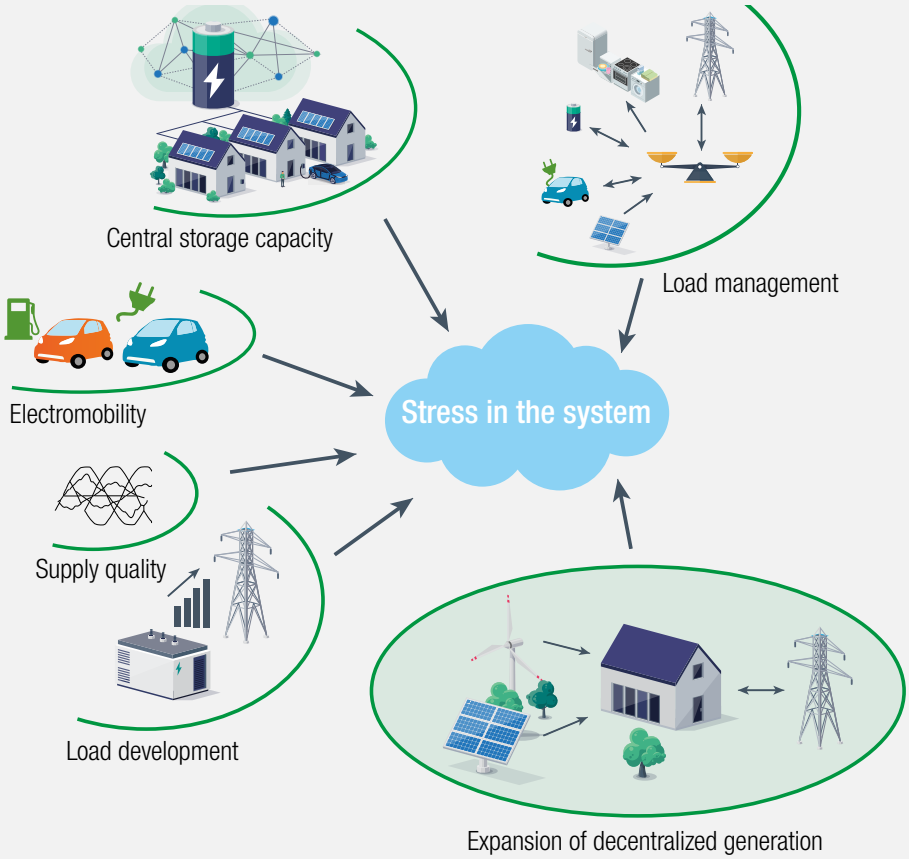
CAMILLE BAUER
GMC-INSTRUMENTS GROUP

APPLICATION SOLUTIONS IN THE SMART GRID

INTELLIGENT MEASUREMENT AND CONTROL SOLUTIONS FOR THE DISTRIBUTION GRID OF TODAY AND TOMORROW

LOAD FLOW • POWER QUALITY • OWN GENERATION

MOBILE POWER QUALITY AND ENERGY CONSUMPTION MONITORING



More and more dynamic loads and decentralized feed-ins are placing an increasing burden on the electrical distribution grid and making it more difficult to manage operations to ensure the supply. Former pure energy consumers are increasingly behaving bidirectionally, i.e. not only drawing energy but also supplying it. This can lead to an imbalance between generated and consumed energy and thus to “stress in the system”. Not least due to PV systems which, regardless of the current load situation, feed into the grids in an uncontrolled manner.

To ensure that the grid voltage provided remains within the permitted limits, it is necessary to know the current grid situation and restore the balance with suitable control measures.

The SmartGridBox measurement solution can be used to monitor and, if necessary, control the operational aspects of the feed-in and distribution of electrical energy in the low-voltage grid. Data on the current grid status, the energy flow, the quality and availability of the supply and the effects of changes or remedial measures in the grid can be recorded.

By combining the devices available in different versions to suit individual requirements, the necessary information can be recorded and, if desired, also used to control feed-in power or loads. An example of an application of the SmartGridBox for controlling PV systems is described below.

