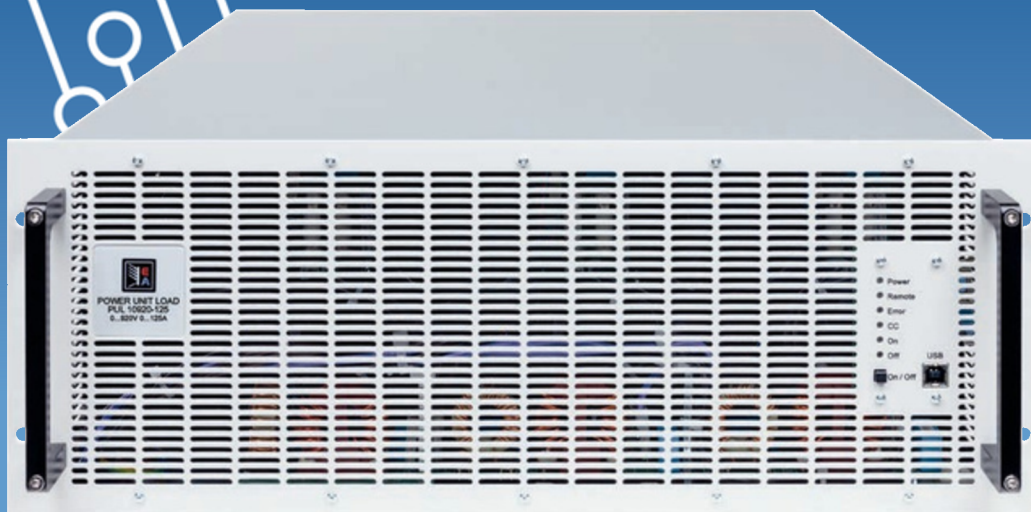




Elektro-Automatik



PUL 10000 4U

Advanced Regenerative DC Loads for
Maximum Efficiency | 30 kW

30 kW

Regenerative Energy Recovery: Returns up to 96% of consumed energy to the grid, reducing operational costs.

Wide Voltage and Current Ranges: Supports 0–80 V to 0–2000 V and 0–40 A to 0–1000 A for diverse testing needs.

Scalable Power Systems: Combine up to 64 units for up to 3840 kW and 64,000 A, with Master-Slave Bus functionality.

Advanced Interfaces: Built-in USB, Ethernet, and optional CAN, EtherCAT, and Modbus for seamless integration.

Compact and Flexible Design: High power density in a compact 4U form factor with autoranging capabilities.

EA-PUL 10000 4U 30 kW

Programmable electronic DC loads
with energy recovery



Features

- Wide range input: 208 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 30 kW per unit
- Voltages from 0 - 80 V up to 0 - 2000 V
- Currents from 0 - 40 A up to 0 - 1000 A
- Flexible power-regulated DC input stages (autoranging)
- Regulation modes CV, CC, CP, CR with fast crossover
- Digital regulation, high resolution with 16-bit ADCs and DACs, selection of voltage control speed: Normal, Fast, Slow
- 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 the same type in all power classes of the 10000 series
- Command languages and drivers: SCPI and ModBus, LabVIEW, IVI

Built-in interfaces

- USB
- Ethernet
- Analog
- USB (front panel)
- 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 (208 V - 240 V $\pm 10\%$, 3ph AC with derating to 18 kW)
- **Frequency:** 45 - 65 Hz
- **Power Factor:** ca. 0.99
- **Leakage Current:** <10 mA
- **Phase Current:** ≤ 56 A @ 400 V AC
- **Overvoltage Category:** 2

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:** ≤ 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:** ≤ 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:** ≤ 2 ms
- **Fall Time 90 - 10% CC:** ≤ 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:** ≤ 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 4U x 668 mm
- **Weight:** 50 kg (110 lbs)
- **Weight with water cooling:** 56 kg (126 lbs)

Available Models

Parameter	PUL 10080-1000	PUL 10200-420	PUL 10360-240	PUL 10500-180	PUL 10750-120
Voltage Range	0 - 80 V	0 - 200 V	0 - 360 V	0 - 500 V	0 - 750 V
Ripple in CV (rms)	≤25 mV (BWL 300 kHz)	≤40 mV (BWL 300 kHz)	≤55 mV (BWL 300 kHz)	≤70 mV (BWL 300 kHz)	≤200 mV (BWL 300 kHz)
Ripple in CV (pp)	≤320 mV (BWL 20 MHz)	≤300 mV (BWL 20 MHz)	≤320 mV (BWL 20 MHz)	≤350 mV (BWL 20 MHz)	≤800 mV (BWL 20 MHz)
UMin for IMax (sink)	0.62 V	1.8 V	2.5 V	1.1 V	1.2 V
Current Range	0 - 1000 A	0 - 420 A	0 - 240 A	0 - 180 A	0 - 120 A
Power Range	0 - 30000 W	0 - 30000 W	0 - 30000 W	0 - 30000 W	0 - 30000 W
Resistance Range	0.003 Ω - 5 Ω	0.0165 Ω - 25 Ω	0.05 Ω - 90 Ω	0.08 Ω - 170 Ω	0.2 Ω - 370 Ω
Output Capacitance	25380 μF	5400 μF	1800 μF	675 μF	450 μF
Efficiency (sink/source)	95.5%	95.3%	95.8%	96.5%	96.5%

