



Elektro-Automatik



60 kW

## PUL 10000 6U

### Bidirectional Power and Unmatched Efficiency for Demanding Applications | 60 kW

**Bidirectional Operation:** Functions as both a power supply and a regenerative electronic load with energy recovery efficiency of up to 96%.

**High Power Capability:** Delivers up to 60 kW per unit, with scalability for parallel operation up to 3840 kW.

**Flexible Autoranging Output:** Provides dynamic voltage and current combinations, supporting a wide range from 0–60 V to 0–2000 V and currents up to 480 A.

**Advanced Connectivity:** Includes built-in USB, Ethernet, and analog interfaces, with optional industrial protocols such as CAN, Modbus, and Profinet.

**Compact and Efficient Design:** Features high energy efficiency, reduced heat generation, and space-saving 6U chassis for versatile installation.

# EA-PUL 10000 6U 60 kW

Programmable electronic DC loads  
with energy recovery



## Features

- Wide range input: 380 V - 480 V, +10%, 3ph AC
- Active Power Factor Correction, typical 0.99
- Regenerative with energy recovery into the grid
- Very high efficiency of up to 96%
- High performance with up to 60 kW per unit
- Voltages from 0 - 360 V up to 0 - 2000 V
- Currents from 0 - 80 A up to 0 - 480 A
- Flexible power regulated DC output/input stage (autoranging)
- Regulation modes CV, CC, CP, CR with fast crossover
- Digital regulation, high resolution with 16 Bit ADCs and DACs, selection of voltage controller speed
- Galvanically isolated Share-Bus for parallel operation of all power classes in the 10000 series
- Master-slave bus for parallel operation of up to 64 units of all power classes in the 10000 series
- Command languages and drivers: SCPI and ModBus, LabVIEW, IVI

## Built-in interfaces

- USB
- Ethernet
- Analog
- USB Host
- Master-Slave-Bus
- Share-Bus

## Optional interfaces

- CAN
- CANopen
- RS232
- Profibus
- EtherCAT
- Profinet, with one or two ports
- Modbus, with one or two ports
- Ethernet, with one or two ports

## Software

- EA - Power Control



## Options

- Water Cooling in stainless steel
- Function generator

# SPECIFICATIONS

## AC Input

- **Voltage, Phases:** 380 V - 480 V  $\pm$ 10%, 3ph AC
- **Frequency:** 45 - 65 Hz
- **Power Factor:** ca. 0.99
- **Leakage Current:** <10 mA
- **Phase Current:**  $\leq$ 110 A @ 400 V AC
- **Overvoltage Category:** 3

## DC Output (static)

- **Load Regulation CV:**  $\leq$ 0.05% FS (0 - 100% load, constant AC input voltage and constant temperature)
- **Line Regulation CV:**  $\leq$ 0.01% FS (380 V - 480 V +10% AC input voltage, constant load and constant temperature)
- **Stability CV:**  $\leq$ 0.02% FS (during 8h of operation, after 30 minutes warm-up, at constant AC input voltage, load, and temperature)
- **Temperature Coefficient CV:**  $\leq$ 30 ppm/ $^{\circ}$ C (after 30 minutes warm-up)
- **Compensation (Remote Sense):**  $\leq$ 5% UNominal
- **Load Regulation CC:**  $\leq$ 0.1% FS (0 - 100% load, constant AC input voltage and constant temperature)
- **Line Regulation CC:**  $\leq$ 0.01% FS (380 V - 480 V +10% AC input voltage, constant load and constant temperature)
- **Stability CC:**  $\leq$ 0.02% FS (during 8h of operation, after 30 minutes warm-up, at constant AC input voltage, load, and temperature)
- **Temperature Coefficient CC:**  $\leq$ 50 ppm/ $^{\circ}$ C (after 30 minutes warm-up)
- **Load Regulation CP:**  $\leq$ 0.3% FS (0 - 100% load, constant AC input voltage and constant temperature)
- **Load Regulation CR:**  $\leq$ 0.3% FS + 0.1% FS current (0 - 100% load, constant AC input voltage and constant temperature)

