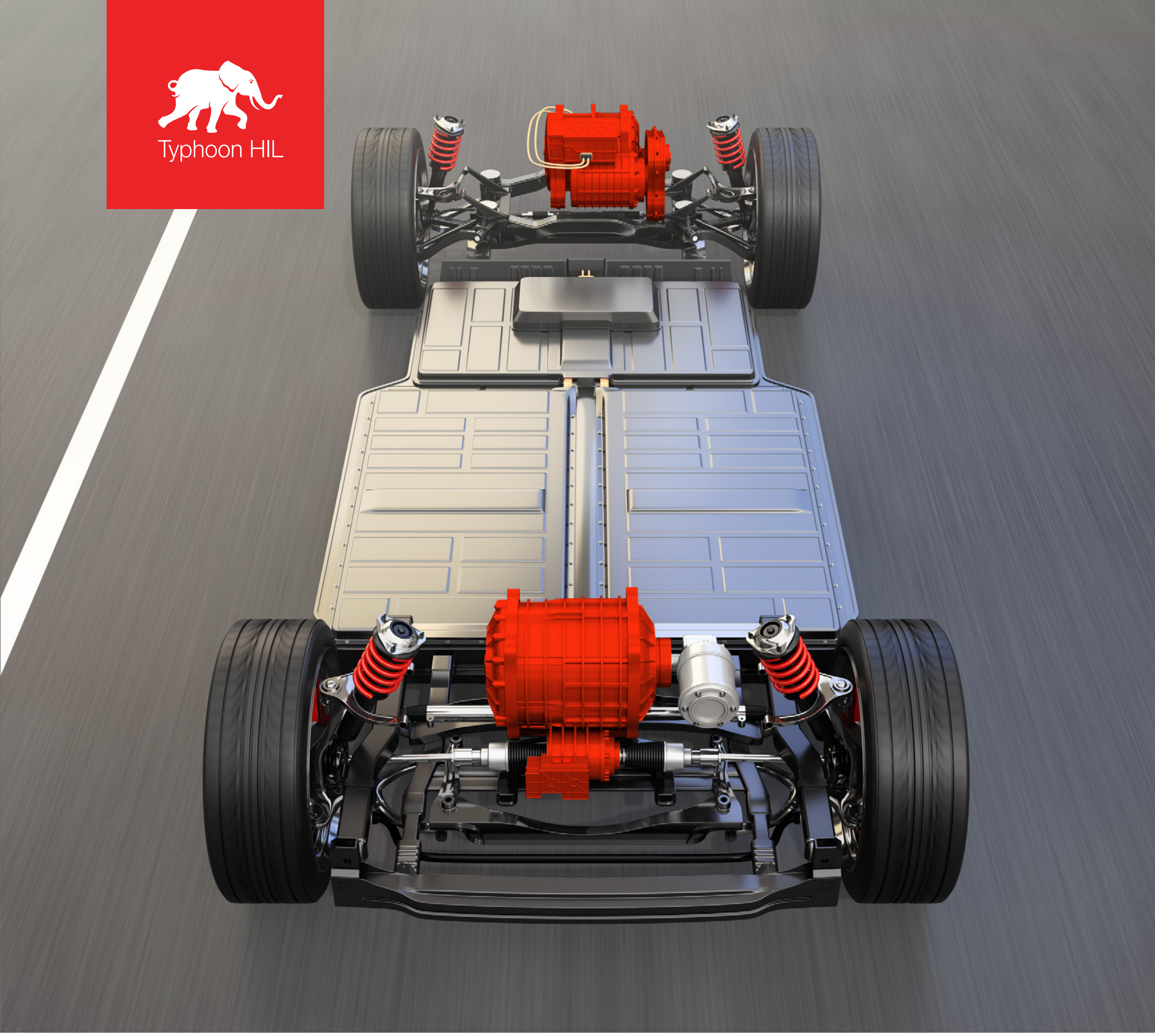


HIL Solutions for Electric Powertrains

Powering e-Mobility forward.

