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PROGRAMMABLE POWER

WHITE PAPER

Programmable Power Products Boost Test of EVs and Charging Stations

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Electric vehicles (EVs) are proliferating as governments, manufacturers, and consumers pursue efficient, low or no-carbon alternatives to vehicles powered by internal combustion engines (ICEs). The EVs, their components, and the charging infrastructure necessary to meet the needs of the expanding fleet of EVs require extensive tests to ensure reliability, safety, and compliance with relevant standards.

Programmable AC sources, DC supplies, and electronic loads are crucial in testing EV-related products, including fast and onboard chargers, batteries, fuel cells, motors, and the many components within hybrid or fully electric drivetrains.

Market Data

According to MarketsandMarkets Research, the global market for battery-electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel-cell electric vehicles (FCEVs) is growing at a CAGR of 13.7%. It will reach $951.9 billion by 2030. The firm says lower battery costs are increasing the demand for electric passenger cars and commercial vehicles.

Several industry initiatives are addressing batteries and other aspects of EVs. Battery innovations are resulting in new, improved battery technologies that increase power densities, bring prices down, or both. To reach these goals, researchers are pursuing alternative chemistries and new production methods.

Battery Market Growth

As an example of such initiatives, Volkswagen has established its PowerCo subsidiary to focus on the development and production of battery cell technology. A facility in Salzgitter, Germany, is intended to become a blueprint for cell factories throughout Europe. To help lower production costs, PowerCo has agreed with Koenig & Bauer to develop a machine that will provide a solvent-free dry coating of cell electrodes, which, Koenig & Bauer says, eliminates the expensive and energy-intensive process of drying wet-coated electrodes. Tesla is also working on a dry-cell technology, which it acquired with the purchase of Maxwell Technologies in 2019. Tesla sold Maxwell in 2021 but retained the dry-cell technology.

Also focusing on batteries, Toyota and BYD, a Chinese battery maker, have established a joint venture called BYD Toyota EV Technology Co. Ltd. (BTET), presenting a BEV sport crossover concept that will be realized in the 2025 model year. In addition, BMW Group and Solid Power have expanded a joint development agreement under which BMW will establish an all-solid-state battery (ASSB) at its facility in Parsdorf, Germany. And Tesla is reportedly partnering with CATL, a Chinese battery maker, to expand the production of lithium-ferro-phosphate (LFP) batteries in the U.S. Although offering lower power densities than cobalt-based batteries, LFP batteries can provide a low-cost alternative for drivers with short commutes.

Also pursuing alternative battery chemistries is the U.S. Department of Energy's Argonne National Laboratory, which recently patented a cathode material that substitutes sodium for lithium. Argonne researchers estimate that a sodium-ion battery would cost one-third less than a lithium-ion battery. They acknowledge that the weight of the sodium vs. lithium could limit the range of a typical vehicle to 180 or 200 miles but add that the technology could appeal to budget-conscious urban dwellers whose daily driving rarely exceeds these distances.

Semiconductors and Other EV Components

Vehicles consume vast quantities of a wide variety of distinct semiconductor device types and have long-used devices such as microcontroller units (MCUs) and mixed-signal chips for window, seat, and door-lock control functions.

As vehicles—and especially EVs—evolve, they require a wide range of products, from display drivers for all-digital dashboards to high-end MCUs that bring data center levels of high-performance computing (HPC) to advanced driver-assistance system (ADAS) features. ADASs are becoming increasingly sophisticated, implementing functions such as active suspension, lane-departure warnings, and collision avoidance, including automatic braking, in response to the various sensor inputs as vehicles move toward full autonomy.

Of course, ADAS features can be relevant to fully ICE vehicles, PEVs, and BEVs. And, as ICE batteries rise in voltage from 12 V to 48 V, the line between ICE and PEV can blur. The move to 48 V is driven partly by a desire to shrink cable sizes and limit I_2R losses. ICE vehicles require more electric power for power steering, suspension, power braking, etc. Still, the higher voltage also facilitates the implementation of mild hybrid operation, in which a relatively small 48-V electric motor assists the ICE engine during low-speed stop-and-go operation, providing regenerative braking and assistance during acceleration.

But of particular importance to PHEVs and BEVs are devices ranging from battery-management-system (BMS) chips for the battery stacks to power semiconductors and gate drivers for traction inverters.

