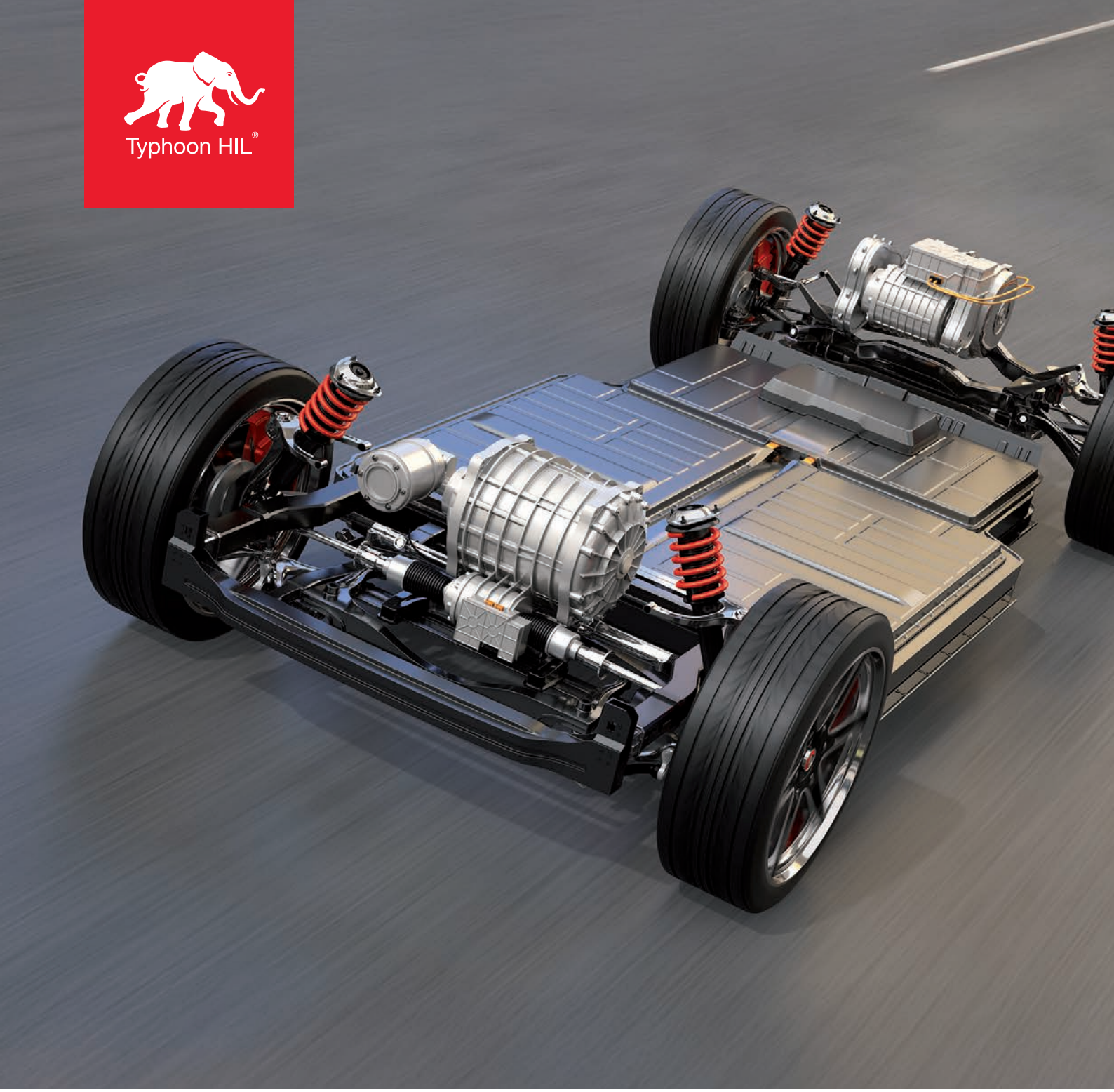
Typhoon HIL®



HIL Solutions for Electric Powertrains

Precision and Reliability for Streamlined EV Powertrain Validation.

