

Future-Proofing the Battery Test Lab

APPLICATION NOTE



This Application Note

- Reviews growth trends across markets such as electric vehicles, battery energy storage systems, aerospace and defense systems, and data centers that are adopting high-power battery systems as power sources
- Explains how rising battery pack voltage and power levels are pushing traditional battery test infrastructure past its design limits
- Describes the design principles a future-ready battery test system requires
- Presents a battery test architecture built around these design principles, then shows how Tektronix implements that architecture in the EA-BTS 10300 Series Battery Cycler and Test System
- Closes with guidance for selecting a battery test system that protects your investment as battery pack voltage and power continue to increase

Introduction

Electrification is expanding well beyond passenger electric vehicles. High-power battery packs now deliver power in aviation equipment, aerospace and defense systems, and hyperscale data centers. In addition, renewable-energy battery backup systems are moving from early adoption into mainstream infrastructure across utilities, homes, and commercial buildings.

This shift touches nearly every form of transportation and energy storage. Passenger cars, commercial trucks, buses, off-highway equipment, marine vessels, and aircraft increasingly rely on battery packs for primary or backup power. Similarly, battery energy storage systems are multiplying as utilities and data center operators look for faster, more flexible, and more sustainable power resources.

Electric vehicles, energy storage systems, and defense platforms require validation of their battery packs before being placed into operation. As battery pack voltage and power increase to meet application demand, test requirements must adapt in kind. A test system purchased today needs to remain capable, safe, and serviceable over time, even as the battery packs it tests grow larger and move to higher voltages.

This application note reviews the market trends and applications driving demand for higher-capability battery test systems. It also examines the challenges these trends create for test labs, describes what test labs need in a system to stay ahead of these challenges, and presents a design approach that addresses the challenges.

Market Trends and Applications

Several markets are driving demand for higher-voltage, higher-power battery pack testing. Each market follows its own adoption curve. However, all of them point toward the same conclusion: battery packs are increasing in capacity, and so is the power that test systems must handle.

Electric Vehicles (EVs)



The 800 V EV powertrain segment is growing at a high rate. Just in the United States, analysts project this segment to grow from roughly \$3.45 billion in 2024 to \$24.41 billion by 2034, a 21.3% compound annual growth rate (CAGR).¹ In China specifically, 800 V passenger vehicle penetration is expected to rise from 6.9% in 2024 to over 35% by 2030.² Demand for faster charging and extended driving range between charges is driving this growth. Battery voltage will continue to climb. Some vehicles are already using 1000 V battery packs.³

Battery capacity is climbing as well. Battery packs in trucks have capacities exceeding 200 kWh today. With fast charging an essential requirement for EV adoption, megawatt charging cycles requiring only 10 minutes are on the horizon.

Commercial and off-highway electrification, in vehicles such as trucks, buses, construction equipment, and marine vessels, trails behind passenger vehicle growth. However, this segment is moving toward higher voltages while adding larger pack capacities per unit.

These trends carry a direct implication for test engineers. Battery pack test systems need headroom above 800 V, ideally to 1000 V and beyond, to validate next-generation platforms with margin rather than matching today's production voltage. Total power capability must also cover a wide range, from bench-scale validation to full-pack production testing.

Battery Energy Storage Systems



Battery energy storage systems (BESS) represent one of the fastest-growing markets for battery packs. The global BESS market is projected to grow from \$50.81 billion in 2025 to \$105.96 billion by 2030, a 15.8% CAGR.⁴

Utility-scale BESS have standardized around 1500 VDC. Most utility-scale solar inverters and converters already use a 1500 VDC input, and BESS installations have followed suit. The higher voltage reduces cable losses substantially compared with lower-voltage designs.

Data centers add another growth vector for BESS. Data center operators are increasingly deploying on-site battery storage for demand response, faster grid interconnection, and load-ramp support. Power magnitude in this market is substantial. Utility-scale BESS containers typically output 3 to 4 MW, and customer demand is pushing toward 6 to 7 MW as project scale increases.

Test systems serving this market must comfortably cover the 1500 V range, and increasingly the 2000 V range. They must also support the multi-hundred-kilowatt to multi-megawatt pack sizes typical of utility, commercial, and industrial energy storage.

Aerospace and Defense



Aerospace and defense applications push battery and power system requirements even further. Electrification and energy storage applications in this market are expected to grow significantly.

One market segment, directed energy weapons, illustrates how much power these platforms now demand. This segment includes the high-power battery and capacitor banks used in radar and laser-weapon systems. Growth in this market segment benefits from power-electronics advances that shrink high-power systems onto deployable platforms.

