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Why You Need Bidirectional DC Supplies with Energy Recovery

09:00 – 09:30 am

Eric Turner - Managing Director
EA Elektro-Automatik

May 25, 2022

AGENDA

- Introduction of EA Elektro-Automatik
- Terminology
- Technology evolution
- Application examples, benefits of bidirectional with energy recovery solutions
- EA's solutions



Elektro-Automatik





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EA ELEKTRO-AUTOMATIK

Innovation & quality for over 40 years

- Europe's leading manufacturer of power electronics for research & development as well as industrial applications
- Privately held, founded in 1974 – over 300 employees
- Design end production located in Germany
- Optimal energy efficiency in production and products
- Green electronic loads: regenerative energy recovery greater than 96%, saving money and the planet!



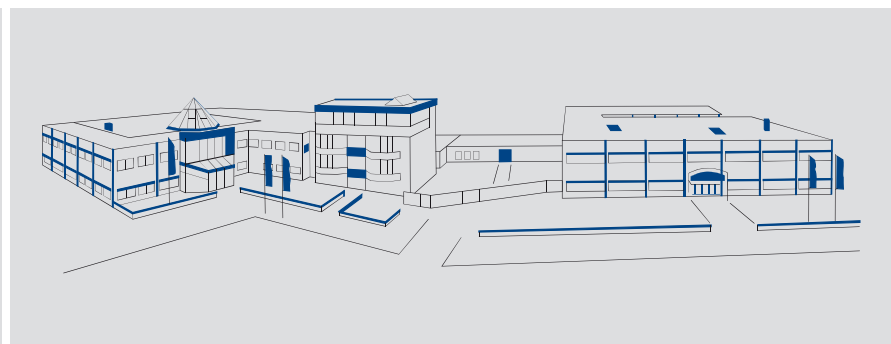


Elektro-Automatik

GLOBAL OPERATION

Worldwide near our customers

- Headquarters in Germany
- Subsidiaries in China and USA
- Worldwide network of partners
- Localized service support

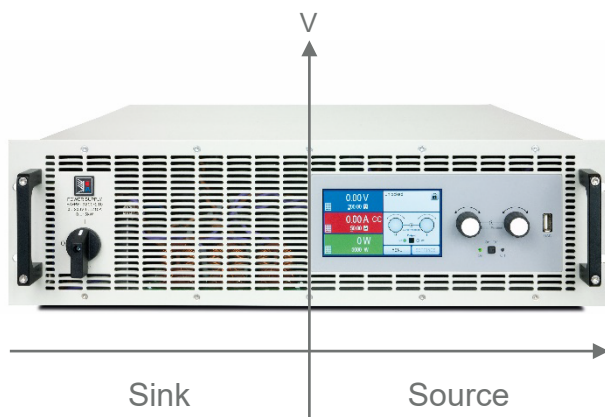


POWER QUADRANTS

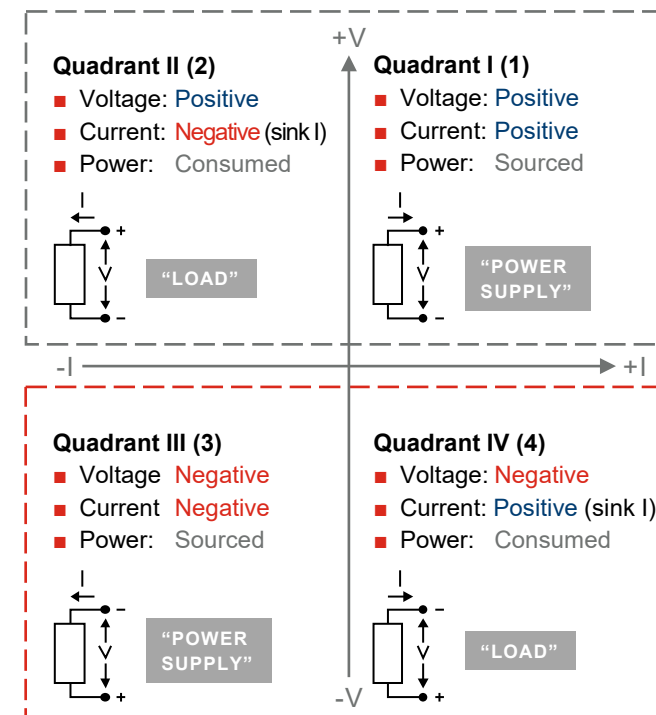
Bipolar vs. Bidirectional

- “Bipolar,” or four quadrant, means the supply is capable of both Positive Voltage/Current and Negative Voltage/Current
- “Bidirectional” is quadrant 1 and 2 which are Positive Voltage/Current and Positive Voltage / Negative Current.
- A bidirectional supply does not produce negative voltage.

Two-quadrant power supply



Four-quadrant bipolar power supply



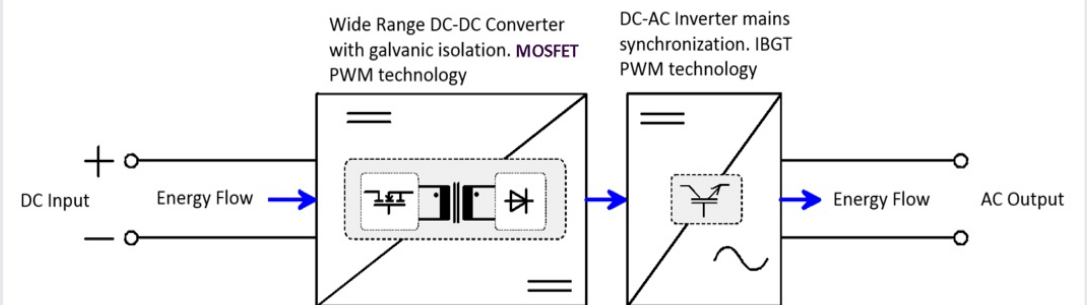
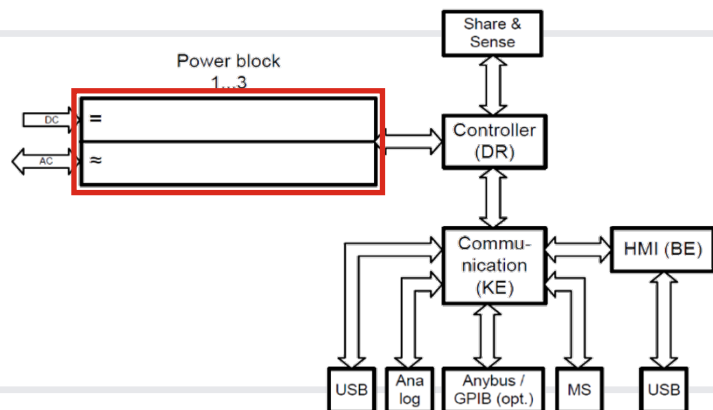
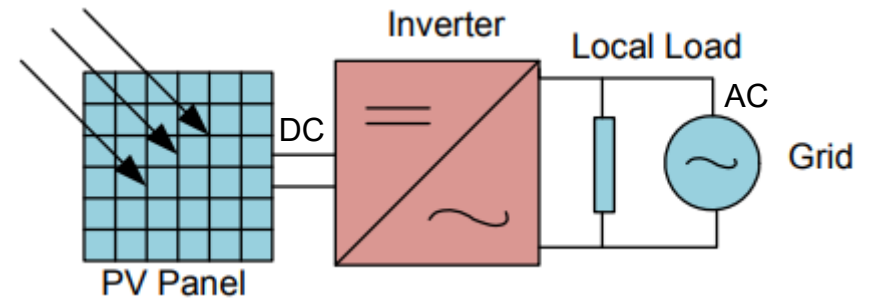
ENERGY RECOVERY

