



THREE BATTERY TESTING CHALLENGES

Advances in Battery Technology and a Growing Market

01

Higher capacity battery cells

Progress in cell technology in terms of capacity and charge-rate demand for higher currents of battery testers.

02

Higher capacity battery modules

As cell technology advances, also the capacity of modules increases. Higher currents at medium voltage level are required.

03

Higher voltage packs

Greater EV efficiency: Higher voltage allows lower load currents and lighter cable harnesses



THREE MORE CHALLENGES

Reducing Test Costs and Ensuring Safe testing

04

Higher test throughput

Increase output to meet the growing demand

05

Save manufacturing floor space

Save manufacturing overhead costs and allow expandability for future increases in capacity

06

Ensuring battery protection

Prevent conditions leading to battery failure and potentially dangerous outcomes; perform 100% testing



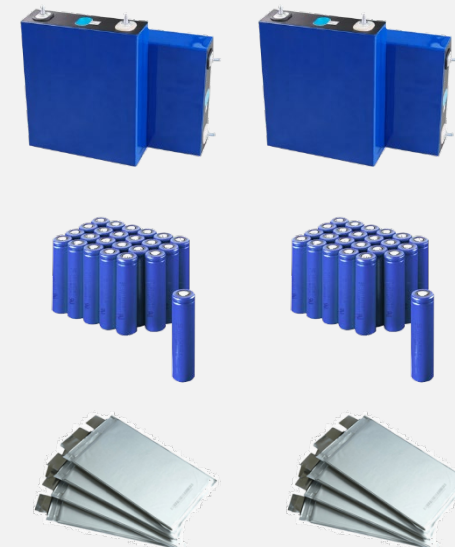
PACK / MODULE / CELL LEVEL TEST



PACK



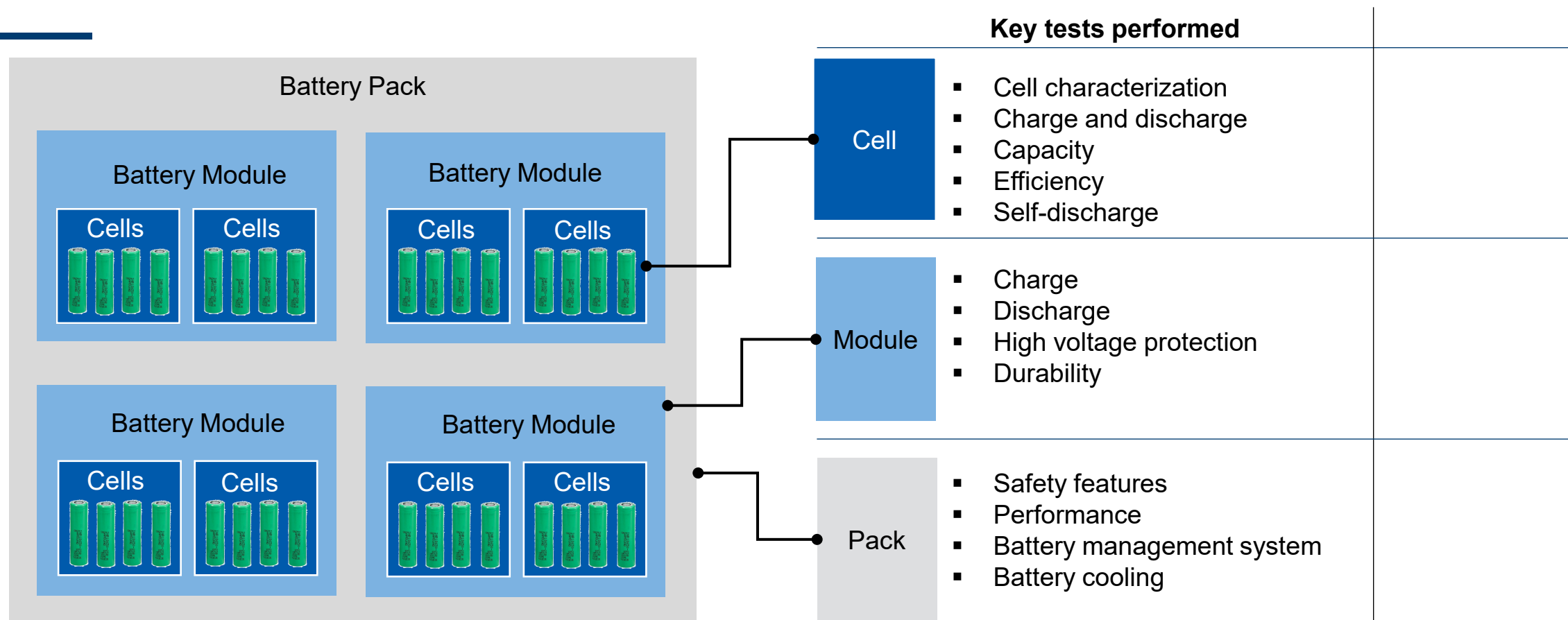
MODULE



CELL



CELL / MODULE / PACK LEVEL TEST

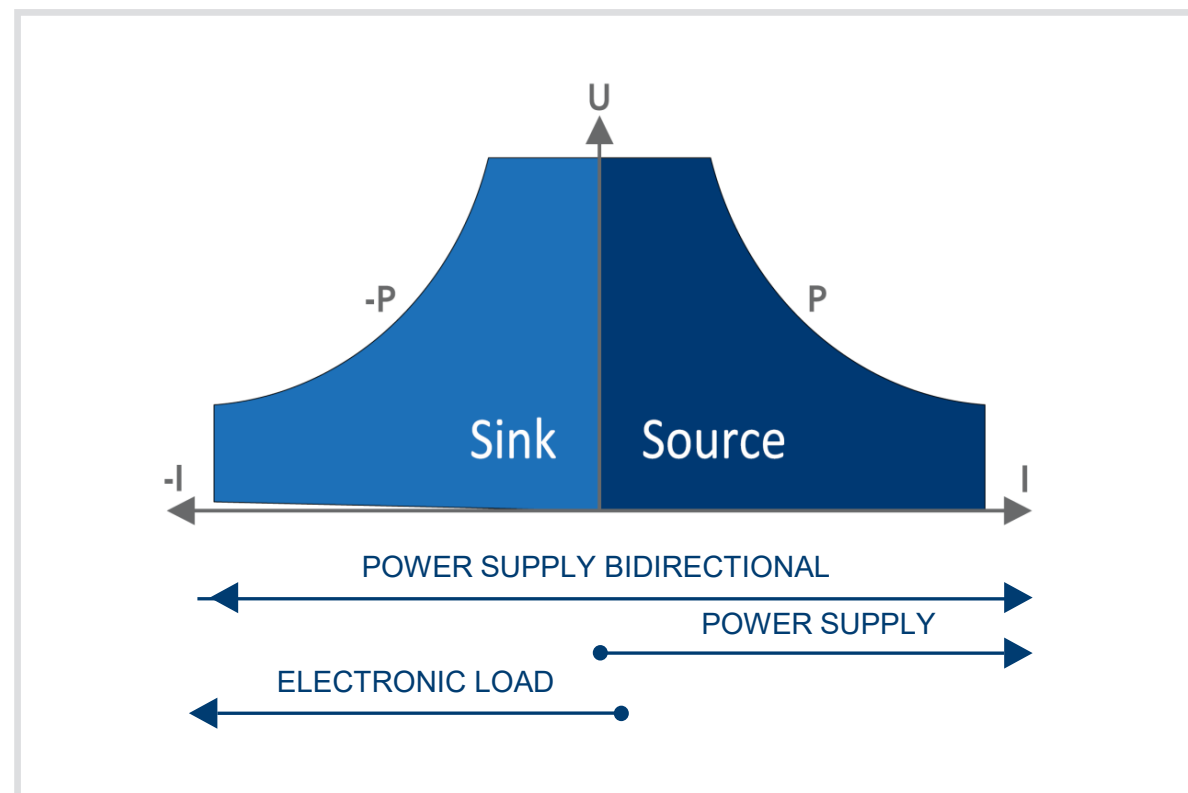




PRODUCT LANDSCAPE

EA-10000 Series

- **PSB** Power Supply Bidirectional
- **PSI** Power Supply Intelligent
- **PS** Power Supply
- **ELR** Electronic Load Regenerative





PRODUCT LANDSCAPE

EA-10000 Series by feature



* Note: 18 kW for 208 Vac grid (relevant for US and Japan)



Elektro-Automatik

EA-BT 20000 BATTERY TESTERS

With Regenerative Energy Recovery

Highest Voltage, Highest Current and Highest Regenerative Efficiency