www.typhoon-hil.com

Electrifying the Road

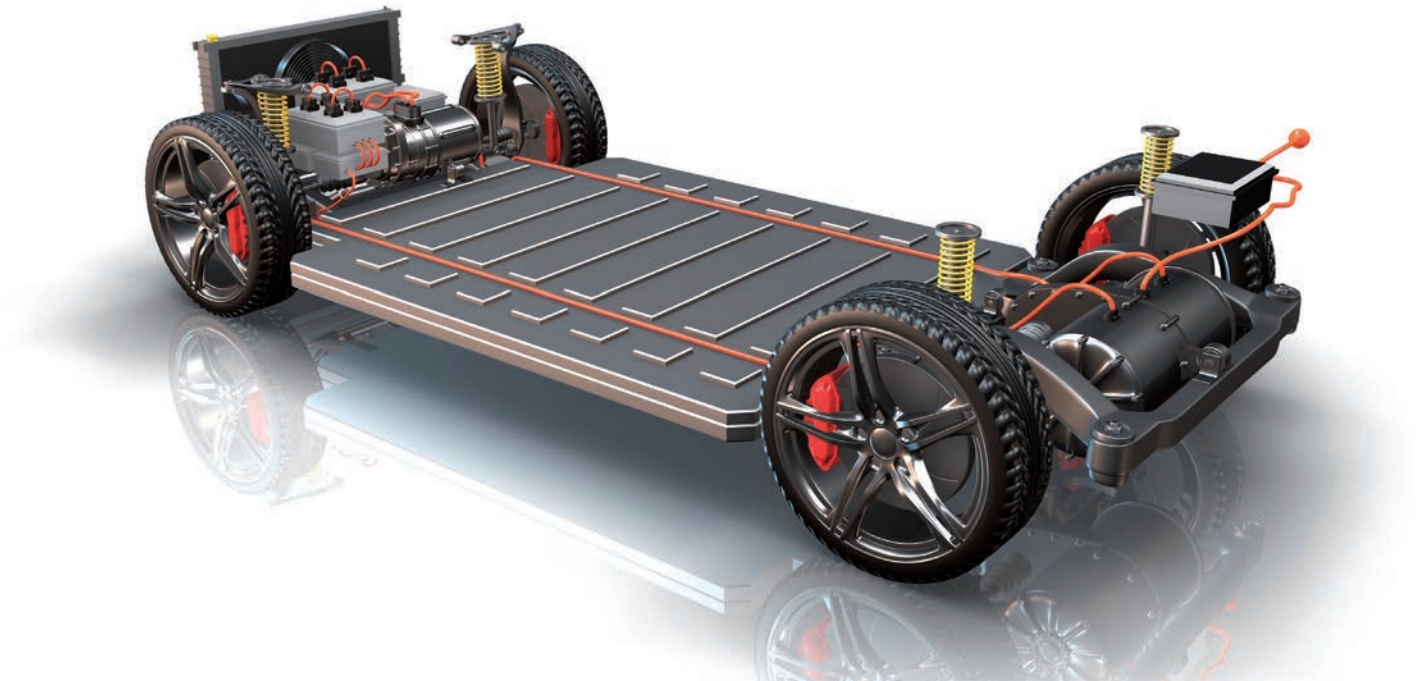
Overcoming barriers in electrifying vehicles

Electric Vehicle (EV) development presents several challenges that must be addressed to make this transportation mainstream. A key factor in this process is control software testing, which is critical for developing and validating a robust and reliable EV powertrain.

Using suitable tools and high-fidelity models is essential for performing accurate simulations and tests, enabling comprehensive safety tests to meet regulatory standards and ensure vehicle safety.

The importance of testing and validation

- The Electric Drive Unit (EDU) must operate efficiently and reliably under various conditions to maximize the vehicle's range and power output.
- The Battery Management System (BMS) must be validated to ensure optimal battery performance and prevent hazards such as overheating and overcharging.
- The On-Board Charger (OBC) requires testing to safely and efficiently charge the vehicle, avoiding potential charging issues.
- The HVAC system must be tested to ensure the functional control of the AC compressor for effective climate management.



Benefits of HIL testing

HIL testing offers multiple advantages that significantly contribute to EV development.

