

# Emulation Test on Electric Vehicles

Ensuring electric cars perform flawlessly with emulation

Rapid growth in the electric vehicle (EV) market is causing a paradigm shift in design verification and performance testing of electric cars. As increased vehicle electrification drives technology investments, automotive engineers are moving to new design and test methods. This includes emulation technology to reduce design cycle time and increase productivity in relatively uncharted territories.

The e-mobility community has been busy addressing consumer sentiment, mainly range anxiety, and how to drive down the cost of the EV battery to make electric cars more affordable. Let's look at how design and test engineers use emulation technology to reduce the design verification cycle time and contain or even reduce the cost of test. The benefits can go a long way to making EVs more affordable and help win the hearts and confidence of drivers.

## Carmakers Shift Gears to Meet the Changing Customer

As recently as a decade ago, carmakers were generally a conservative lot. Automotive innovations had longer development cycles compared with other technology. The reasons for this cumbersome pace included the need to conform to stringent crash test standards and legislative traffic safety and pedestrian requirements in different end markets.

With global climate change and increased smog, drivers realize their love affair with their gas-guzzlers over the past century has contributed to pollution. That has sparked interest in low- to zero-emission alternatives such as electric cars.

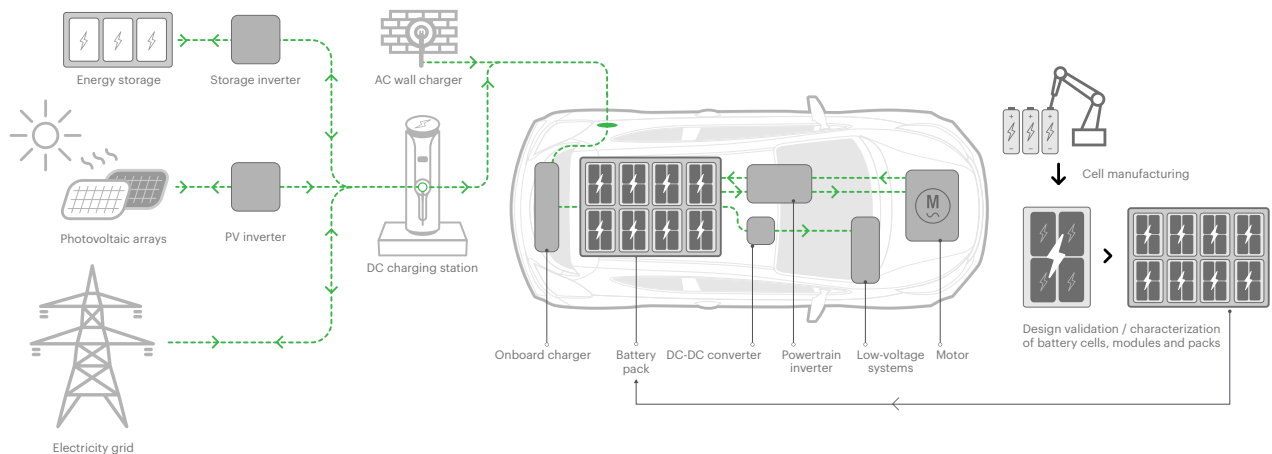
A report <sup>1</sup> by IHS Markit shows that by 2030, over one in four new passenger cars sold will be an EV. Many automotive OEMs are investing in the transition from producing internal combustion engine (ICE) and hybrid EVs to fully electric vehicles.

In the conventional ICE car, the automotive designer has fewer parameters to tackle. For instance, the ICE runs on either gasoline or diesel, with improved models offering better torque and horsepower. In contrast, the ICE's new-age EV cousin has many more specific requirements.

<sup>1</sup> IHS Markit Report: Pivoting to an Electrified Future

EV carmakers must grapple with an entire high-energy e-mobility ecosystem to ensure conformance to safety and performance standards. Interoperability is another vital factor. The makers of electric vehicle supply equipment (EVSE) need to cater to car models with differing plugs, while EVs sold around the world need to meet local EVSE power supply specifications.