Theory of Operation



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Much like a solar inverter, DC energy is converted to a common DC bus which is then converted into AC through a grid-synchronized current source.



TYPICAL EV COMPONENTS

Bidirectional Devices



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Charging Systems



Battery Cells



HV-Batteries



48 V Batteries



48 V Drives



HV-Inverter



HV-Heater



HV Cooling-Systems



Fuel Cells



HV-Fuses



HV-Switches



Charging Cables



HV-Cables & Plugs



Research



HV-Power-Distribut.



Electric Vehicles



Battery Modules



Onboard Charger



DC Ch.-Management



Testing Institutes



Energy Storage System

ADVENTURES IN ELEKTRO SPACE

PSB Bidirectional – Testing Battery Packs



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Adventures in Elektro Space (English)

▶ PLAY ALL



2:35

**EA Power Supplies & Loads
Have Superior Service and...**

EA Elektro-Automatik
376K views • 5 months ago



2:20

**EA Autoranging Power
Supply Testing Dynamic...**

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537K views • 6 months ago



2:38

**EA Turnkey Power Racks
240kW Mass Testing Batter...**

EA Elektro-Automatik
282K views • 7 months ago



2:40

**EA ELR Regenerative
Electronic Load Testing Fuel...**

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2:38

**EA PSB Bidirectional Power
Supply Testing Battery Pack...**

EA Elektro-Automatik
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<https://www.eapowered.com/adventure/#TheBidirectionalSolution>

BIDIRECTIONAL EVOLUTION

Traditional Source/Sink – 1st Generation

Setup

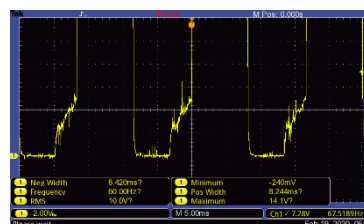
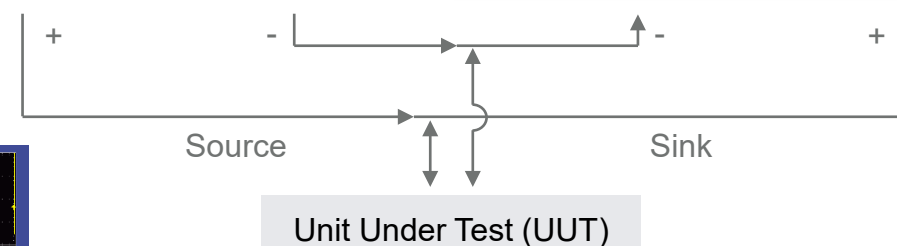
- Traditional bidirectional capability was achieved using two individual assets.
- A programmable DC supply sources power to UUT.
- The programmable DC load sinks UUT power.

Challenges

- Controlling and synchronizing two assets.
- Safety to ensure the UUT does not sink power back to the supply, causing DC supply damage.
- Matching the DC supply to the load to ensure similar Source / Sink capability
- Zero dead time between source and sink
- Cost implications of two assets
- Heat management from linear load
- Zero crossing “glitch”

Programmable
Autoranging DC Supply

Programmable
Linear DC Load



BIDIRECTIONAL EVOLUTION

Traditional Source/Sink – 2nd Generation

Setup

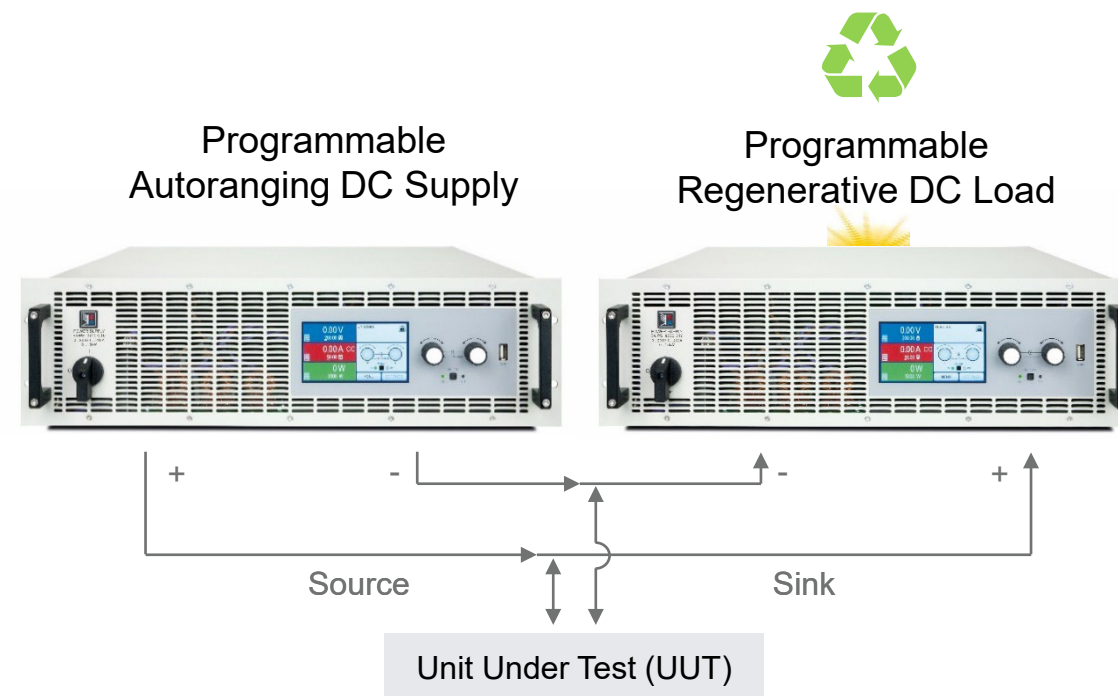
- Same two individual assets.
- A programmable DC supply sources power to UUT.
- The programmable DC load sinks UUT power.