Opportunities for Programmable Power Products in EV Test

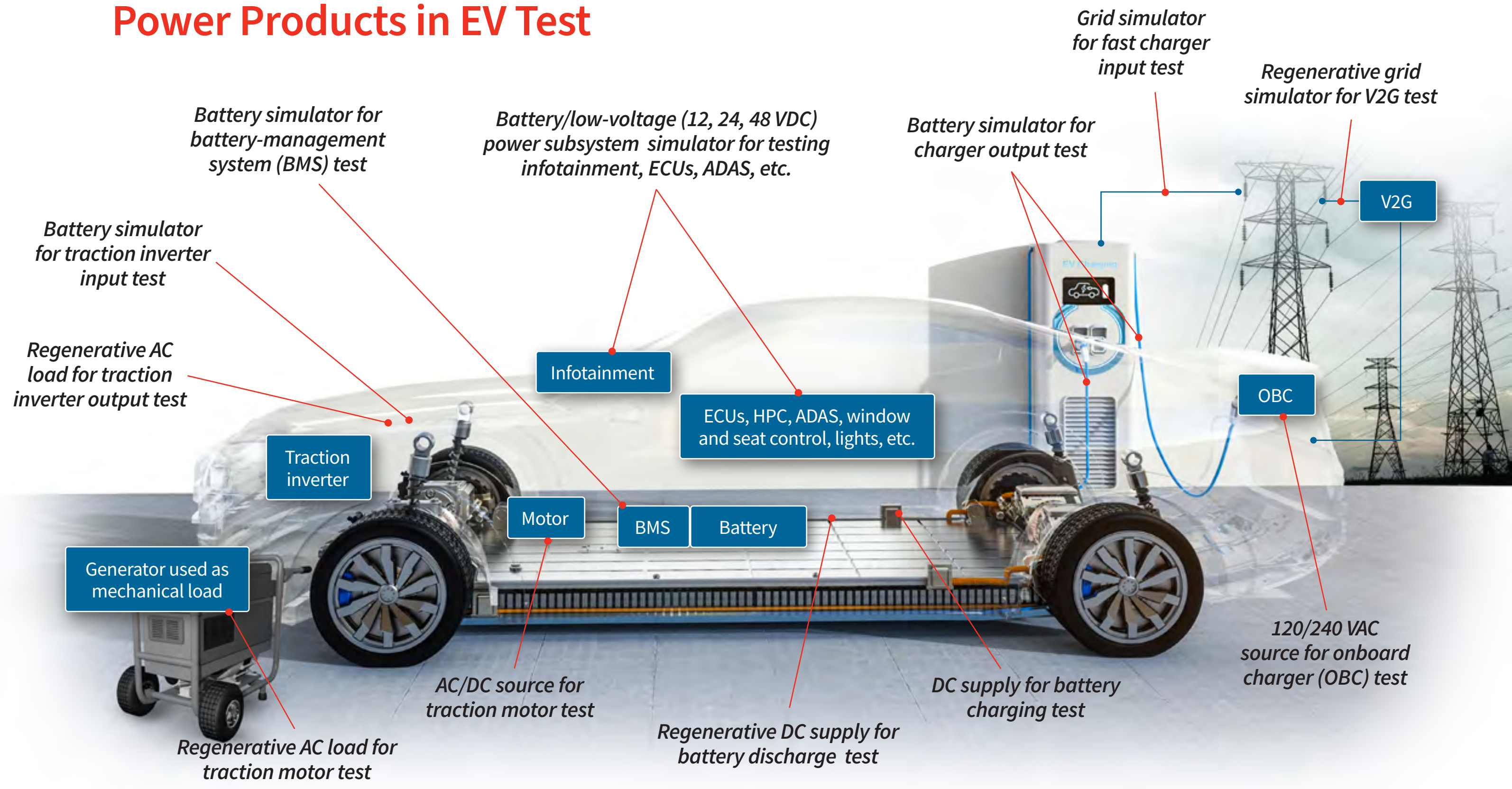

Figure 1

Programmable power in EV Test

Batteries, chargers, charging infrastructure, and semiconductors and other components all require extensive testing—extending from the subsystem level to the complete final charging station or the EV itself. Programmable power has key roles to play in all aspects of this testing.

Figure 1 illustrates some of these roles. Fast DC charger manufacturers require AC grid simulators to test a charger's input and battery simulators to test the charger's DC output. Vehicle onboard chargers require household voltage-level programmable AC sources to test their inputs and battery simulators to test their outputs. The EV's high-voltage battery also needs thorough test. A programmable DC supply can test a battery's charging cycle, but typically, a regenerative DC supply tests both charge and discharge cycles repetitively.

