kHz
- Evaluation according to EN 50160 / 61000-2-x
- 512 MB Data logger
- Ethernet, RS485, USB



# UMD 710EVU

## Key Features

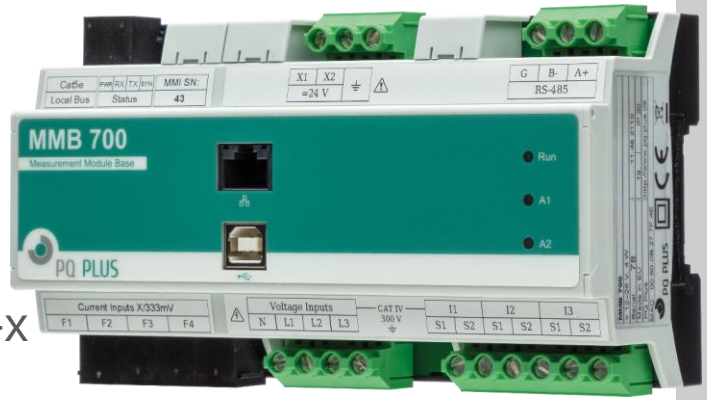
- 3U, 3I CAT IV/300 V
- 4 Quadrant measurement
- sampling 28.8 kHz
- UI class 0.05
- 128th harmonic / opt.: 9 kHz
- Evaluation according to EN 50160 Class A
- Evaluation according to EN 61000-2-x
- 512 MB Data logger
- Ethernet, RS485, Opt.: IEC60870-104



# MMB 700

## Key Features

- 3U, 15I CAT IV/300 V
- 4 quadrant measurement
- sampling 28.8 kHz
- UI class 0.2
- 128th harmonic / opt.: 9 kHz
- Evaluation according to EN 50160 / 61000-2-x
- 512 MB Data logger
- Ethernet, RS485, Opt.: IEC 60870-5-104



# UMD 97EVU

## Key Features

- 3U, 3I CAT IV/300 V
- 4 Quadrant measurement
- sampling 25.6 kHz
- UI class 0.2
- 50th harmonic
- Opt. evaluation according to EN 50160
- 512 MB Data logger
- Ethernet, RS485, USB
- Opt. Modbus Master with slave display

# UMD 97

## Key Features

- 3U, 3I CAT III/300 V
- 4 Quadrant measurement
- sampling 25.6 kHz
- UI class 0.2
- 50th harmonic
- Opt. evaluation according to EN 50160
- 512 MB Data logger
- Ethernet, RS485, USB
- Opt. Modbus Master with slave display

# UMD 705

## Key Features

- 3U, 3I CAT III/300 V
- 4 Quadrant measurement
- sampling 25.6 kHz
- UI class 0.2
- 50th harmonic
- Opt. evaluation according to EN 50160
- 512 MB Data logger
- Ethernet, RS485, USB

# UMD 98RCM-T

## Key Features

- 3U, 4I, 1x RCM, 1x Pt100 CATIII/300V
- 4 quadrant measurement
- sampling 25,6 kHz
- UI class 0.2
- 50th harmonic
- Opt. evaluation according to EN 50160
- 512 MB Data logger
- Ethernet, RS485, USB
- Opt. Modbus Master with slave display

# UMD 96

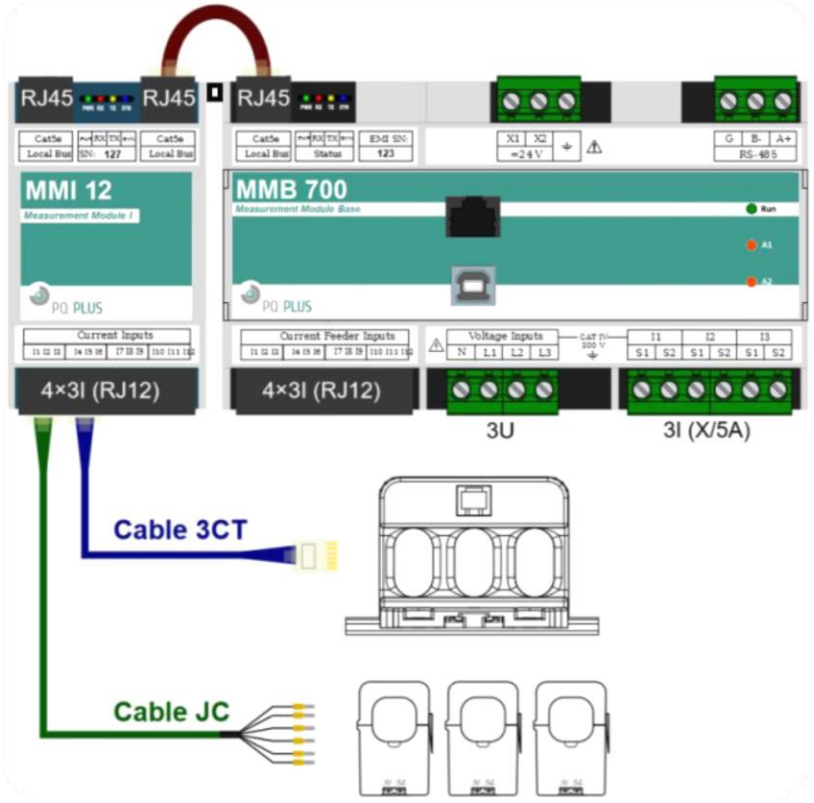
## Key Features

- 3U, 3I CAT III/300 V
- 4 Quadrant measurement
- sampling 25.6 kHz
- UI class 0.2
- 50. harmonics
- 1 Dig. inputs / 2 Dig. outputs
- Ethernet, RS485