Power magnitude in defense and aerospace programs can already exceed commercial EV and BESS power levels by a wide margin. A radar power system can require up to 6 MW. A directed-energy weapons program can run at 1.5 to 3 MW. Also, a nuclear-propulsion materials-testing program is targeting up to 10 MW.

Defense and aerospace programs are therefore already testing packs at multi-megawatt scale and up to 2000 VDC. This puts them ahead of where commercial EV and BESS voltage standards sit today, making them an early indicator of where other markets are headed.

Different Markets, But Similar Trends

Across electric vehicles, energy storage, and aerospace and defense, the same two variables rise together. Voltage is moving from sub-1000 V toward 1500 to 2000 V. Total pack or system power is moving from hundreds of kilowatts toward multiple megawatts.

This pattern carries a straightforward but important consequence. A test system purchased for today's voltage and power ceiling risks becoming obsolete well before the end of its useful service life.

Traditional Battery Test Infrastructure Is Under Pressure

Rising voltage and power levels are exposing weaknesses in traditional battery test infrastructure. These systems have numerous limitations:

- **Fixed voltage and current ceilings:** Many first-generation battery test systems were built around a specific voltage and power envelope. These systems cannot be conveniently upgraded as battery packs grow in capacity, forcing an early and costly replacement decision.
- **Monolithic architecture and downtime risk:** A single component failure can take an entire test stand offline for an extended period.
- **Facility footprint constraints:** Low power-density legacy equipment limits the maximum test capacity that can be installed into available floor space.
- **Energy consumption and utility cost:** Test systems that use conventional electronic load designs or resistor banks waste discharged battery pack energy as heat. This drives up both electricity costs and cooling demand.
- **Software and control-platform limitations:** General-purpose operating systems are not designed for uninterrupted, multi-month test runs. As a result, they risk unplanned shutdowns during long-duration testing.
- **Safety exposure at higher voltage and power:** As battery pack voltage and current rise, so do the consequences of a fault, increasing test system protection requirements.

Engineering teams need to evaluate their battery test infrastructure to prepare for the next generation of higher voltage and higher power battery packs.

Design Principles for Future-Ready Test Infrastructure

Test labs need a system built around several design principles to stay ahead of rising battery pack demands. Each principle addresses one of the limitations described in the previous section.

Scalability to Match Rising Battery Capacity

A future-ready system allows the addition of power and voltage headroom over time. Engineers should not need to replace the entire system every time a new program calls for more capacity.

Adaptable, Modular Performance

Flexible hardware and software configuration lets engineers test different pack chemistries, form factors, and duty cycles. This flexibility should not require hardware changes.

Floor-Space Efficiency

High power density lets test capacity grow without facility expansion. Optimizing for space efficiency is essential for labs facing rising program volume and higher capacity battery packs, but limited space for battery test systems.

Energy-Efficient Operation

Low operating power draw controls utility costs. The ability to return absorbed energy rather than dissipate it as heat further reduces both energy costs and cooling infrastructure demand.

Reliability

A control architecture and hardware base engineered for uninterrupted operation supports long test durations. This becomes especially important for multi-month drive-cycle or duty-cycle validation programs.

Safety

Comprehensive, built-in protection should match the higher voltage and power levels these systems must handle. Safety features should be an essential part of the design.

Service and Support

Fast access to technical support, along with a service model that minimizes downtime, keeps test programs on schedule when something does go wrong.

The Tektronix EA-BTS 10300 Series: A Future-Ready Implementation on a Next-Generation Architecture

Tektronix has developed a new architecture for addressing these requirements in its EA-BTS 10300 Series Battery Cycler and Test System. This architecture rests on several pillars.



Scalability and Flexibility

The EA-BTS 10300 architecture supports 0 to 1500 VDC as a standard range, with a 2000 VDC option available for testing today's high-voltage packs and tomorrow's higher-voltage designs. In addition, the architecture allows expansion from a single 30 kW configuration up to 3.84 MW and beyond by paralleling racks. Total current capacity can reach 30,720 A. The same platform serves electric vehicles, aerospace/defense, and BESS battery pack testing, so engineering teams can standardize on one platform across multiple programs.

Modularity

The EA-BTS 10300's architecture uses standard, off-the-shelf instrumentation in its power racks. The addition of an instrument easily increases the maximum test system voltage or the maximum power capacity. The input/output bus bar simplifies safe integration into a power rack.