Reduced development time and continuous control testing

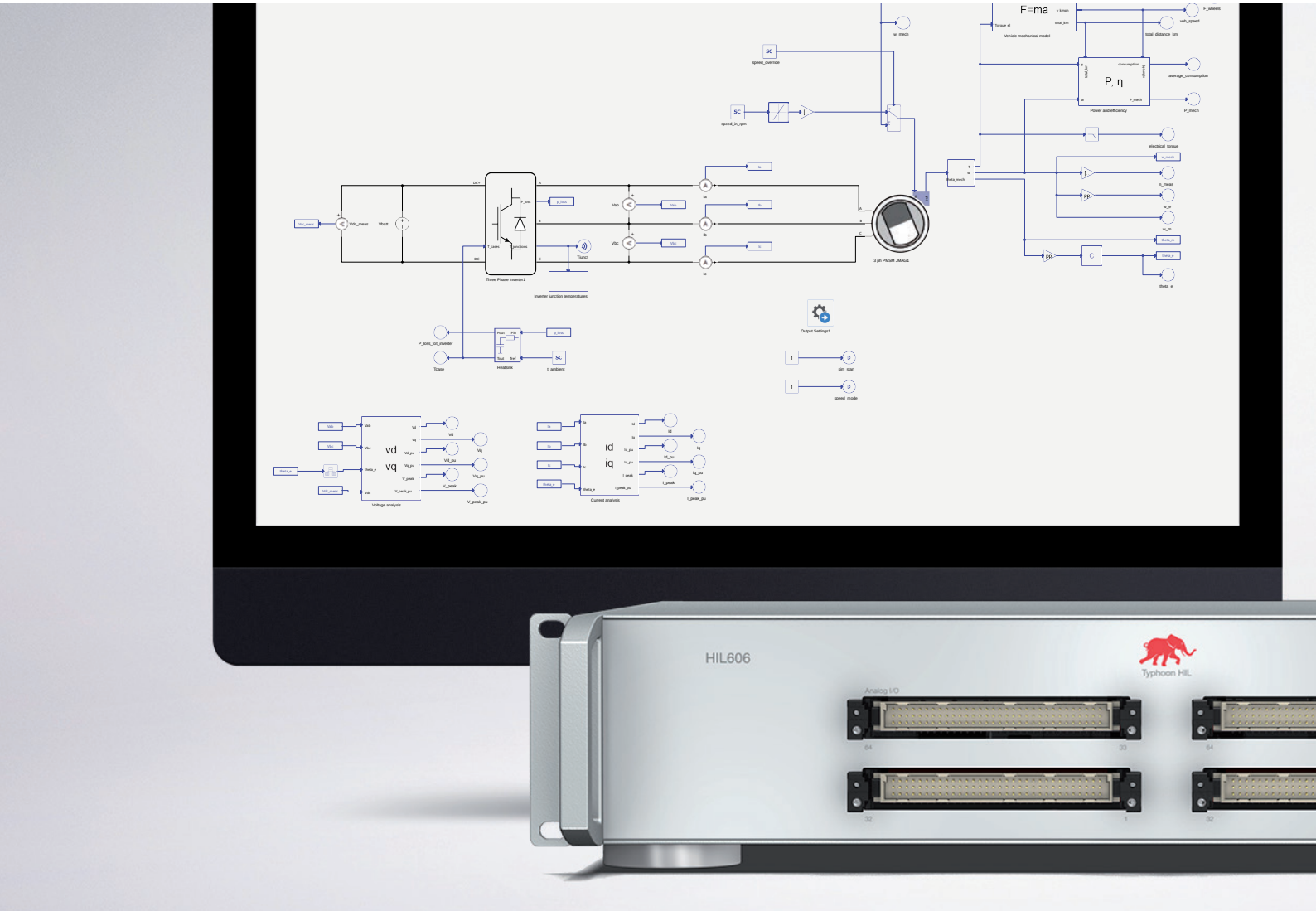
HIL testing shortens the development cycle and validates software without requiring physical prototypes. Detailed signal HIL control software verification and validation throughout the V-curve drastically improves product quality.

Increased accuracy and reliability of test results

High-fidelity models enable the validation of systems under realistic conditions, delivering precise and reliable test results.

Safe testing of real-world scenarios and fault conditions

HIL testing allows for the safe simulation of real-world scenarios and fault conditions, enabling developers to address potential issues before they occur in the field.



