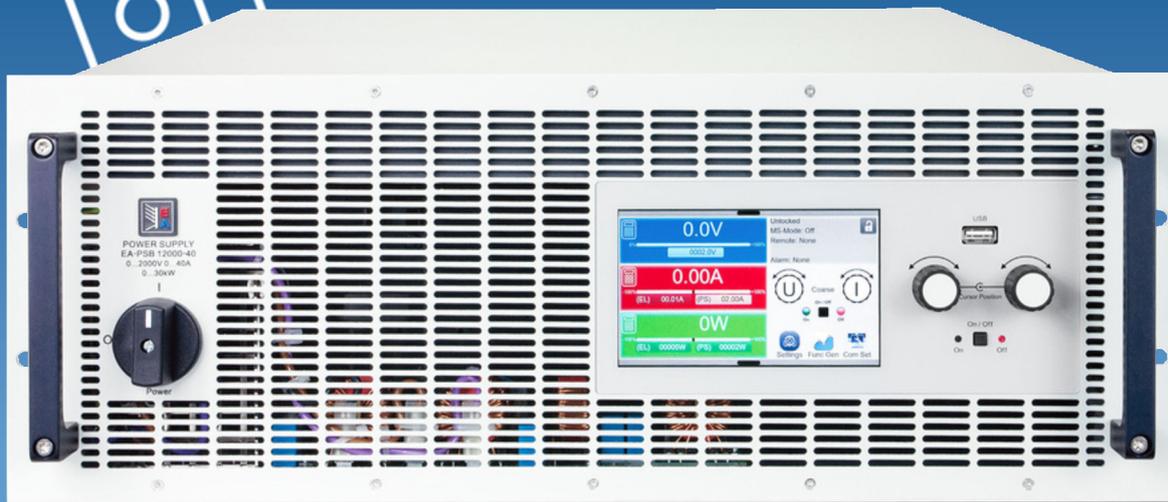




Elektro-Automatik



EA-BT 20000 Triple

Precision Battery Testing with Triple Output and Regenerative Efficiency

Triple Output

Triple Independent Outputs: Up to 10 kW, 600 A, and 920 V per channel.

Regenerative Energy Recovery: Over 96% efficiency, reducing energy costs.

Flexible Autoranging Technology: Full power across a wide range of voltages and currents.

Integrated Battery Testing & Simulation: Streamlined testing and state-of-health evaluation.

Advanced Connectivity: USB, Ethernet, EtherCAT, CAN FD, and more for seamless integration.

EA-BT 20000 TRIPLE

Battery Tester
with regenerative energy recovery



Features

- Wide range input: 208 V - 480 V, +10%, 3ph AC
- Active Power Factor Correction, typical 0.99
- Battery tester, 2-quadrants for charge and discharge
- In discharge operation regenerative with energy recovery into the grid
- Very high efficiency of up to over 96%
- Voltages from 0 - 10 V up to 0 - 920 V
- High performance with up to 10 kW per channel
- Currents from 0 - 40 A up to 0 - 600 A per channel
- Flexible power-regulated DC output/input stages (autoranging)
- Regulation modes CV, CC, CP, CR with fast crossover
- Digital regulation, high resolution with 16-bit ADCs and DACs, selection of control speed: Normal, Fast, Slow
- Galvanically isolated Share-Bus for parallel operation
- Master-Slave-Bus for parallel operation
- Built-in Interfaces with 1 ms communication speed
- Typical battery tester functionality integrated
- Integrated Battery test mode, battery simulation
- Command languages and drivers: SCPI and ModBus, LabVIEW, IVI

Built-in interfaces

- USB
- Ethernet 1 Gbit/s
- EtherCAT
- CAN FD
- Master-Slave-Bus
- Share-Bus
- USB Host on Front panel
- 3 digital inputs
- 3 relay contacts
- 3 temperature sensor inputs

Software

- EA - Power Control
- EA - Battery Simulator

Options

- Water Cooling in Stainless Steel



SPECIFICATIONS

AC Input

- **Voltage, Phases:** 380–480 V \pm 10%, 3-phase AC (208–240 V \pm 10%, 3-phase AC with derating to 18 kW)
- **Frequency:** 45–65 Hz
- **Power Factor:** Typical 0.99
- **Leakage Current:** <10 mA
- **Phase Current:** \leq 56 A @ 400 V AC
- **Oversvoltage 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 (208–480 V AC \pm 10% supply voltage, constant load and constant temperature)
- **Stability (CV):** \leq 0.02% FS (during 8 h 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 of warm-up)
- **Load Regulation (CC):** \leq 0.1% FS (0–100% load, constant AC input voltage and constant temperature)
- **Line Regulation (CC):** \leq 0.01% FS (208–480 V AC \pm 10% supply voltage, constant load and constant temperature)
- **Stability (CC):** \leq 0.02% FS (during 8 h 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 of warm-up)
- **Load Regulation (CP/CR):** \leq 0.3% FS + 0.1% FS current

Protective Functions

- **Oversvoltage 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 Output (Dynamic)

- **Rise Time (10–90%, CV):** \leq 10 ms
- **Fall Time (90–10%, CV):** \leq 10 ms
- **Rise Time (10–90%, CC):** \leq 2 ms
- **Fall Time (90–10%, CC):** \leq 2 ms

Display Accuracy

- **Voltage:** \leq 0.05% FS
- **Current:** \leq 0.1% FS

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 tables
- **DC Output to Interfaces:** 1000 V DC (models up to 360 V rating), 1500 V DC (models from 500 V rating)

Control Interfaces (Digital)