Challenges

- Controlling and synchronizing two assets.
- Safety to ensure the UUT does not sink power back to the supply, causing DC supply damage.
- Matching the DC supply to the load to ensure similar Source / Sink capability
- Zero dead time between source and sink

Benefits

- Regenerates up to 96% of loaded energy to the localized grid. Results in cost reduction making the two-asset solution more cost effective.



BIDIRECTIONAL EVOLUTION

Next Generation Source/Sink



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Setup

- Single chassis solution.
- A bidirectional programmable DC supply sources power and sinks UUT power.

Challenges

- None

Benefits

- Controlling and synchronizing one assets.
- Sink power back to the supply will not cause damage.
- Source / Sink capability are the same, 100% full power.
- Approximately 25% cost reduction over a two-chassis solution.
- 50% reduction in size
- Regenerates up to 96% of loaded energy to the localized grid driving operational cost reduction.

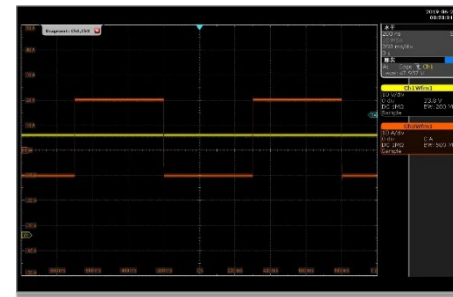


Bidirectional, Programmable
Autoranging DC Supply and Load



Source
Sink

Unit Under Test (UUT)

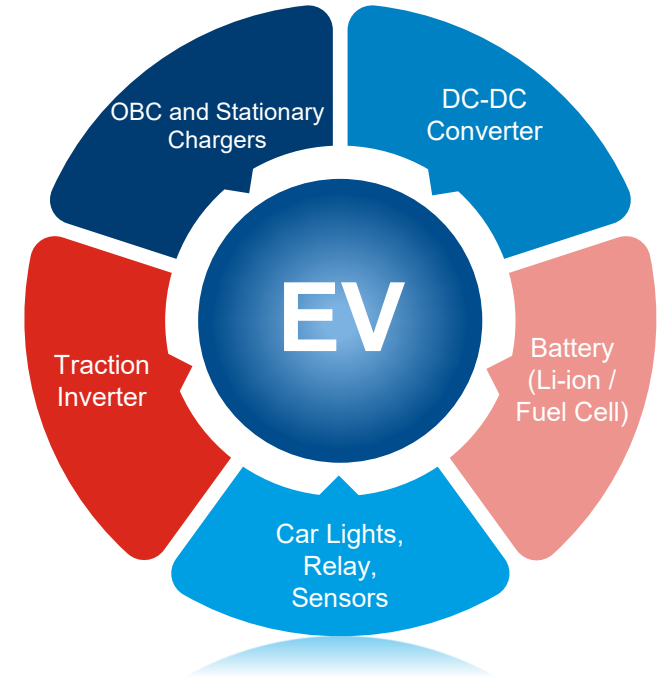
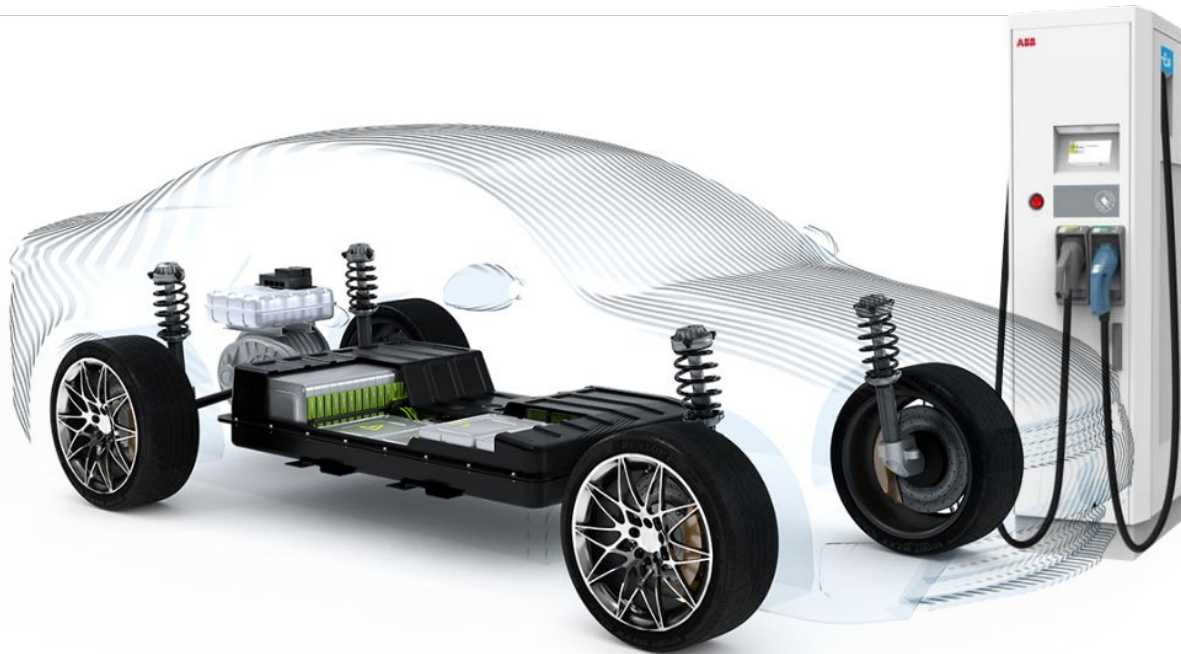