Safety Critical Components of the Electrified Powertrain

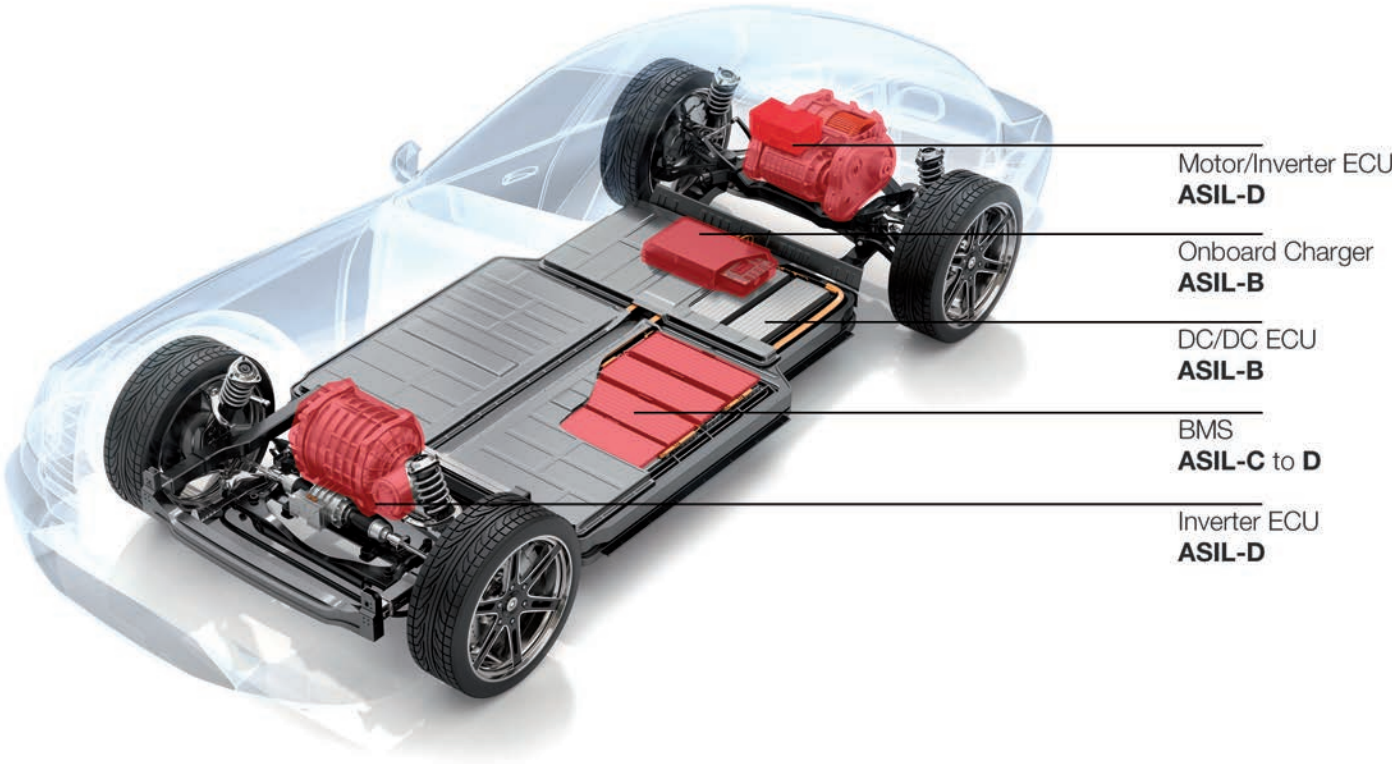
Ensuring automotive safety with ISO 26262

Central to ISO 26262 are the ASIL (Automotive Safety Integrity Level) classifications. They categorize safety requirements based on the probability and severity of potential harm from system failures. These classifications guide the implementation of safety measures, ensuring automotive components meet stringent safety standards and effectively protect both vehicles and occupants.

For more information about ASIL for EV powertrains.