The BMS has a critical role, including cell monitoring and balancing, plus state-of-charge measurement for predicting the remaining driving range. This last function can be particularly challenging, especially with specific battery chemistries, including the aforementioned LFP. An LFP battery has a very flat discharge characteristic, with the voltage level near the end of the charge being nearly equal to the fully charged voltage. A BMS must accurately monitor the voltage drop to avoid a BMS underreporting the remaining range, and a programmable DC supply used as a battery simulator in a BMS test must accurately and repeatably reproduce this flat characteristic.

A programmable DC supply can take on other EV test roles as well. It can be configured as a battery simulator for power input to a traction inverter under test. In contrast, a regenerative DC/AC unit can be used as the traction inverter load. In addition, a programmable AC source can power a traction motor under test, and a generator can mechanically load the traction motor itself, with the generator's output returned to the grid using a regenerative AC source.

Even fully electric vehicles will continue to use low-voltage batteries and associated power circuitry to power ECUs, infotainment systems, lights, and actuators. Low-voltage programmable DC supplies that can cover the 12-V, 24-V, or 48-V ranges can be used to ensure these low-voltage subsystems work as specified overall expected fluctuations of DC power.

Another EV technology receiving attention is a vehicle-to-grid (V2G), in which an EV not in use can return battery power to the grid during peak demand or serve as a backup power source. For example, Ford, in conjunction with SunRun, offers technology that will reroute power from an F-150 Lightning pickup truck to a properly equipped home during power outages. Another use case involves electric school buses, which serve their primary purpose predominantly in the early mornings and late afternoons. If fully charged using renewable energy sources, these vehicles can return power to the grid when not in operation. A regenerative grid simulator can assist in testing V2G technology, ensuring compliance with relevant specifications such as IEEE 1547.

Programmable Power for EV Test

AMETEK Programmable Power offers a full range of programmable AC, DC, and AC + DC products that can be used for EV and EV value-chain product testing.

The new Sorensen Intelligent-Bidirectional Energy AMplified (i-BEAM) and Modular (Mi-BEAM) Series programmable bidirectional regenerative DC power supplies offer ratings up to 2,000 V and 4,800 A with power ranging from 12kW for a single system to a parallel system delivering up to 1.3 MW.

Both the i-BEAM and Mi-BEAM can handle battery simulation, battery test, fuel-cell test, and motor test applications as described in our recent white paper Programmable Bidirectional, Regenerative DC Power Aids Battery, Inverter, Fuel-Cell, and Motor Test Across Multiple Industries.

For battery simulation and test, the i-BEAM and Mi-BEAM's top voltage range is well suited to handle the highest automotive battery pack voltages while lower rated voltage modules are ideal for battery module level testing. See our recent application note Discover Powerful Battery Testing & Simulation with Bidirectional DC Technology for more information.

Also suitable for EV testing is the Sorensen SGX Series uni-directional modular DC power supplies, which deliver 10 V to 1,000 V at 5 kW to 30 kW with higher parallel power capability and which are designed for exceptional load transient response, low noise, and high-power density. Customers are using the SGX Series for various aspects of EV power drivetrain testing to include DC/DC converters and miscellaneous 12-48 VDC components.

Additionally, for charger (OBC), EVSE and V2G test, AMETEK Programmable Power provides the California Instruments Sequoia programmable four-quadrant regenerative AC grid simulator, which delivers 0 to 333 VAC L-N and 0 to 3,000 A/phase at 15 kVA to 1.08 MVA. Sequoia uses silicon carbide (SiC) technology to provide compactness and robustness in a floor-standing chassis. And for applications not requiring regeneration, the company offers the California Instruments Tahoe Series of precision programmable AC and DC sources, which offer the same voltage, current, and kVA ratings.

Conclusion

As the EV market evolves, test challenges extend from grid-connected chargers and V2G equipment to vehicle high- and low-voltage batteries and from the power semiconductors in traction inverters to the HPC ADAS processors critical to performance and safety. Programmable power has a key role to play in testing all aspects of EV performance, making sure that all components work together under a wide range of operating voltage and current conditions. AMETEK Programmable Power offers a full range of programmable AC and DC products that address all aspects of EV research and development, and test. Visit the AC Power Sources and DC Power Supplies product pages for more information.