E-MOBILITY ECOSYSTEM

Electric Vehicle



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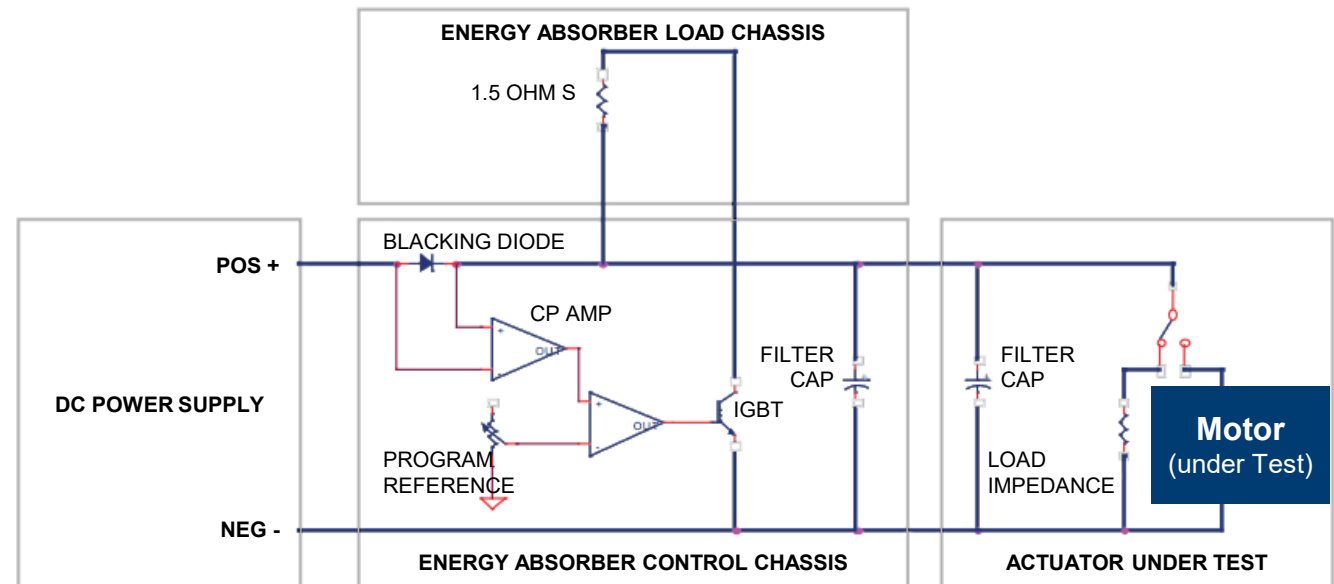
EV

Traction Inverter / Motor Test



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- As voltage to the motor is reduced (deceleration) the motor turns into a generator.
- Sinking power into a unidirectional supply increases internal bus voltages resulting in supply failure.
- The load chassis absorbs the energy generation.
- External circuitry increases complexity, particularly in high power/voltage applications.
- Diode failure is common mode of failure in this system, leaving the supply unprotected.



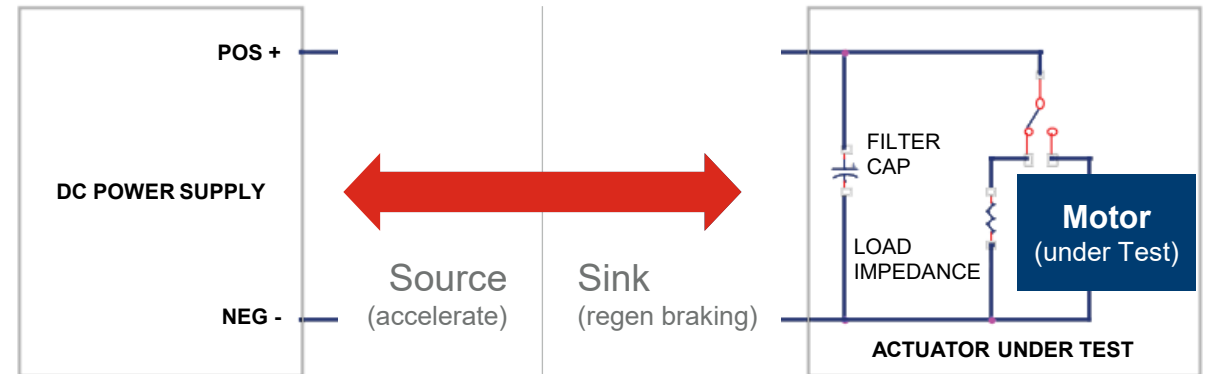
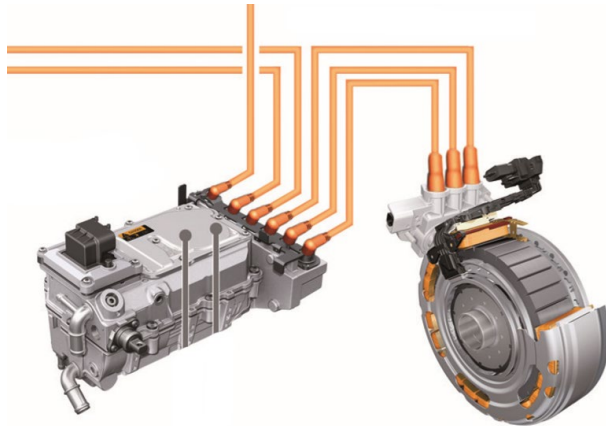
EV

Traction Inverter / Motor Test

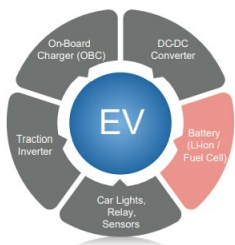


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- Combining the power supply and load into a single solution reduces test system architecture complexity
- Cost and space savings
- Resolves risk of damage during sink mode of operation



	Plug-In-Hybrid	BEV
Voltage Level	300 – 450 V	300 – 900 V
Electric Motor	60 – 120 kW	> 150 kW
Electric Driving Range	~50 km	> 200 km