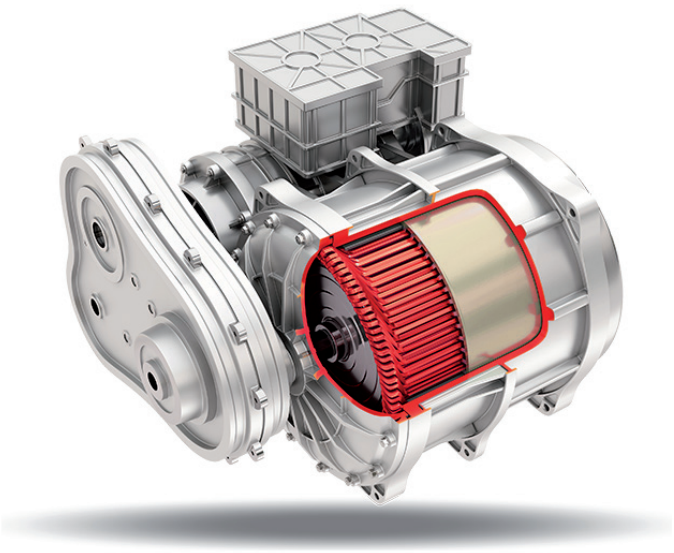
ASIL validation with Typhoon HIL

Typhoon HIL offers comprehensive HIL solutions for validating electrified powertrain components in compliance with ISO 26262, from ASIL-A to ASIL-D. Our turnkey test benches provide appropriate hardware, seamless interfacing, and fault insertion capabilities, all backed by high-fidelity models to ensure reliability throughout the verification and validation process. Additionally, our team of experts can support your engineers with tool confidence level verification and ISO 26262 compliant testing.



Accurate electric machine modeling

- Improved testing efficiency and effectiveness using high-fidelity plant models consistently across different stages of software development.
- Agile communication between hardware and control design teams.
- High-fidelity FEA-based motor models accurately replicate physical motors.
- Analyze spatial harmonics, nonlinear flux saturation effects, losses, and fault insertion.
- Automate testing of embedded software across a wide range of scenarios and operating conditions, including faults.
- Thermal modeling with integrated position and speed feedback.



High-fidelity inverter modeling

- Utilize wide-bandgap semiconductor switches (SiC, GaN) with PWM frequencies of up to 300+ kHz in simulations.
- Precisely simulate switch losses and thermal models to ensure minimal power losses.
- Detailed inverter modeling (forward voltage drop, on-resistance, switching delay, etc.) for precise control.
- Ready-to-use power converter models that accelerate the development process.
- Import models from MATLAB/Simulink, FMI/FMU, C, and PSIM.
- IIntuitive and easy-to-use schematic design, transitioning from MIL/SIL to C-HIL in one environment.

Drive e-Mobility Forward

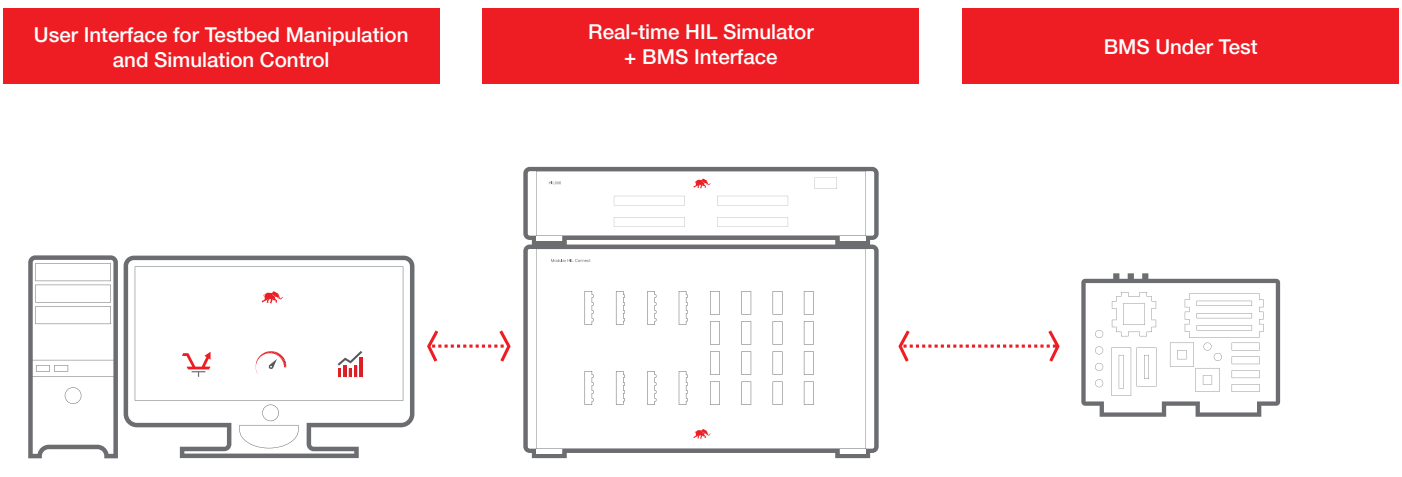
Lead the charge on EV BMS

An advanced BMS is essential for ensuring peak performance and safety, thereby extending the lifespan of EV batteries. However, designing and testing control software for the BMS can be time-consuming, costly, and may involve potential safety risks.