- 3-Channel and single channel models
- Highest current output – **600 A and 1000 A**
- Highest voltage output – **920 V and 2000 V**
- Up to **10 kW/channel** and **30 kW** in one instrument
- 3 Channels paralleled deliver – **1800 A**
- Higher current through paralleling of devices (up to 64 single or 2 triple)
- Highest efficiency for returning absorbed power to the grid – up to **96 %**





EA SOLUTIONS

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

For Research, Development, and Manufacturing

Single Channel Series

- 10 models (4U) + 10 models (3U)
 - 6 kW up to 30 kW
 - Maximum Outputs:
 - 80 V / 1000 A with AutoRanging
 - 2000 V / 40 A with AutoRanging

Triple Channel Series

- 8 models
 - Up to 10 kW / channel
 - Maximum outputs:
 - 10 V / 600 A per channel
 - 920 V / 40 A per channel
 - 1800 A with 3 channels in parallel

All Models

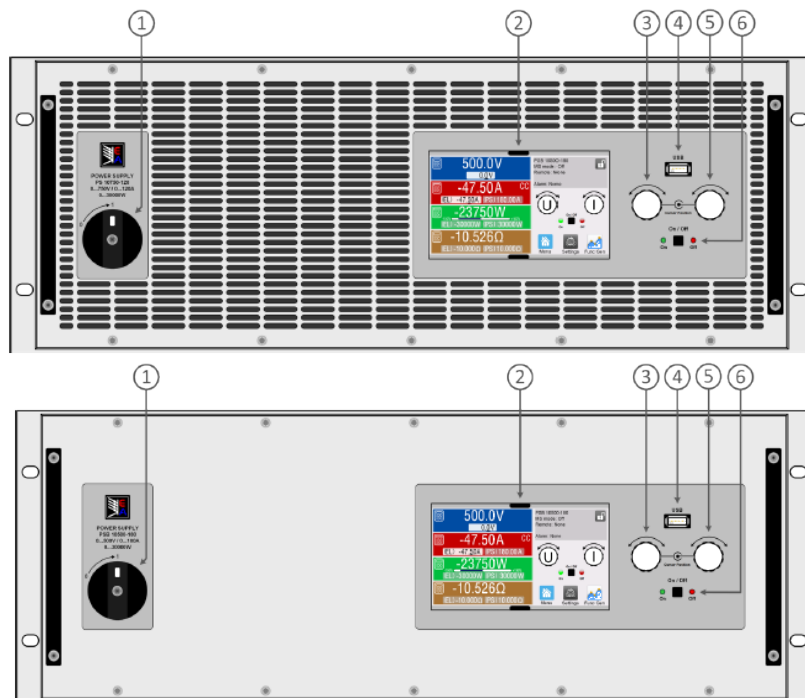
- Battery test, battery cycling operating modes
- Ability to measure capacity in Ah
- Communicates and controls with 1 ms command speeds
- Regenerative recovery up to 96%



REGENERATIVE RUNS COOL

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

EA-BT 20000 series – as air or water cooled



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



A/C cost savings

Reduce A/C costs through high efficiency

Only 5% of the total power is converted into waste heat. With water cooling there is nearly no heat transfer to the ambient air.

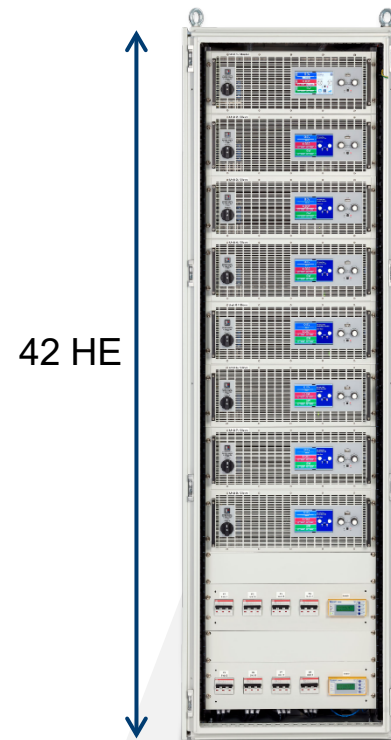
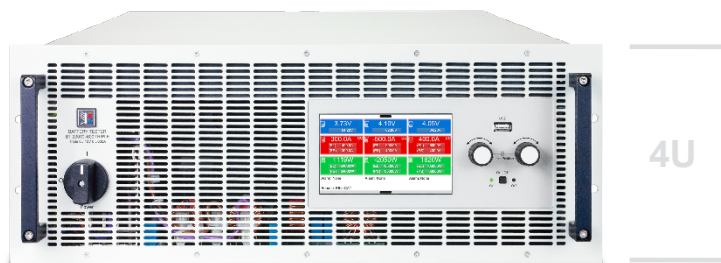