- **Built-in, Galvanically Isolated:** USB, Ethernet (1 Gbit), EtherCAT Slave, CAN FD
- **Communication Speed:** 1 ms
- **USB Host (Front Panel):** For data acquisition

Interfaces (Analog)

- **Built-in, Galvanically Isolated:** 16-pole connector
- **Inputs:** 3 independent inputs
- **Outputs:** 3 independent outputs as relay contacts
- **Temperature Inputs:** 3 independent temperature sensor inputs

Device Configuration

- **Parallel Operation:** Up to 3 channels 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 B), CISPR 11 (Class B), FCC 47 CFR part 15B (Class B), 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 4U x 668 mm (26.3 in)
- **Weight:** 50 kg (110 lb)
- **Weight with Water Cooling:** 56 kg (126 lb)

Available Models

| Parameter | BT 20010-400 Triple | BT 20010-600 Triple | BT 20060-340 Triple | BT 20080-340 Triple |
|---------------------------|---------------------|---------------------|-----------------------|-----------------------|
| Number of Channels | 3 channels | 3 channels | 3 channels | 3 channels |
| Voltage Range | 0 - 10 V | 0 - 10 V | 0 - 60 V | 0 - 80 V |
| Ripple in CV (rms) | ≤25 mV (BW 300 kHz) | ≤25 mV (BW 300 kHz) | ≤25 mV (BW 300 kHz) | ≤25 mV (BW 300 kHz) |
| Ripple in CV (pp) | ≤320 mV (BW 20 MHz) | ≤320 mV (BW 20 MHz) | ≤320 mV (BW 20 MHz) | ≤320 mV (BW 20 MHz) |
| UMin for IMax (sink) | 0.62 V | 0.62 V | 0.62 V | 0.62 V |
| Current Range | ±400 A per channel | ±600 A per channel | ±340 A per channel | ±340 A per channel |
| Power Range | ±4000 W per channel | ±6000 W per channel | ±10,000 W per channel | ±10,000 W per channel |
| Device Power Range | ±12,000 W | ±18,000 W | ±30,000 W | ±30,000 W |
| Resistance Range | N/A | N/A | N/A | N/A |
| Output Capacitance | 8460 μF | 8460 μF | 8460 μF | 8460 μF |
| Efficiency (Sink/Source) | 95.1% | 95.1% | 95.1% | 95.5% |
| Insulation (Negative DC) | ±600 V DC | ±600 V DC | ±600 V DC | ±600 V DC |
| Insulation (Positive DC) | +600 V DC | +600 V DC | +600 V DC | +600 V DC |
| Standard Article Number | 02133001 | 02133002 | 02133003 | 02133004 |
| Water Cooling Article No. | 02143001 | 02143002 | 02143003 | 02143004 |

| Parameter | BT 20200-140 Triple | BT 20360-80 Triple | BT 20500-60 Triple | BT 20920-40 Triple |
|---------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Number of Channels | 3 channels | 3 channels | 3 channels | 3 channels |
| Voltage Range | 0 - 200 V | 0 - 360 V | 0 - 500 V | 0 - 920 V |
| Ripple in CV (rms) | ≤40 mV (BW 300 kHz) | ≤55 mV (BW 300 kHz) | ≤70 mV (BW 300 kHz) | ≤250 mV (BW 300 kHz) |
| Ripple in CV (pp) | ≤300 mV (BW 20 MHz) | ≤320 mV (BW 20 MHz) | ≤350 mV (BW 20 MHz) | ≤1200 mV (BW 20 MHz) |
| UMin for IMax (sink) | 1.8 V | 2.5 V | 1.1 V | 2.0 V |
| Current Range | ±140 A per channel | ±80 A per channel | ±60 A per channel | ±40 A per channel |
| Power Range | ±10,000 W per channel |
| Device Power Range | ±30,000 W | ±30,000 W | ±30,000 W | ±30,000 W |
| Output Capacitance | 1800 μF | 600 μF | 225 μF | 40 μF |
| Efficiency (Sink/Source) | 95.3% | 95.8% | 96.5% | 96.5% |
| Insulation (Negative DC) | ±1000 V DC | ±1000 V DC | ±1500 V DC | ±1500 V DC |
| Insulation (Positive DC) | +1000 V DC | +1000 V DC | +2000 V DC | +2000 V DC |
| Standard Article Number | 02133005 | 02133006 | 02133007 | 02133008 |
| Water Cooling Article No. | 02143005 | 02143006 | 02143007 | 02143008 |

General

The BT 20000 Triple series from EA Elektro-Automatik is a high-performance battery tester with regenerative energy recovery. Designed as a two-quadrant device, it features three independent channels capable of functioning as chargers and electronic loads for discharging. In discharging mode, the system regeneratively feeds energy back into the local grid with an efficiency of up to over 96%, significantly reducing energy costs and heat generation.

Each channel in the BT 20000 Triple series offers a wide DC voltage range from 0–10 V up to 0–920 V and currents from 0–40 A to 0–600 A, making it adaptable for various applications. The device uses flexible autoranging technology, enabling full power across a wide range of voltage and current combinations. For even higher power and current demands, all units include a Master-Slave-Bus, allowing up to three channels to operate in parallel. This configuration can deliver up to 30 kW and 1800 A as a single channel. For example, engineers can use this system to test individual cells with three channels of 0–10 V and 0–600 A or as a single channel offering 0–10 V and 0–1800 A. The BT 20000 Triple series also incorporates advanced features like alarm and warning management, industrial interfaces, and software solutions, ensuring seamless integration into complex testing environments.