Figure 1 illustrates the complexity of the e-mobility environment. Each component and subsystem, from the smallest battery cells to charging stations and infrastructure, must meet mission-critical safety and performance standards.



**Figure 1.** EVs are driving technology investment across the e-mobility ecosystem

## Higher Voltage, Costs, and Risk

Probably the most noticeable change for automotive electrical and electronics designers is the addition of high-voltage, high-power batteries. Key challenges for designers involve integrating batteries in the 300 V range or higher on low-power platforms traditionally using 12 V. These high voltages pose additional costs and risk, even as manufacturers work to ensure smooth, safe power conversion for the various onboard electrical subsystems.

EV test equipment that can handle this new environment may be many times more expensive than comparable low-power equipment (i.e., 1 kW versus 10 kW power sources). Operating expenses also increase. For example, the amount of electricity a 10 kW power source consumes is 10x that of a 1 kW power source when sourcing full power. All of this power creates an enormous amount of heat that requires increasing the facility's cooling capability.

Moreover, manufacturers must comply with high-voltage safety regulations, such as NFPA 79 in the United States. And, they need to consider extra equipment, such as a safety disconnect system, all of which adds to the overall cost.

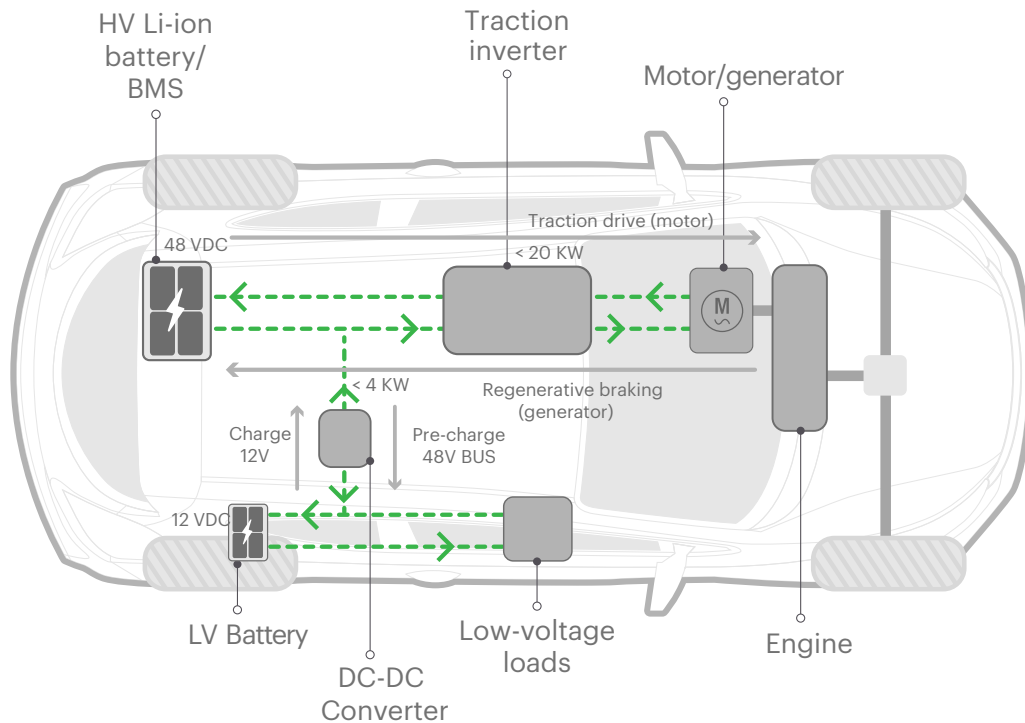
## Emulating High-Power Onboard Batteries

One of the most vital subsystems in any EV is the battery. EVs use large batteries to store energy. Energy flows into the battery pack as it charges, either from regenerative braking or from the grid. It discharges from the pack to power the vehicle and its accessories. This energy is measured by electrical current and voltage.

To ensure that it charges safely and delivers the promised power, the EV battery must undergo rigorous testing. Emulating the EV battery allows its battery operating life to be accurately characterized. It also enables early product failures to be detected. Because of this, automotive manufacturers are increasingly turning to battery emulation solutions that allow them to test devices under realistic conditions.