Available Models

Parameter	PUL 10920-125	PUL 11000-80	PUL 11500-60	PUL 12000-40
Voltage Range	0 - 920 V	0 - 1000 V	0 - 1500 V	0 - 2000 V
Ripple in CV (rms)	≤250 mV (BWL 300 kHz)	≤300 mV (BWL 300 kHz)	≤400 mV (BWL 300 kHz)	≤500 mV (BWL 300 kHz)
Ripple in CV (pp)	≤1200 mV (BWL 20 MHz)	≤1600 mV (BWL 20 MHz)	≤2400 mV (BWL 20 MHz)	≤3000 mV (BWL 20 MHz)
UMin for IMax (sink)	2 V	3.4 V	3.2 V	3.7 V
Current Range	0 - 125 A	0 - 80 A	0 - 60 A	0 - 40 A
Power Range	0 - 30000 W	0 - 30000 W	0 - 30000 W	0 - 30000 W
Resistance Range	0.25 Ω - 550 Ω	0.4 Ω - 650 Ω	0.8 Ω - 1500 Ω	1.7 Ω - 2700 Ω
Output Capacitance	100 μF	200 μF	75 μF	50 μF
Efficiency (sink/source)	96.5%	95.8%	96.5%	96.5%

General

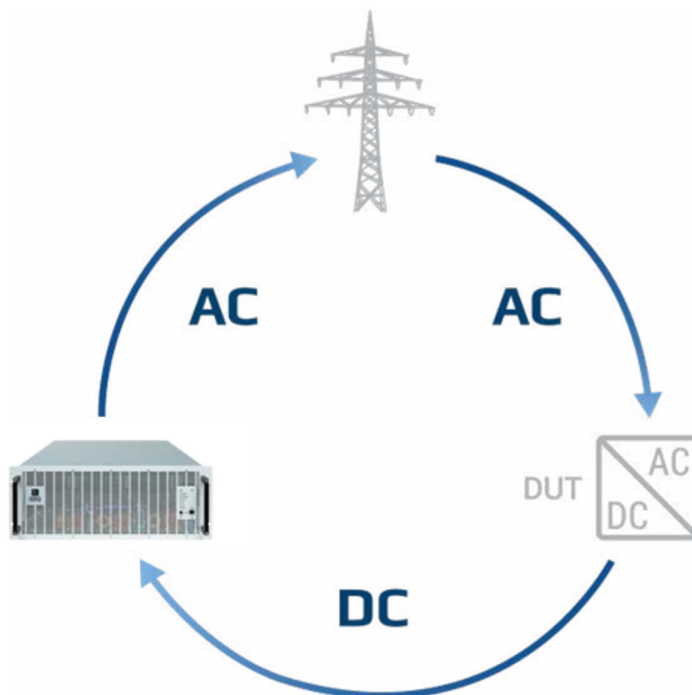
The PUL 10000 4U series from EA Elektro-Automatik represents the pinnacle of programmable electronic DC loads with energy recovery. These devices achieve up to 96% efficiency, feeding consumed energy back into the local or public grid, reducing operational costs and minimizing heat generation. Their wide input range and three-phase compatibility ensure seamless operation on nearly all global mains voltages. Supporting voltages from 0–80 V to 0–2000 V and currents from 0–40 A to 0–1000 A, they offer exceptional flexibility for a wide variety of testing scenarios. The autoranging input stage provides constant power over a broad range, while the Master-Slave Bus enables scalability to systems delivering up to 3840 kW and 64,000 A, ensuring unparalleled performance in high-demand environments.

AC Connection

The PUL 10000 4U series is equipped with an active power factor correction (PFC), delivering high efficiency with minimal energy consumption. The wide input voltage range of 208–240 V (derated to 18 kW) and 380–480 V across three phases allows operation in a vast majority of global grids. This adaptability reduces the need for multiple devices or configurations, saving both time and cost.

Energy Recovery

With an energy recovery system that achieves over 96% efficiency, the PUL 10000 4U converts consumed energy back into the grid as AC power. This eliminates the excessive heat generated by traditional loads, reducing air conditioning requirements and cutting operational costs. Its bidirectional design ensures a seamless transition between power source and load, offering unmatched flexibility for dynamic testing environments.