AC Connection

The BT 20000 Triple series is equipped with an active Power Factor Correction (PFC) system, delivering high efficiency and low energy consumption. Its wide AC input voltage range (208–240 V and 380–480 V, 3-phase) ensures compatibility with global power grids. The system automatically adjusts to the available grid voltage without requiring additional configuration. In grids with 208–240 V, the system automatically applies derating to the DC output power.

Energy Recovery

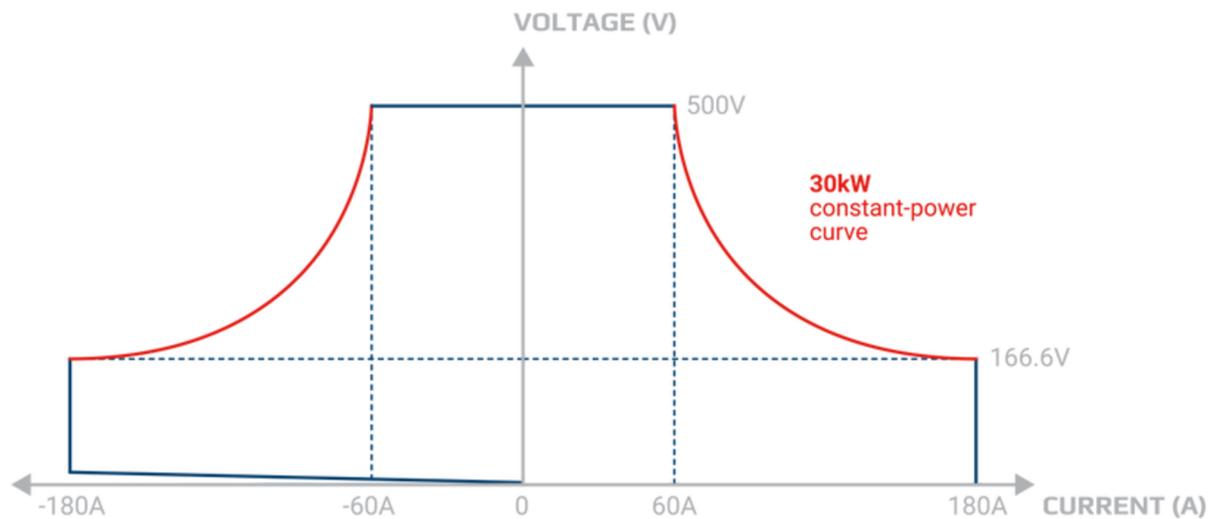
The BT 20000 Triple series provides regenerative energy recovery, feeding up to 96% of discharged energy back into the grid. This reduces operational costs and minimizes heat output, a significant advantage over conventional systems. Lower heat generation also decreases the need for intensive air conditioning, further improving cost efficiency.

DC Output

Each channel in the BT 20000 Triple series provides a DC voltage range from 0–10 V up to 0–920 V and supports both positive and negative currents from 0–40 A up to 0–600 A. This makes the system ideal for two-quadrant operations, including charging and discharging. The flexible autoranging output stages offer a wide range of voltage, current, and power configurations, enabling engineers to handle diverse testing requirements with a single system. Compared to traditional battery testers, the BT 20000 Triple offers superior flexibility and performance.

DC Connection

DC output connections are made via copper rails located at the rear of the device. For applications requiring higher power, multiple devices can be easily connected in parallel. The system design allows for straightforward linking of units using vertical copper rails, minimizing setup complexity. For additional safety, the device includes a protective cover to ensure contact protection during operation.



The Principle of Autoranging

Autoranging technology allows the BT 20000 Triple to maintain full power across a wide range of voltage and current combinations. This feature dynamically adjusts output to optimize performance, making it possible to address multiple test scenarios without requiring additional hardware. Engineers benefit from this flexibility, as a single unit can meet diverse voltage and current requirements, reducing equipment costs and simplifying test setups.

Interfaces

The BT 20000 Triple series comes standard with a comprehensive set of digital and analog interfaces, all galvanically isolated from the DC side to ensure safe and reliable operation. Communication is fast, with a speed of 1 ms.

Available interfaces include:

- USB
- Ethernet 1 Gbit/s
- EtherCAT
- CAN FD
- USB Host (front panel)

Additionally, the device features 3 digital inputs, 3 relay contacts, and 3 temperature sensor inputs. For larger systems, the Master-Slave-Bus and Share-Bus allow seamless integration of multiple devices, enabling them to operate as a single unit with symmetrical load sharing. This feature simplifies the management of high-performance systems and ensures efficient operation.

High-Performance Battery Test Systems

The BT 20000 Triple series supports high-power applications with systems delivering up to 240 kW in a single cabinet. By connecting multiple BT 20000 devices in parallel using vertical copper rails, engineers can achieve impressive power density while minimizing space requirements. For example, a 19" cabinet with 42U provides 240 kW of power while occupying only 0.6 m² (6.5 sqft) of floor space. The integrated Master-Slave-Bus allows for up to 8 cabinets, with a total of 64 units (30 kW each), to function as a single device, enabling combined outputs of up to 1920 kW.

Master-Slave-Bus and Share-Bus

The BT 20000 Triple series leverages the Master-Slave-Bus and Share-Bus for seamless integration of multiple devices. When these features are used, the system behaves as a single cohesive unit. The Master-Slave-Bus aggregates and displays system data, such as total power and current, on the master device. Any warnings or alarms from slave devices are consolidated for easy monitoring. The Share-Bus ensures equal load distribution across connected devices, maximizing system efficiency and reliability.