FOOTPRINT SAVINGS

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Manufacturing Overhead Savings – Highest density power instrumentation

Challenge	EA-BT 20000 Single and EA-BT 20000 Triple
Save manufacturing floor space	30 kW power in a 4U, full rack wide enclosure



- One < 200 cm (19-in) cabinet can house **240 kW**
- Only **0.6 m² (6.5 ft²)** of floor space needed for 240 kW
- Parallel as many as 64 units into **8 cabinets** to provide a capacity of **1.92 MW**

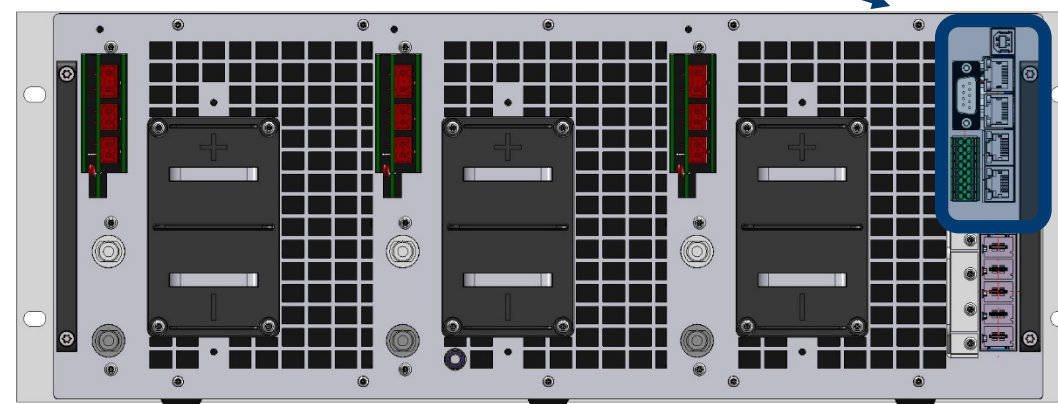
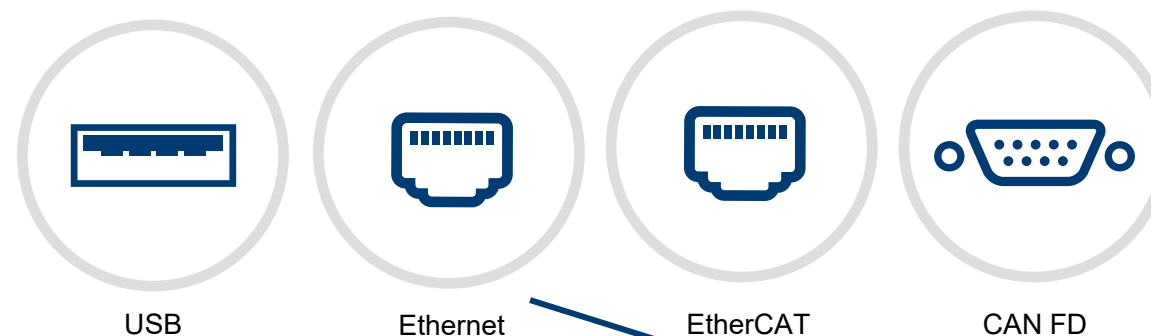


FAST COMMUNICATION

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

New communication interface

- **1 ms communication speed**
 - 1 ms command response time
 - High-speed data acquisition with 1ms
- **Communication interfaces**
 - EtherCAT (2x In/Out, 1xMaster)
 - Ethernet 1 GBit
 - CAN FD (5 Mbit)
 - USB
- Program using either SCPI or ModBus

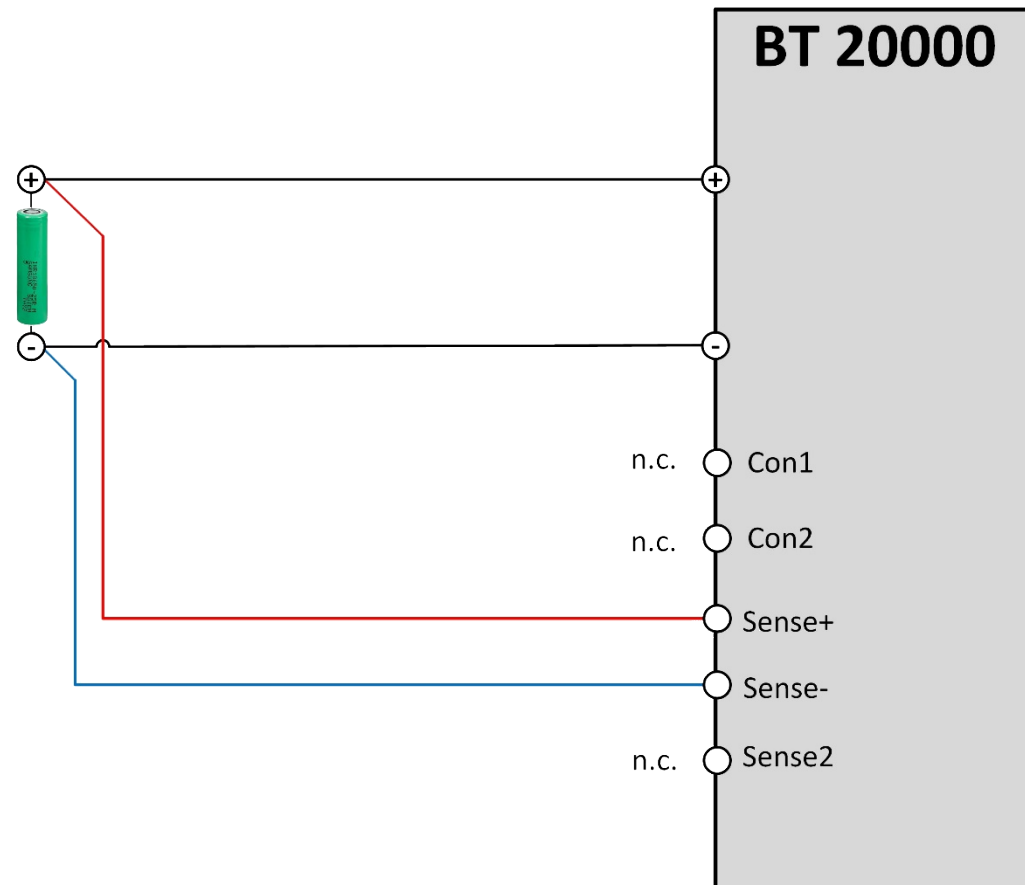




CELL TEST

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Standard configuration for cell test