The Principle of Energy Recovery

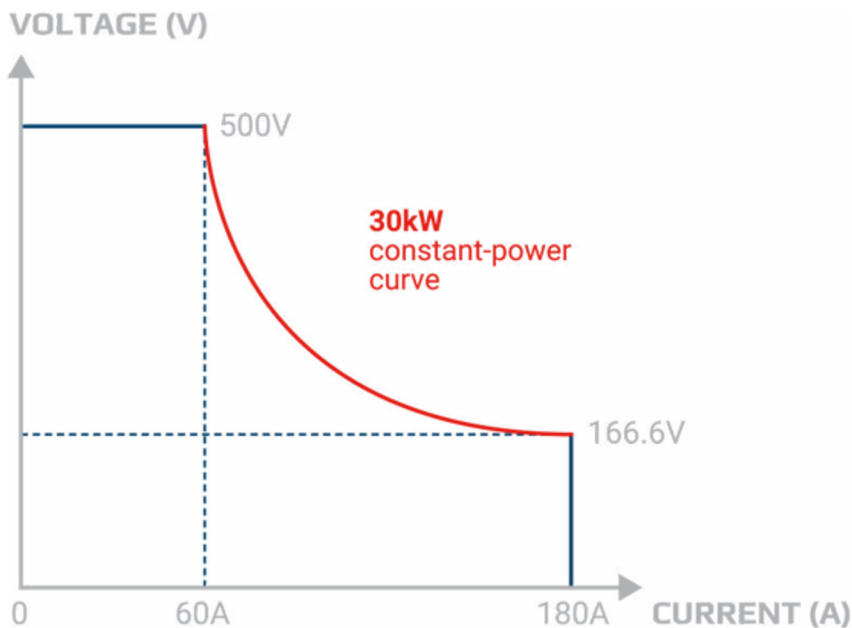
The energy recovery capability is exemplified in typical applications where a device under test (DUT) draws power, converts it to DC, and feeds it into the PUL 10000 4U. The system then reconverts the DC energy into AC, feeding it back into the grid with minimal losses. This closed-loop system significantly reduces energy waste and enhances sustainability.

DC Input

The PUL 10000 4U series supports a broad input range of 0–80 V to 0–2000 V, accommodating currents from 0–40 A to 0–1000 A. Its autoranging technology dynamically adjusts voltage and current to maintain constant power across this range, enabling engineers to work with multiple configurations without needing additional devices. The design emphasizes flexibility and efficiency, making it ideal for dynamic and variable testing conditions.

DC Connection

The DC input connection features a robust copper rail system on the rear of the device, ensuring durability and reliability. For applications requiring greater performance, multiple units can be easily connected in parallel using vertical copper rails. A protective cover enhances safety, while the modular design ensures a scalable solution for any power requirement.



The Principle of Autoranging

Autoranging technology in the PUL 10000 4U series enables a dynamic adjustment of voltage and current to deliver full power across a wide operational range. This feature eliminates the need for multiple devices to handle varying voltage and current requirements, simplifying workflows and reducing equipment costs. Engineers benefit from greater flexibility and efficiency, allowing them to tackle diverse applications with a single unit. Autoranging ensures the device remains versatile and adaptable, making it ideal for both high and low-power testing scenarios.

Interfaces

Built for modern integration, the PUL 10000 4U comes with standard galvanically isolated interfaces, including USB, Ethernet, and analog ports. These enable precise monitoring and control of voltage, current, power, and resistance. Optional industrial interfaces like CAN, EtherCAT, and Modbus ensure compatibility with various automation systems. This comprehensive suite of interfaces makes the PUL 10000 4U a reliable choice for both standalone and integrated setups.

High-Performance Systems

By leveraging parallel operation, multiple PUL 10000 4U units can be combined to create systems delivering up to 3840 kW and 64,000 A. The Master-Slave Bus allows synchronized operation, while the Share Bus ensures equal load distribution. This scalability minimizes downtime and maximizes efficiency, making the PUL 10000 4U suitable for demanding applications requiring significant power output.

Master-Slave-Bus and Share-Bus

The Master-Slave Bus and Share Bus systems allow multiple devices to function as one synchronized unit. The Master-Slave Bus consolidates total power and current data from all connected units, ensuring that all performance metrics are monitored and displayed on the master device. Meanwhile, the Share Bus equally distributes the load across all devices, enhancing the reliability and longevity of the system. This innovative architecture enables large-scale power systems to function with the same ease and efficiency as a single unit, ensuring consistent performance and reducing the need for complex individual management.



Example Representation

A fully assembled and operational 240 kW system.

Applications

Battery Test for Electro Mobility

The PUL 10000 4U series is engineered for rigorous battery testing applications, supporting cell, module, and pack evaluations. With its ability to precisely measure voltage and current, it ensures the reproducibility and reliability needed for critical tests like State-of-Health (SOH) assessments for second-life classification and End-of-Line (EOL) testing. Its high efficiency (up to 96%) not only reduces energy costs but also minimizes the environmental impact. Whether integrated into automated systems or standalone setups, the PUL 10000 4U offers flexible and dependable solutions for advancing energy storage technologies.