www.typhoon-hil.com

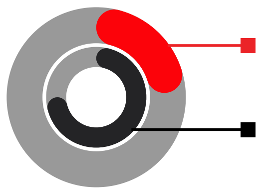
Powering e-Mobility Forward

Reducing CO_2 emissions from transportation

Today, about 24% of the overall carbon released into the atmosphere comes from the transportation sector, and road vehicles – cars, trucks, buses, and two- and three-wheelers – account for nearly three-quarters of transport CO2 emissions. [1]

With the major target of achieving carbon neutrality by 2050, automakers around the globe have striven to accelerate the decarbonization of vehicles in the next few decades. However, worldwide electric vehicle (EV) adoption requires technological improvements and innovations in the automotive industry, including:

- Higher power levels;
- Complex power electronics controllers;
- Longer driving range;
- Reduced battery size & costs;
- Minimal power losses;
- Communication protocols validation;
- Data connectivity features;
- Increased safety.



Addressing these challenges means, developing cutting-edge innovations in power electronics and control systems for e-mobility applications but with traditional tools, this can be a challenging, time-demanding, and expensive process.

Empowering agile control development

For EVs to have a low carbon footprint, it is crucial that we supply electric powertrains using intermittent renewable energy sources. Engineers around the globe have been working to develop the precise power electronics and controls needed to do this. In this sense, hardware-in-the-loop (HIL) devices are empowering agile control development in all aspects of e-mobility, from the electric motors, power electronics, and batteries, to intelligent charging systems.

[1]: Improving the sustainability of passenger and freight transport - https://www.iea.org/topics/transport

Learn more on Typhoon HIL e-mobility website page.

Why Typhoon HIL?

With our HIL solution, you can rapidly go from control prototyping to automated testing, reducing development time, costs, and safety risks.

- Vertically integrated hardware & software solution.
- No 3rd party software tools are required.

- Built for e-mobility applications.
- Compatible with test automation tools.
- Ultra-high fidelity models.

- True plug-and-play HIL solution.
- Intuitive & easy-to-use schematic.
- Compact encapsulated models.

Control development stage:
Typhoon HIL can be used both for software-in-the-loop (SIL) and controller hardware-in-the-loop (C-HIL) testing.

Automated converter controller testing:
Tests can run and generate reports automatically.

System integration stage:
System-level software integration for verification & validation.

Interoperability testing:
Our solution can be used to test the interoperability between chargers and EVs.

Validating EV Powertrains Efficiently

Designing and testing electric powertrains is challenging

The powertrain is the centerpiece of electric vehicles, comprising the onboard charger, inverter, electric motor, and battery pack. As EV technology and regulations continue to evolve, the design complexity of electric powertrains has been increasing both in power electronics and control systems.

Some of challenges around the design and testing of electric powertrains are:

- More complex control systems;
- Enhanced energy density;
- More advanced topologies of electric motors;
- Increased DC voltages;
- Wide band-gap semiconductors & resonant converters;
- Lack of integration between design & testing tools.