PRODUCT FEATURES OF THE SmartGridBox

Various solutions are possible depending on the use case.

Common features of the SmartGridBox variants (use case 1-3):

- Voltage and grid status recording
- Monitoring and recording of voltage events
- Device power supply from measuring input or separate connection Overvoltage protection (SPD) as an option
- Communication via mobile network as an option
- Comprehensive cyber security
- IP65 housing, pre-wired
- External dimensions of housing: 360 x 160 x 91 mm

Device with Rogowski current measurement

BASIC DEVICE	ADDITIONAL FEATURES	APPLICATION
SINEAX DM5000 (power flow analysis with event recording)	• Rogowski current measurement (L1, L2, L3, N / PEN) • Acquisition and recording of load profiles • Option PME: Wireless energy flow recording (up to 100 currents)	• Energy management • Load flow monitoring • Provide grid status data
LINAX PQ5000 (power flow analysis, incl. power quality analysis)	• Rogowski current measurement (L1, L2, L3, N / PEN) • Acquisition and recording of load profiles • Comprehensive power quality analysis in accordance with IEC 61000-4-30 Ed. 3, Class A • Additional monitoring and recording of current, frequency, unbalance and signal voltage events • Option PME: Wireless energy flow recording (up to 100 currents)	• PQ compliance verification • Comprehensive recording of PQ events • Energy management • Load flow monitoring • Provide grid status data
LINAX PQ5000CL (Power flow analysis “High Performance”, incl. power quality analysis)	• Rogowski current measurement (L1, L2, L3, N / PEN) with Current Link modules for up to 10 measuring points • Power analysis of all measuring points • Optional communication via IEC 61850	• PQ conformity check • Load flow monitoring • Provide grid status data
CENTRAX CU5000 (controller unit with measuring function for PV systems for grid-compatible operation)	• Rogowski current measurement (L1, L2, L3, N / PEN) • Acquisition and recording of load profiles • Option PME: Wireless energy flow recording (up to 100 currents)	• Collection of measurement data from other SmartGridBoxes • Data analysis with the help of a Soft-PLC application • Control and / or regulation of processes or generation plants using the Soft-PLC application • Energy management • Load flow monitoring • Providing grid status data