BMS validation using Typhoon HIL

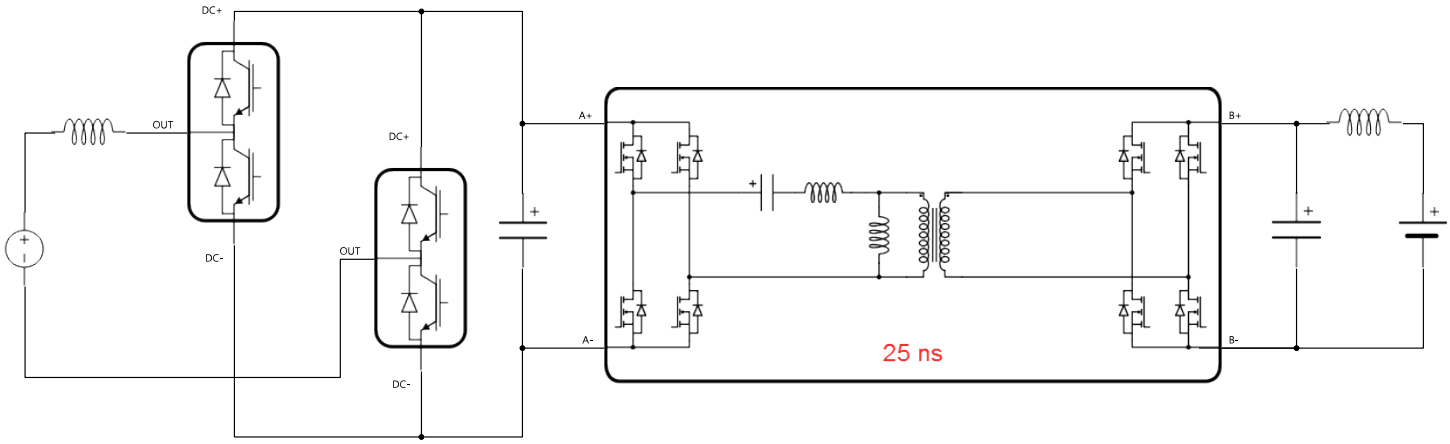
With Typhoon HIL BMS Solutions, you can design and test BMS controllers using high-fidelity models of batteries and converters, saving time and enhancing your manufacturing processes.

- Replicating the electrical and performance characteristics of batteries enables accurate modeling and ensures interoperability.
- Perform high-fidelity simulations of current spikes and voltage drops, allowing for predicting and mitigating potential issues.
- Create testing setups for both low and high-voltage (>1 kV) battery systems.
- Simulate how the BMS responds to dangerous scenarios, such as faults, using a safe and efficient approach.