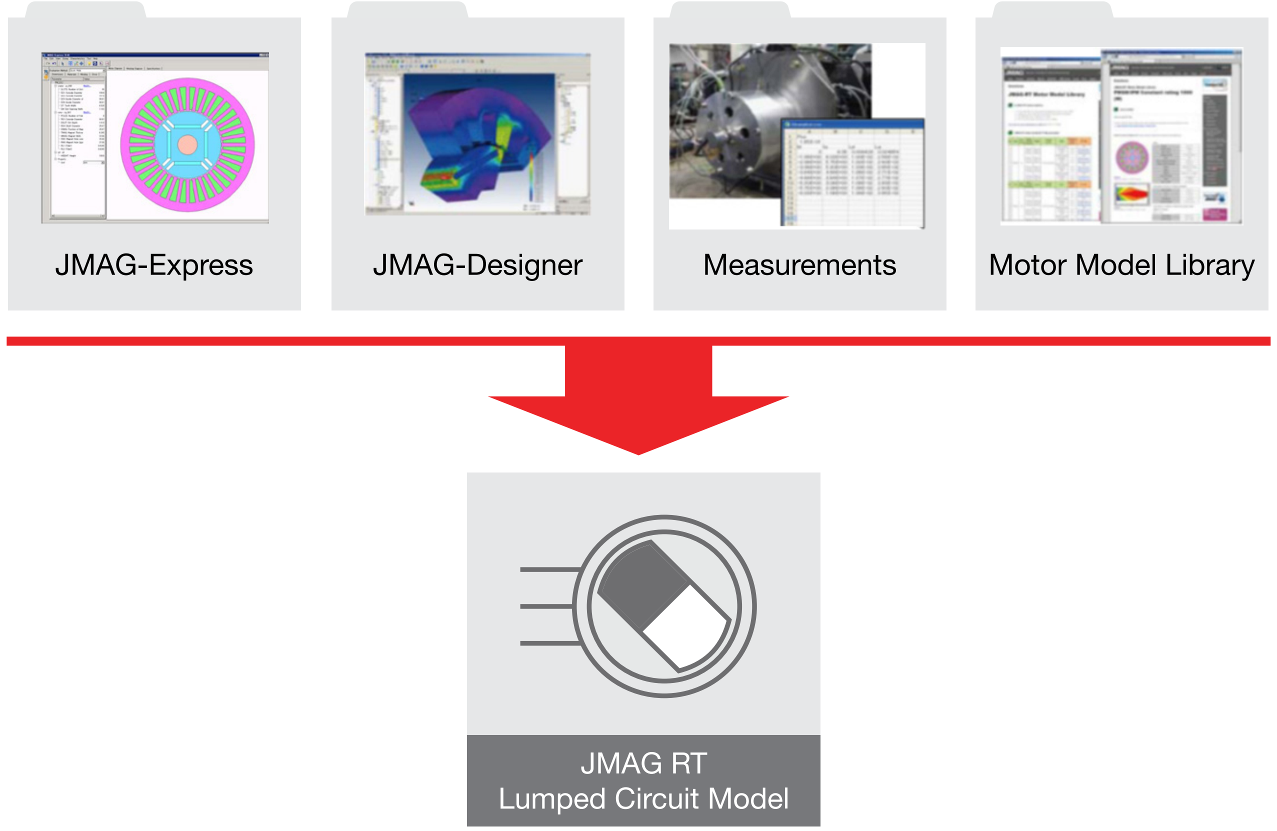
Typhoon HIL advantages

Our HIL solution is a fully integrated toolchain that was tailor-made for the design and testing of EV controls. It can be combined with other software and hardware platforms without the need for third-party tools. Our products can be easily integrated with design simulation tools and are compatible with existing automation platforms.

- Down to 200 ns time step with 3.5 ns digital input oversampling.
- Up to 300 kHz switching frequency DC/DC converter models.
- High-fidelity electric motor models: spatial harmonics, saturation, losses, fault injection.
- Model import from JMAG FEA, Matlab/Simulink, FMI/FMU, C, PSIM.
- Compatible with 3rd party test tools: ECUTest, NI Veri-stand, EXAM, PyTest.

High-fidelity model continuity

JMAG-Typhoon HIL integration now enables EV software developers to have the same fidelity level of plant models across MIL/SIL and HIL. Model continuity is maintained across the whole software development workflow using high-fidelity machine models generated from the Finite Element Model.