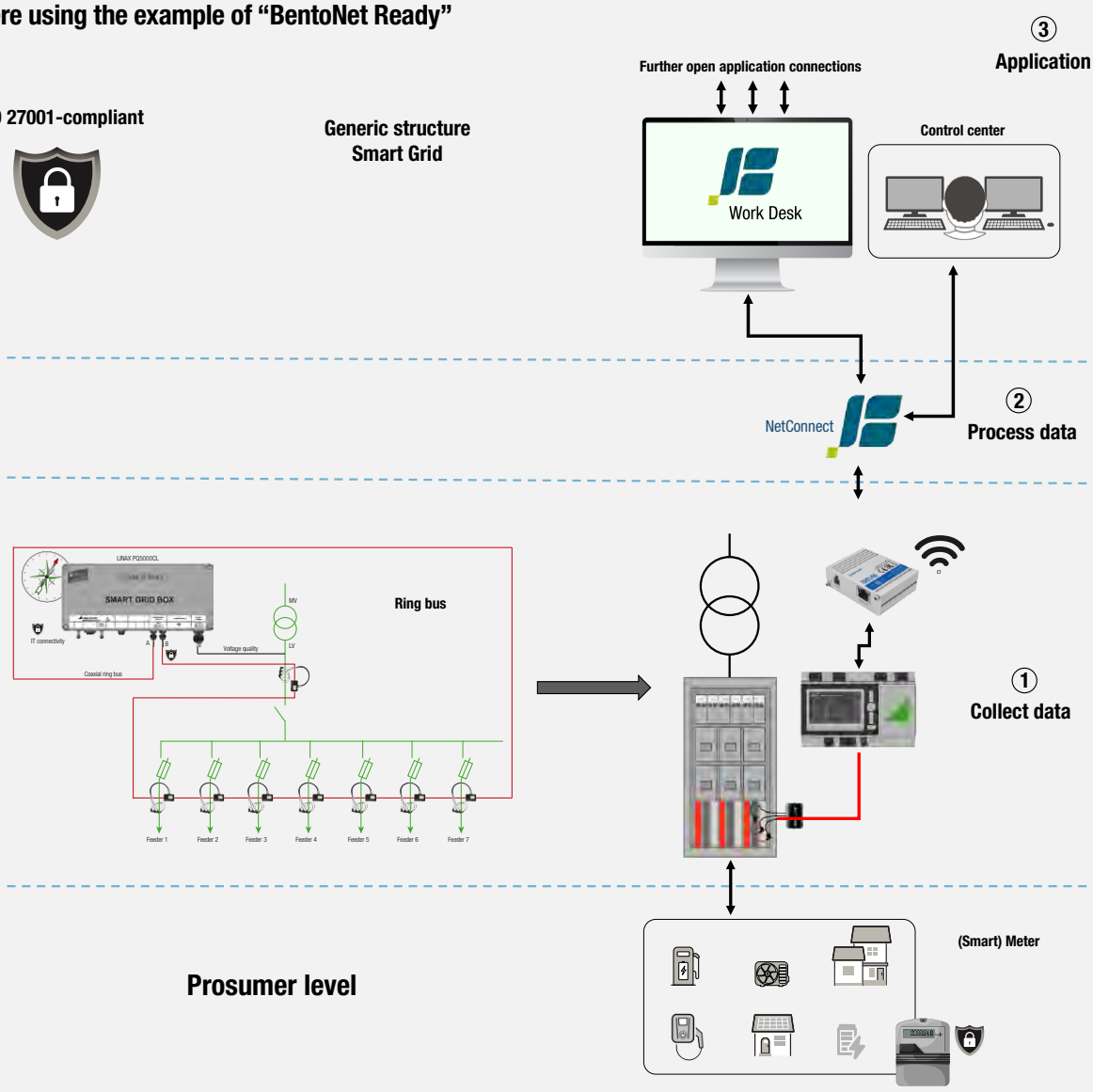
The **PME (Power-Monitor-Energy) option** extends the functionality of the respective basic device to an energy center by collecting additional information about the distribution of energy or the consumption of individual loads via radio. This scalable solution makes the temporal power flows transparent and can be used for energy management in transformer stations or industrial plants, for example. Wireless modules based on Rogowski coils are used as sensors, powered via batteries or USB-C. Up to 100 currents, divided between the PME sensors for 3 or 4 conductors each, can be securely recorded without additional wiring (AES-128 encryption). Once per second, not only the current values but also, thanks to synchronization with the voltage measurement of the base unit, comprehensive power data are determined and average loads, load profile data and energy meter values are derived, which are also stored in the device as time histories.

USE CASE 1: “ADVANCED” MEASUREMENT WITH HIGH OUTPUT ACCURACY; WIRED

Here using the example of “BentoNet Ready”

ISO 27001-compliant

Generic structure Smart Grid



Features:

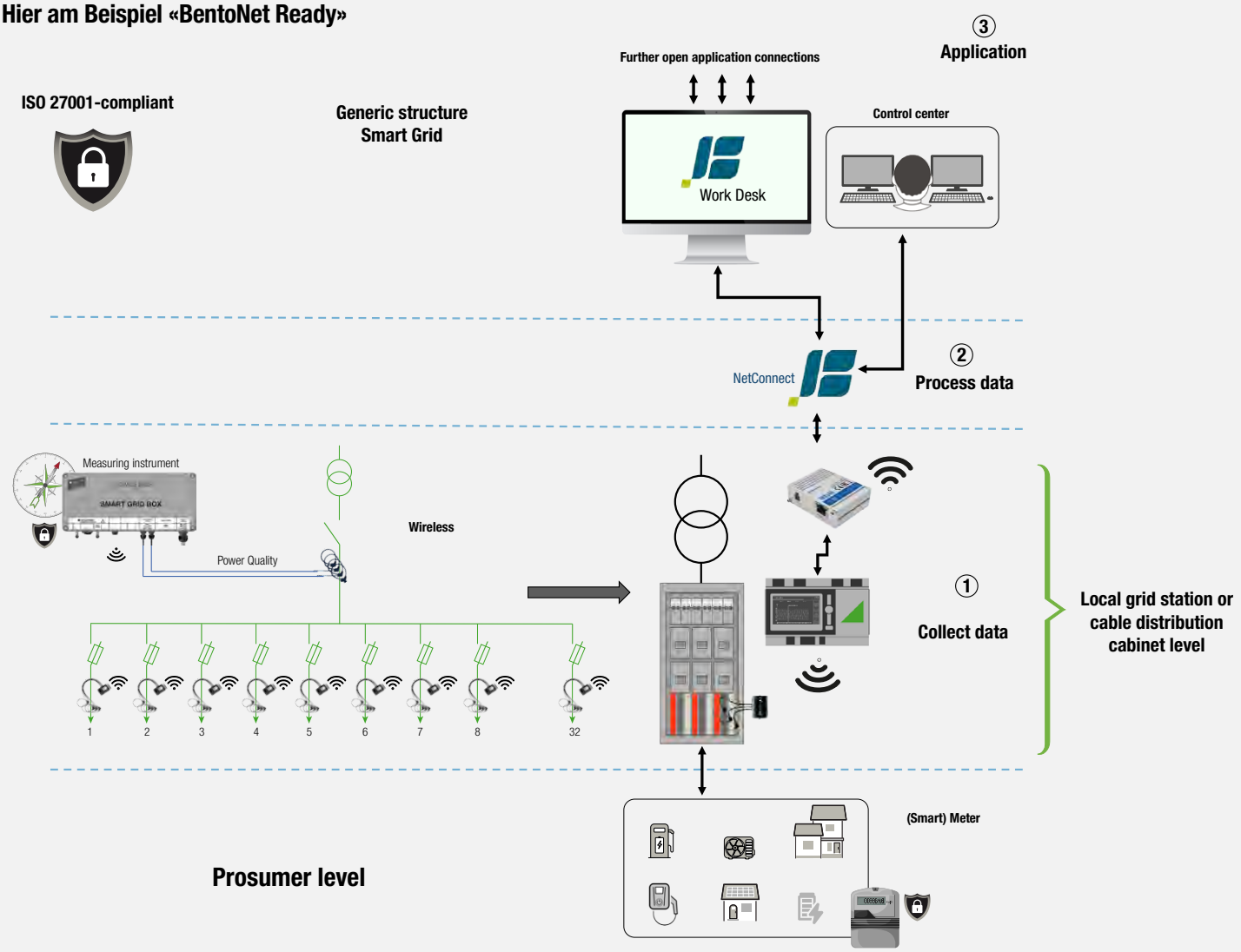
- Zero-blind technology for the fastest acquisition of status data (54kHz sampling)
- Real-time data can be set in top-of-second mode or >1s (only available via IEC61850 data push, broadband and high-performance IT systems)
- Not only load, but also power and power quality data available
- Up to 20kA per outgoing circuit possible (e.g. also for measuring the main distribution board with the same module)
- All status data is fully synchronized with each other (overall grid dynamics)
- Early problem localization through network transparency
- BentoNet-Ready (secure data connectivity with various application options (e.g. LoadFlow, RetoFlow, PowerFactory, SINCAL, ...)
- Fichtner Digital Grid and Venios Ready
- MQTT currently being implemented
- “Install and immediate use” for the pilot phase AND the roll-out

Conclusion:

Highest measurement performance for a dynamic and fully computable network with real-time data