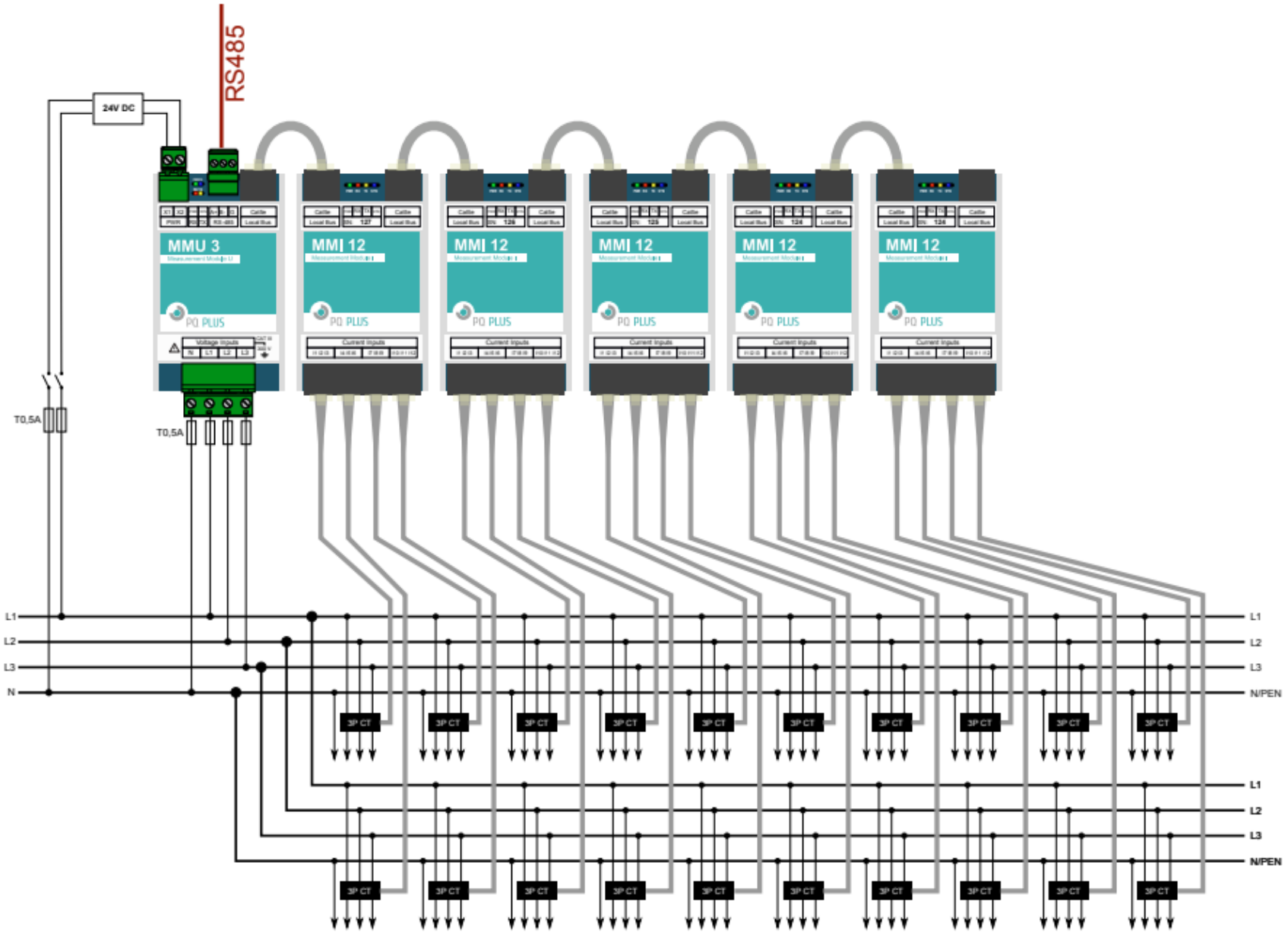
# Modular outgoing feeder measurement

## Connection example with the master MMB 700

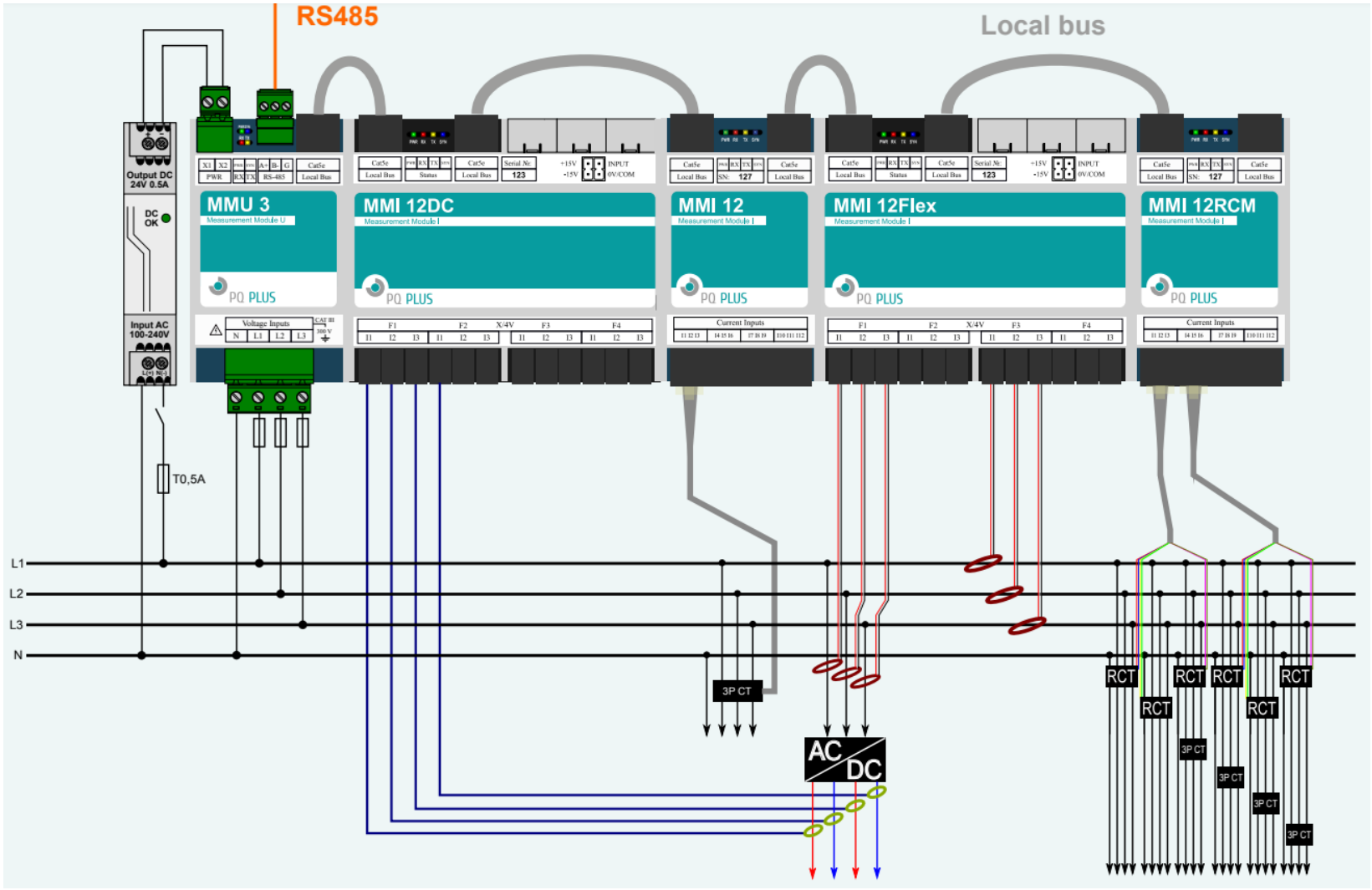
- Feeder measurement according to DIN EN 50160 class A
- Outgoing feeder measurement for up to 60 currents
- Easy installation
- Flexible use
- Space-saving feeder measurements