The onboard energy subsystems must withstand harsh environments, including extreme temperatures and vibrations, both of which affect battery performance. Emulators allow engineers to imitate high-power batteries and study how the battery performance impacts various devices under test (DUTs) under different conditions, such as transient voltage dropouts or power surges, which can adversely affect other devices.

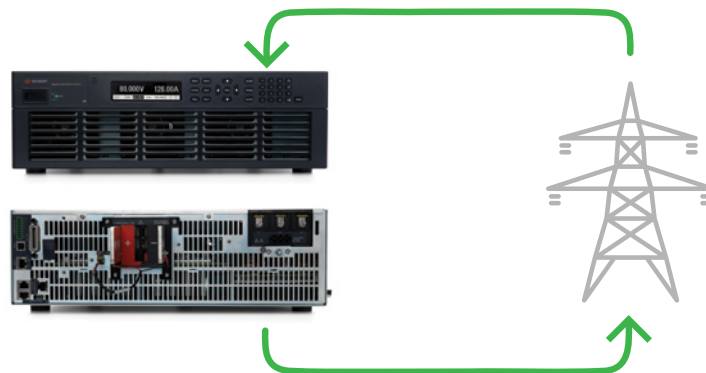
Emulators can also act as both DC-to-DC bidirectional power converters and DC-to-AC converters. As a DC-DC converter example, the design engineer can use an emulator to test the behavior of onboard subsystems. That includes down-converting 48 V DC to power 12 V devices like the vehicle's air conditioner or up-converting from the 12 V bus to the 48 V bus of the vehicle's battery management system (see Figure 2).



**Figure 2.** DC-DC conversion in a mild-hybrid electric powertrain architecture

Most EV batteries draw energy from the power grid. However, energy efficiency innovations are now allowing engineers to work on EVs that will sink excess energy in the car battery or devices back to the electrical grid. This involves DC-AC conversion, as the grid operates on an AC platform. Engineers can use emulators to create such an environment and validate the performance of various subsystems, from onboard EV subsystems to the EVSE (Figure 3).

Some emulators, such as the **Keysight RP7900**, can regenerate 90% of the power from the EV DUTs back to the grid. This reduces the amount of heat that the DUTs would otherwise produce, saving cooling costs.