USE CASE 2: “ADVANCED” MEASUREMENT WITH HIGH OUTPUT ACCURACY; WIRELESS

Hier am Beispiel «BentoNet Ready»



Features:

- Not only load, but also power and power quality data available
- Up to 1kA per (phase) outgoing circuit possible
- Average values up to 1/min and instantaneous values 1/s
- All status data is fully synchronized with each other
- BentoNet-Ready (secure data connectivity with various application options (e.g. LoadFlow, RetoFlow, PowerFactory, SINCAL, ...)
- Early problem localization through network transparency
- Wireless technology can be used for various Camille Bauer standard measuring devices (PQI or PMD)
- Measure up to 33(25) outgoing circuits simultaneously
- “Install and immediate use” for the pilot phase AND the roll-out

Conclusion:

High performance for a dynamic and computing-capable grid

USE CASE 3: GRID-FRIENDLY CONTROL OF PV SYSTEMS

High levels of solar radiation can lead to voltage increases if the power fed in exceeds the consumption. To ensure that the grid voltage remains within the permitted range, it is therefore necessary to limit the power fed into the grid by the solar system. In this case, this was achieved by automatically controlling the solar inverters via the generation system›s controller based on the status data in the distribution grid.

To record the grid status, a SmartGridBox is installed in each distribution cabinet to which at least one solar system is connected. Devices with different basic devices are used for this purpose. The SINEAX® DM5000, referred to as the "VK Follower" in the diagram, is used to record the respective status in a distribution cabin and transmit the measurement data to the data center ("VK Leader") via an LTE router with VPN. This is a SmartGridBox with CENTRAX® CU5000, which also has a control unit in addition to the measurement unit. This compares the statuses with the specifications and forwards the corresponding setpoint specifications to the EZA controllers, which then control the inverters so that PV systems only feed an unlimited amount of electricity into the grid when this is actually beneficial to the grid.

This system is flexible and easily scalable, works autonomously and therefore does not place a burden on existing control systems. If several PV systems are connected to the same grid connection point and limit values are violated, all PV systems are affected simultaneously and therefore without discrimination. The integrated cyber security (OT) of the SmartGridBoxes, which prevents direct manipulation, and the use of a VPN structure ensure maximum security within the critical infrastructure.