Example Representation

An example of a fully assembled and wired 240 kW system, showcasing the scalability and efficiency of the BT 20000 Triple series. This visual representation highlights how the system can be tailored to meet demanding high-power testing requirements while maintaining a compact footprint.

Applications

Battery Testing for Electromobility

The BT 20000 Triple series is designed to address the rigorous demands of testing battery cells, modules, and packs used in electromobility applications. It supports a wide range of tests, including State of Health (SOH) checks for second-life classification and End-of-Line (EOL) testing. With precise voltage and current measurement, reproducibility, and reliability, the BT 20000 Triple ensures accurate data acquisition for high-performance batteries. The flexibility of the system allows seamless integration into automated testing setups, making it an ideal choice for research, development, and production environments.

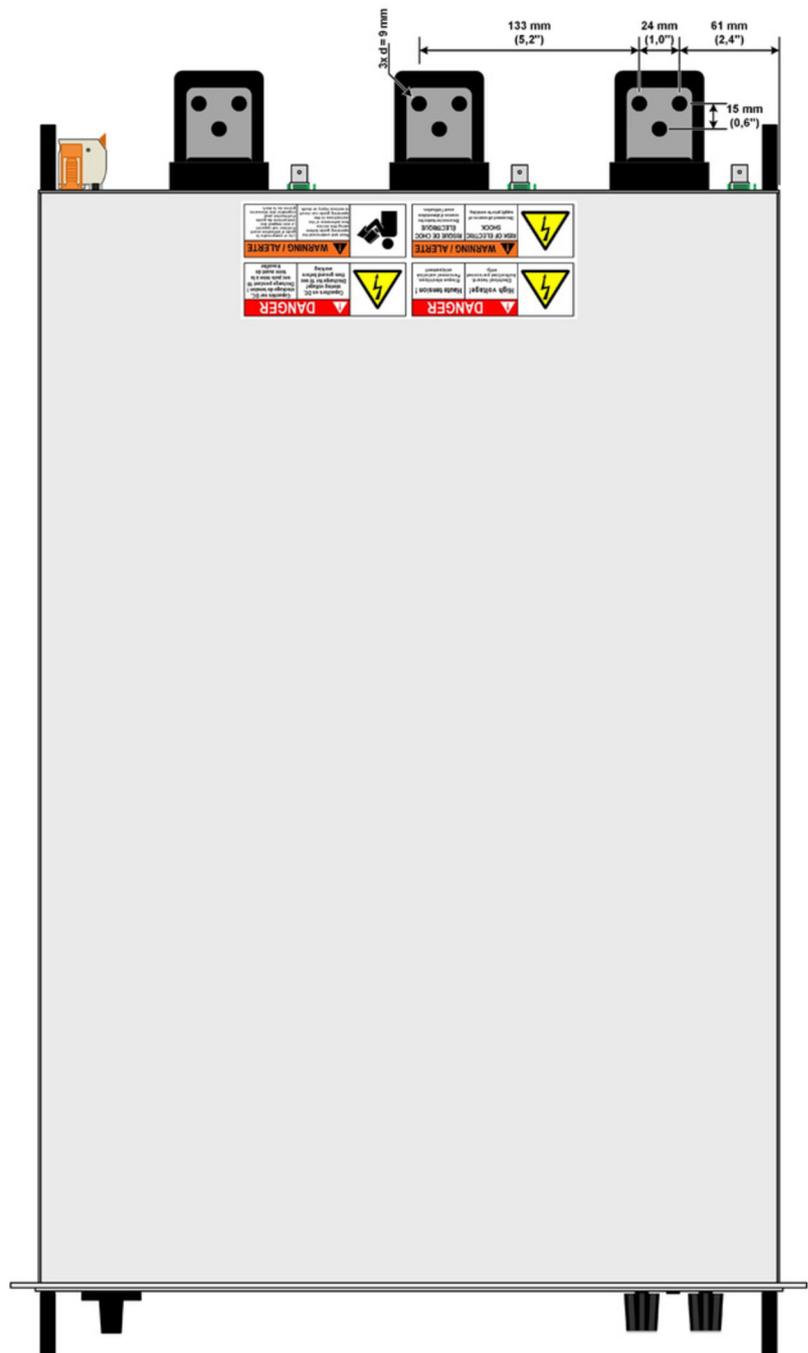
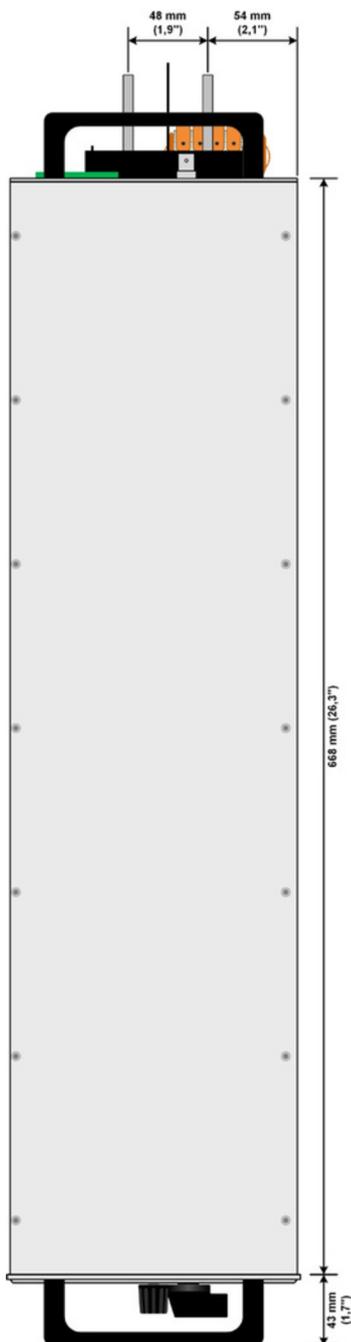
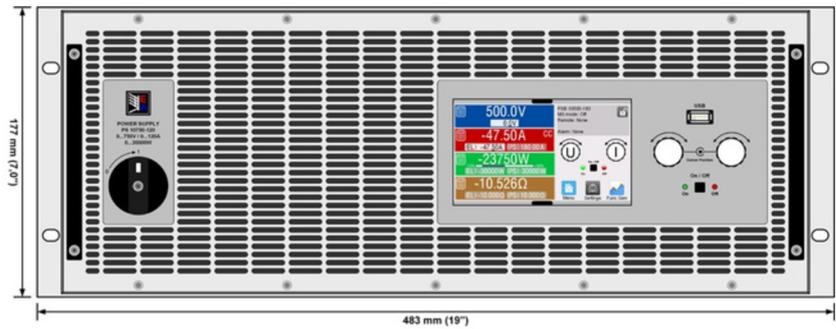
Battery Simulation