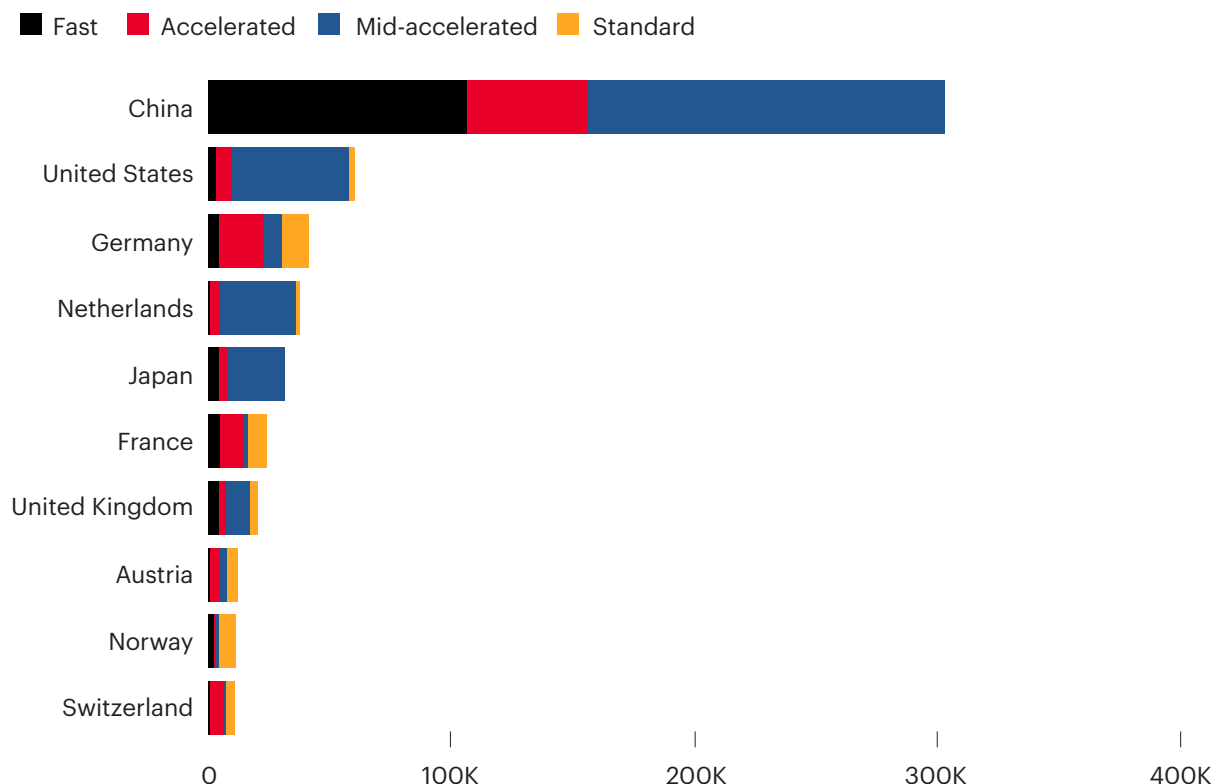


**Figure 3.** Keysight RP7900's regenerative power capability emulates sinking of power from the EV back to the AC mains

# Emulate Charging Stations and Electric Vehicles

To allay consumer concerns about access to charging stations, the auto industry is ramping up investments in EVSE infrastructure.

According to [BloombergNEF](#), the global EV fleet, bolstered by 632,000 public charging outlets, reached 5 million in 2018 (Figure 4). A scenario of one EV for every three cars on the road by 2030 will require 14- to 30-million public chargers deployed worldwide to serve regular passenger vehicles. This spells huge market potential for EVSE makers.