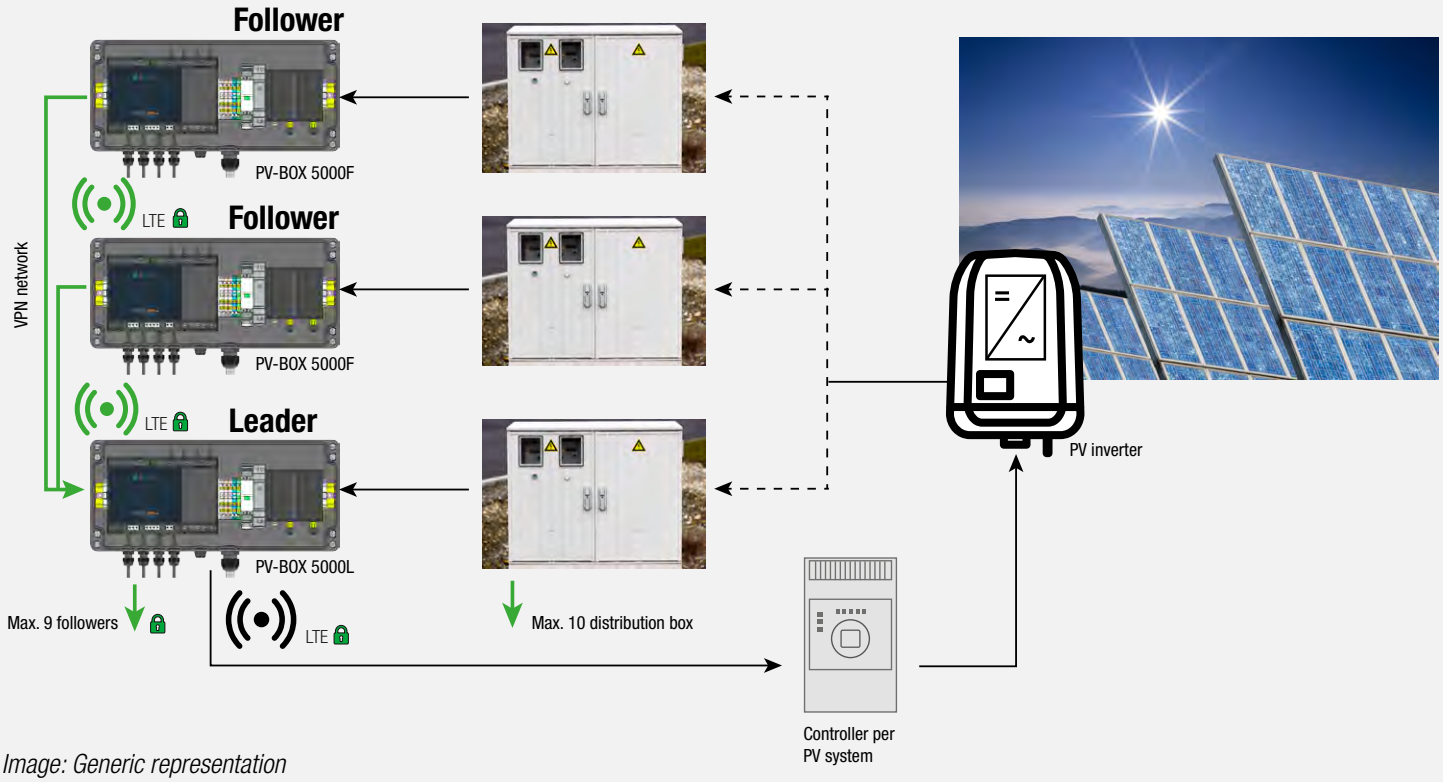


Image: Generic representation

Further details can be found in the documentation "Operating a PV system for grid support"

[1] EZA stands for generation plant

[3] The VPN network (mobile radio and/or broadband) is either provided by the customer or can also be provided by a secure integrated system, such as BentoNet.

TECHNICAL DATA SmartGridBox

VOLTAGE INPUTS

SMARTGRID-BOX-	xxxx xxxx 1x /3x	xxxx xxxx 2x /4x
Nominal voltage:	100…230 V_{LN} 173...400 V_{LL}	57,7…400 V_{LN} 100...693 V_{LL}
Measuring range max.:	265 VLN, 460 V_{LL}	520 VLN, 900 V_{LL}
Measurement category:	300V CAT III	600V CAT III
Perm. overload capacity:	265 V_{LN}, 460 V_{LL}	520 V_{LN}, 900 V_{LL}
Measurement uncertainty:	± 0,1%	
Own consumption:	≤ U^2 / 1,54 MΩ per phase	

CURRENT MEASUREMENT INPUTS depending on device version

- **Basic device CU5000 / DM5000 / PQ5000**
  Measuring range: 0…3000 A (max. 3800 A)
  Further data in the operating instructions for the Rogowski coil ACF 3000
- **Current Link** — **Current Module 3P / 3PN**
  Measuring range 1: 400 A (typ.), 1000 A (max.)
  Measuring range 2: 8 kA (typ.), 20 kA (max.);
  Measurement category: 600 V CAT IV
  Measurement uncertainty: ± 0,5% (centered conductor, without external field)
  Angular error: ± 1,0°
  Design: 3 or 4 Rogowski coils
- **Option PME** — **Current module CTR75-1000A**
  Number of channels: 3 or 4
  Max. Number of modules: 25...33 (≤100 currents per PME control center)
  Frequency range: 10 Hz bis 100 kHz
  Max. Rated current I_N: 1000 A
  Max. measurable current: 1,2 x I_N
  Starting current: 2 A (Fundamental vibration component)
  Sampling rate: 6 kHz
  Query interval: progr. 1...20 s, default setting 1 s
  Transmission power: progr. -12...8 dBm, default setting 0 dBm
  Reach: 10 m at transmission power 0 dBm
  Auxiliary energy: 4 x 1.5 V AA battery or USB-C (5 V DC)
  Batteries: Energizer Ultimate Lithium AA (Not included in the scope of delivery)
  Battery life: approx. 10 years, at transmission power 0 dBm
  Messunsicherheit: ±0,5 % (IEC 60688)
  Active / reactive energy: Class 3.0 typical (IEC 62053)