The BT 20000 Triple series can simulate batteries at the cell, module, or pack level, providing engineers with a powerful tool for optimizing energy storage systems and their associated components. The system includes integrated safety features, such as overcurrent protection (OCP), which acts as a safety fuse to prevent damage. Voltage monitoring ensures the system operates within predefined limits, triggering warnings or alarms if thresholds are exceeded. These capabilities enable safe and controlled testing, ensuring high reliability during simulation tasks.

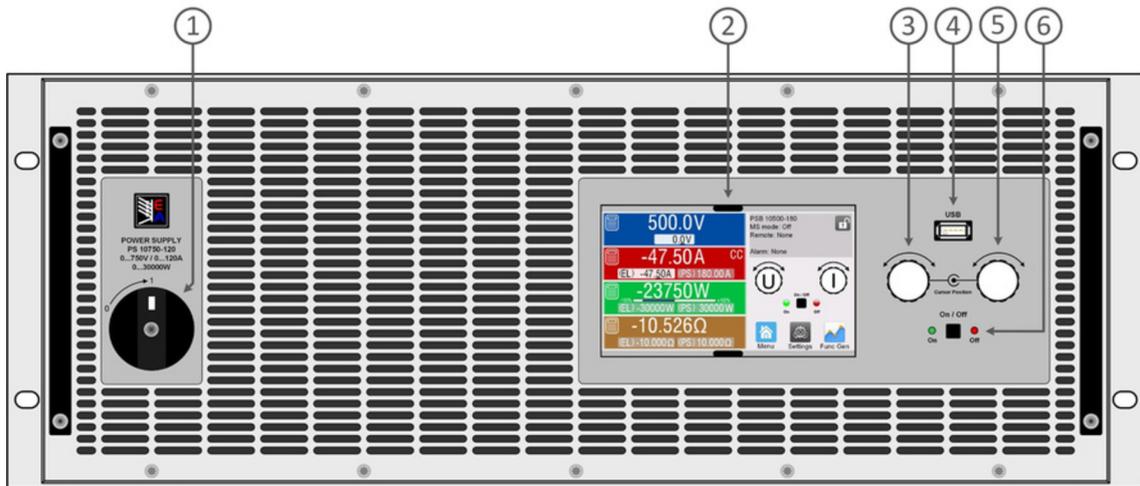
Battery Recycling

The BT 20000 Triple series is also suitable for recycling applications, particularly for discharging retired batteries from electric vehicles. The system's SOH check determines whether batteries are viable for second-life use. If the remaining capacity is insufficient, the device can safely discharge the battery at high load currents, even at voltages below 2 V. The regenerative energy recovery feature ensures that up to 96% of discharged energy is returned to the grid, making the process highly cost-effective and energy efficient.