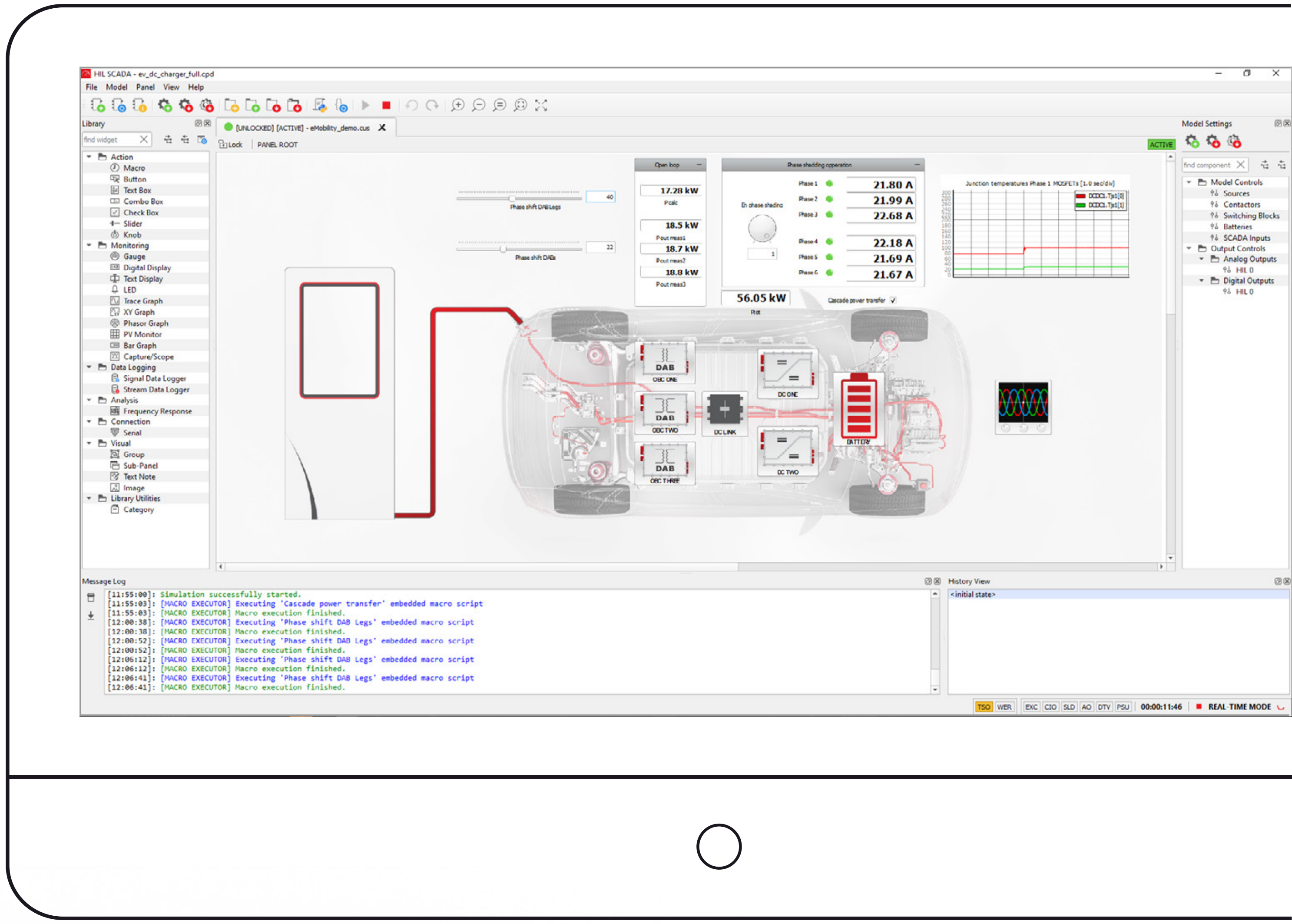


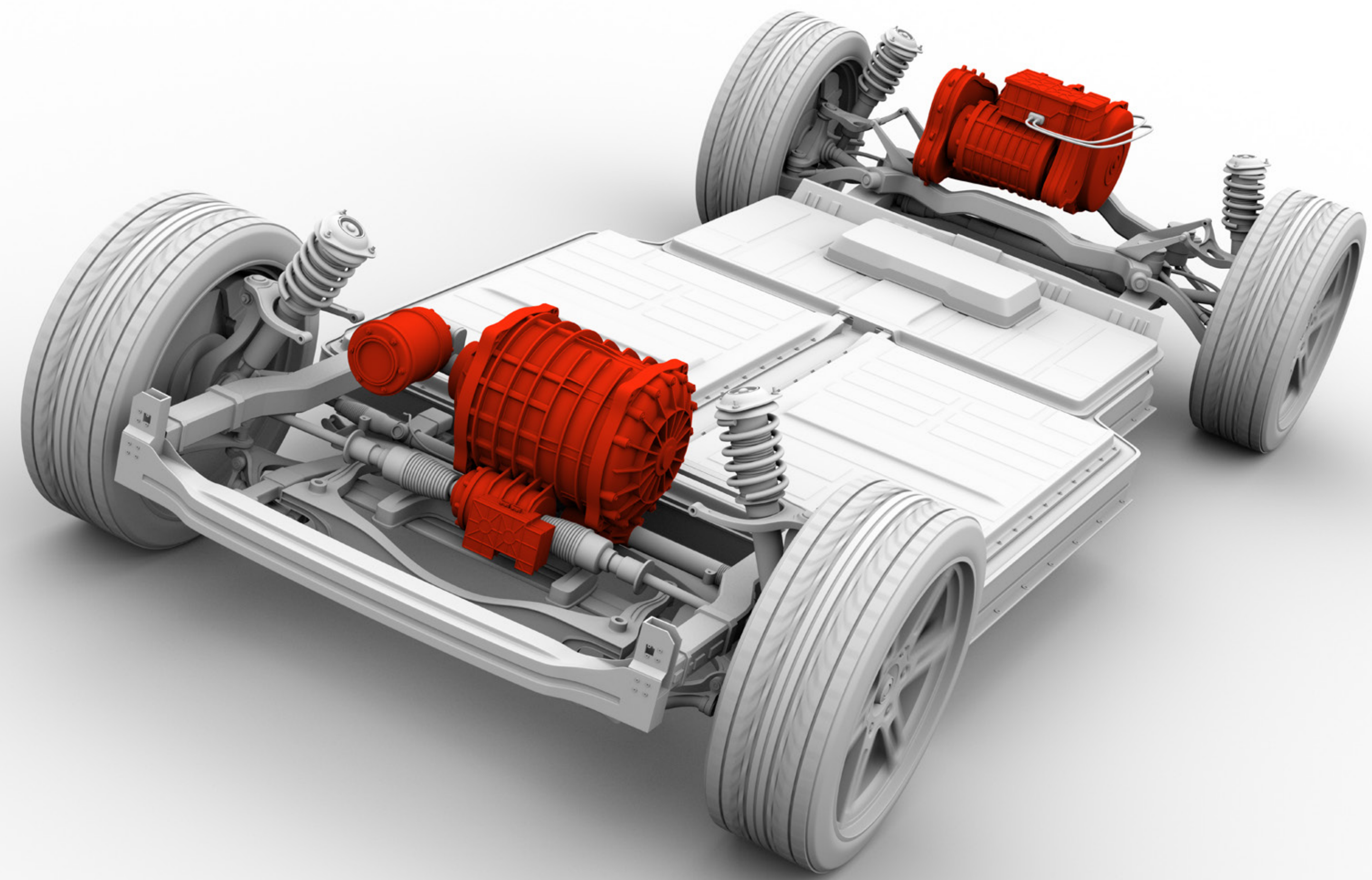
The JMAG-RT model file is imported to Typhoon HIL Control Center in order to simulate the motor in the loop with the actual electronic control unit (ECU) in real-time. The motor model includes non-linear flux saturation effects, spatial harmonics, and loss data. This enables your HIL system to emulate the behaviors of the physical system as close as possible and enable test automation of the embedded software through a wide range of scenarios and operating conditions in a repeatable manner, including faults.

Typhoon HIL + JMAG benefits

- Direct import of high-fidelity models into the Typhoon HIL toolchain.
- Improved testing efficiency and effectiveness.
- Agile communication between hardware and control design teams.
- The high-fidelity FEA-based motor model accurately replicates an actual physical motor.
- Real-time simulations with the actual ECU (engine control unit).
- Test automation of the embedded software through a wide range of scenarios and operating conditions, including faults.

Driving Power Electronics Ahead





Improving the efficiency of EV traction inverters

Power electronics are found throughout EVs, converting and controlling electric power flow between all the elements of the vehicle. Among these, the traction inverter controlling the electric motor is the centerpiece of the powertrain, so it is crucial to determine driving behavior and the system's overall efficiency.

Inverters designed for EV applications need to achieve minimal power losses, high thermal performance, precise control, high power densities, and safe operation at high DC voltages, while maintaining a low cost and compact size. Designing and testing EV inverters is usually a time-consuming, expensive, and hazardous process, and this is where Typhoon HIL changes everything.

Designing & testing power converters with Typhoon HIL

- Utilize wide-bandgap semiconductor switches (SiC, GaN) with PWM frequencies of up to 300+ kHz in your simulations.
- Simulate switch losses and thermal models precisely.

- Detailed inverter modeling (fwd voltage drop, on-resistance, switching delay, etc.).
- Ready-to-use power converter models.