## Protective Functions

- **Overvoltage Protection (OVP):** Adjustable 0 - 110% UNominal
- **Overcurrent Protection (OCP):** Adjustable 0 - 110% INominal
- **Overpower Protection (OPP):** Adjustable 0 - 110% PNominal
- **Overtemperature Protection (OT):** DC output shuts down in case of insufficient cooling

## DC Input (Dynamic)

- **Rise Time 10 - 90% CC:**  $\leq$ 2 ms
- **Fall Time 90 - 10% CC:**  $\leq$ 2 ms

## Insulation

- **AC Input to DC Output:** 3750 Vrms (1 minute, creepage distance >8 mm)
- **AC Input to Case (PE):** 2500 Vrms
- **DC-Output to case (PE):** Depending on the model, see model table
- **DC Output to Interfaces:** 1000 V DC (models up to 360 V rating), 1500 V DC (models from 500 V rating)

## Interfaces (Digital)

- **Built-in, Galvanically Isolated:** USB, Ethernet (100 MBit), USB front panel, all for communication
- **Optional, Galvanically Isolated:** CAN, CANopen, RS232, Modbus TCP, Profinet, Profibus, EtherCAT, Ethernet

## Interfaces (Analog)

- **Built-in, Galvanically Isolated:** 15-pole D-Sub
- **Signal Range:** 0 - 10 V or 0 - 5 V (switchable)
- **Inputs:** U, I, P, R, remote control on/off, DC output on/off, resistance mode on/off
- **Outputs:** Monitor U and I, alarms, reference voltage, DC output status, CV/CC regulation mode
- **Accuracy (U/I/P/R):** 0-10 V:  $\leq$ 0.2%, 0-5 V:  $\leq$ 0.4%

## Device Configuration

- **Parallel Operation:** Up to 64 units of any power class in the 10000 series, with Master-Slave Bus and Share Bus

## Safety and EMC

- **Safety Standards:** EN 61010-1, IEC 61010-1, UL 61010-1, CSA C22.2 No 61010-1, BS EN 61010-1
- **EMC Compliance:** EN 55011 (Class A), CISPR 11 (Class A), FCC 47 CFR part 15B (Class A)
- **EN 61326-1 Includes tests:** EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6
- **Safety Protection Class:** Class 1
- **Ingress Protection:** IP20

## Environmental Conditions

- **Operating Temperature:** 0–50  $^{\circ}$ C (32–122  $^{\circ}$ F)
- **Storage Temperature:** -20–70  $^{\circ}$ C (-4–158  $^{\circ}$ F)
- **Humidity:**  $\leq$ 80% relative humidity, non-condensing
- **Altitude:**  $\leq$ 2000 m ( $\leq$ 6,600 ft)
- **Pollution Degree:** 2

## Mechanical Construction

- **Cooling:** Forced air flow from front to rear (temperature-controlled fans), optional water cooling
- **Dimensions (W x H x D):** 19" x 6U x 668 mm
- **Weight:** 76 kg (168 lbs)
- **Weight with water cooling:** 82 kg (180 lbs)