# Modular outgoing feeder measurement

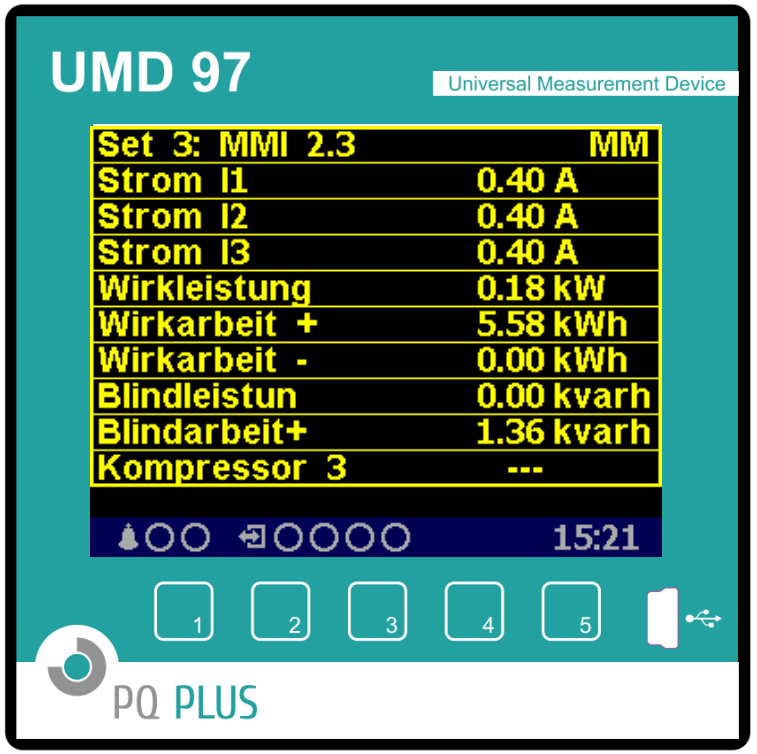


# Modular outgoing feeder measurement



# Modular outgoing feeder measurement

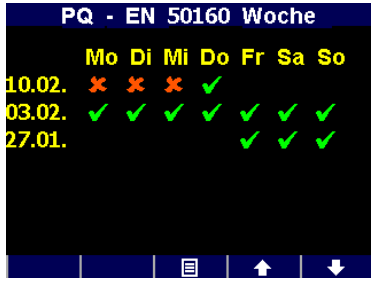
- Display of the outgoing feeders with UMD 97 / UMD 98 or UMD 913
- Storage of feeder measurements
- Feeder measurement according to DIN EN 50160
- Ethernet (Modbus TCP/IP)
- Outgoing feeder measurement for 60 currents

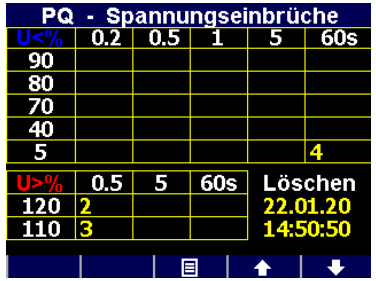


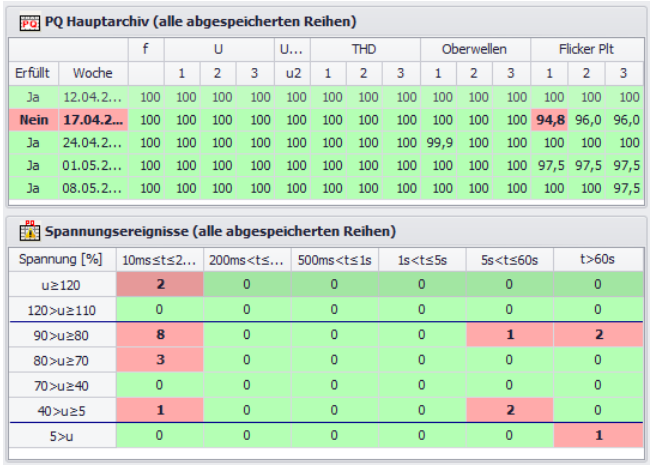
# Firmware Modules

## PQ S / PQ A

Acquisition and evaluation according to EN 50160



PQ Hauptarchiv (alle abgespeicherten Reihen)

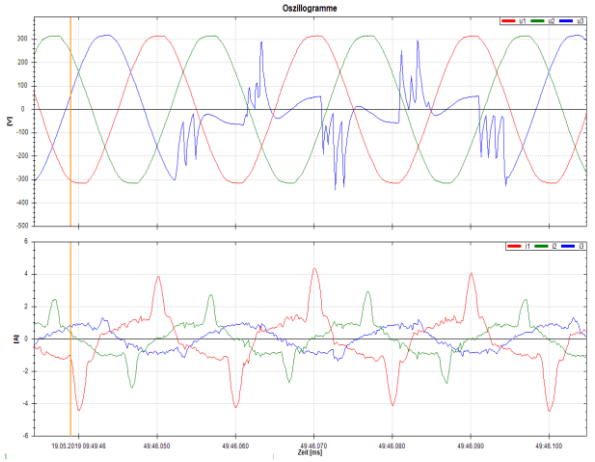
| | | f | U | | | U... | THD | | | Oberwellen | | | Flicker Plt | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Erfüllt | Woche | | 1 | 2 | 3 | u2 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Ja | 12.04.2... | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Nein | 17.04.2... | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 94,8 | 96,0 | 96,0 |
| Ja | 24.04.2... | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99,9 | 100 | 100 | 100 | 100 | 100 |
| Ja | 01.05.2... | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97,5 | 97,5 | 97,5 |
| Ja | 08.05.2... | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97,5 |

Spannungsereignisse (alle abgespeicherten Reihen)

| Spannung [%] | 10ms≤t≤2... | 200ms<t≤... | 500ms<t≤1s | 1s<t≤5s | 5s<t≤60s | t>60s |
|---|---|---|---|---|---|---|
| u≥120 | 2 | 0 | 0 | 0 | 0 | 0 |
| 120>u≥110 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90>u≥80 | 8 | 0 | 0 | 0 | 1 | 2 |
| 80>u≥70 | 3 | 0 | 0 | 0 | 0 | 0 |
| 70>u≥40 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40>u≥5 | 1 | 0 | 0 | 0 | 2 | 0 |
| 5>u | 0 | 0 | 0 | 0 | 0 | 1 |

## GO (General Oscillogram)

Graphical, high-resolution recording during stress events



# Firmware Modules

## Modbus Master

Modbus master for subordinate slave devices. For up to 20 slave devices the Modbus register addresses can be mapped and logged on the master.

## RCS - Ripple control signals

The RCS module (for mains or signal voltage) activates the possibility to detect, evaluate, decode and store various ripple control signals on the monitored power system.