- Model import from Matlab/Simulink, FMI/FMU, C, PSIM.
- Intuitive & easy-to-use schematic, from MIL/SIL to C-HIL in one environment.

"With HIL, we were able to focus on the design of the controller without the need for complicated test preparation.

Ryota Kitamoto
Engineer at Honda R&D

Read more:

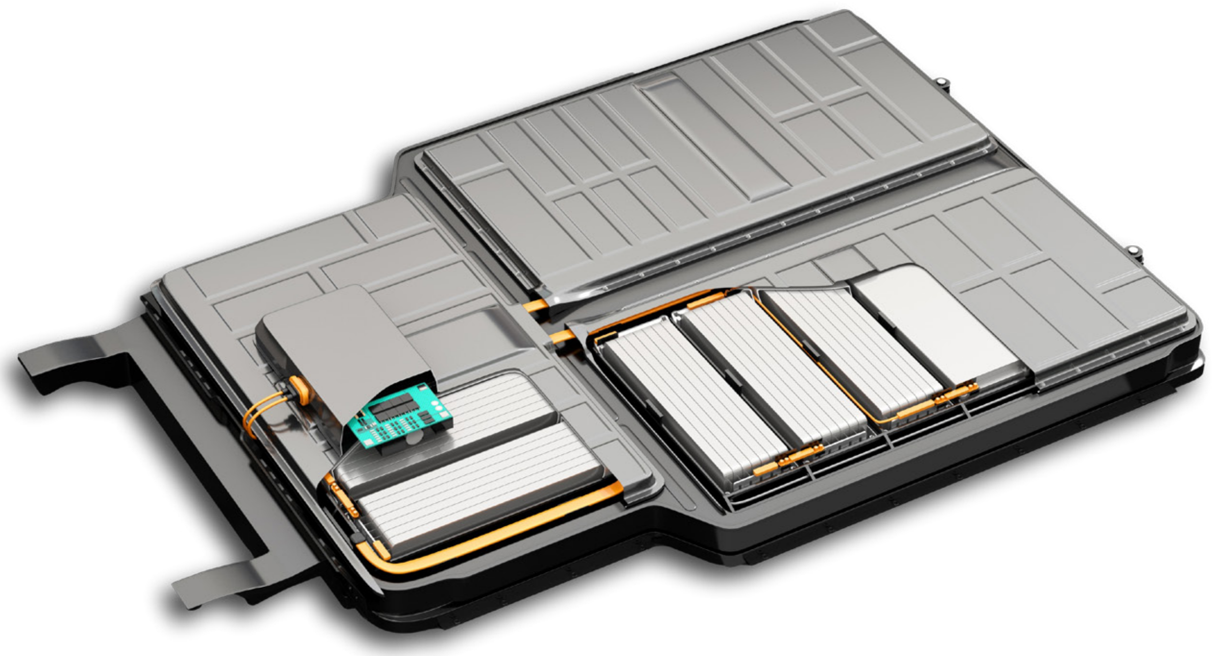
Ensuring Efficient Charging

Designing EV Battery Management Systems (BMS)

An advanced Battery Management System (BMS) is vital to ensure peak performance, safety, and prolonged battery lifetime of EVs. However, designing and testing controllers for an EVs' BMS can be time-consuming, costly, and involve safety risks.

Testing controllers with real batteries and supply equipment in the early stages of development can be costly and lead to several safety issues. EV applications in particular pose major challenges in control and battery operation that need to be overcome, and a well-designed and efficient BMS can avoid several problems, including:

- Charge capacity restriction;
- Performance degradation;
- Reduced lifespan;
- Thermal runaway;
- Fire hazards in extreme cases.



