SOLUTION
BRIEF

ni.com

EV Powertrain Test

Explore NI's Solutions

Electric vehicle (EV) powertrain components and systems are rapidly evolving and test teams must keep pace and perform at their best. Engineers leverage NI's highly adaptable, platform-based test approach across the product development process to accelerate test development, improve test and product performance, and effectively manage data and systems.

ARTURO VARGAS
TRANSPORTATION SOLUTIONS
MARKETING, NI

Battery Pack/Module Test

EV Battery quality and performance directly impact brand, marketability, and margins for EV automakers. Rapidly changing battery technology hinders the acceleration of validation activities and requires expensive capital investments and resources to meet time-to-market commitments and cost expectations.

To determine battery performance, durability, and safety, engineers test for hundreds of variables, over multiple environmental conditions, charge/discharge profiles, failure modes, and long periods of time. Additionally, compliance testing to meet standards such as IEC 62660 or SAE J2464 adds complexity to the already highly demanding job of testing EV batteries.

A Solution that Evolves with You

NI's battery test solutions help you keep up with the need to scale your test capability and respond to time-to-market pressures by providing you the flexibility of a customizable solution, the speed of out-of-the-box functionality, and the openness of our software-connected approach to:

01

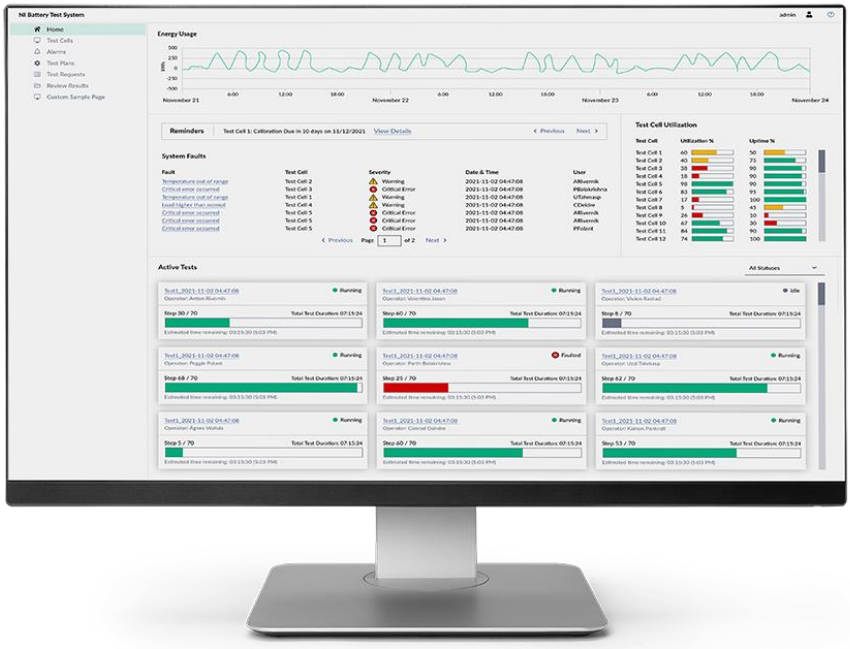
Focus on Test, Not Distractions
Get to test faster with the out-of-the-box functionality of NI's Battery Test System (BTS) software or customize your test plan to meet any test need, with any test configuration, faster.

02

Disencumber Test Engineering
Reduce development overhead with a unified software tool-chain for requesting, implementing, executing, and reporting on test results, with customizable UIs for different roles and users.

03

Keep Up With Scale and Budget
Lower total cost of test by seamlessly connecting to existing equipment, adding new equipment, and scaling to large tester fleet deployments while preserving ability to make, fast, data-driven decisions from test results.



The NI Advantage

01

Respond to time-to-market pressures with a system architecture that scales and adapts from single test cells to large scale, distributed battery test labs.