## Available Models

Specification	PUL 10360-480	PUL 10500-360	PUL 10750-240	PUL 10920-250	PUL 11000-160	PUL 11500-120	PUL 12000-80
Voltage Range (V)	0 - 360 V	0 - 500 V	0 - 750 V	0 - 920 V	0 - 1000 V	0 - 1500 V	0 - 2000 V
Ripple in CV (rms) (mV BW 300 kHz)	≤55 mV	≤70 mV	≤200 mV	≤250 mV	≤300 mV	≤400 mV	≤500 mV
Ripple in CV (pp) (mV BW 20 MHz)	≤320 mV	≤350 mV	≤800 mV	≤1200 mV	≤1600 mV	≤2400 mV	≤3000 mV
UMin for IMax (sink) (V)	2.5 V	1.1 V	1.2 V	2.0 V	3.4 V	3.2 V	3.7 V
Current Range (A)	0 - 480 A	0 - 360 A	0 - 240 A	0 - 250 A	0 - 160 A	0 - 120 A	0 - 80 A
Power Range (W)	0 - 60000 W	0 - 60000 W	0 - 60000 W	0 - 60000 W	0 - 60000 W	0 - 60000 W	0 - 60000 W
Resistance Range (Ω)	0.025 - 45 Ω	0.04 - 85 Ω	0.1 - 185 Ω	0.125 - 275 Ω	0.2 - 325 Ω	0.4 - 750 Ω	0.85 - 1350 Ω
Output Capacitance (μF)	3480 μF	1560 μF	765 μF	465 μF	387 μF	173 μF	85 μF
Efficiency (sink/source up to, %)	95.8%	96.5%	96.5%	96.5%	95.8%	96.5%	96.5%
Negative DC Pole to PE (V)	±1000 V	±1500 V	±1500 V	±1500 V	±1500 V	±1500 V	±1500 V
Positive DC Pole to PE (V)	+1000 V	+2000 V	+2000 V	+2000 V	+2000 V	+2000 V	+2000 V
Article Number (Standard)	01143010	01143011	01143012	01143013	01143014	01143015	01143016
Article Number (Standard + Water Cooling)	01573001	01573002	01573003	01573004	01573005	01573006	01573007



## General

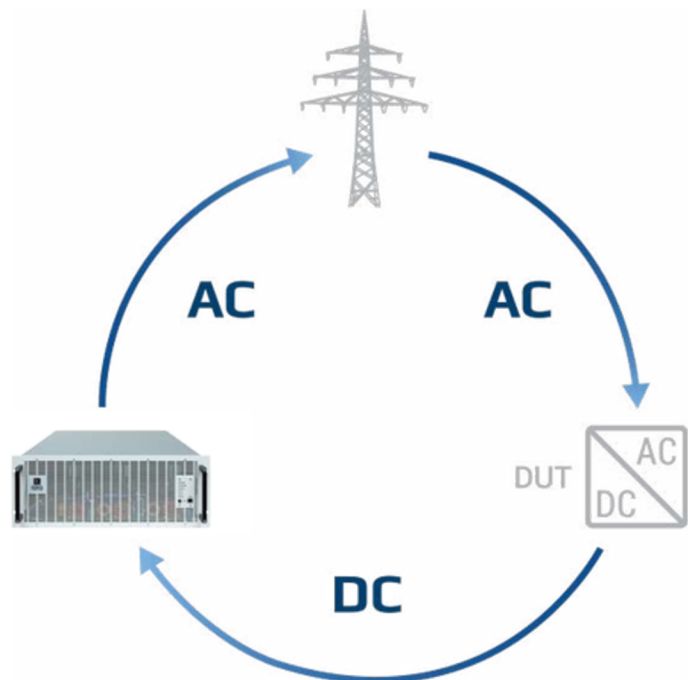
The PUL 10000 series represents a cutting-edge range of programmable electronic DC loads designed for precision and efficiency. These devices are regenerative, feeding consumed DC energy back into the local or public grid with up to 96% efficiency. Their three-phase design and wide input range allow seamless operation across global mains voltages. Featuring autoranging input stages, the series adapts dynamically to a broad spectrum of voltages and currents, supporting applications from 0–360 V to 0–2000 V and up to 480 A. Scalability is a key feature, enabling up to 64 devices to be combined into a single system with a capacity of up to 3840 kW, all while operating as a unified entity with seamless functionality.

## Energy Recovery

The energy recovery technology in the PUL 10000 series is both cost-effective and environmentally friendly. Energy consumed during load operations is efficiently returned to the grid with up to 96% recovery efficiency, significantly reducing energy costs. By minimizing heat generation, these devices reduce the need for intensive cooling systems, providing a compact, cost-effective solution for a variety of applications.

## AC Connection

Equipped with active power factor correction (PFC), the PUL 10000 series ensures high efficiency and low energy consumption. These devices are compatible with a wide AC voltage range from 380–480 V, making them suitable for operation in the majority of global grids. This robust input capability ensures stable and reliable performance for diverse industrial and laboratory environments.