Technical drawings BT 1000 Triple 4U <200 V

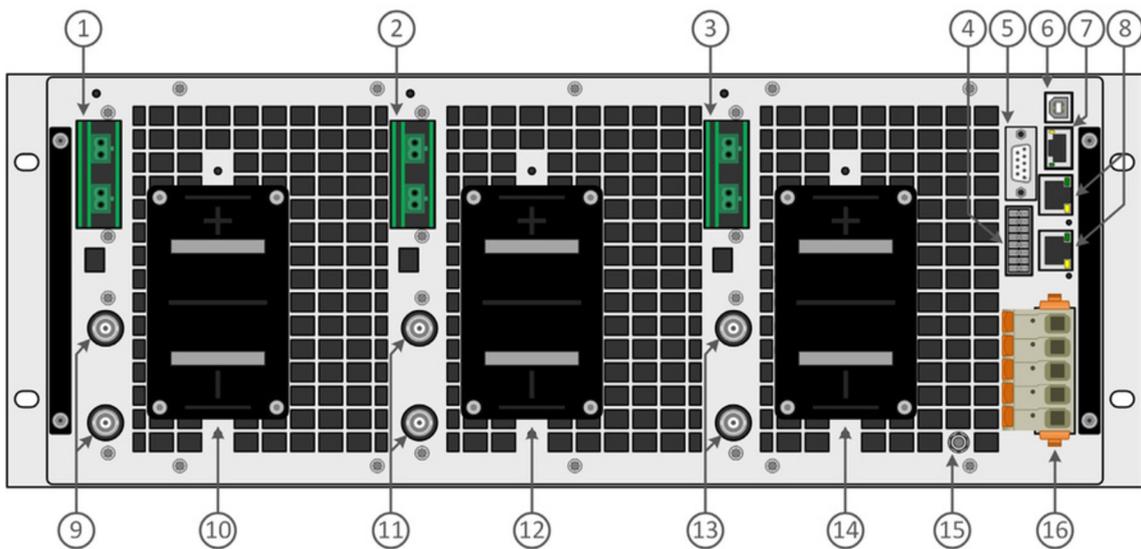


Front panel description BT 10000 Triple 4U



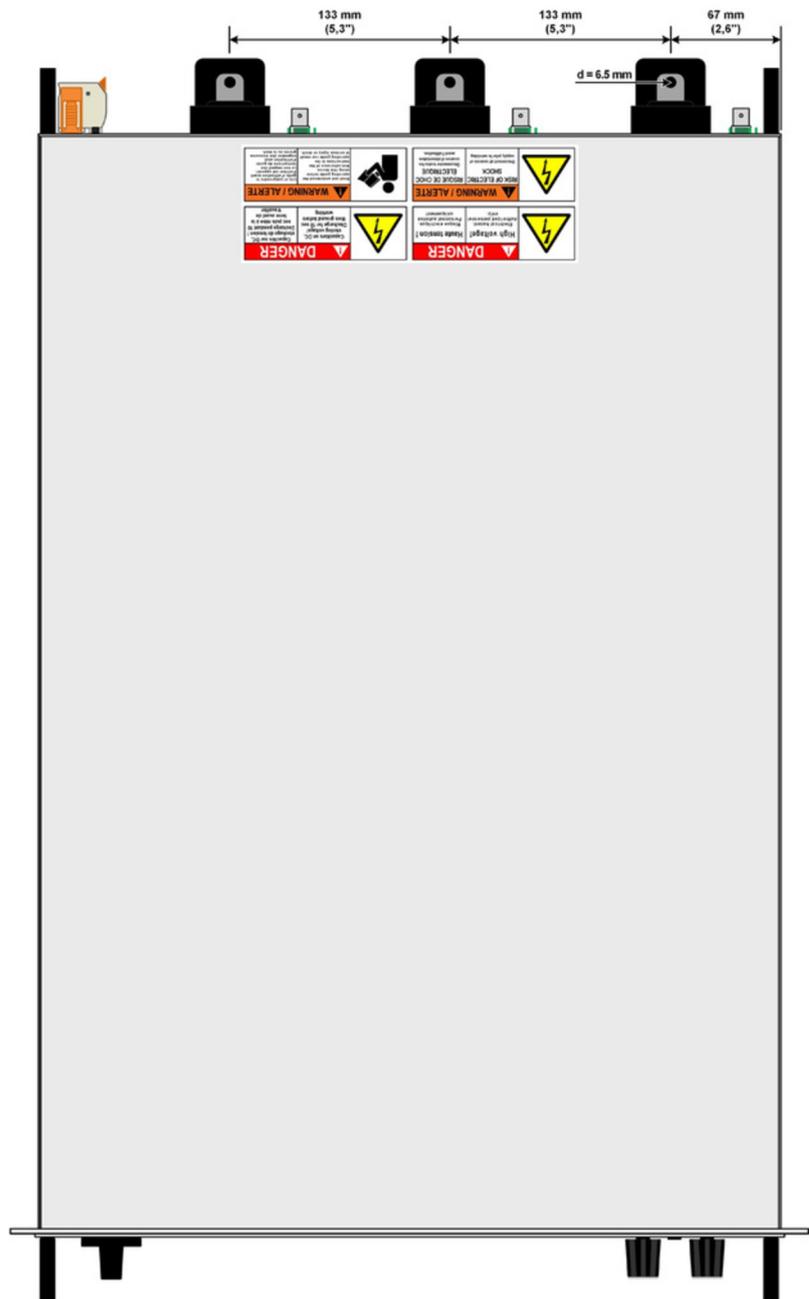
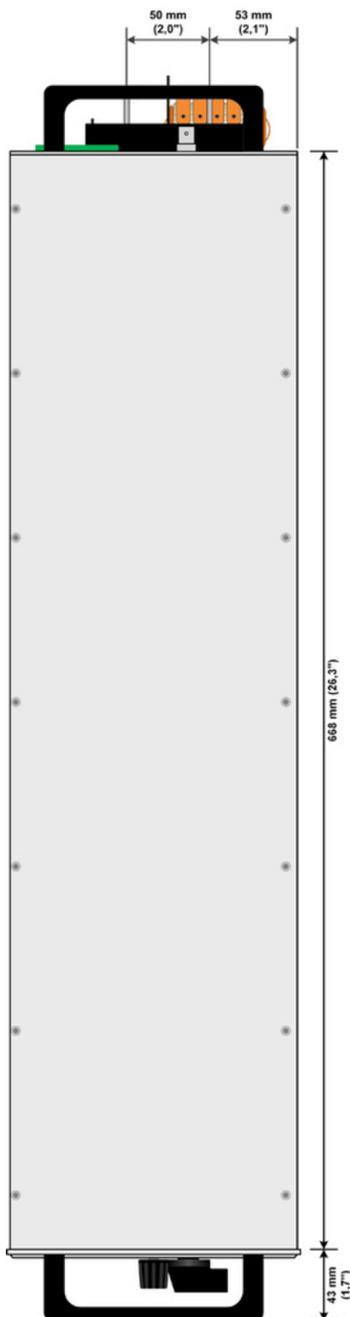
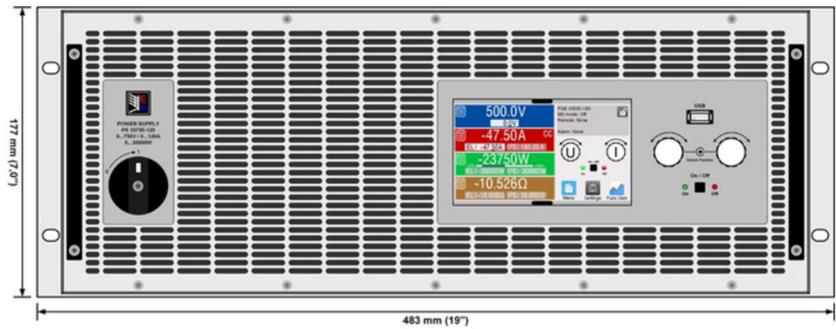
1. Power switch
2. TFT control interface, interactive operation and display
3. Rotary knob with push-button action, for settings and control
4. USB host, uses USB sticks for data logging and sequencing
5. Rotary knob with push-button action, for settings and control
6. On / Off push-button with LED status display