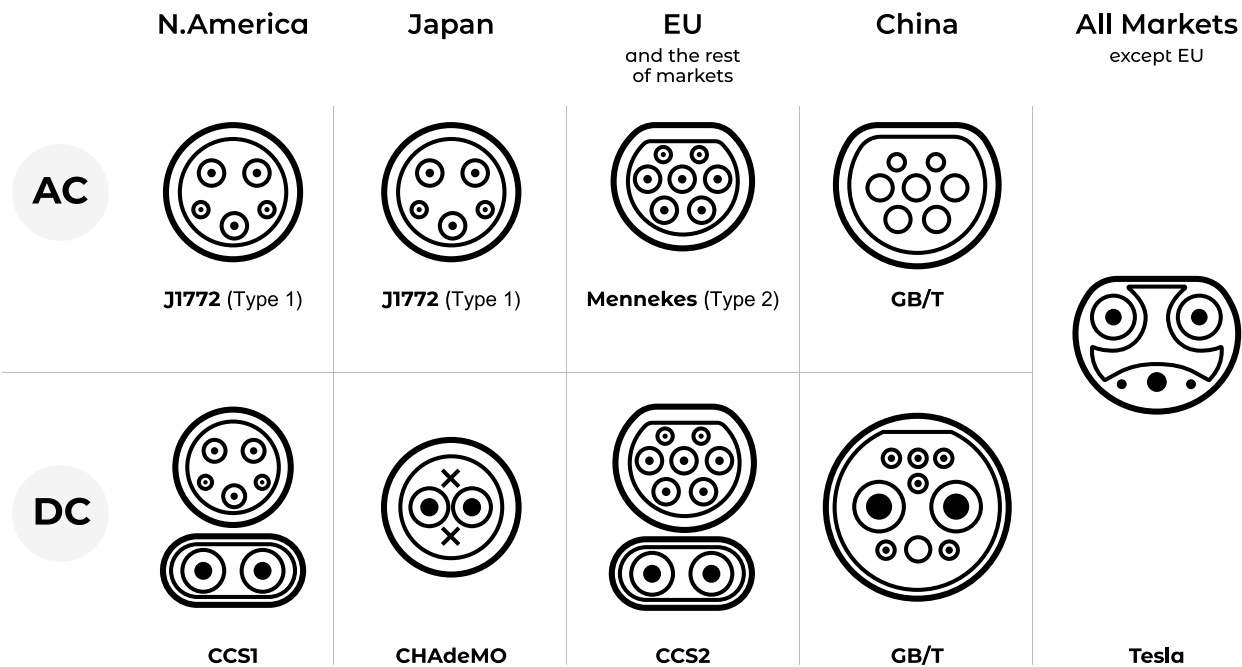


**Figure 4.** Location of public charging infrastructure in top 10 nations in 2018 (source: [BloombergNEF](#))

Charging stations are classified by levels:

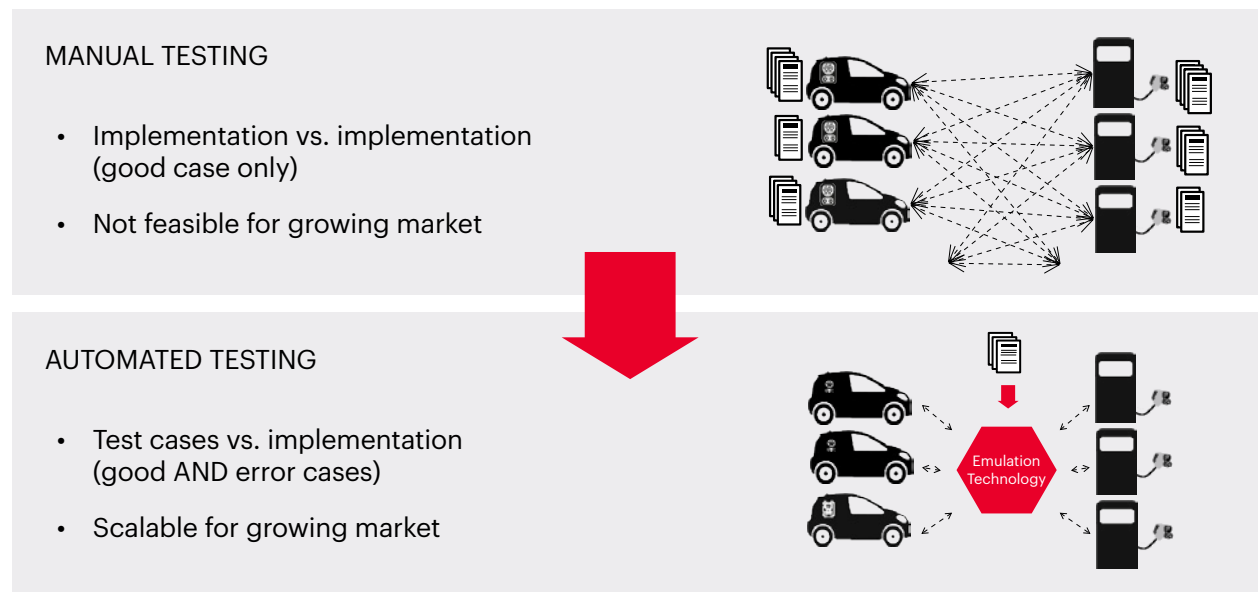
Level 1 - AC Slow Charge	Level 2 - AC Moderate Charge	Level 3 - DC Fast Charge
<p>The slowest and least expensive, these are mainly for overnight domestic charging.</p> <p>You can charge anywhere from a standard electrical outlet with 120 V.</p>	<p>These are capable of charging a small to medium-sized car (24 kWh battery) in 4 to 6 hours.</p> <p>These common AC wall chargers are for home use when you are not in a hurry. They generate less heat than Level 3, making them better for the battery.</p>	<p>These work fast and can charge a 24 kWh battery to 80% in roughly 30 minutes.</p> <p>They raise the temperature of batteries, which may impact the performance of lithium-ion car batteries. External temperature affects charging.</p>

Besides the different AC and DC electrical platforms, both electric car makers and EVSE makers must contend with interoperability and conformance regulations as they attempt to take their businesses worldwide (Figure 5).