# Firmware Modules

## Supraharmonics

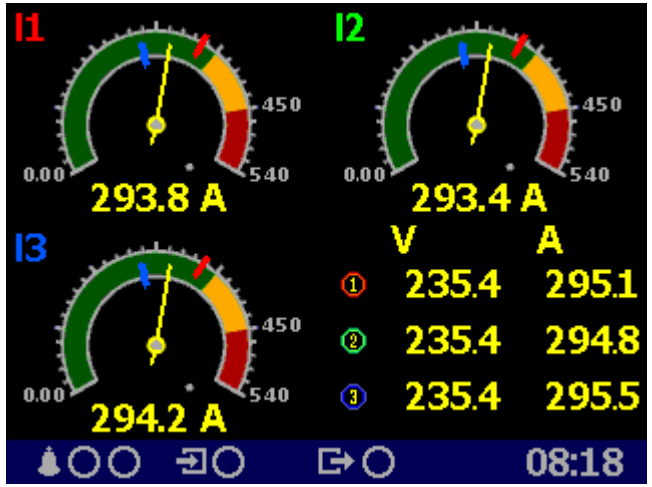
The module allows the measurement of harmonics in the range 2 kHz - 9 kHz. The so-called super harmonics for current and voltage are measured according to EN 61000-4-7 ed. 2.

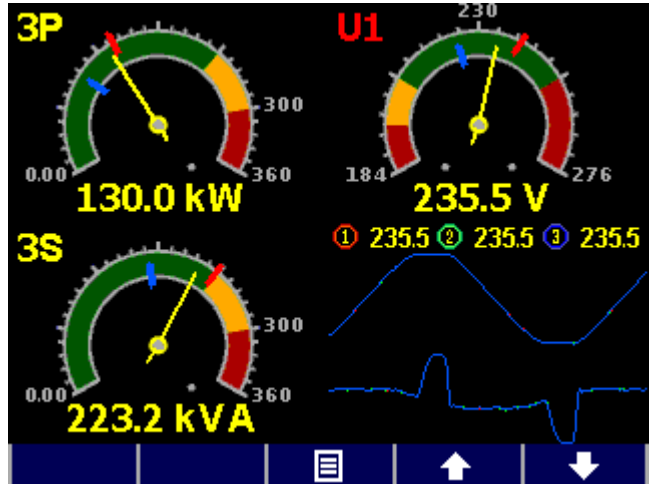
## IEC 104

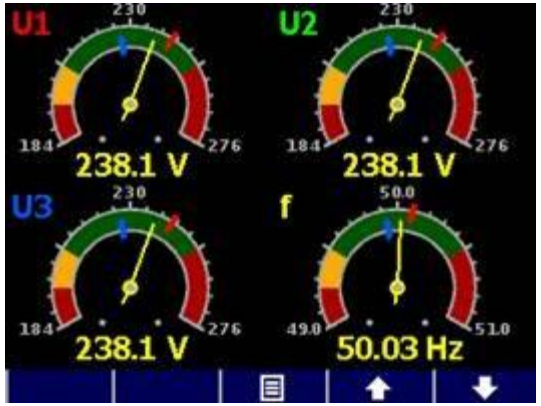
The module enables communication according to IEC 60870-5-104 between control station and substation via a standard TCP/IP network

# New displays

## Drag pointer




# VDE-AR-N 4110

## The standards change

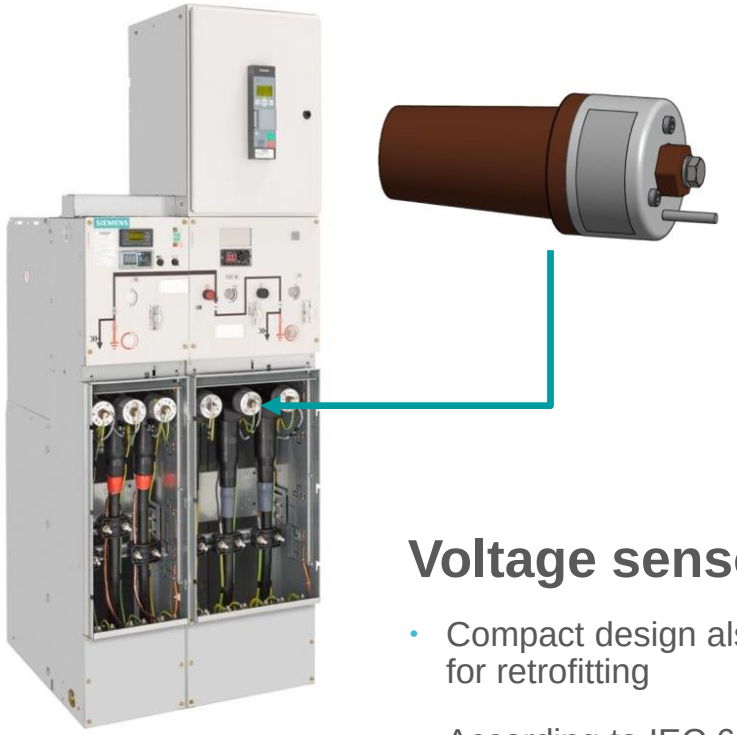
- VDE-AR-N 4110: "Technical Rules for the Connection of Customer Installations to the Medium-Voltage Network and their Operation (TAR Medium Voltage)".
- The TAR describes a fault recorder for customer installations.
- Appendix F lists the requirements for the fault recorder.
- UMD 710A power quality meter meets the requirements of Annex F

# Direct connection of voltage sensors

Local substations usually do not have clearing measuring fields with current and voltage transformers

## UMD 710MVU

- Three-channel current measurement in class A
- Harmonics up to 128th harmonic
- Opt.: 2 kHz - 9 kHz
- Sampling rate 28.8 kHz
- Power quality according to EN 50160
- 4 digital inputs/outputs