Nominal frequency: 42...50...58Hz or 50,5...60...69,5Hz (only CU/DM/PQ5000)

Sampling rate: 18 kHz (U), 54 kHz (I at PQ5000CL)

Internal data memory: 16 GB

AUXILIARY ENERGY

Power consumption: ≤ 40VA

- From measuring input L1-N: SMARTGRID-BOX-xxxx xxxx 1x / 3x
- Separate connection: SMARTGRID-BOX-xxxx xxxx 2x / 4x
  Nominal voltage: 100…230V AC 50/60Hz / DC ±15%

UNINTERRUPTIBLE POWER SUPPLY UPS (OPTION)

Capacity	1150 mAh, 4,5 Wh
Bridging time	5 times 3 minutes
Service life	3 to 5 years

INTERFACES

ETHERNET	Optional connection
Physics	Ethernet 100 Base TX; RJ45 socket
Mode	10/100 MBit/s, Full/half duplex, autonegotiation
Protocols	Modbus/TCP, http, https, IPv4, IPv6, NTP
Optional protocol:	IEC 61850
TIME REFERENCE	Internal clock
Accuracy	± 2 minutes/month (15 to 30 °C)
Synchronization	via NTP-Server

ENVIRONMENTAL CONDITIONS, GENERAL INFORMATION

Operating temperature:	–10 to 15 up to 30 to + 55 °C (without UPS) 0 to 15 to 30 to + 35°C (with UPS)
Storage temperature	–25 to +70 °C
Temperature influence	0.5 x basic error per 10 K
Long-term drift	0.5 x basic error per year
Other	Application group II (IEC/EN 60 688)
Relative humidity	<95 % without condensation
Operating height	≤2000 m above sea level

SECURITY

Protection class	II (protective insulation, voltage inputs with protective impedance)
Degree of soiling	2
Contact protection	IP65 (closed housing)

MECHANICAL PROPERTIES

Weight:	ca. 3.5kg
Dimensions L x B x H:	360 x 160 x 91 mm

Further technical data can be found in the documentation for the base unit used.

The online selector can be used to configure the SmartGridBox:
https://camillebauer.com/produkt/smartgridbox/

ACCESSORIES	ARTICLE NO.
Current module 3P, with triple Rogowski converter Ø75mm, approx. 0.5 m connection cable Colors: L1 = brown, L2 = black, L3 = grey	187 593
Current module 3PN, with 4-fold Rogowski converter Ø75mm, approx. 0.5 m connection cable Colors: L1 = brown, L2 = black, L3 = grey, N = blue	187 105
Current module 3P, with triple Rogowski converter Ø100mm, approx. 0.5 m connection cable Colors: L1 = brown, L2 = black, L3 = grey	189 137
Current module 3PN, with 4-fold Rogowski converter Ø100mm, approx. 0.5 m connection cable Colors: L1 = brown, L2 = black, L3 = grey, N = blue	189 129
SMA connection cable BM-RCM, length 0.5 m	187 634
SMA connection cable BM-RCM, length 1 m	188 585
SMA connection cable BM-RCM, length 2 m	190 777
SMA connection cable BM-RCM, length 5 m	187 642
SMA connection cable BM-RCM, length 10 m	187 650
... other lengths on request	
PME Rogowski wireless sensor 3P, 3-channel, Ø 75 mm	189 281
PME Rogowski wireless sensor 3PN, 4-channel, Ø 75 mm	189 273

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