**Figure 5.** Examples of charging standards around the world. Emerging standards like Chaoji (CHAdeMO 3.0) and MCS (Megawatt Charging System) will enable even more efficient charging

Traditionally, engineers would conduct manual testing and then match individual car models to various charging stations, each with differing standards. In today's fast-growing market, this test strategy is not feasible. Instead, both EV makers and EVSE providers are turning to automated emulation technology to validate their designs for interoperability (Figure 6).



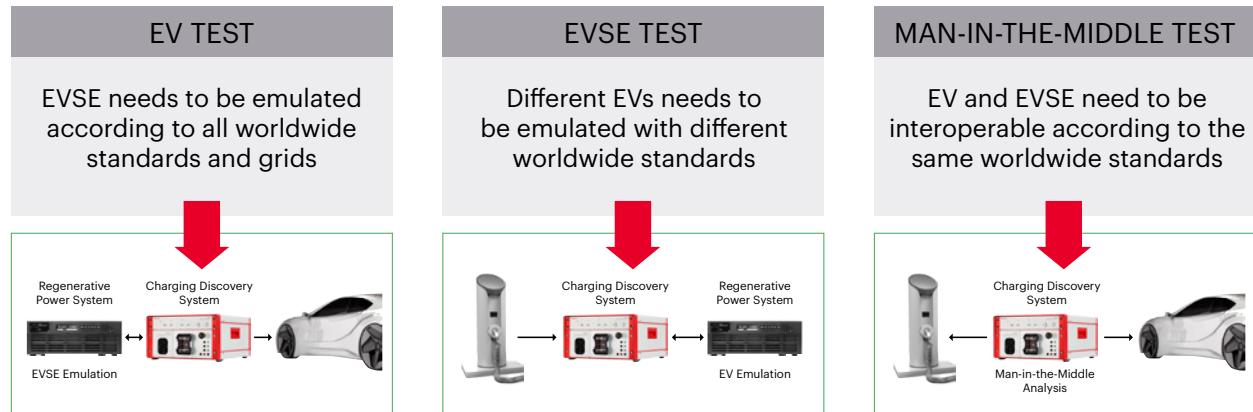
**Figure 6.** Evolution of charging interface tests, enabled by emulation solutions such as Keysight's Charging Discovery System (CDS)

Leading EVSE suppliers and automakers are working closely with test experts to enable new and more efficient ways of testing and validating the performance of charging interfaces. Keysight helps both automakers and EVSE suppliers with these tests using emulation technology.

Essentially, test engineers have created a powerful and versatile charging interface test solution. It can emulate charging connectors and electrical sources of any EV supply equipment or electric vehicle, with the help of a bidirectional power source.



In what is known as a man-in-the-middle test, the emulator measures and decodes communications and power signals between the EVSE and the EV, helping identify potential interoperability issues. The manufacturer can rely on the same equipment to run different test parameters, depending on the charging standards of each country or the charging point and vehicle models (Figure 7).



**Figure 7.** Emulators replace costly or impractical test setups; validating how each DUT performs in real-world conditions

## Emulation of Battery Cells, Modules, and Packs

Better and cheaper battery cells are key to driving EV adoption. Many automakers have specialized teams working on EV energy storage and usage systems to meet these challenges and more. Developing and testing new high-power energy storage technologies and the interconnection of multiple energy storage cells to form modules/packs that run an EV requires an intelligent battery management system (BMS). A good BMS assumes important safety, control, and regulation functions by monitoring parameters such as voltage, current, temperature, and state-of-charge. The BMS is also responsible for thermal management, energy management, cell balancing, and performance. The implementation of these functionalities is the greatest challenge in BMS development and validation.

For the purpose of reproducible testing and BMS optimization, Keysight provides the Scienlab BMS environment: instead of real cells, Scienlab cell emulators are connected to emulate various cell types of a range of cell models.

Keysight works with leading automakers using its Scienlab BMS environment to ensure the EV of the future performs flawlessly, from blueprint to wheels on the road.

# Related Information

Solution Page: [Charging Test Equipment and Solutions for EV and EVSE](#)

Poster: [Advancing the E-Mobility Ecosystem](#)

White paper: [Emulation Test on Connected Cars](#)