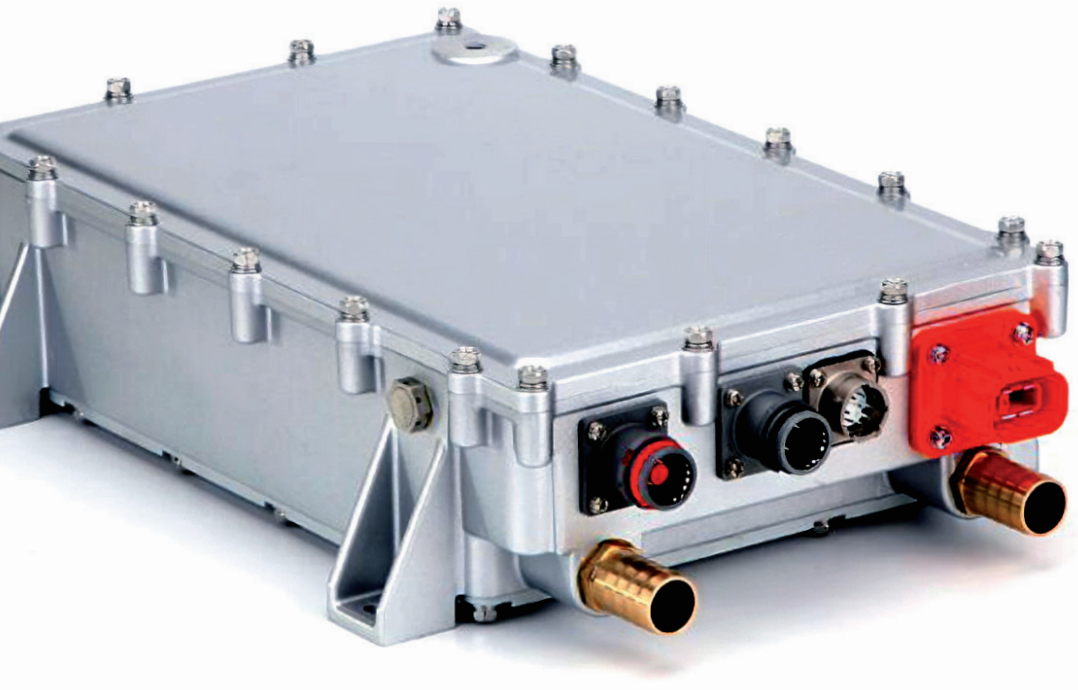


Boost OBC verification and validation

Typhoon HIL's specialized hardware simplifies the simulation of OBC components and switching capabilities in real time. This enables testing these features in a virtual environment, ensuring they operate safely and reliably under a wide range of conditions.



- Take advantage of a vast library of high-fidelity power converter models for OBCs and pre-packaged models of wide-bandgap semiconductors, such as SiC and GaN.
- Simulate the dynamics of power converter topologies with high switching frequencies (up to 300 kHz) using Typhoon HIL's DC-DC converter solver with a 25 ns HIL simulation step.
- Replicate grid fault conditions and instability events to evaluate communication protocols.
- Validate communications and controllers for bidirectional OBCs using a safe testing environment.
- Test software compliance with charging standards and protocols established in the EV industry, such as ISO 15118.
- Enhance OBC test writing speed with our Pytest based test framework, TyphoonTest. Create custom scripts that define test scenarios, input conditions, and expected outputs for the HIL simulation.



For more information about onboard chargers.

e-Drive HIL Testbed

Speed up EV development with the e-Drive HIL Testbed

The e-Drive HIL Testbed enables you to comprehensively test and validate your controllers before building physical prototypes. You can accelerate product development and explore different test conditions to ensure your control systems perform reliably, even under disturbances and faults.

This all-in-one solution offers a powerful and flexible emulation platform, precisely replicating the electrical behavior of an EDU through ultra-high-fidelity models. With extensive interfacing and connectivity options, it seamlessly integrates into your existing testing environment.

A turnkey solution for EV testing

- Down to 200 ns simulation time step with 3.5 ns digital oversampling, enabling unparalleled precision in your tests.
- Interfaces with existing system-level simulators and HIL test bench setups.
- ASAM XIL compliance guarantees integration with other automotive test tools.
- True plug-and-play HIL solution, saving time and providing significant benefits through accelerated test cycles, increased test coverage, and improved reliability.
- Subject the Device Under Test (DUT) to a variety of conditions, including faults, variations, and transient events, all in real-time.

Scalability and flexibility in Typhoon HIL's offerings enable the testing platform to quickly adjust to the diverse range of EV powertrain components. Whether testing a simple motor controller or a complex, integrated powertrain system, **Typhoon HIL solutions provide the tools and capabilities to scale the testing environment according to your specific requirements**.

BMS HIL Testbed

Lead the charge in e-Mobility with the BMS HIL Testbed

The BMS is essential for ensuring performance, safety, longevity, accuracy, and efficient battery operation in EV powertrains. With state-of-the-art battery systems designed for up to 1000V, there is an increasing demand for streamlined design and fully automated testing throughout the entire product lifecycle, from early development to integration and maintenance.

However, the BMS development process is often fragmented and highly time-consuming due to its complexity and need for integration and interoperability with other powertrain components. Typhoon HIL's advanced simulation and testing platforms provide comprehensive solutions that enable engineers to rigorously validate BMS performance under various conditions, testing BMS systems up to 1000V.

Resources

- Up to 256 cell emulation channels, with thermistor emulation
- High voltage pack voltage emulation
- Current sensor emulation
- Isolation resistance test
- High voltage interlock test

System-level integration

The BMS test platform supports various communication protocols, including CAN bus, LIN, SENT, SPI, and Modbus, enabling comprehensive testing of BMS interactions with other EV subsystems. This ensures the BMS can accurately limit power output in critical scenarios, such as during thermal management or SoC constraints.

Typhoon HIL advanced testing and simulation solutions

Typhoon HIL's real-time simulation tools enable the emulation of complex battery behaviors under various conditions, including fault scenarios. These systems can simulate up to 300 cells with a simulation step time of 100 µs, providing a highly detailed and responsive testing environment.