Rear panel description BT 10000 Triple 4U <200 V

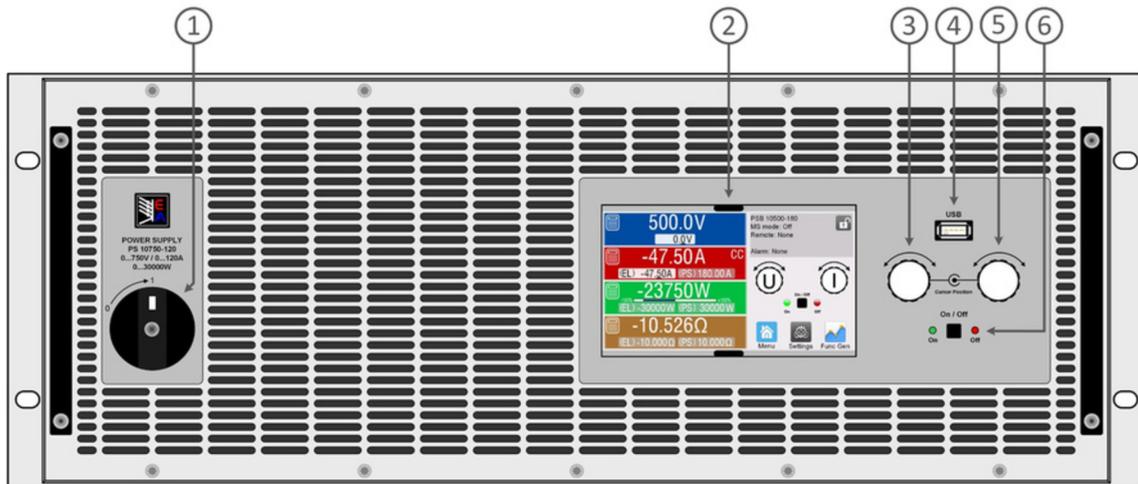


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| <ol style="list-style-type: none"> 1. Remote sense connectors Channel 3 2. Remote sense connectors Channel 2 3. Remote sense connectors Channel 1 4. Input / Output 16 pole connector 5. CAN FD interface 6. USB interface 7. Ethernet interface 1 Gbit 8. EtherCAT Slave | <ol style="list-style-type: none"> 9. Share-Bus connectors Channel 3 10. DC output connector (copper blades) Channel 3 11. Share-Bus connectors Channel 2 12. DC output connector (copper blades) Channel 2 13. Share-Bus connectors Channel 1 14. DC output connector (copper blades) Channel 1 15. Grounding connection screw (PE) 16. AC input connector |
|---|---|