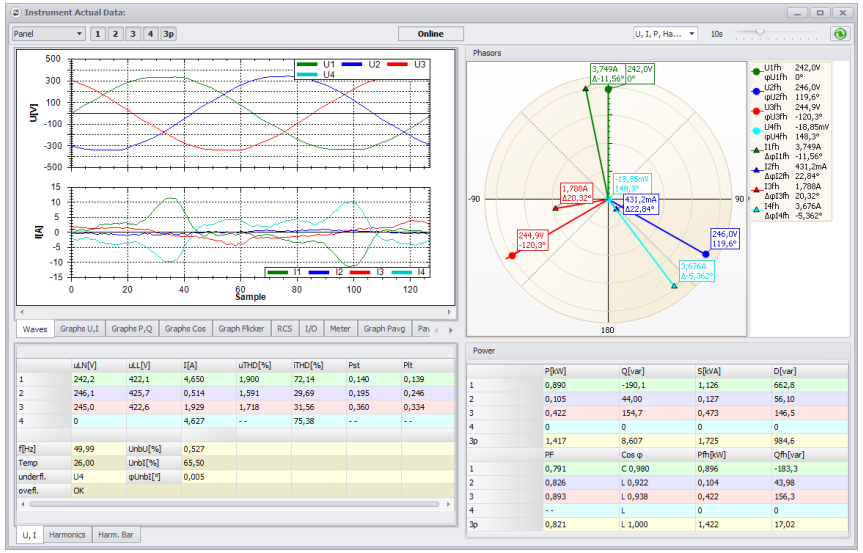
## Voltage sensor

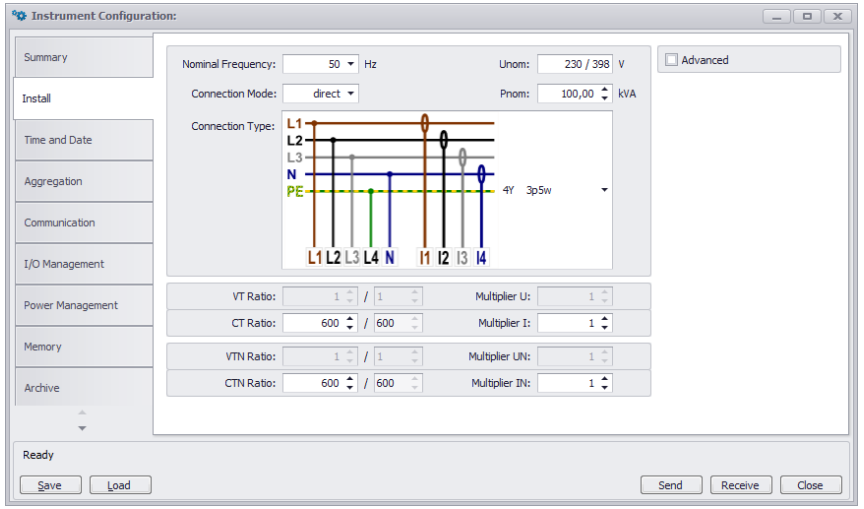
- Compact design also suitable for retrofitting
- According to IEC 61869-11
- Primary voltage 20 kV/√3
- Secondary voltage 3.25 V/√3
- 50/60 Hz
- Accuracy 0.5/3 P

# ENVIS - Software

ENVIS.DAQ

- Configuration
- Live data
- Memory



# ENVIS - Applications

ENVIS

- Visualization
- Evaluation
- Compare

**Hauptarchiv (letzte 50000 Reihen)**

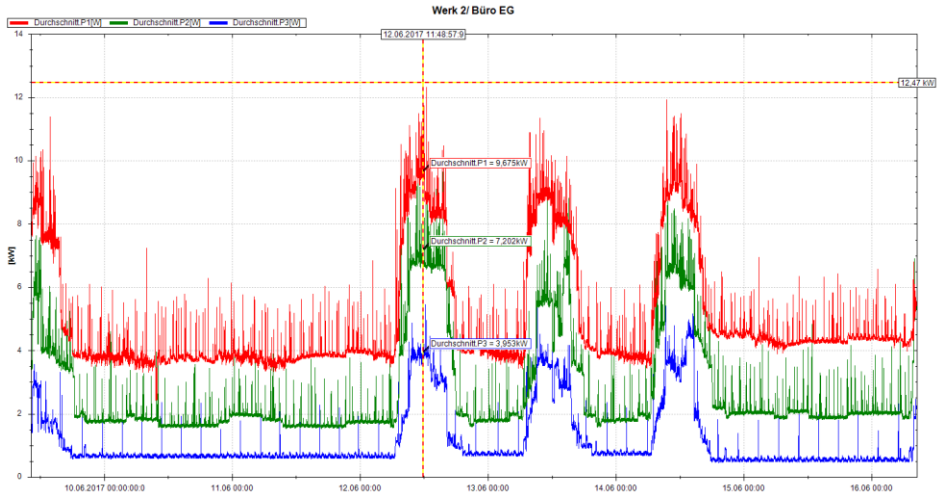
| Größe | Maximum | Durchschnitt | min | Max Zeit | Min Zeit |
|---|---|---|---|---|---|
| f [Hz] | 50,11 | 50,00 | 49,89 | Dienstag, 10. Mai 2016 07:02:00 | Sonntag, 8. Mai 2016 23:03:00 |
| U1 [V] | 243,2 | 236,7 | 227,0 | Donnerstag, 28. April 2016 13:14:00 | Donnerstag, 28. April 2016 22:13:00 |
| U2 [V] | 242,6 | 224,4 | 96,63 | Freitag, 29. April 2016 11:43:00 | Mittwoch, 25. Mai 2016 10:52:00 |
| U3 [V] | 243,0 | 236,4 | 226,4 | Donnerstag, 5. Mai 2016 13:48:00 | Donnerstag, 28. April 2016 22:10:00 |
| I1 [A] | 103,6 | 8,673 | 0 | Mittwoch, 4. Mai 2016 15:05:00 | Dienstag, 19. April 2016 08:06:00 |
| I2 [A] | 93,79 | 7,801 | 0 | Mittwoch, 18. Mai 2016 10:49:00 | Montag, 18. April 2016 17:44:00 |
| I3 [A] | 51,57 | 0,968 | 0 | Donnerstag, 28. April 2016 13:41:00 | Montag, 18. April 2016 18:31:00 |
| 3P [kW] | 34,86 | 3,074 | -7,241 | Dienstag, 26. April 2016 13:39:00 | Dienstag, 24. Mai 2016 18:52:00 |

**PQ Hauptarchiv (alle abgespeicherten Reihen)**

| | | f | U | | | Uns... | THD | | | Oberwellen | | | Flicker Plt | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| entspre... | Woche | | 1 | 2 | 3 | u2 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| kein | 06.04.2016 | 100 | 99,8 | 99,8 | 99,8 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 94,0 | 94,0 | 94,0 |
| ja | 11.04.2016 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| ja | 18.04.2016 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97,1 | 97,1 | 97,1 |
| ja | 25.04.2016 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| ja | 02.05.2016 | 100 | 100 | 99,9 | 100 | 99,9 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 98,8 | 100 |
| ja | 09.05.2016 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 98,2 | 100 |
| ja | 17.05.2016 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97,7 | 96,2 | 97,7 |