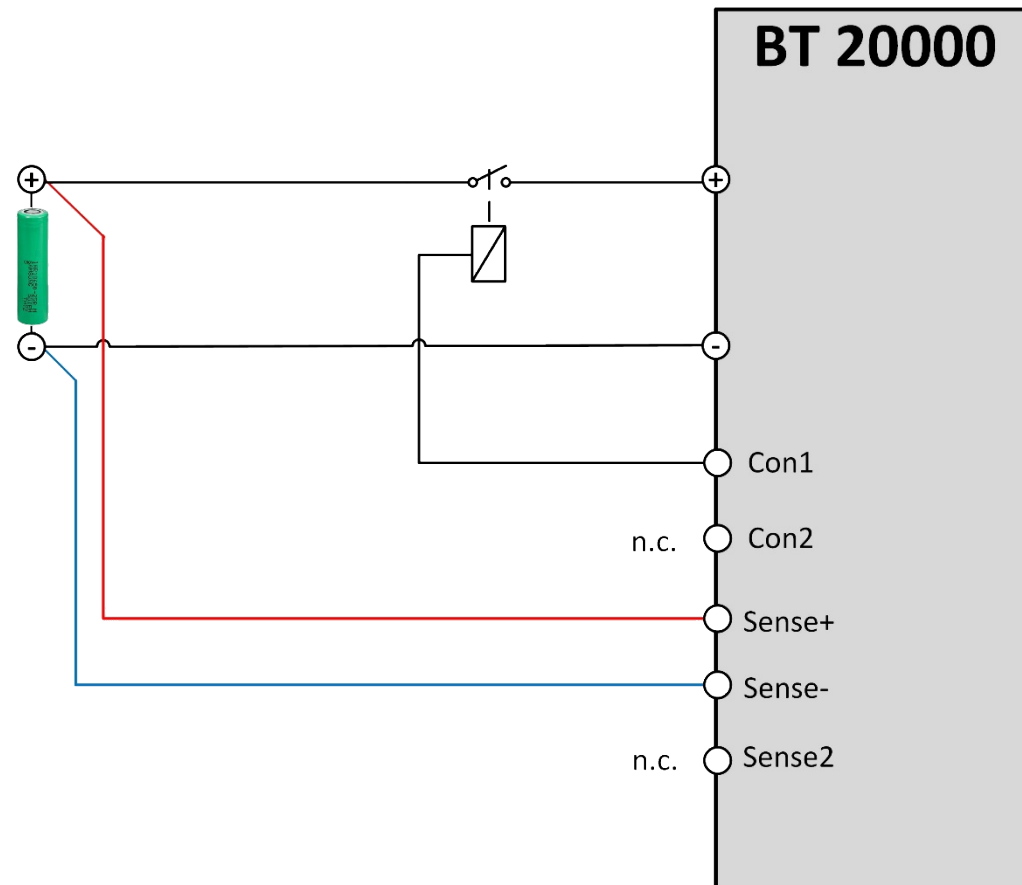


CELL TEST

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Standard configuration for cell test

- High- side contactor controlled by BT20000

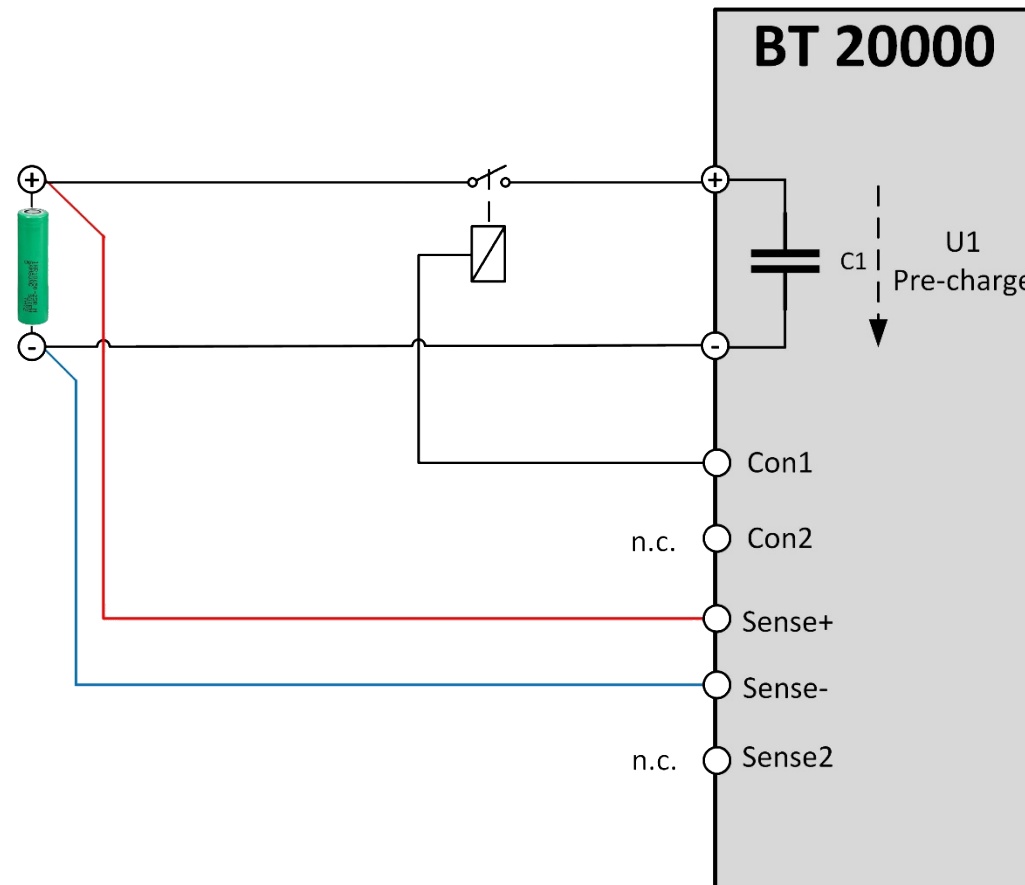


CELL TEST

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Standard configuration for cell test

- High- side contactor controlled by BT20000
- Active PreCharge





PRE-CHARGE PROTECTION

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Active pre-charge will minimize unwanted inrush currents

If a test object is connected to the test device, an inrush current occurs, when the battery cell puts energy into the output capacitor of the test device. This is unwanted for several reason:

- **The current could damage the battery or the test equipment**
- **Operators are concerned because they can potentially observe sparking at the terminal when connecting**
- **Existing DC contactors will wear down fast if each time there is a peak current**

Therefore, pre-charge of the output capacitor is needed.