BATTERY TEST

Typical Test Setup

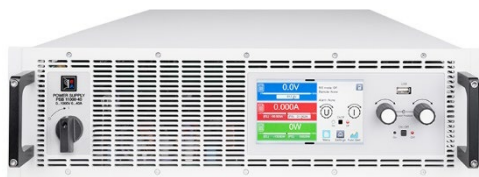


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CHARGE & DISCHARGE TEST SYSTEM



PSB 10010-120 2U

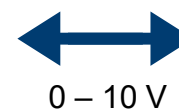


PSB 10500-90 3U

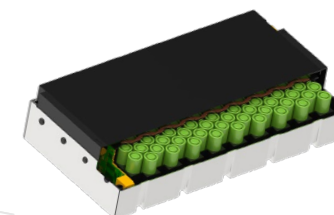
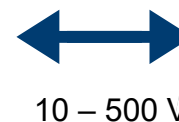


PSB 11000-80 4U

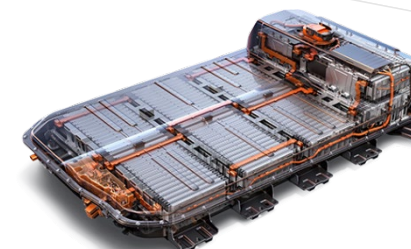
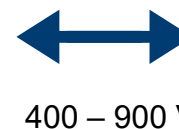
DEVICE-UNDER-TEST



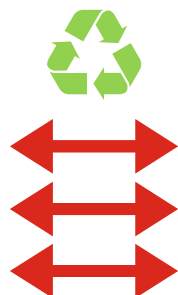
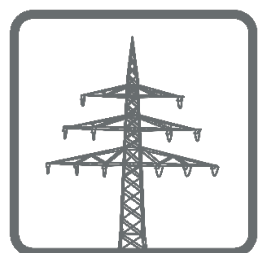
Cell

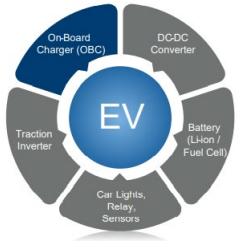


Module



Pack



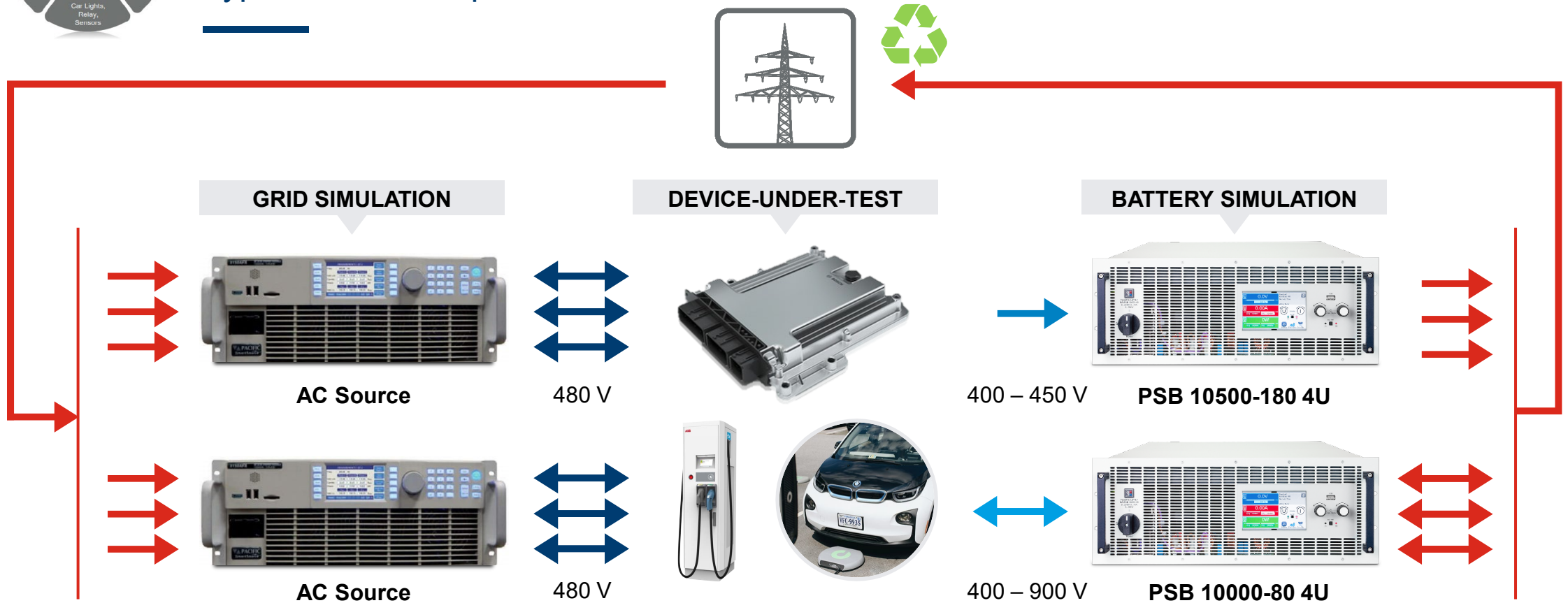


EV CHARGERS

Typical Test Setup



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AUTOMOTIVE TEST STANDARD

Safety Test Standards

Automotive Safety Standard

■ LV 123

- Unlimited Operating Capability
- Upper Limited Operating Capability
- Lower Limited Operating Capability
- Highly Limited Operating Capability
- Overvoltage / Undervoltage
- Present Voltage Dynamic and Present Voltage Ripple

■ ISO 16750-2

- Short Voltage Drop
- Reset behavior at voltage drop
- Starting profile

■ VW 80300

- EHV-01 Operation within the regular HV operating voltage range
- EHV-02 Operation within the HV overvoltage range
- EHV-03 Operation within the HV undervoltage range
- EHV-05 Generated HV voltage dynamics