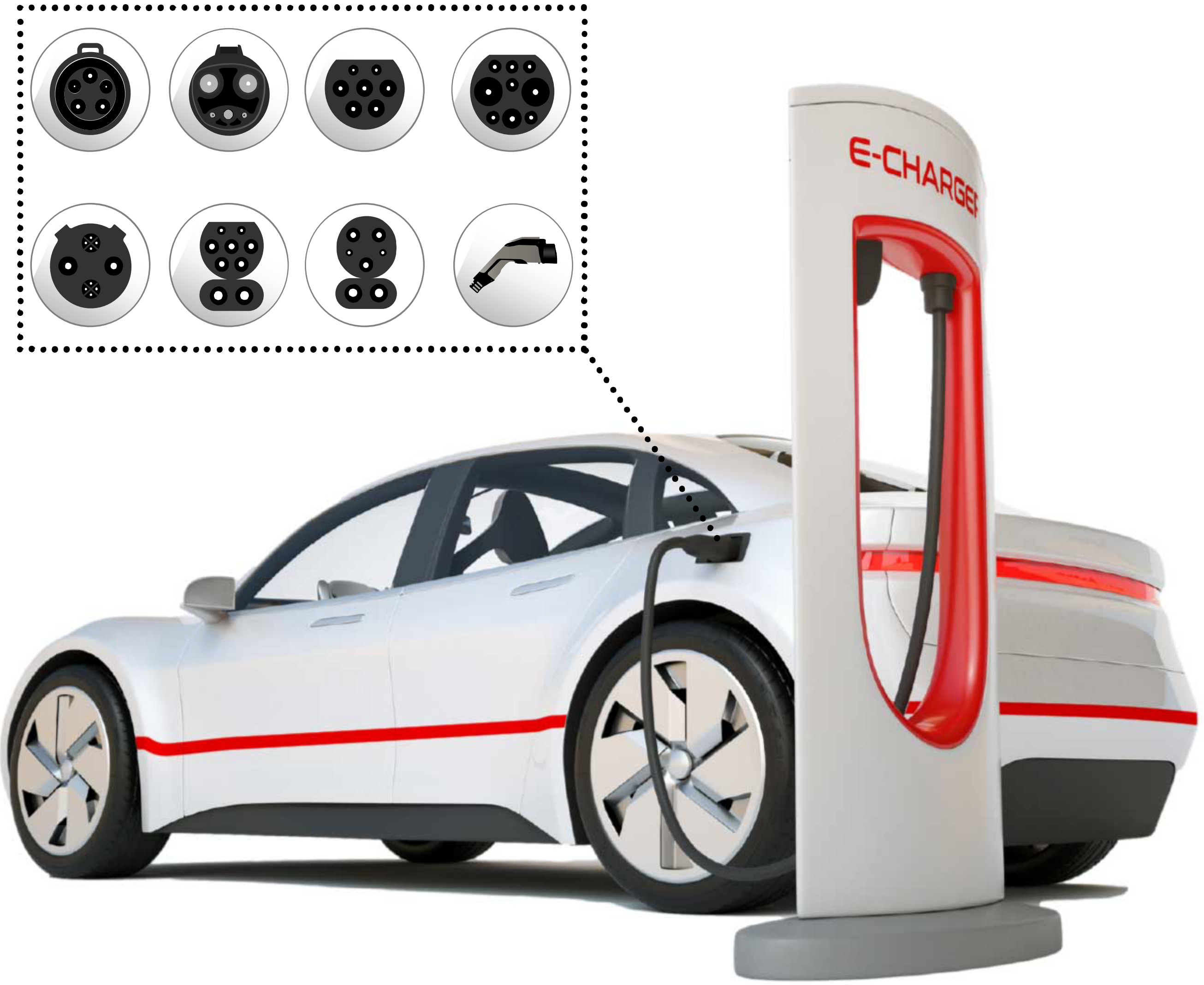
Safe BMS validation

With the Typhoon HIL toolchain, you can design and test BMS controllers utilizing high-fidelity models of batteries and converters. Therefore, you can pre-validate your project and solve most issues before performing tests with physical prototypes.

- Pre-built, drag-and-drop battery and converter models.
- Create testing setups for both low and high voltage (>1 kV) battery setups.

- Parameterize and validate your system with standard communication protocols.
- Simulate and test how communication delays and failures affect your real-time model.

- Test controller performance during fault conditions.
- Perform high-fidelity simulations of current spikes and voltage drops.



Scaling the Charging Network

Building the charging infrastructure of the future

The deployment of electric vehicle stationary equipment (EVSE) is crucial for mainstream EV adoption and, therefore, for achieving a zero-emissions future. Charging equipment is designed, engineered and installed to ensure safety while cars are recharged so that users only need to plug the charger into the EV while the EVSE takes care of all the rest.