BT 20000 offers an automated active pre-charge. Due to complete independent internal and external sense measurement, the device will pre-charge its internal capacitor without using any energy from the battery under test.

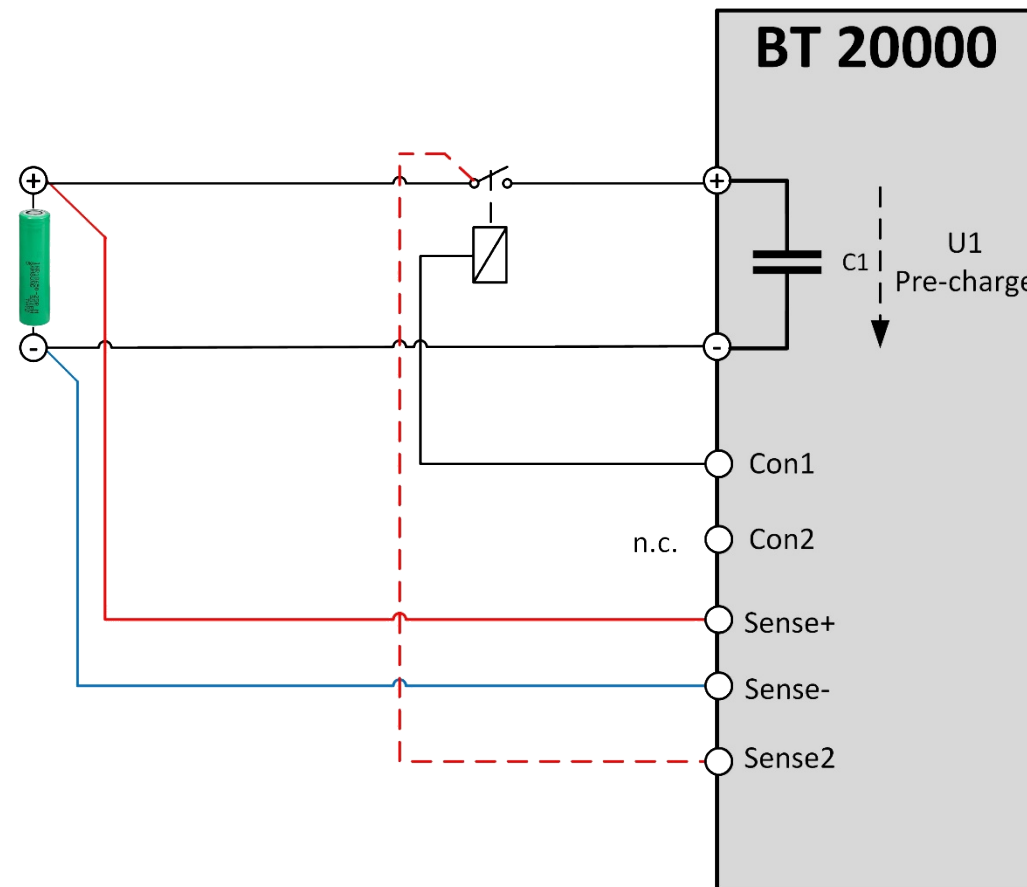
BT 20000 close the external DC contactor once the active pre-charge is finished.

CELL TEST

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Standard configuration for cell test

- High- side contactor controlled by BT20000
- Active PreCharge
- Optional: Reverse polarity detection





REVERSE POLARITY DETECTION

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Safer operation – Reverse polarity detection avoids faulty connections

The reverse polarity detection is achieved through a second sense connection.

It is intended to be a fixed installed part of the test stand and does not change when a new test object is connected.

As this part of the installation is always fix, it is not affected by a set of possible mistakes the operator might run into:

- Operator might put test object and sense in reverse
- Operator might mix up different sense channels
- Sense might fall apart during test

With the capability to detect such faults, the operational safety of the entire test stand increases



ZERO CURRENT PROTECTION

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

“Zero current turn-off” on DC contactor

- DC contactors will wear down fast if DC loop is opened while current flows.
- The BT 20000 will always set the current to zero before the contactors open.
- This is also possible if the fast stop option is used.

DYNAMIC SENSE REGULATION

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Dynamic Sense Regulation (DSR) and Connection Overload Monitoring

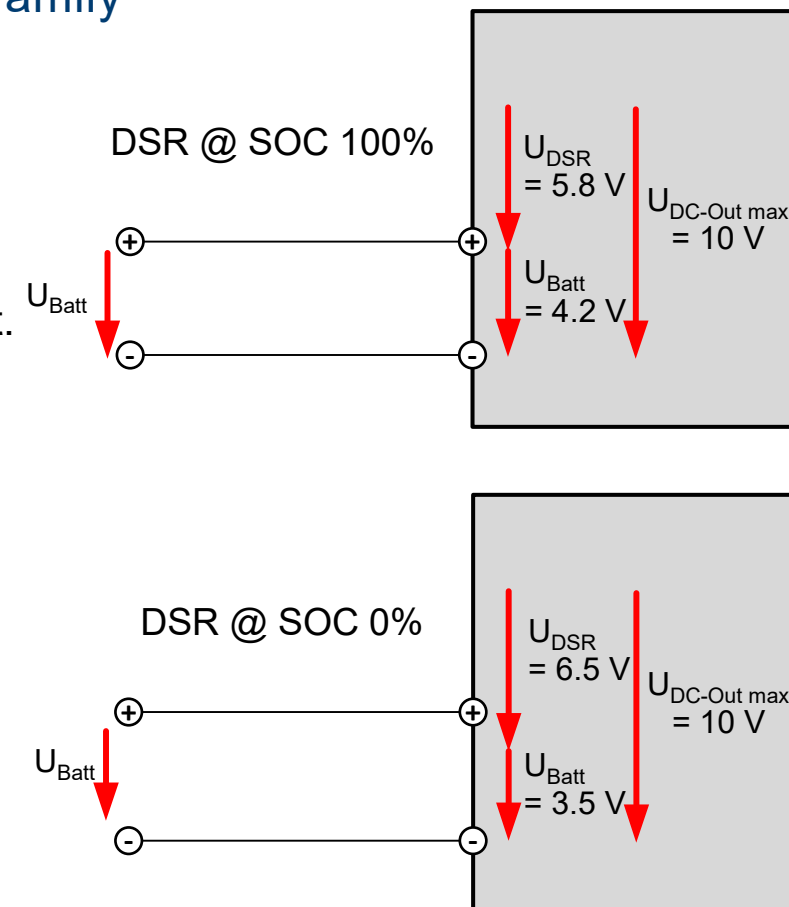
BT 20000 measures the internal and external sense completely independent.