Technical drawings BT 1000 Triple 4U >360 V

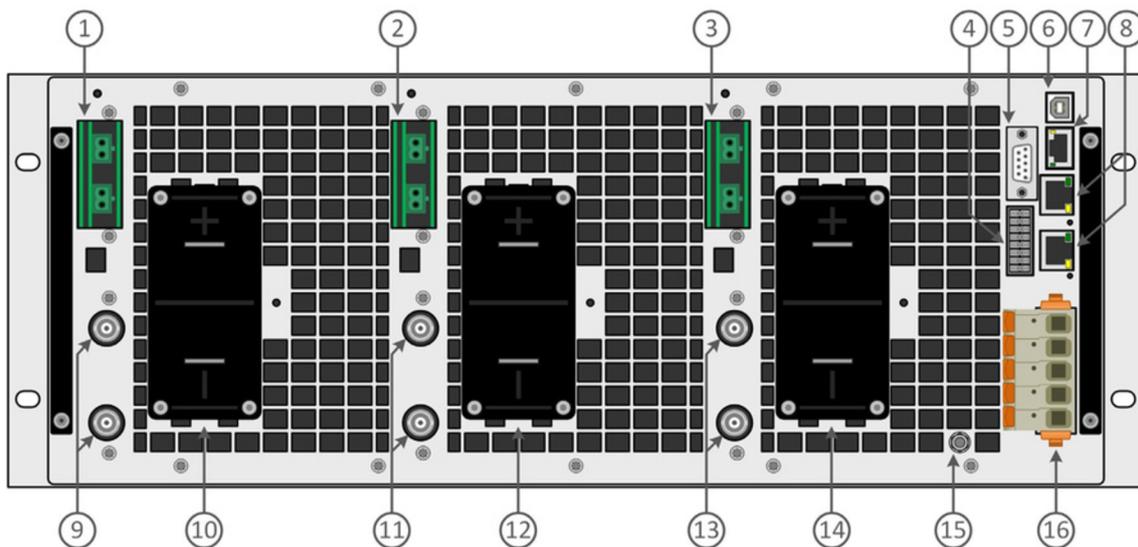


Front panel description BT 10000 Triple 4U



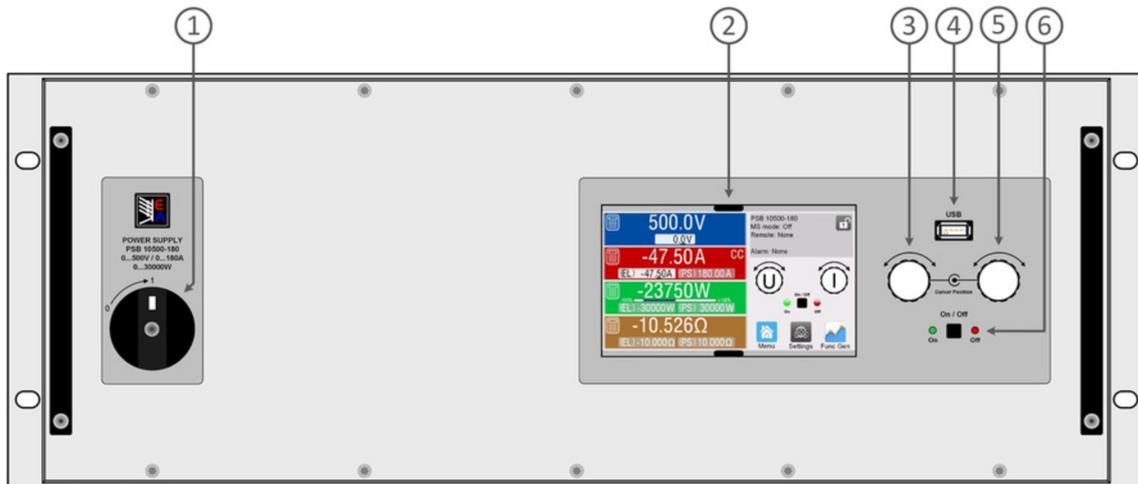
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Rear panel description BT 10000 Triple 4U >360 V



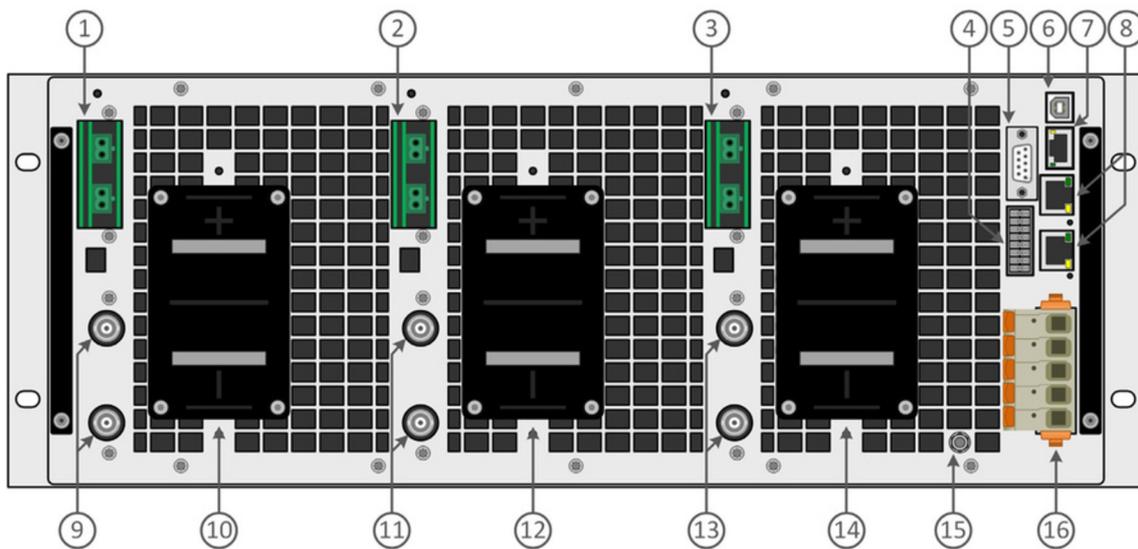
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| 1. Remote sense connectors Channel 3 | 9. Share-Bus connectors Channel 3 |
| 2. Remote sense connectors Channel 2 | 10. DC output connector (copper blades) Channel 3 |
| 3. Remote sense connectors Channel 1 | 11. Share-Bus connectors Channel 2 |
| 4. Input / Output 16 pole connector | 12. DC output connector (copper blades) Channel 2 |
| 5. CAN FD interface | 13. Share-Bus connectors Channel 1 |
| 6. USB interface | 14. DC output connector (copper blades) Channel 1 |
| 7. Ethernet interface 1 Gbit | 15. Grounding connection screw (PE) |
| 8. EtherCAT Slave | 16. AC input connector |

Front panel description BT 10000 Triple 4U with Water Cooling



1. Power switch
2. TFT control interface, interactive operation and display
3. Rotary knob with push-button action, for settings and control
4. USB host, uses USB sticks for data logging and sequencing
5. Rotary knob with push-button action, for settings and control
6. On / Off push-button with LED status display

Rear panel description BT 10000 Triple 4U with Water Cooling



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|---|---|
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|---|---|

W5 Engineering
Phone: (971) 244-8200
Email: help@W5engineering.com
www.W5engineering.com/eapowered

EA Elektro-Automatik Inc.
9845 Via Pasar
San Diego, CA 92126 USA