User-Configurable Software

User-configurable software lets test engineers adapt test sequences, parameters, and screen layouts for different test types, including thermal tests and dynamic electrical tests. The software implements widgets to allow engineers to create displays without having to develop custom code. EA-BTS 10300 architecture also supports standard drive-cycle simulations for EVs, such as various federal urban driving schedules, FUDS, SFUDS, GSFUDS, dynamic stress test (DST), and an international drive cycle (ECE-ISL), along with user-defined and imported profiles.

High Power Density and Space Efficiency

This architecture delivers up to 360 kW in a single 42U rack occupying only 6.5 square feet. Thus, test labs can add substantial power capacity without requiring facility expansion.

Energy Efficiency

When the battery pack is supplying energy, the test system architecture returns energy to the grid with up to 96% regenerative efficiency. The design saves utility costs and significantly reduces required cooling infrastructure.

Safety Systems

Comprehensive safety functions protect both the equipment and the operating personnel:

- Polarity-reversal protection and voltage-matching checks, accurate to within 1% of battery voltage
- Pre-charge protection
- Battery temperature monitoring
- Emergency stop and configurable emergency shutdown sequencing
- Share-Bus load balancing that ensures every instrument in a paralleled system carries an equal share of the load, within 1%, preventing any single unit from becoming overloaded
- Contactors on the power source input/output lines to completely remove power from the battery pack-under-test

Reliability Through Real-Time, Linux-Based Control

Real-time, Linux-based control architecture reduces the risk of operating-system-driven interruptions during long tests, unlike general-purpose Windows-based systems. A watchdog system monitors for system lock-up and notifies users of a problem. This prevents long periods of lost cycling time or lost test data. Real-time technology, combined with Share-Bus load-balancing technology, also allows the system to grow without sacrificing control speed or response time.

Implementing The New Platform for Future-Ready Battery Test Protocols

Proven Hardware: Autoranging, SiC-Based Bidirectional Supplies with Waveform Generation

The EA-BTS 10300 Series is built on standard, field-proven high-power bidirectional power supplies. Tektronix backs this hardware with its experience in silicon carbide (SiC) MOSFET-based power electronics design. SiC transistors can operate at higher switching frequencies. This, in turn, allows use of smaller magnetics, smaller heatsinks, fewer components, and higher power density than legacy silicon-based designs achieve.

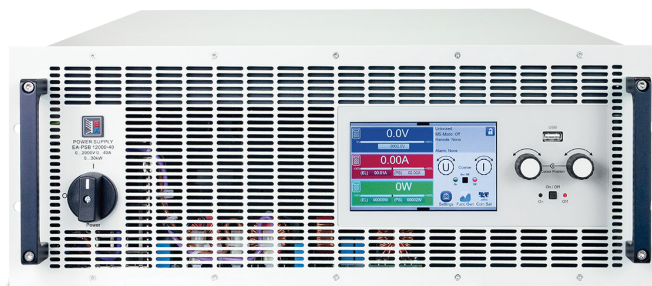


Figure 1. The Tektronix family of bidirectional power supplies provide the power sourcing and regenerative loading for the battery test system

The bidirectional power supplies employ true autoranging to allow delivery or absorption of maximum rated power down to 1/3 of the maximum output voltage. Unlike instrumentation without true autoranging, the test system can cycle a high-power battery pack without a range change interruption. The supplies allow simulation of fast power ramp-up and ramp-down with slew rates under 500 μ s.

Combined with built-in arbitrary waveform generation, the supplies can create custom waveform profiles. The supplies can simulate or test complex load transients such as turn-on and fast load changes.

Designed and Supported for Minimized Downtime

The design of the battery test system supports minimized downtime. With standard, off-the-shelf instrumentation, facility technicians can quickly replace a faulty instrument with a spare instrument. Alternatively, the system software can adapt to a hardware change. Once a defective component is isolated or removed, the system can restart and operate at reduced power, avoiding a total shutdown.

In addition, Tektronix offers fast response for technical support of its battery test systems. Tektronix support personnel respond to customer requests for assistance, generally within a few hours and no longer than 24 hours. Hardware, software, and technical support all contribute to keeping systems up and running.

Selecting a Battery Test System

A test engineering team must develop a test system to test 250 kW battery packs with a 1200 V output voltage. The battery packs will serve as backup power systems. Tektronix has battery test systems with 300 kW capacity. One system, the model 103000-30, supports 300 kW, 1500 V, and can deliver and absorb up to 600 A. The test system comprises a single 42 U rack. The 1500 V rating provides headroom for overvoltage test conditions and 600 A to comfortably exceed the 208 A that the battery pack can deliver.