Building a smart EV fast-charging network that rivals our current gasoline distribution system is no small feat. Test engineers are central to this effort: from developing and validating innovative charging features and communication protocols that can securely start a charging session, to designing and testing high-power, high-current converters and complex power electronic controllers that can deliver power safely.

Leading the charge with Typhoon HIL

Typhoon HIL is empowering engineers to optimize the development time and costs of EVSE. Our toolchain contains optimized models of EV and EVSE and a rich library of automated tests where you can perform high-fidelity, real-time simulations in a fully safe environment, without the safety risks that with when testing high-power converters and batteries.

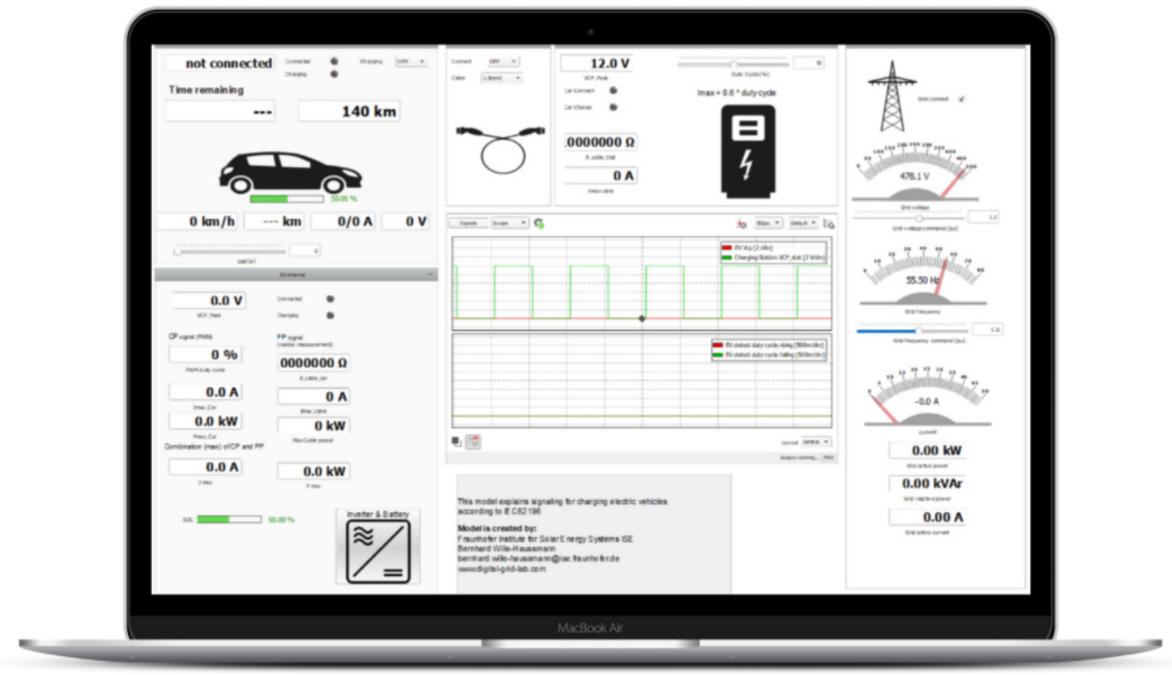
- High-fidelity EV and power converters models;
- Vast library of automated tests to provide constant 24/7 testing with clear reports and results;
- Power converter losses simulation;
- Test of controller performance during faults and grid disturbances;
- Simulate with real EVSE communication messages.

EV-to-charger interoperability

Ensuring compatibility between the key system components — vehicles, charging stations, charging networks, and the grid — and the software systems that support them is important for worldwide EV adoption. Those elements need to work together seamlessly and effectively.

Tests are needed to be made to verify interoperability between the charging station and the EV. When done physically, many EVs are needed and the parameters can change from vehicle to vehicle. Therefore, real-time simulation with the Typhoon HIL toolchain can help manufacturers virtualize and optimize this complex, costly, and time-consuming validation process.

- EV interoperability testing with your HIL-compatible model of the EVSE with power amplifier;
- EV & EVSE models optimized for ultra high-fidelity real-time simulations;
- Tests against existing standards (CCS, ISO 15118-2, IEC61851-1, J1772, IEC 62196, and more).



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