This offers advantages as:

- Ability to pre-charge
- Offering dynamic regulation by using full voltage range of 10 V
 - to ensure best current rise time in dynamic tests
 - cable and connection check for cable losses or bad connections

Connection overload monitoring:

- COW (Cable overload warning)
- COP (Cable overload protection)





MODULE & PACK TEST

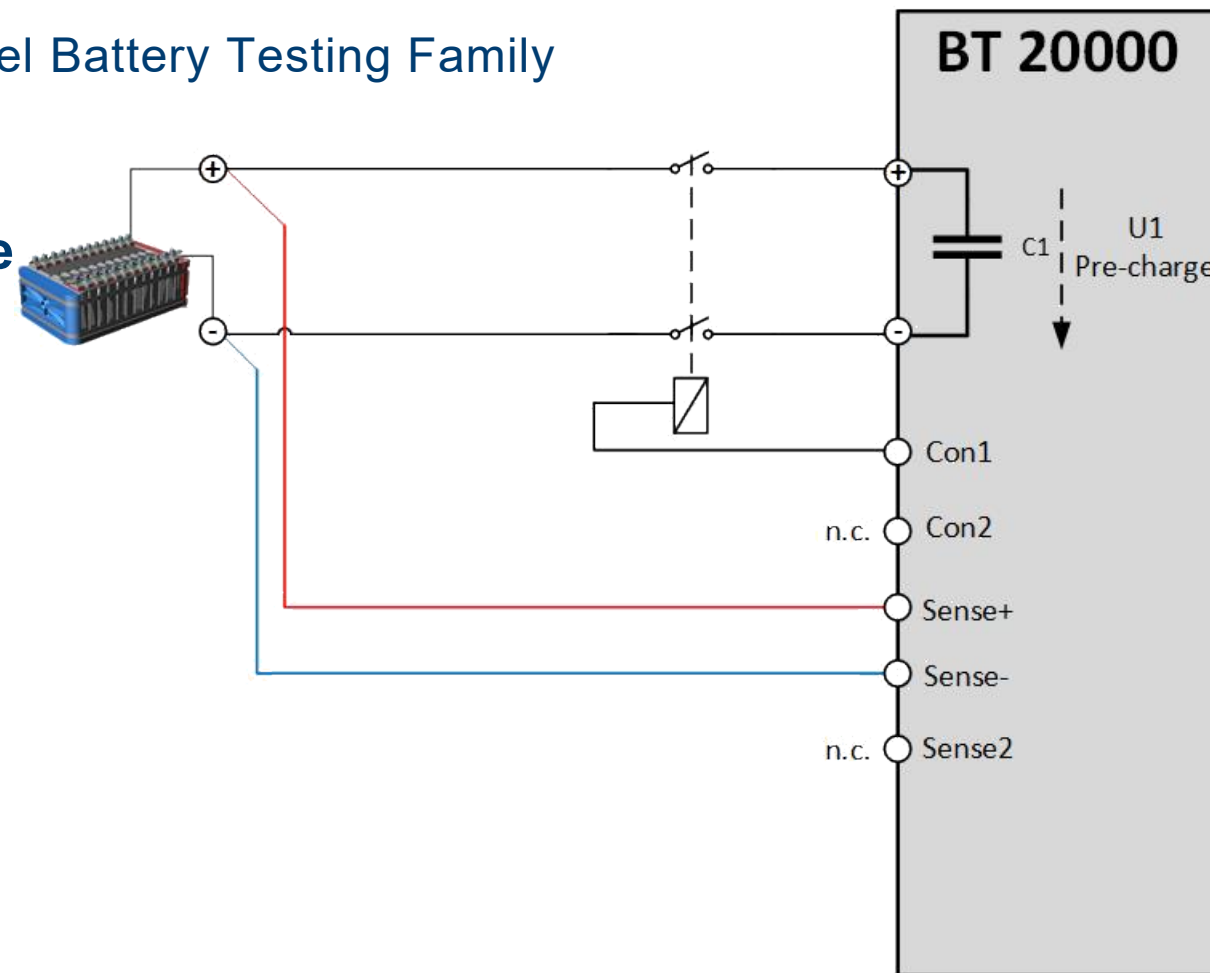
EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Standard configuration for pack & module

- High- side contactor controlled by BT20000
- Low side contactor controlled by BT20000
- Active Pre-Charge
- Reverse polarity detection optional



Source of images: BMW (i3 battery pack), ZSW (battery module)