Once the appropriate battery test system model has been selected, the test team should consider the following:

- Determine if environmental control equipment, such as heating/cooling chambers, is required for burn-in or quality control testing. If so, interface the environmental chamber to the battery test system through the chamber control interface.
- Monitor battery pack temperature with information fed directly from the battery pack's battery management system (BMS). Monitor other important locations on the battery pack, such as on the exterior case, bus bars, and other potential hot spots.
- Ensure connections to the battery pack are through the test system's contactors so that power to the battery pack can be galvanically interrupted if an emergency condition occurs.
- Ensure power wiring is properly sized and separate power wiring from remote sense wiring.
- Select either air or water cooling for the test system based on available facility infrastructure and the required cooling needed for a 300 kW test system.

Figure 2 illustrates the setup for testing a battery pack.

The supplied EA-BTS 10300 Series software provides test and data acquisition flexibility. Test system engineers can control program flow by creating test sequences using widgets. The widgets allow customization to define test protocols, display data, and export data. The battery test systems include both hardware and software flexibility. Figure 3 shows the options available when creating a widget.

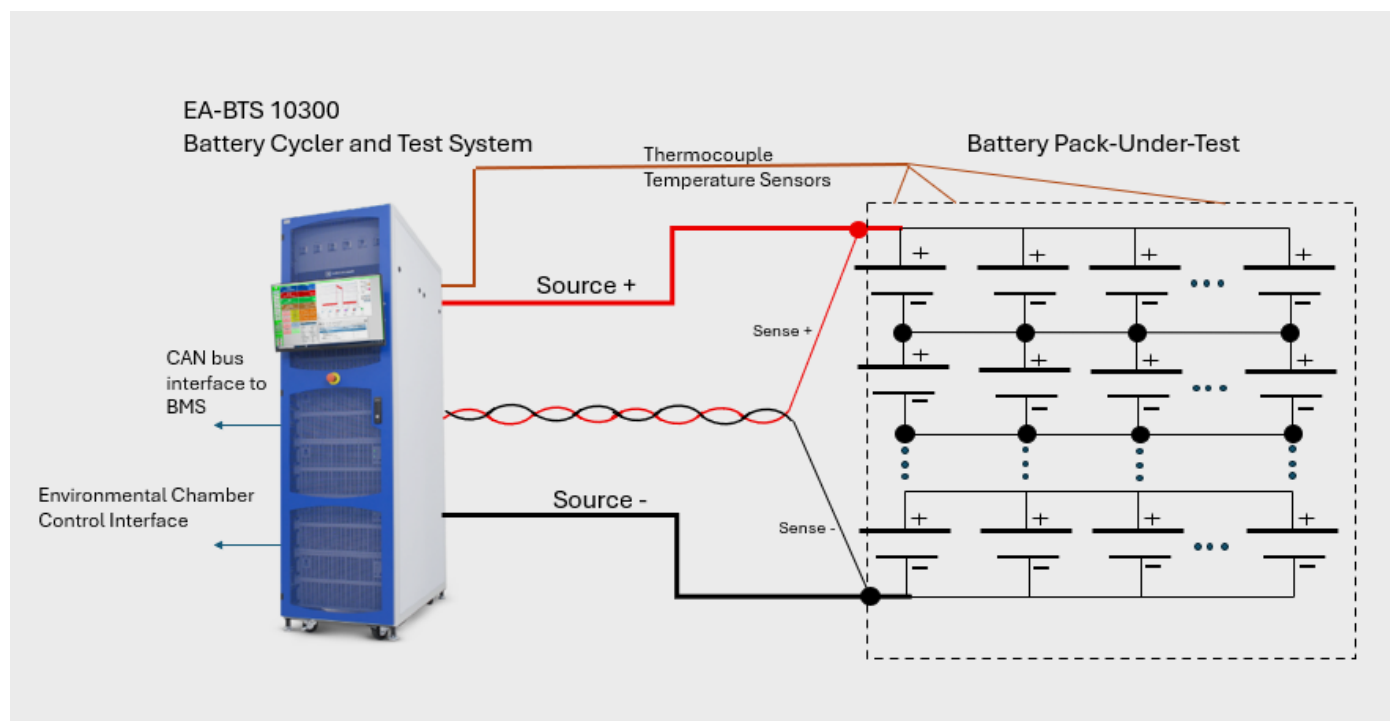


Figure 2. Battery test system connections to a battery pack-under-test

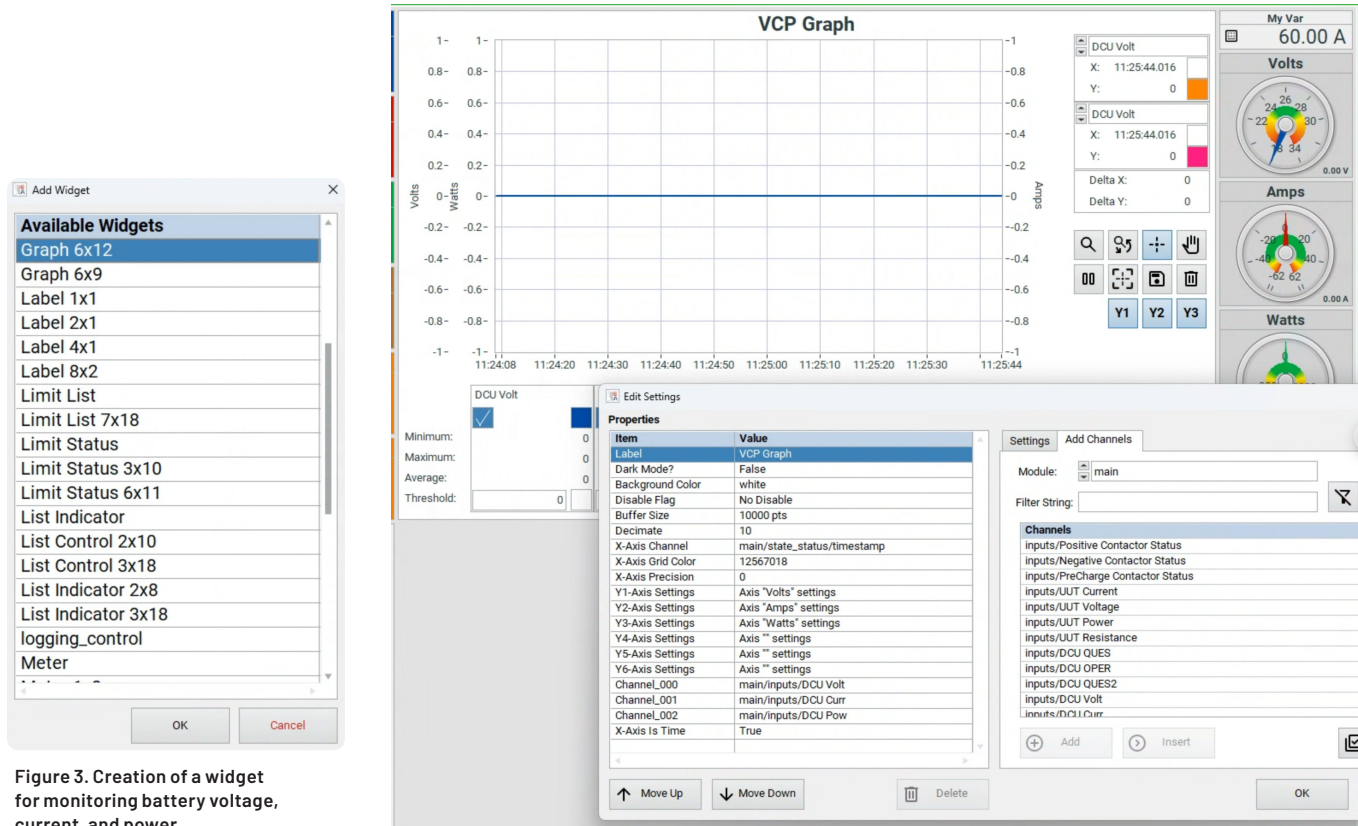


Figure 3. Creation of a widget for monitoring battery voltage, current, and power

Protecting the Investment in Battery Testing Systems

Battery packs across EV, BESS, aerospace/defense, and other markets are moving toward higher voltage and higher power. Test labs need to select systems that will remain relevant as this trend continues.

When evaluating a battery test system, look for scalability, modularity, reliability, safety, and technical support. These features determine whether a system will meet test needs for tomorrow, not just today.

The Tektronix EA-BTS 10300 Series battery cycler and test System protects the investment in a battery test system. The system provides voltage headroom to 2000 V, power scalability to 3.84 MW and beyond, high power density, comprehensive safety systems, real-time reliable control, and a service model built to minimize downtime. With Tektronix, engineering teams can expand, adapt, and maintain their test system as program needs change.

To learn more about the EA-BTS 10300 Series Battery Cycler and Test System, visit the [EA-BTS 10300 Series product page](#) or [contact Tektronix](#) for assistance.

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Rev. 02.2022

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