**Spannungsereignisse (alle abgespeicherten Reihen)**

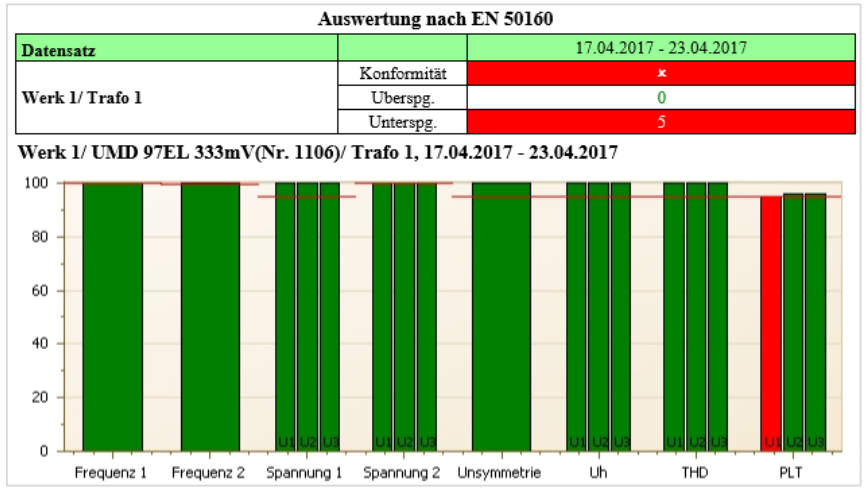
| pannung [% | 10ms≤t≤200ms | 200ms<t≤500ms | 500ms<t≤1s | 1s<t≤5s | 5s<t≤60s | None |
|---|---|---|---|---|---|---|
| u≥120 | 4 | 0 | 0 | 0 | 0 | 0 |
| 120>u≥110 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90>u≥80 | 2 | 0 | 0 | 0 | 0 | 0 |
| | | | | 0 | 0 | 0 |
| | | | | 0 | 1 | 2 |
| | | | | 0 | 0 | 0 |
| | | | | 0 | 0 | 0 |



# ENVIS - Applications

ENVIS.Online


- Automation
- Alerting
- Reporting

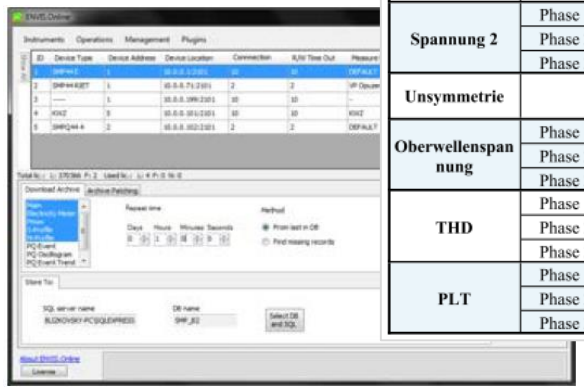


**Auswertung nach EN 50160**

| Datensatz | | 17.04.2017 - 23.04.2017 |
|---|---|---|
| Werk 1/ Trafo 1 | Konformität | x |
| | Uberspg. | 0 |
| | Unterspg. | 5 |

**Werk 1/ UMD 97EL 333mV(Nr. 1106)/ Trafo 1, 17.04.2017 - 23.04.2017**





| | | Messbeispiele | Erfüllung der Bedinung aus EN 50160 | Konformitätsgrad | übereinstimmen |
|---|---|---|---|---|---|
| Frequenz 1 | | 21544 | 100% of Beispiele in einem Woche 47Hz < f < 52Hz | 100,00 | ja |
| Frequenz 2 | | 21544 | 99,5% of Beispiele in einem Woche 49,5Hz < f < 50,5Hz | 100,00 | ja |
| Spannung 1 | Phase 1 | 361 | 95% of Beispiele in einem Woche 90% < Un < 110% | 100,00 | ja |
| | Phase 2 | 361 | | 100,00 | ja |
| | Phase 3 | 361 | | 100,00 | ja |
| Spannung 2 | Phase 1 | 361 | 100% of Beispiele in einem Woche 85% < Un < 110% | 100,00 | ja |
| | Phase 2 | 361 | | 100,00 | ja |
| | Phase 3 | 361 | | 100,00 | ja |
| Unsymmetrie | | 361 | 95% of Beispiele in einem Woche unb < 2% | 100,00 | ja |
| Oberwellenspannung | Phase 1 | 361 | Tabellen 'Individual harmonic limits' | 100,00 | ja |
| | Phase 2 | 361 | | 100,00 | ja |
| | Phase 3 | 361 | | 100,00 | ja |
| THD | Phase 1 | 361 | 95% of Beispiele in einem Woche THD < 8% | 100,00 | ja |
| | Phase 2 | 361 | | 100,00 | ja |
| | Phase 3 | 361 | | 100,00 | ja |
| PLT | Phase 1 | 361 | 95% of Beispiele in einem Woche PLT < 1 | 90,30 | kein |
| | Phase 2 | 361 | | 90,30 | kein |
| | Phase 3 | 361 | | 90,30 | kein |

# Gridcal basis of energy distribution processes

- Central asset management via GridCal provides customized network analyses and remote maintenance in the MV and LV area for ONS and generation plants
- modern web technologies incl. meteorological data
- GridCal Operator as decentralized component incl. resource data in the digital twin with load profile measurement
- Network planning module including socio-economic data
- Reactive power management
- Redispatch measures Real-time measured values from the UMD measuring devices for 36 h Forecast module for generation and consumption
- Costly extensions of the network infrastructure (civil engineering works) are avoided or delayed by up to 50%.
- Reduction of system losses (heat) by up to 30%.
- Energy savings and avoidance of cyber security risks by eliminating cloud solutions

# Management of communication and measurement technology

- GridCal is an easy-to-install system solution consisting of hardware and software for the complete digitization of electrical distribution networks. It is based on a hybrid approach that combines centralized and decentralized components. The management of the communication and measurement technology is carried out with the help of modern web technologies by a central server on site - the GridCal operator.
- **Decentralized data** evaluation In contrast, the main data aggregation as well as the decentralized data pre-evaluation via GridCal take place in the grid stations themselves. The biggest advantage of the GridCal solution is that not every measurement has to be transferred to the main control center or to an expensive cloud solution.

# Focus on what is important

- Only the important data records are transmitted, such as overvoltages and undervoltages or equipment overloads. The causes of all these events can be investigated in the central management server with further detailed network analyses. In combination with the GridCal operator, the merging of measurement and equipment data such as cables and transformers is child's play, as the GridCal operator takes over the manual, time-consuming and error-prone data merging.

# Mobile networks for autonomous operation

- At the same time, the GridCal operator provides different information for the different user groups so that most important responses can be determined without delay. In addition to monitoring, real-time tasks such as **load management** in the **grid stations** can be performed completely autonomously. GridCal does not require any special IT infrastructure as it uses state-of-the-art web technology and standard protocols. Data sovereignty was the top priority in the development of the system and therefore grid data never leaves the grid operator unintentionally.