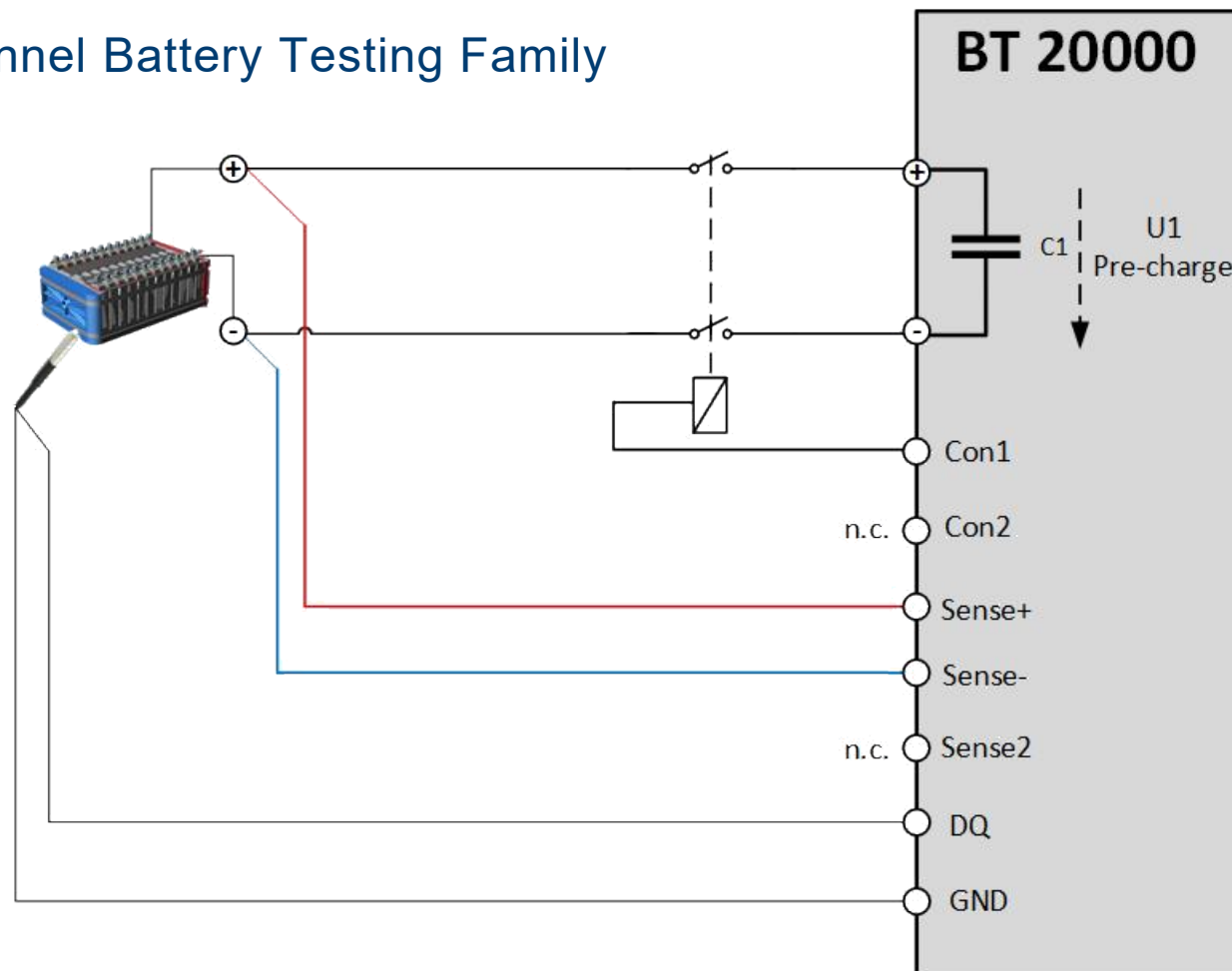


MODULE & PACK TEST

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

External temperature sensor

- Input for Maxim 1-Wire bus temperature sensor
- e.g. DS18B20 like in the sketch
- Usable temperature range: -55 to 125 °C
- ± 0.5 °K Accuracy from -10 °C to +85 °C
- Possible query time is less than 750 ms



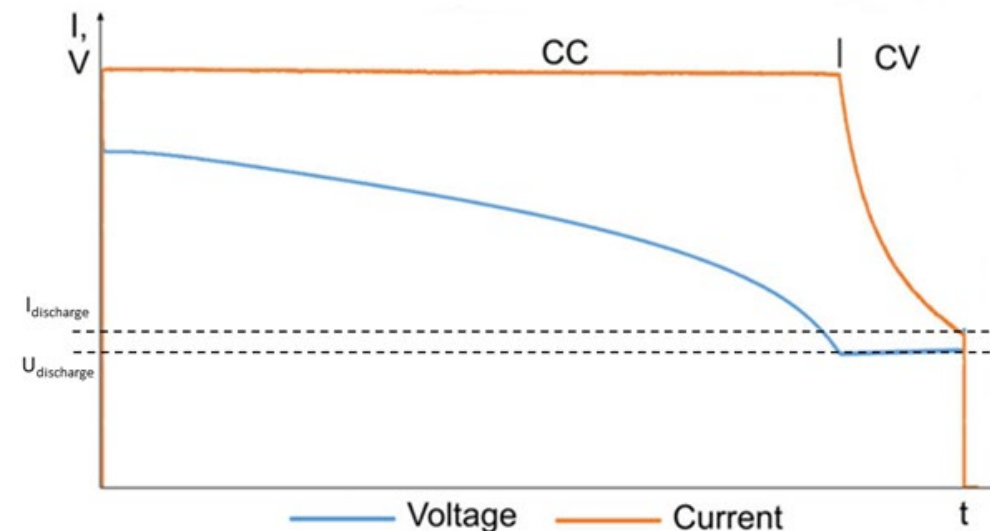


BATTERY RECYCLING AND 2ND LIFE

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Integrated CC-CV behaviour

- The BT 20000 series offer CC-CV behaviour as required for Li-Ion charging and discharging
- During discharging two parameters need to be adjusted
 - $U_{\text{discharge_end}}$
 - $I_{\text{discharge_end}}$
- For battery recycling $U_{\text{discharge_end}}$ can become 0.7 V



BATTERY CAPACITY MEASUREMENT

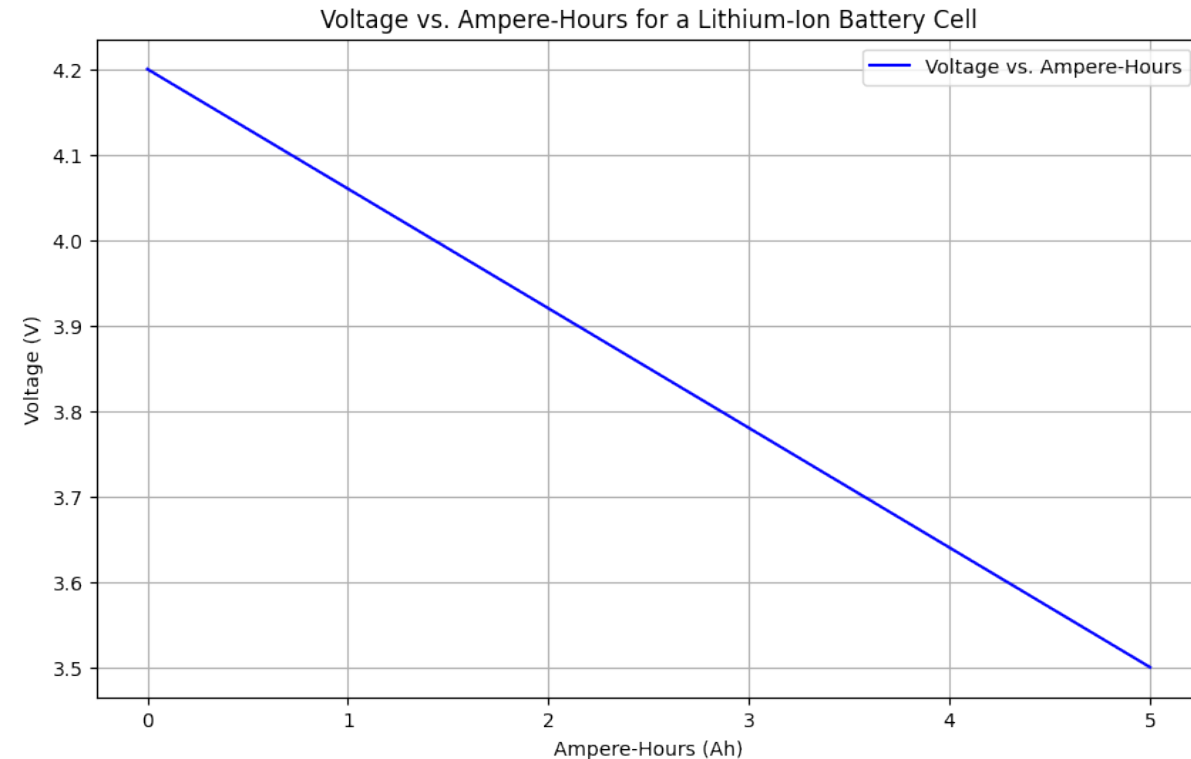
EA-BT 20000 Single Channel and Triple Channel Battery Testing Family