## The principle of energy recovery

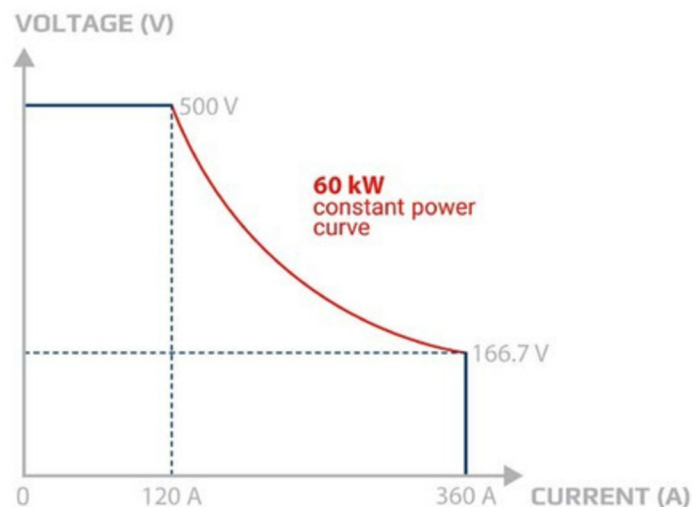
The energy recovery process in the PUL 10000 series highlights its advanced technology. During operation, the device under test (DUT) draws energy from the mains, converting it into DC power. This energy is then regenerated back into an AC current and fed into the grid by the PUL 10000 device. This bidirectional process ensures minimal energy loss, reduces environmental impact, and maximizes overall system efficiency.

## DC Input

The PUL 10000 series features a versatile DC input range that supports voltages from 0–360 V to 0–2000 V and currents from 0–80 A to 0–480 A. These flexible input stages, equipped with autoranging capabilities, deliver maximum power across a wide operating range. This ensures compatibility with a broad spectrum of applications, from high-voltage industrial systems to precision laboratory environments.

## DC Connection

The DC connection for the PUL 10000 series is designed with simplicity and scalability in mind. Each device includes copper rails located at the rear, facilitating secure and efficient power connections. For higher performance demands, multiple devices can be linked in parallel using vertical copper rails, creating scalable systems with minimal effort. A contact protection cover ensures user safety during operation.



## The principle of autoranging

Autoranging technology enables the PUL 10000 series to dynamically adjust its voltage and current output to maintain full power across a wide operating range. This advanced functionality eliminates the need for multiple devices to cover different voltage and current combinations, providing unparalleled flexibility and efficiency in both industrial and laboratory settings.

## Interfaces

The PUL 10000 series comes equipped with galvanically isolated interfaces, ensuring safe and reliable integration into complex systems. Standard interfaces include USB and Ethernet, as well as an analog interface that supports control and monitoring of voltage, current, power, and resistance. Additional optional industrial interfaces like CAN, Profinet, Modbus, and EtherCAT expand the series' adaptability, making it suitable for a variety of automation and communication needs.

## High-Performance Systems

The PUL 10000 series offers scalable power systems capable of handling up to 3840 kW, making them ideal for the most demanding industrial applications. By using the DC outputs of multiple units connected with vertical copper rails, users can build high-power configurations with minimal effort. For example, a 19" cabinet with 42 U height can deliver 300 kW while taking up just 0.6 m<sup>2</sup> (6.5 sqft) of floor space. The integrated Master-Slave Bus supports up to 13 cabinets or 64 devices (each with 60 kW) to function as a single, unified system, ensuring efficiency and seamless operation.

## Master-Slave-Bus and Share-Bus

The Master-Slave Bus and Share-Bus technologies enable the PUL 10000 series to operate as a cohesive multi-unit system. The Master-Slave Bus centralizes control and data monitoring, consolidating total power, current, and system status onto the master device display. The Share-Bus, on the other hand, ensures balanced load distribution across all connected devices, optimizing performance and prolonging system life. Together, these systems simplify complex power configurations, offering reliability and ease of operation for large-scale applications.



## Example Representation

A fully assembled and operational 240 kW system.