Fuel Cell Test

When it comes to testing fuel cells, stacks, or complete fuel cell systems, the PUL 10000 4U delivers the high precision and reproducibility engineers demand. It enables comprehensive evaluation of resistance, performance, and operational lifespan, ensuring rapid and economical results. The energy recovery system reduces operational costs by feeding energy back into the grid, while parallel device configurations maintain accuracy and performance even for high-current applications. This makes it an invaluable tool for the evolving fuel cell industry.

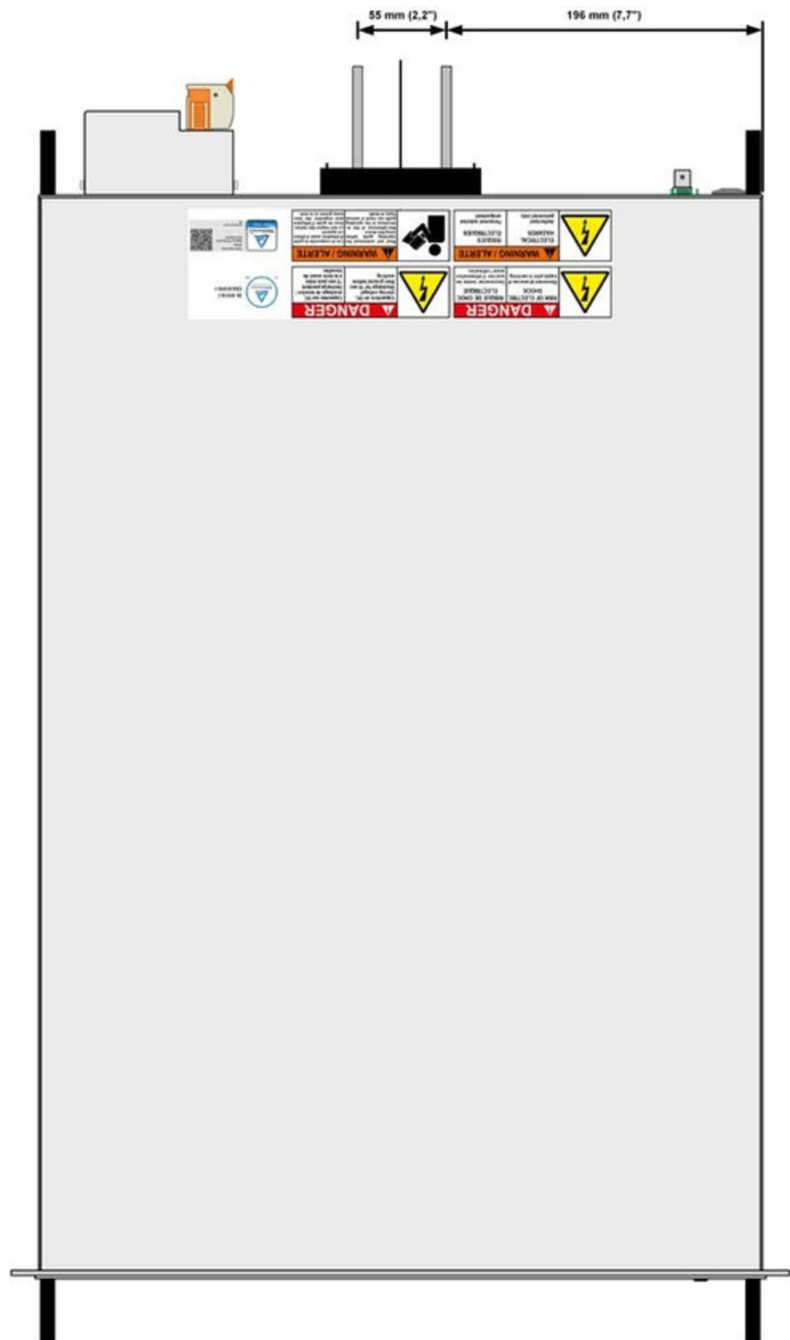
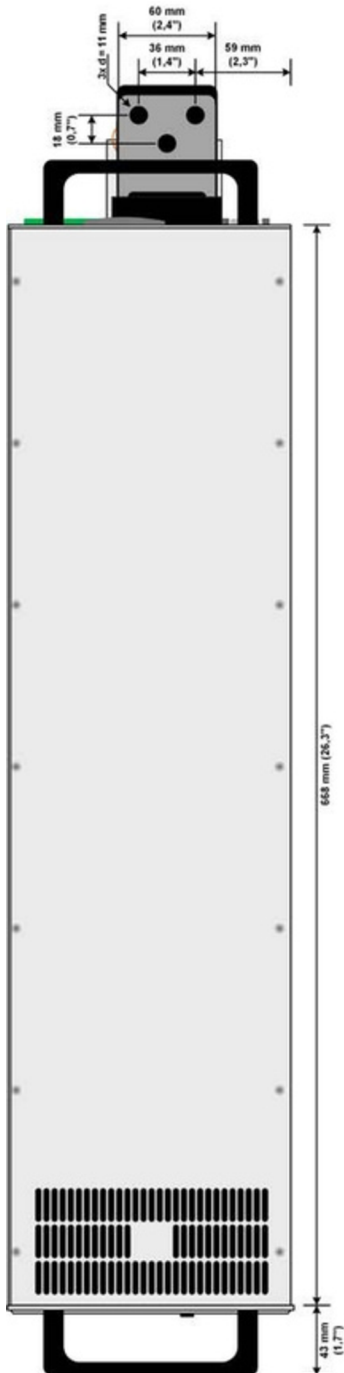
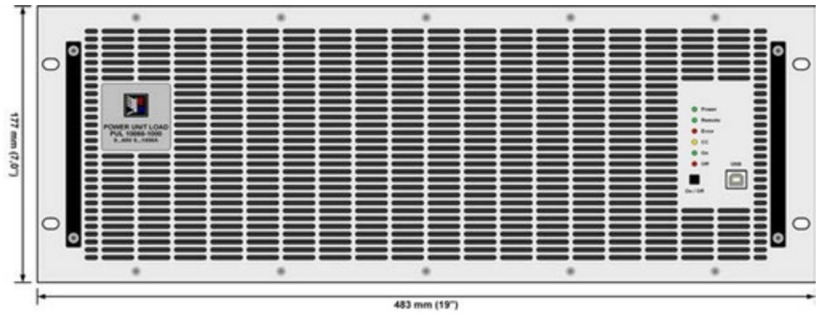
On-Board Charger Test