DAIMLER

VOLKSWAGEN

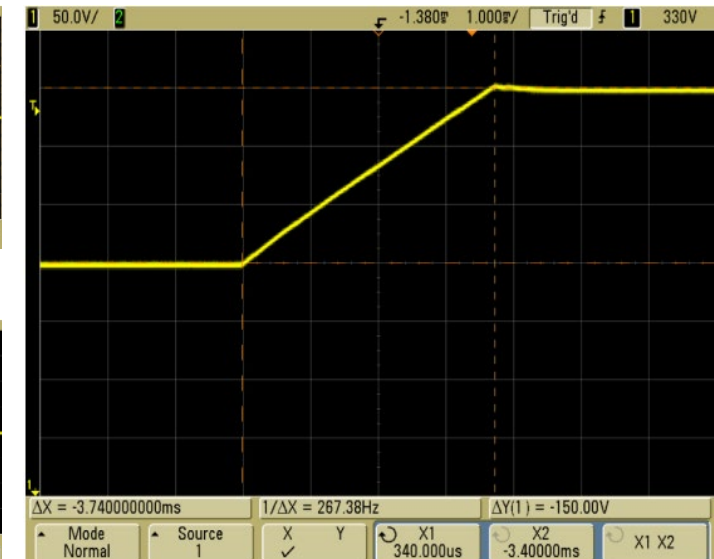
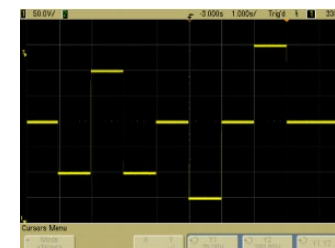
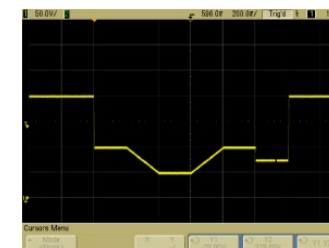
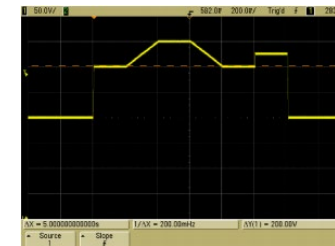
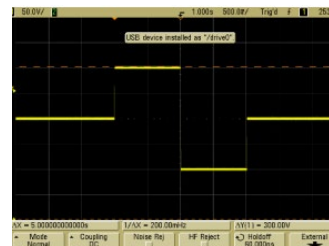
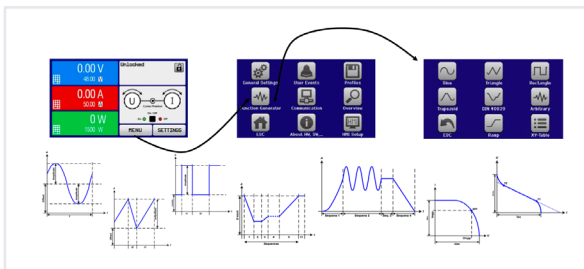


PORSCHE

Table 29 – Test parameters for EHV-06 System HV voltage dynamics

DUT operating mode	II.c with IV.b and II.c with IV.c
HV voltage	As per figure 22
LV voltage	V_{op}
Internal resistance of HV source	$R_{i,HV}$ as per section 4
Hold time	$t_h \geq 5 \text{ s}$ – but at least as long as required for the DUT's power and operation to reach a steady state and for all measured values to be recorded
HV voltage rate of change	450-VDC electric system: $(\Delta V_{HV}/\Delta t) = 20 \text{ V/ms}$ 900-VDC electric system: $(\Delta V_{HV}/\Delta t) = 40 \text{ V/ms}$ or as per Component Performance Specification
Temperatures	T_{max} with $T_{cool,max}$ T_{RT} with $T_{cool,nom}$ T_{min} with $T_{cool,min}$
Number of cycles	3
Number of DUTs	6

- Integrated function generator provides the ability to create non-linear voltage and current waveforms in both Source & Sink mode.
- VW 80300 requires high voltage transient testing.
- Transients required to be 20V/msec for 450Vdc based hardware and 40V/msec for 900Vdc based hardware.
- Function generator allows users to program customizable transients.



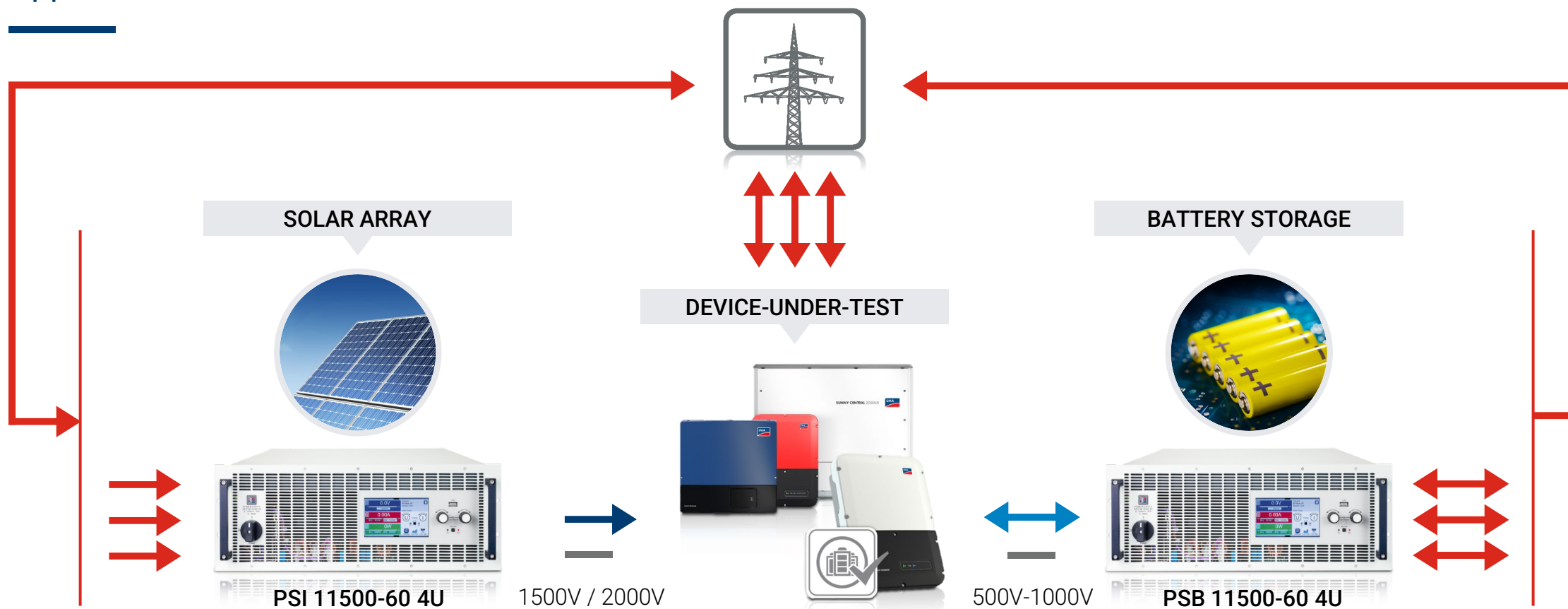
Rise Time: $150V / 3.75ms \sim 40V/ms$



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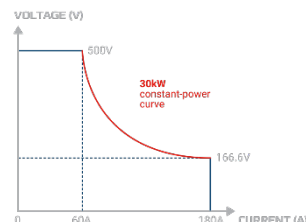
PV INVERTER AND ENERGY STORAGE