# Applications

## Battery Test for Electromobility

The PUL 10000 series is designed to meet the rigorous demands of battery testing for electric vehicles. With its wide application range, it accommodates testing for cells, modules, and packs, including assessments for State of Health (SOH) and End-of-Line (EOL) classifications. These devices ensure accurate measurements of voltage and current, offering high reproducibility and reliability in both automated and integrated testing environments. Moreover, their energy efficiency of up to 96% delivers significant cost savings during extended testing cycles.

## Fuel Cell Test

The PUL 10000 series excels in testing the electrical characteristics of fuel cells, stacks, and systems, providing precise and reproducible results. These devices facilitate rapid evaluations of resistance, performance, and lifecycle, while their energy recovery capabilities guarantee high cost efficiency. For larger systems requiring higher currents, multiple units can be operated in Master-Slave mode, maintaining performance and accuracy throughout testing.

## On-Board Charger Test

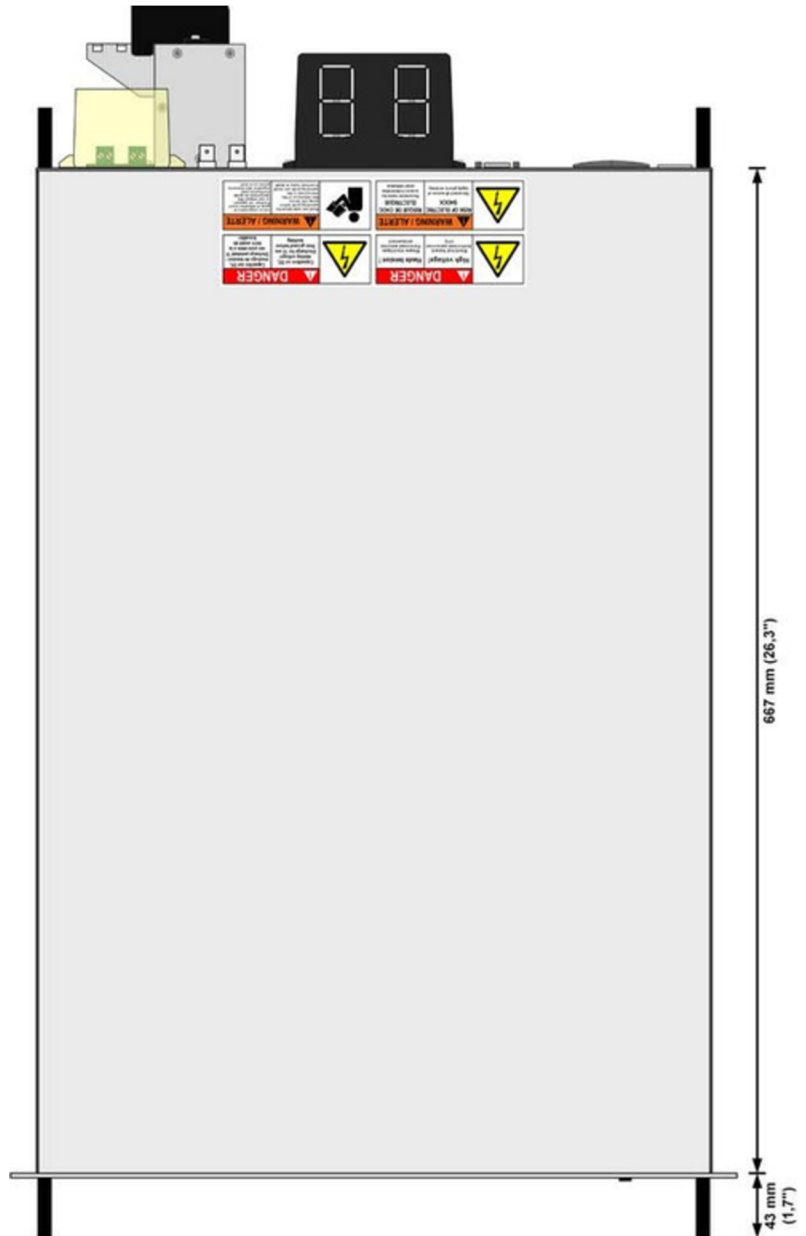
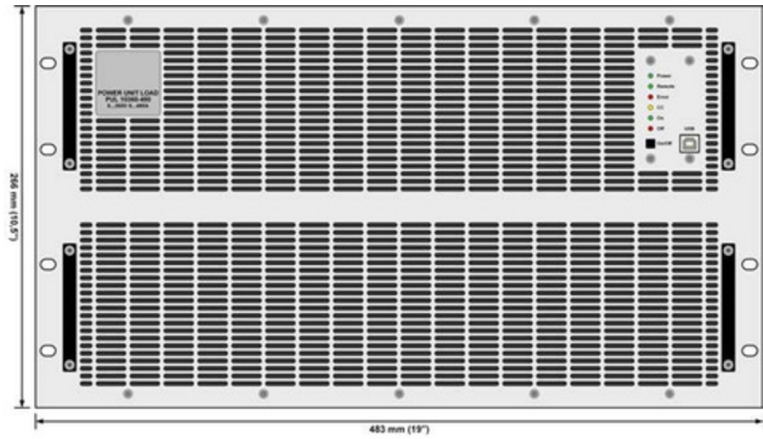
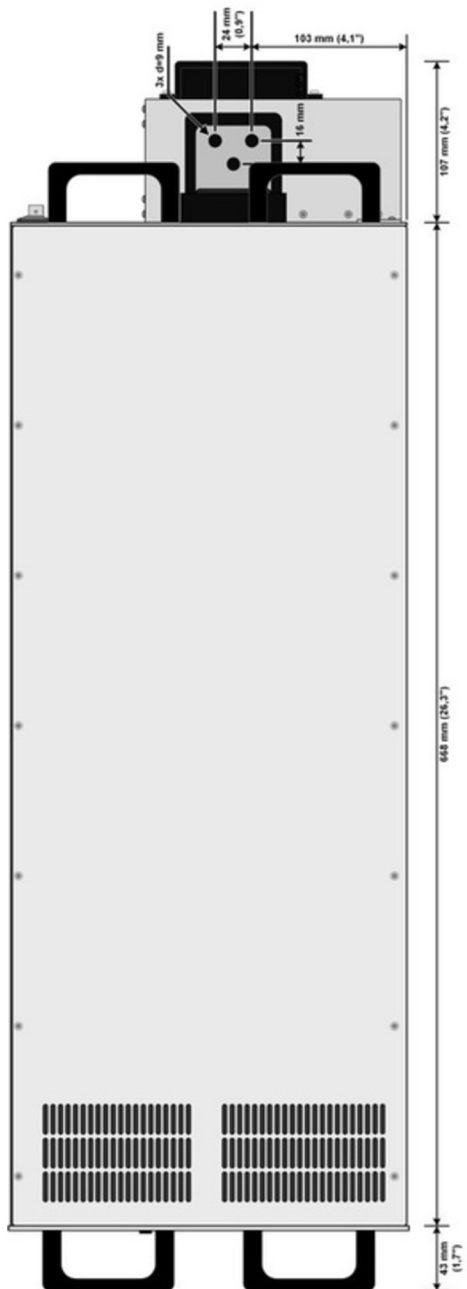
When testing on-board chargers (OBCs), the PUL 10000 series offers unparalleled flexibility and precision. With features like sequencing and logging functions, users can record dynamic test conditions and save results for analysis. Adjustable voltage regulation speeds (Normal, Fast, Slow) ensure compatibility with the control characteristics of the Device Under Test (DUT), preventing operational conflicts and ensuring smooth, reproducible outcomes.