Testing on-board chargers (OBCs) requires flexibility and precision, and the PUL 10000 4U excels in both. With its sequencing and logging features, engineers can generate reproducible test data for a wide range of electrical conditions. The device's adjustable voltage regulation speeds—Normal, Fast, and Slow—prevent conflicts between the test system and the device under test, ensuring smooth operation and accurate results. These capabilities make the PUL 10000 4U a reliable partner in optimizing on-board charging technologies.

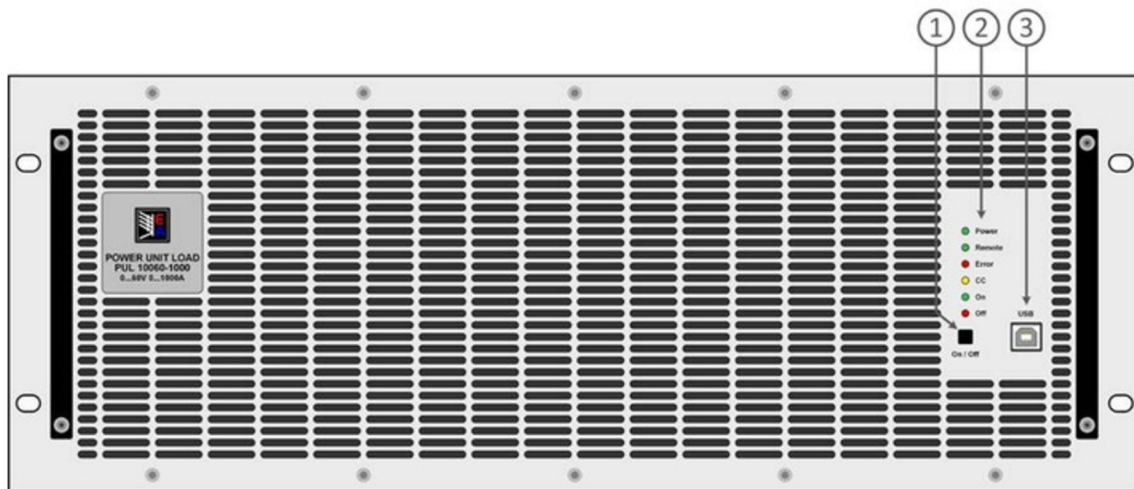
Battery Recycling

The PUL 10000 4U supports the growing need for sustainable battery recycling by facilitating efficient State-of-Health (SOH) checks and thorough discharge processes. Its autoranging technology ensures high discharge currents even at low voltages, allowing for maximum energy recovery. With its regenerative energy feedback system, the device feeds up to 96% of energy back to the grid, reducing both energy consumption and costs. This capability positions the PUL 10000 4U as an essential tool for advancing the circular economy of energy storage.