Application

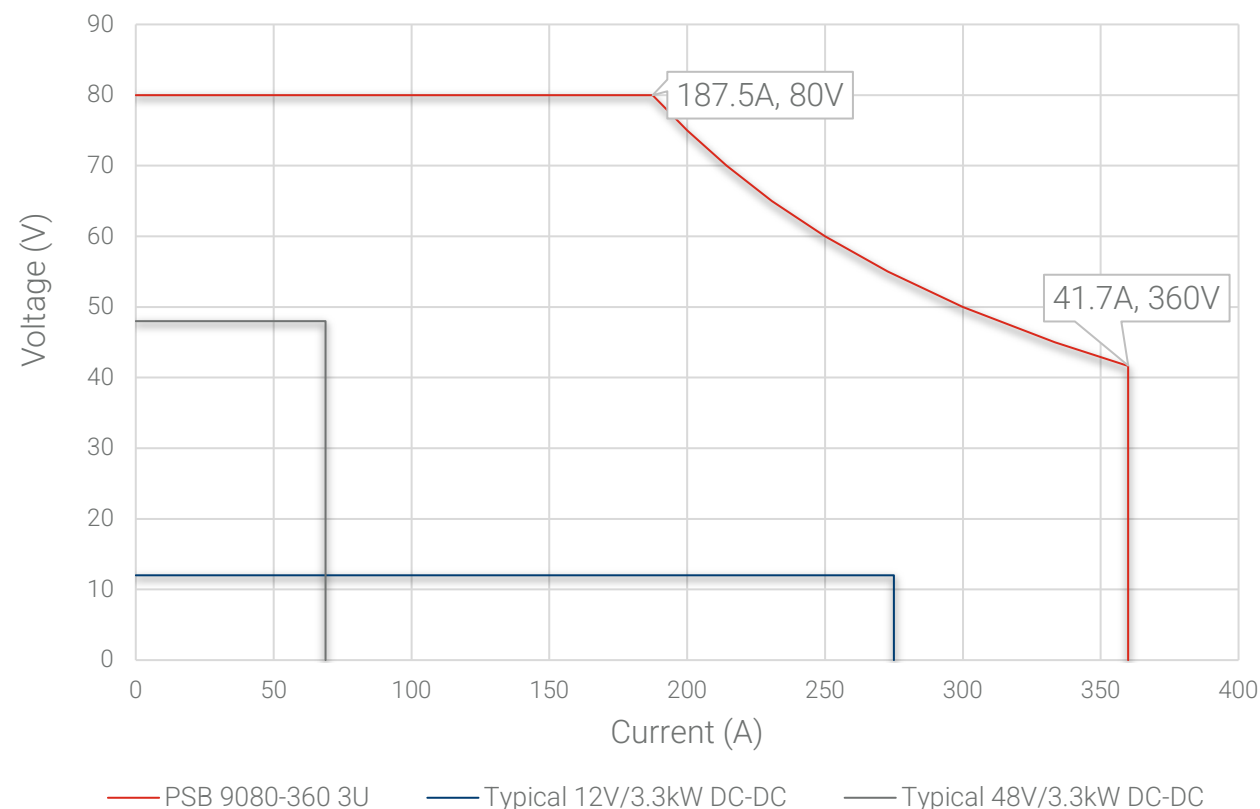


AUTORANGING

Not just another power supply!



- “Autoranging” describes a programmable DC source that automatically outputs a wide output range of both voltage and current to maintain full power output across a wide operation range.
- Maximum power output available from 33% of max voltage through max voltage.
- Serves a larger number of UUT’s.
- Avoids oversizing the power supply to meet high current/low voltage and low current/high voltage applications.
- One instrument can serve many test applications



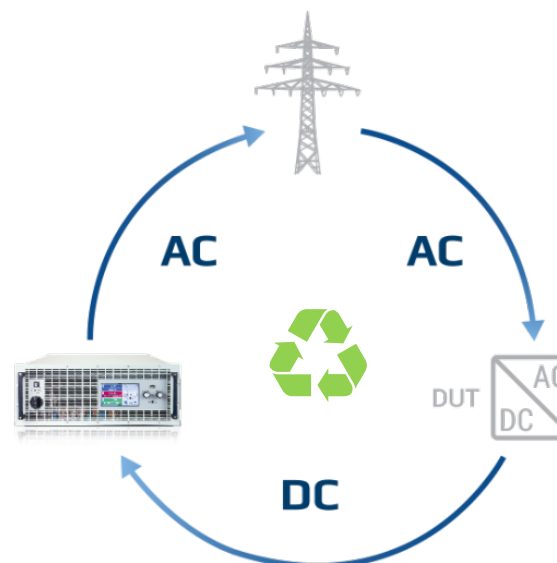


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PSB 10000 SERIES

Bidirectional DC Supply Family

- EA Elektro-Automatik PSB 10000 Series
 - 1.5 - 3kW – 2U
 - 5 - 15kW – 3U
 - 30kW+ – 4U
- Use individually or parallel for high power.
- Parallel up to 64 chassis (1.92MW)
- Mix and match like voltage models
- Source /Sink Regenerative DC
- Up to 2,000 Vdc
- Integrated function generator.
- Industry leading efficiency up to 96%