# Mobile measurement

MMD 97

- Mobile measuring case
- Rogowski coils
- IP 65
- < 2 kg
- EN 50160
- 512 MB memory

# Mobile measurement

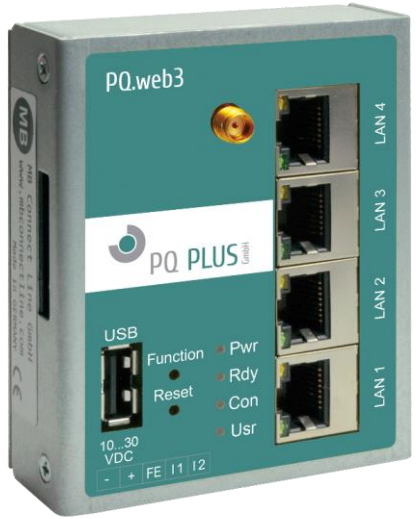
MMD 98RCM

- Mobile measuring case
- 4 current inputs
- 2 RCM inputs
- Rogowski coils
- IP 65
- < 2 kg
- EN 50160
- 512 MB memory
- External supply / buffering possible

# Remote connection

PQ.web

- Industrial router
- Integrated Ethernet switch
- Secured VPN connection
- 2G, 3G, 4G, WIFI
- Global SIM
- 2 x DI's




# Accessories

## Radio receiver
## GPSkempfänger GPS

- Time synchronization of the UMD measuring devices
- Small, compact design
- Applicable worldwide
- IP 54

# Accessories

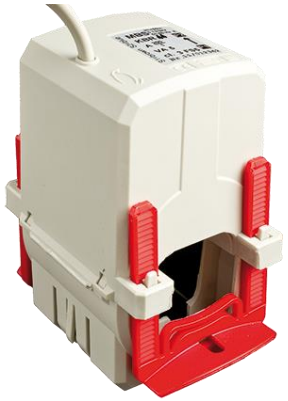
## IoT – LoRaWAN Interface

- Connection of the universal measuring devices and energy meters with Modbus RTU via LoRaWAN.
- The IoT LoRaWAN interface is a class C device and connects to the meters via the RS485 interface
- Configuration can be done wirelessly via downlink packets
- IP 65

# Accessories

## Current transformer

- Current transformer:
- Plug-on converter
- Conversion transformer
- Residual current transformer
- Rogowski coil
- x/1A//5A//100mA//333mV



# NH load-break switch disconnector

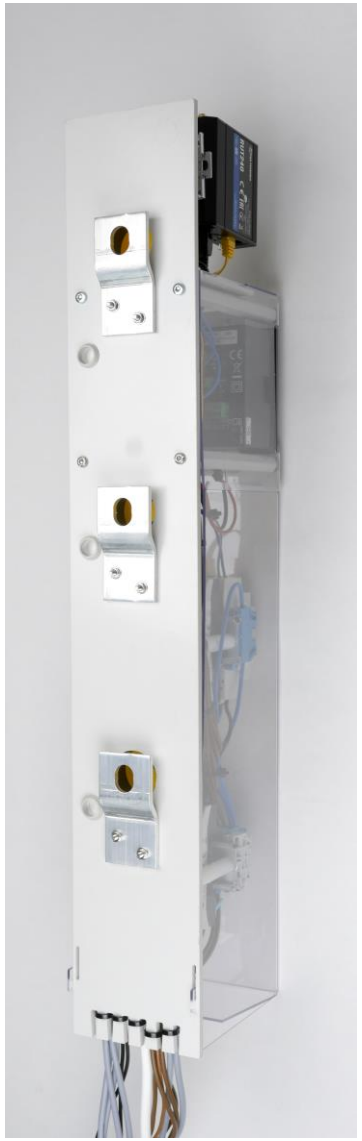
Intelligent NH2 load break bar

- incl. measuring device + NS transducer
- Opt. evaluation according to EN 50160
- Robust construction
- 1-pole or 3-pole switchable

# Measuring system in safety edge format NH2

Feed measurement incl.