Technical drawings PUL 10000 4U <200 V

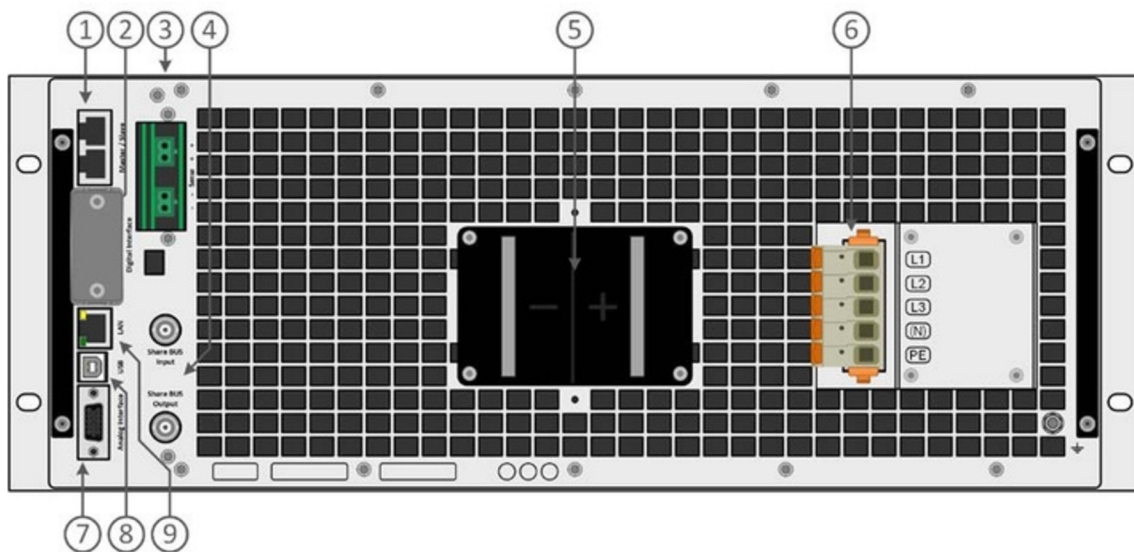


Front panel description PUL 10000 4U



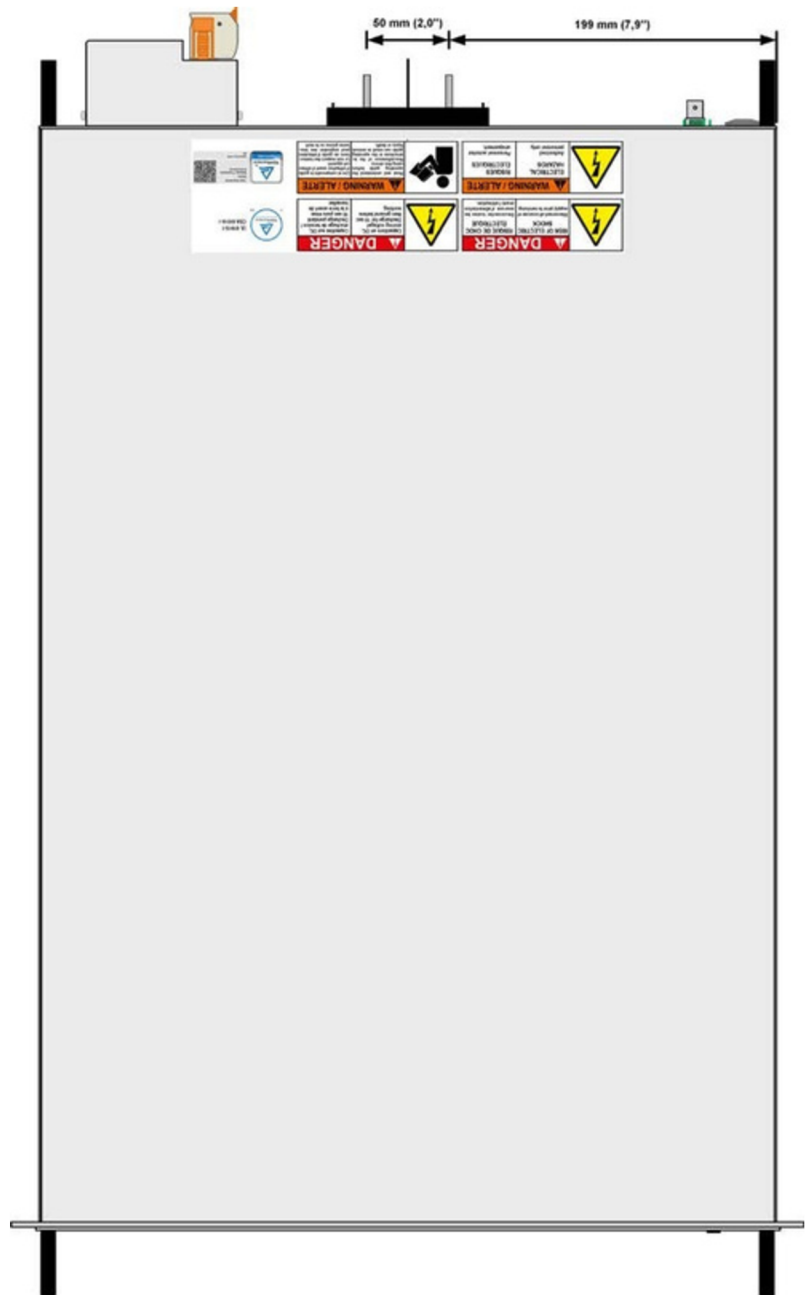
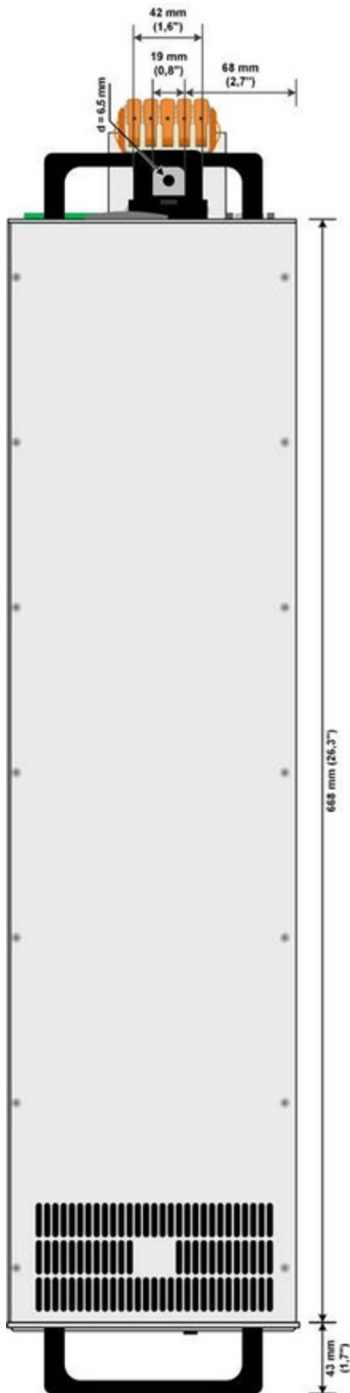
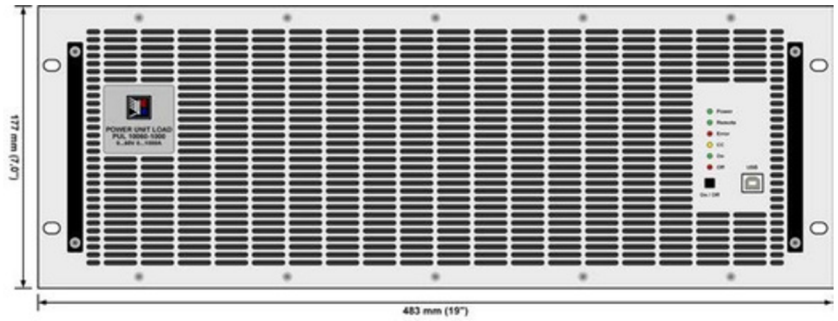
1. On / Off push-button
2. LED status display
3. USB Interface