SINE



TRIANGLE



RECTANGLE



TRAPEZOID



DIN 40839



ARBITRARY



RAMP



XY-TABLE

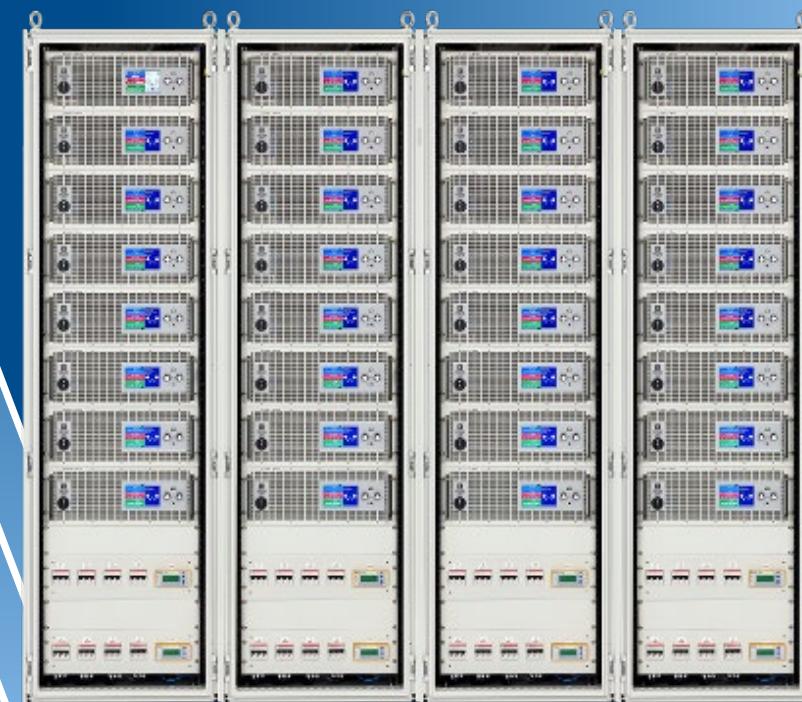


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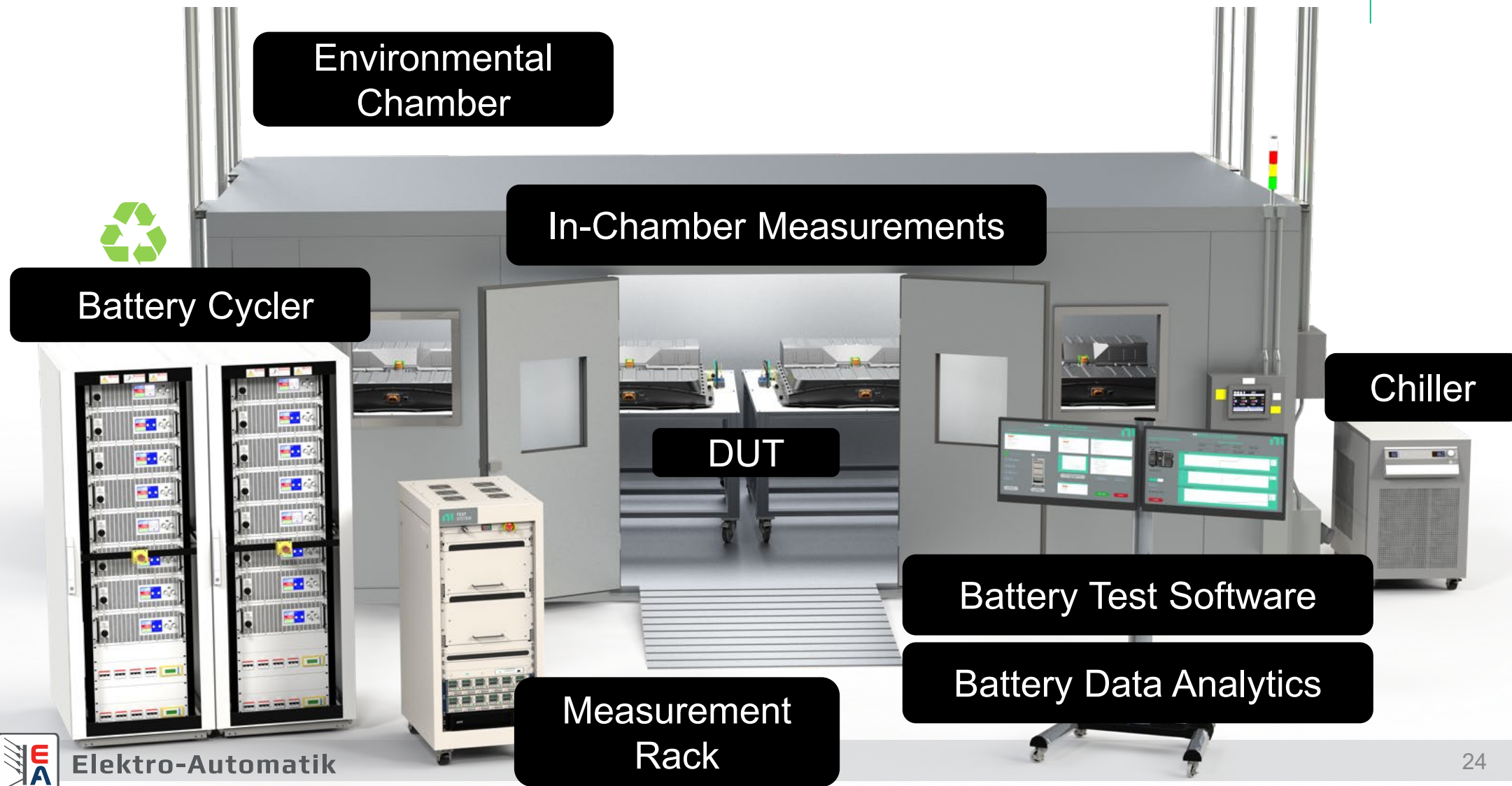
SYSTEMS & TURNKEY POWER RACKS

19"-cabinet systems

- For high-power sources and electronic loads
- **Modular construction**, available as unidirectional source, unidirectional load (conventional or regenerative) or as a combination of source and load (bidirectional)
- Multichannel and ability to operate in parallel (master-aux)
- Delivered turnkey, plug and play ready
- **Selectable standard conformity:** UL 61010 (safety), EN60950 (IT facilities) and EN 60204-1 (safety for machines)



Battery Lab Typical Layout





Elektro-Automatik

THANK YOU

For choosing EA Elektro-Automatik

شكرا

THANK YOU

Gracias

謝謝

Grazie

MERCI

DANKE

יה **connect**