8 outgoing measurements

# New building loading concept

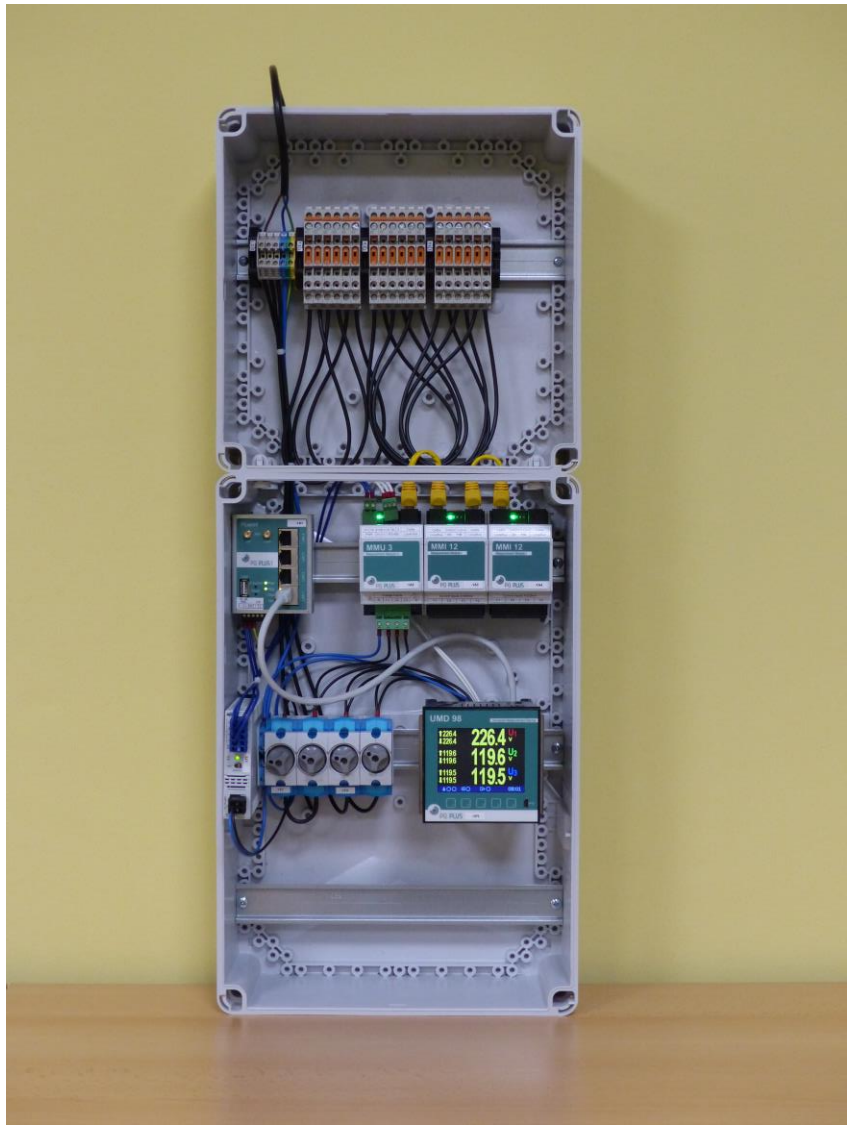
Applications in network operation

# Retrofit

Applications in network operation

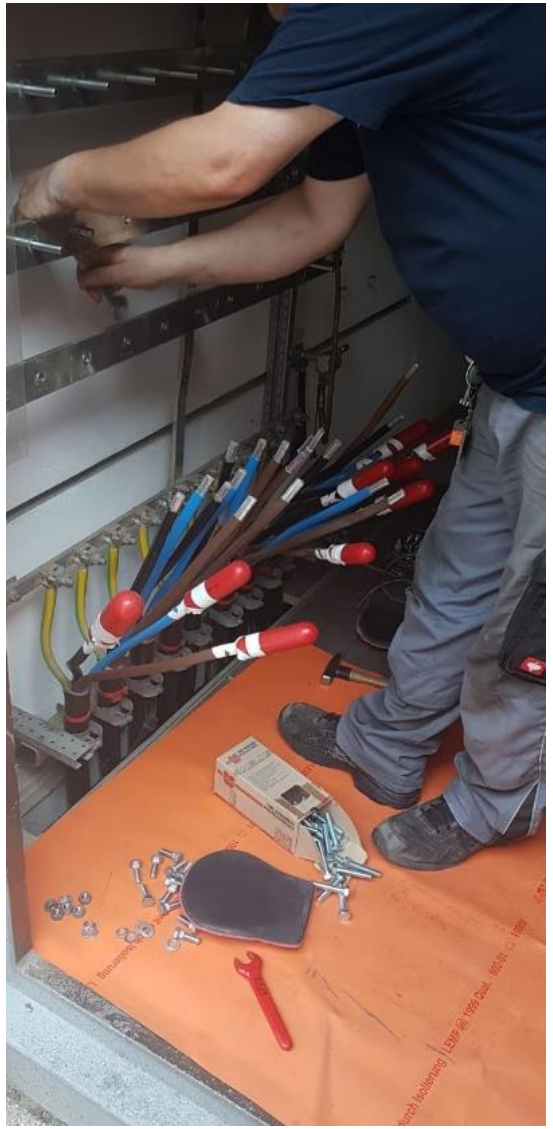

# Retrofit

Applications in network operation

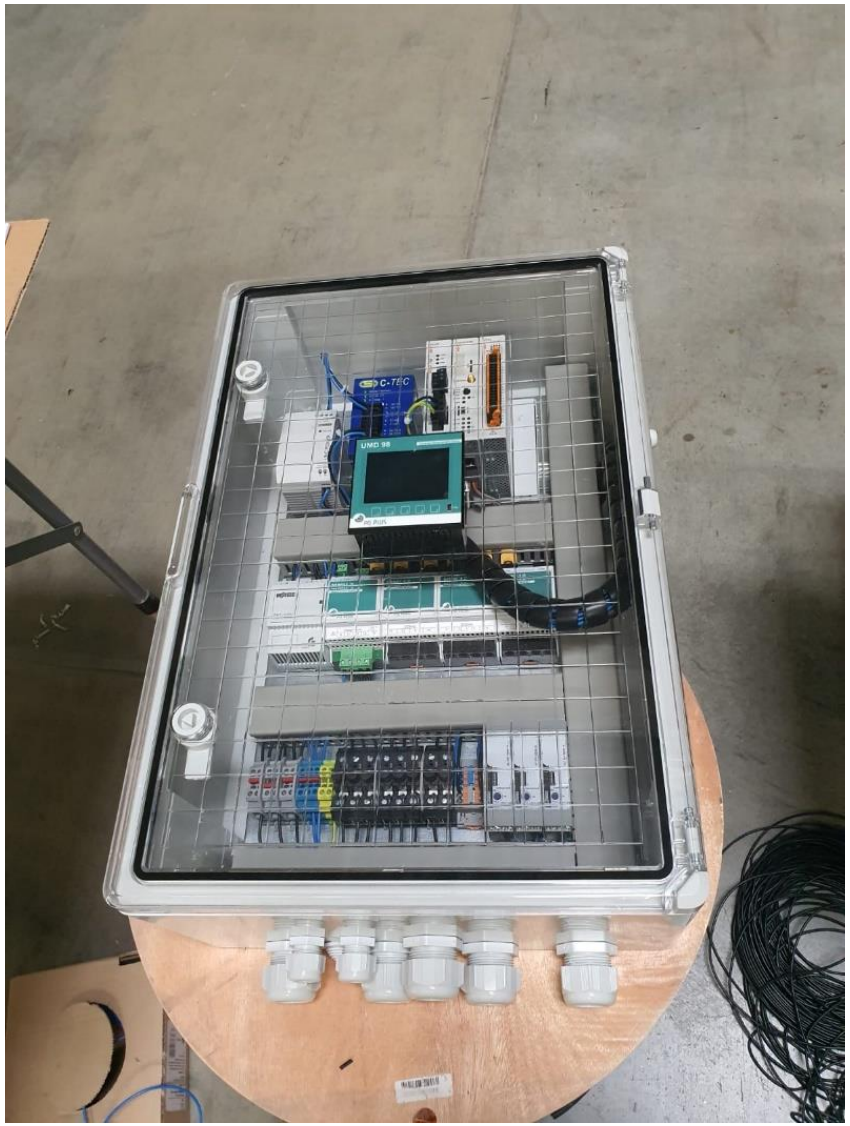
# Implementation Intelligent ONS

Primary Periphery Conversion



# Implementation Intelligent ONS

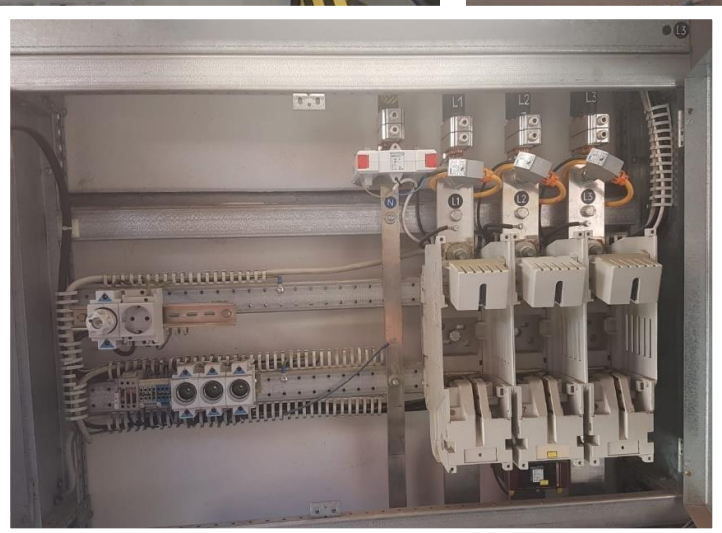
Secondary periphery




# Implementation Intelligent ONS

Secondary periphery in the ONS





# Data evaluation

- Connection of the measuring devices via PQ.web - router via mobile communication
- PQ Plus automatically reads the data in defined cycles and stores them in the database in a German data center (TÜV Level 3 certified)
- Customized reporting
  - Every week all reports to the AG
  - Only report including data if standards were violated
- Data can be sent to the customer at any time if required
- Customer can access his devices himself at any time via a portal
- Enormous resource savings for the customer

# QUESTIONS?

Thank you for your attention