Rear panel description PUL 10000 4U <200 V

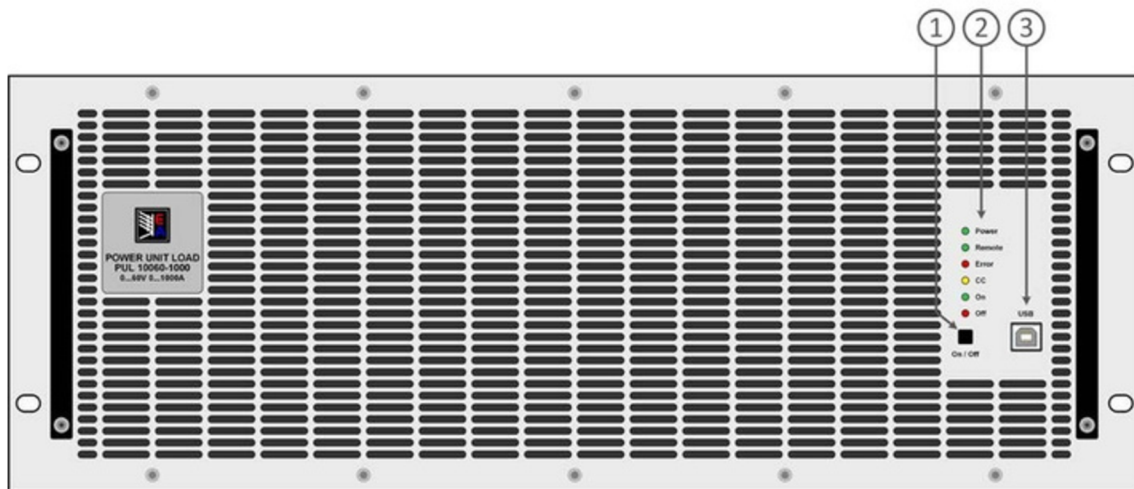


1. Master-Slave-Bus connectors to set up a system for parallel connection
2. Slot for interfaces
3. Remote sense connectors
4. Share bus connectors to set up a system for parallel connection
5. DC output connector (copper blades)
6. AC input connector
7. Connector (DB15 female) for isolated analog programming,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