The BMS HIL testbed includes cell emulators that can simulate a wide range of cell parameters such as State of Charge (SoC), State of Health (SoH), terminal voltage, and temperature. The interface supports fault injection (e.g., short circuits, over-voltage conditions) without physical risks, enabling thorough validation of BMS software.

Battery cell modeled interdependencies

Function of / Effect	Temperature	State of Charge	State of Health	Charge/Discharge History
State of Charge	✓		✓	✓
Coulombic Efficiency	✓		✓	
Open Circuit Voltage	✓	✓		
Available Capacity	✓		✓	
Internal Resistance	✓		✓	
Transient V-I Response	✓		✓	
OCV Hysteresis	✓	✓		✓
Self-Discharge				
Thermal Losses	✓		✓	

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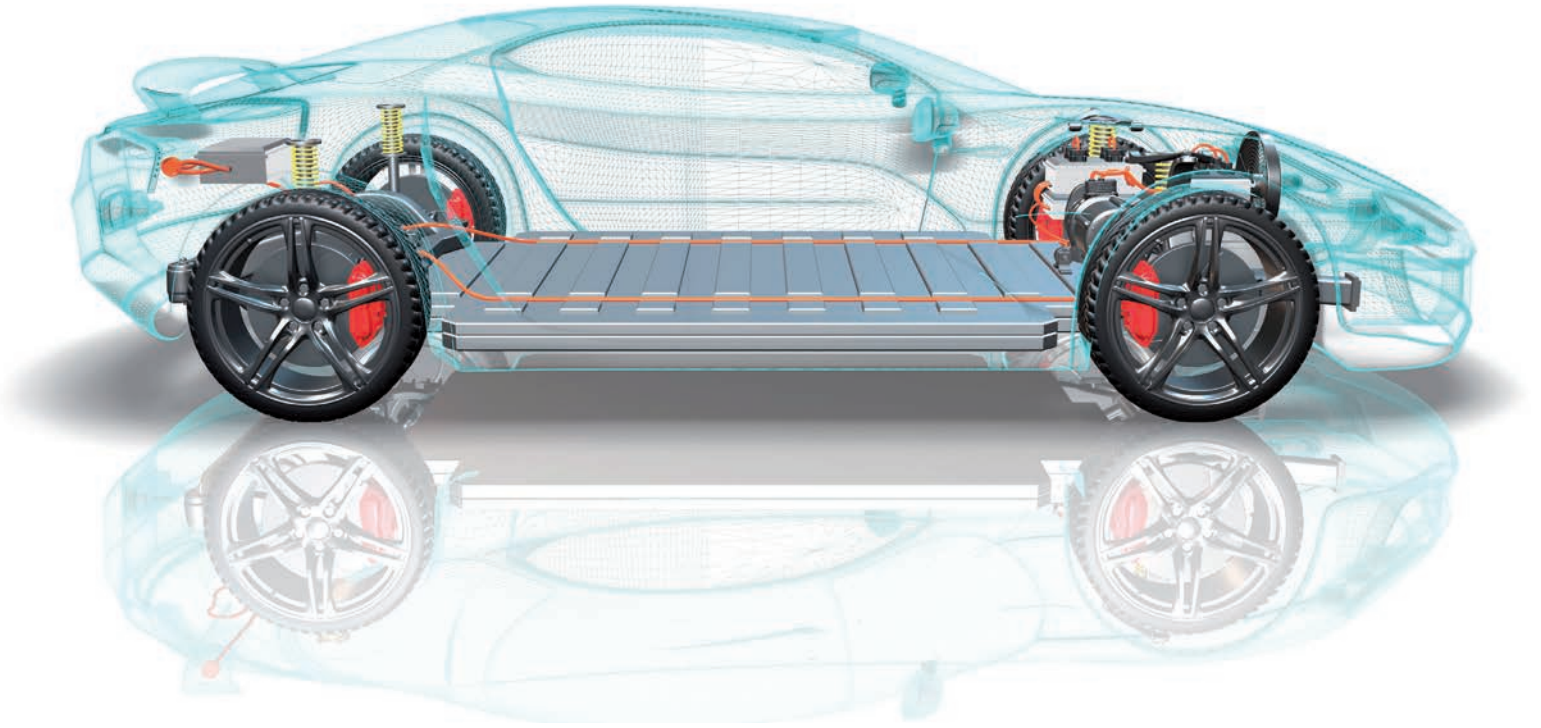

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