## Battery Recycling

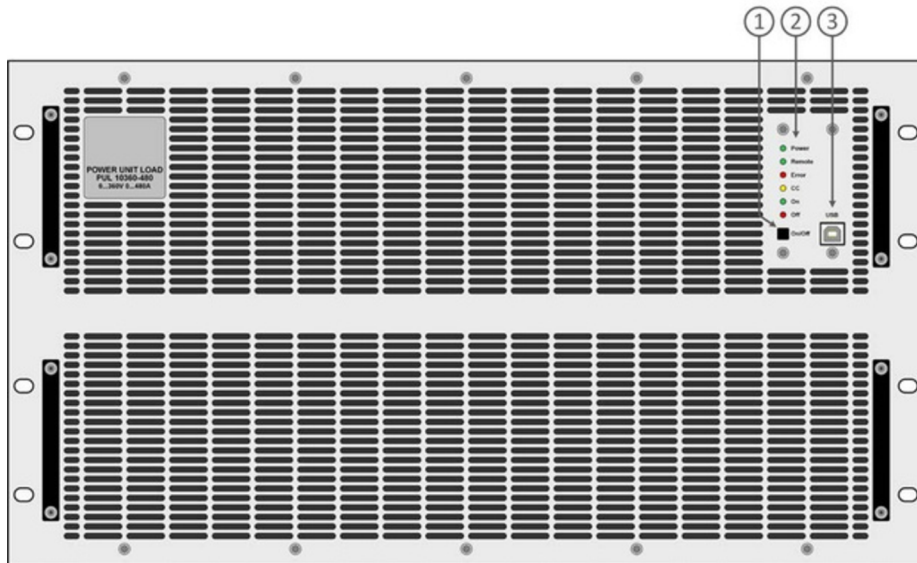
The PUL 10000 series supports battery recycling by providing efficient methods for assessing and discharging retired batteries. With a built-in State of Health (SOH) check, users can quickly evaluate a battery's suitability for second-life applications. If recycling is necessary, the autoranging capability ensures maximum discharge, even at voltages below 2 V. Additionally, the devices achieve energy recovery efficiency of up to 96%, making the recycling process both cost-effective and environmentally friendly.