Technical drawings PUL 10000 4U >360 V

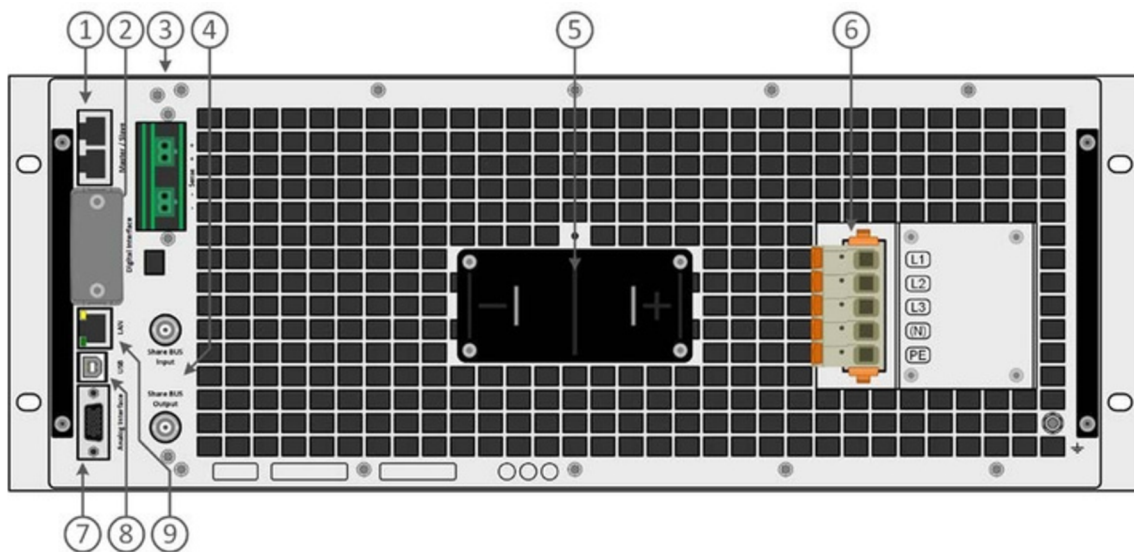


Front panel description PUL 10000 4U



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

Rear panel description PUL 10000 4U >360 V



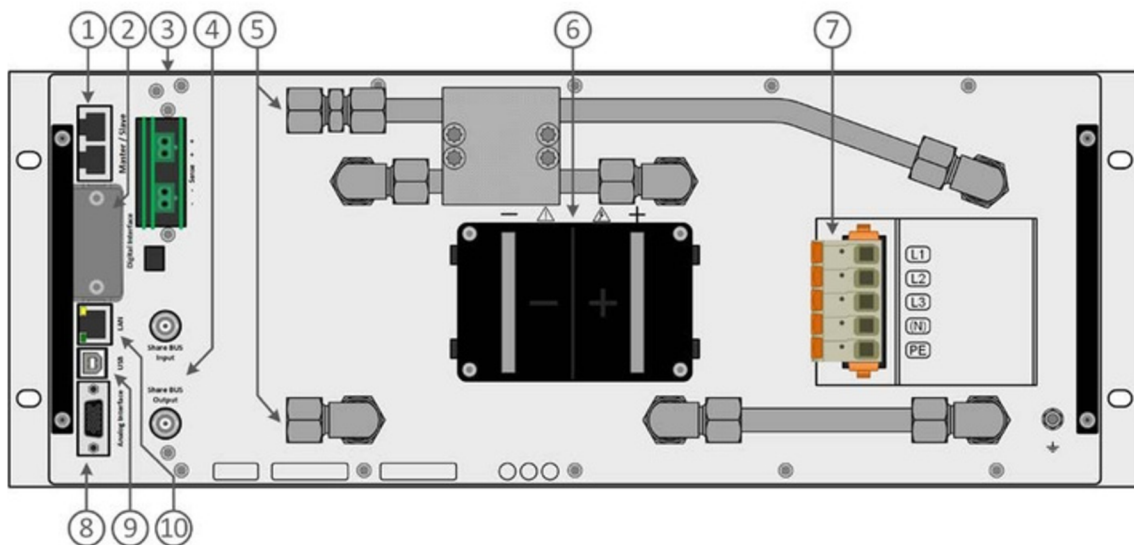
1. Master-Slave-Bus connectors to set up a system for parallel connection
2. Slot for interfaces
3. Remote sense connectors
4. Share bus connectors to set up a system for parallel connection
5. DC output connector (copper blades)
6. AC input connector
7. Connector (DB15 female) for isolated analog programming,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

Front panel description PUL 10000 4U WC (water cooling option)



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

Rear panel description PUL 10000 4U WC (water cooling option)



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

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