Elektro-Automatik

Integrated Amperehour counter

- The BT 20000 series has an Ah-counter included
- In 2nd life applications the remaining capacity of the cell is important to know
- Typical process:
 1. Fully charge the battery to 100% SOC
 2. Fully discharge the battery to 0% SOC
- Example on the right side:
 - Discharge of a 5 Ah cell from 100% SOC (@ 4.2V) down to 0% SOC (@3.5V)



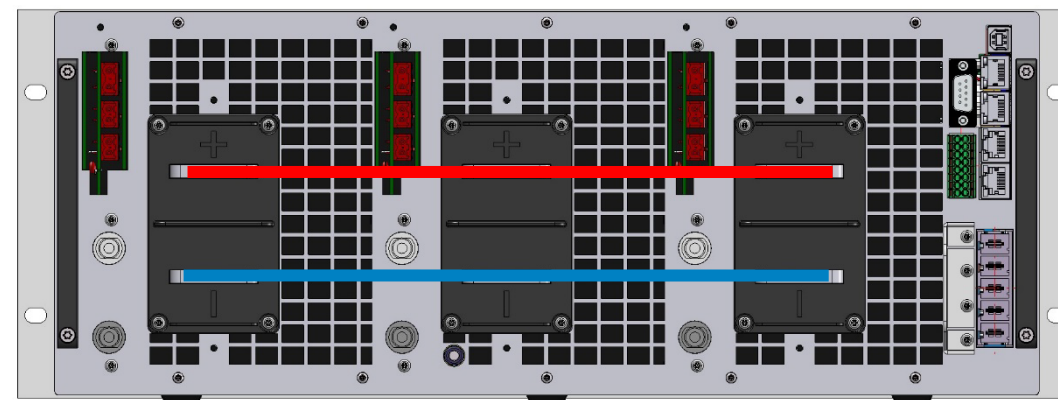


SUPERIOR EA PERFORMANCE

EA-BT 20000 paralleling capabilities

Master-Auxiliary-Bus Variant 1

- Grouping of 3 DC-Out of triple device → 1800 A
- By connecting
 - Busbars
 - Share-Bus

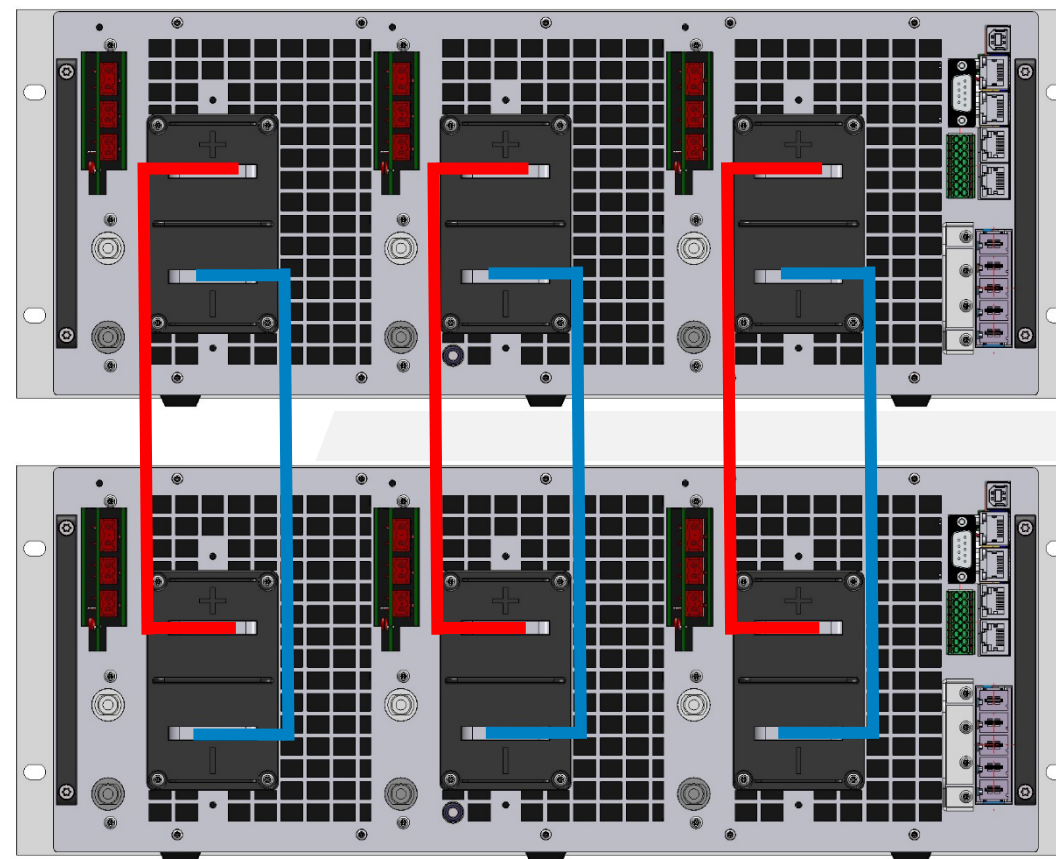


SUPERIOR EA PERFORMANCE

EA-BT 20000 paralleling capabilities

Master-Auxiliary-Bus Variant 2

- Paralleling vertical channels of devices
(2 triple channels or 64 single devices)
- By connecting
 - Busbars
 - Share-Bus
 - EtherCAT





ADDITIONAL BATTERY PROTECTION

EA-BT 20000 Single Channel and Triple Channel Battery Testing Family

Instrument Safety monitoring for instrument and battery protection

Challenge	EA-BT 20000 Single	EA-BT 20000 Triple
Ensuring battery protection	<ul style="list-style-type: none">Overvoltage protectionOvercurrent protectionOverpower protectionOvertemperature protectionControls for DC circuit breakers	<ul style="list-style-type: none">Overvoltage protection/channelOvercurrent protection/channelOverpower protection/channelOvertemperature protection/channelControls for DC circuit breakers/channel