# Technical drawings PUL 10000 6U

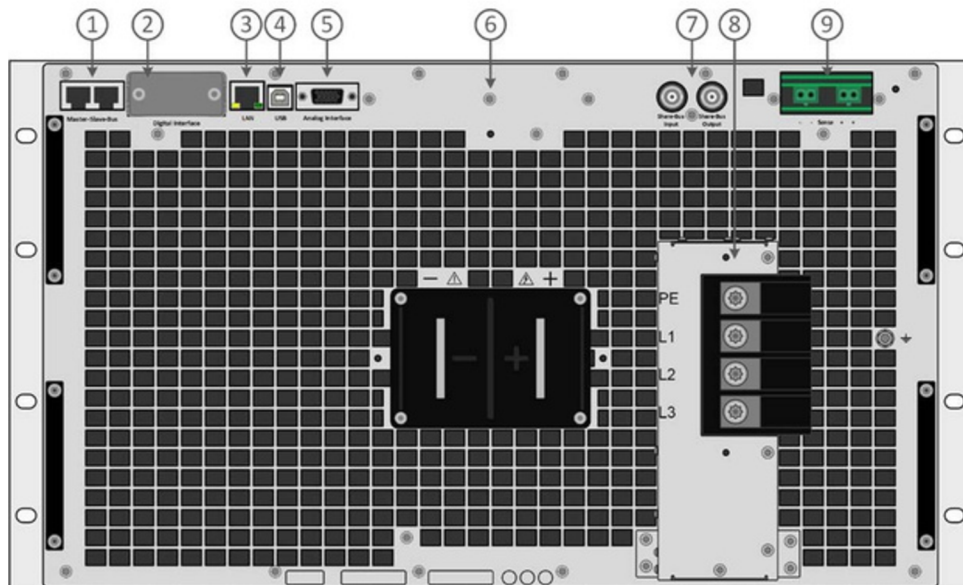


## Front panel description PUL 10000 6U



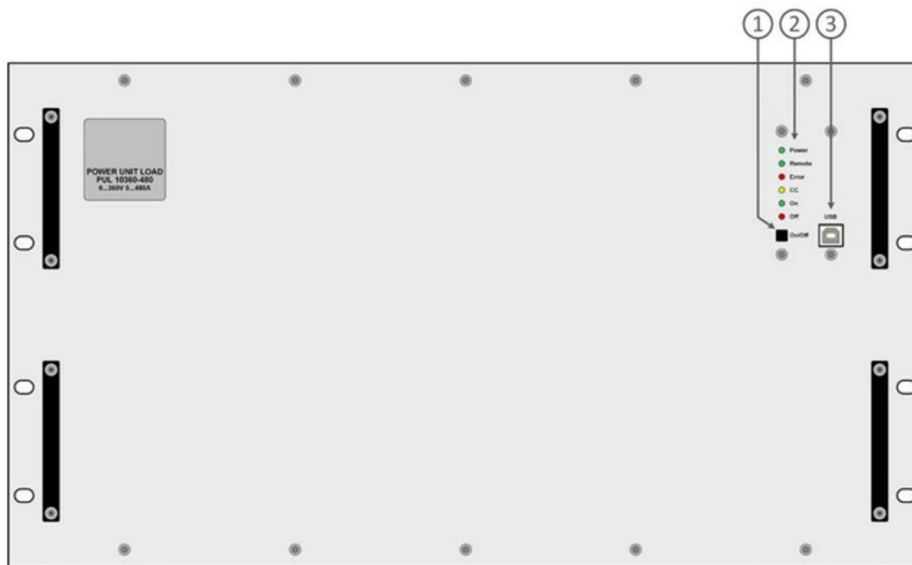
1. On / Off push-button
2. LED status display
3. USB Interface

## Rear panel description PUL 10000 6U



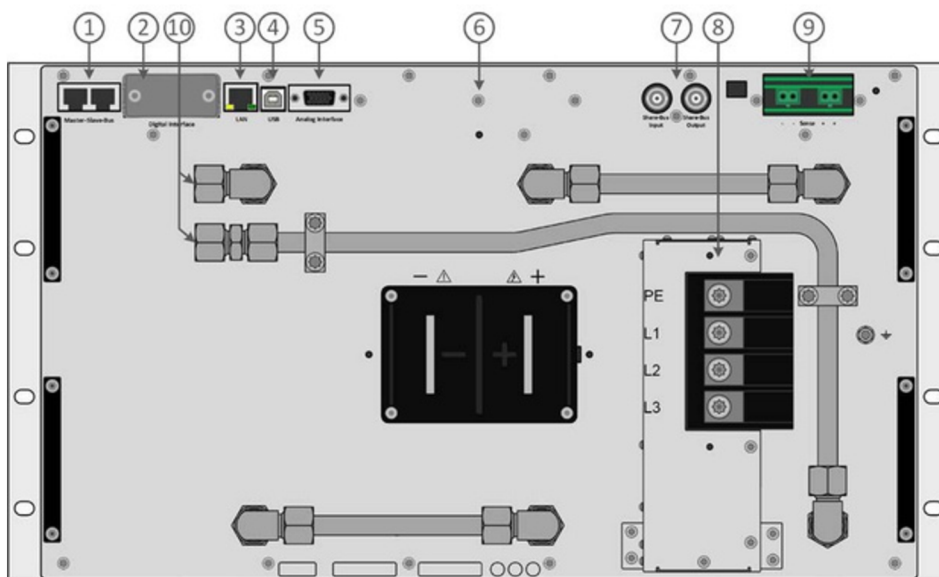
1. Master-Slave-Bus connectors to set up a system for parallel connection
2. Slot for interfaces
3. Ethernet interface
4. USB interface
5. Connector (DB15 female) for isolated analog programming, monitoring and other functions
6. DC output connector (copper blades)
7. Share-Bus connectors to set up a system for parallel connection
8. AC input connector
9. Remote sense connectors

## Front panel description PUL 10000 6U WC (water cooling option)



1. On / Off push-button
2. LED status display
3. USB Interface

## Rear panel description PUL 10000 6U WC (water cooling option)



1. Master-Slave-Bus connectors to set up a system for parallel connection
2. Slot for interfaces
3. Ethernet interface
4. USB interface
5. Connector (DB15 female) for isolated analog programming, monitoring and other functions
6. DC output connector (copper blades)
7. Share-Bus connectors to set up a system for parallel connection
8. AC input connector
9. Remote sense connectors
10. Water inlet and outlet

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