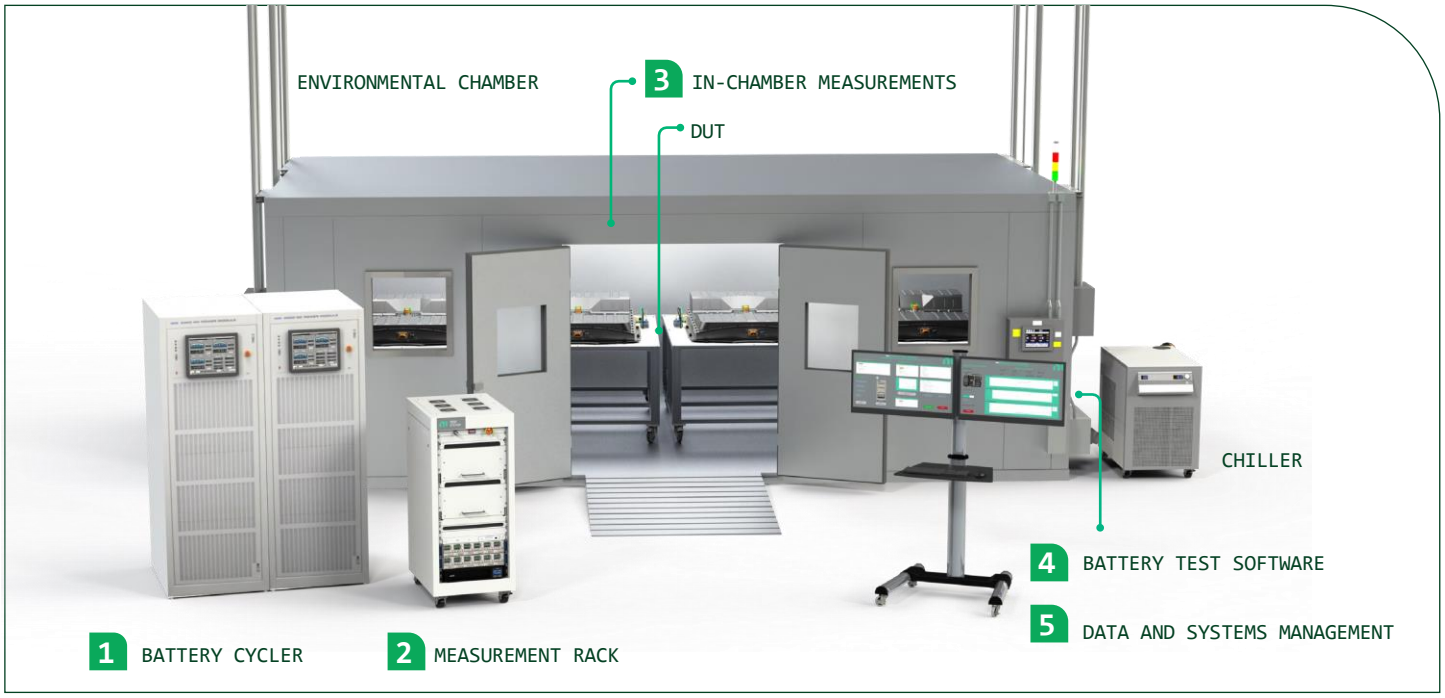
02

Optimize OpEx and reduce overall CO_2 footprint of your battery test facility by leveraging powerful management software to improve test cell utilization and efficiency

03

Deliver higher-performance batteries, faster, and in budget, maximizing utilization, traceability, repeatability and never losing test data.

NI Battery Test System (BTS)



1 Power electronics from NI or 3rd party, such as NH Research, Heinzinger, Elektro-Automatik and others for battery cycling, connected through an instrument abstraction layer that allows the integration, swapping, and control of the high-power equipment, without the need to modify the rest of the test system.

2 Measurement rack with real-time controller, expandable to thousands of channels for direct, synchronized DUT measurement, BMS communication, and other variables from the chamber or other test and control equipment with minimum incremental cost per channel.

3 Rugged, IP-rated, in-chamber measurement modules and thermal chamber control for temperature and humidity profile test execution, and other DUT measurements like strain, voltage, current, or vibration.

4 Battery test software with out-of-the-box experience and flexibility to customize implementation, including plug-ins, drivers, and analysis/test IP; with lossless data logging for best traceability and repeatability of test, all on a unified software toolchain.

5 NI's data and system management software for creation of customized data dashboards to maximize utilization and uptime, as well as perform facility management to optimize energy usage and reduce CO_2 footprint.

Battery Management System (BMS) HIL Test

The BMS plays a critical role in safely squeezing every mile out the electric vehicle (EV) battery. To validate that BMS communication, safety functions, cell balancing, and fault monitoring algorithms are working properly, engineers perform Hardware-in-the-loop (HIL) testing by emulating battery cells and simulating sensors, I/O, and communication to other ECUs.

A Solution that Evolves with You

01

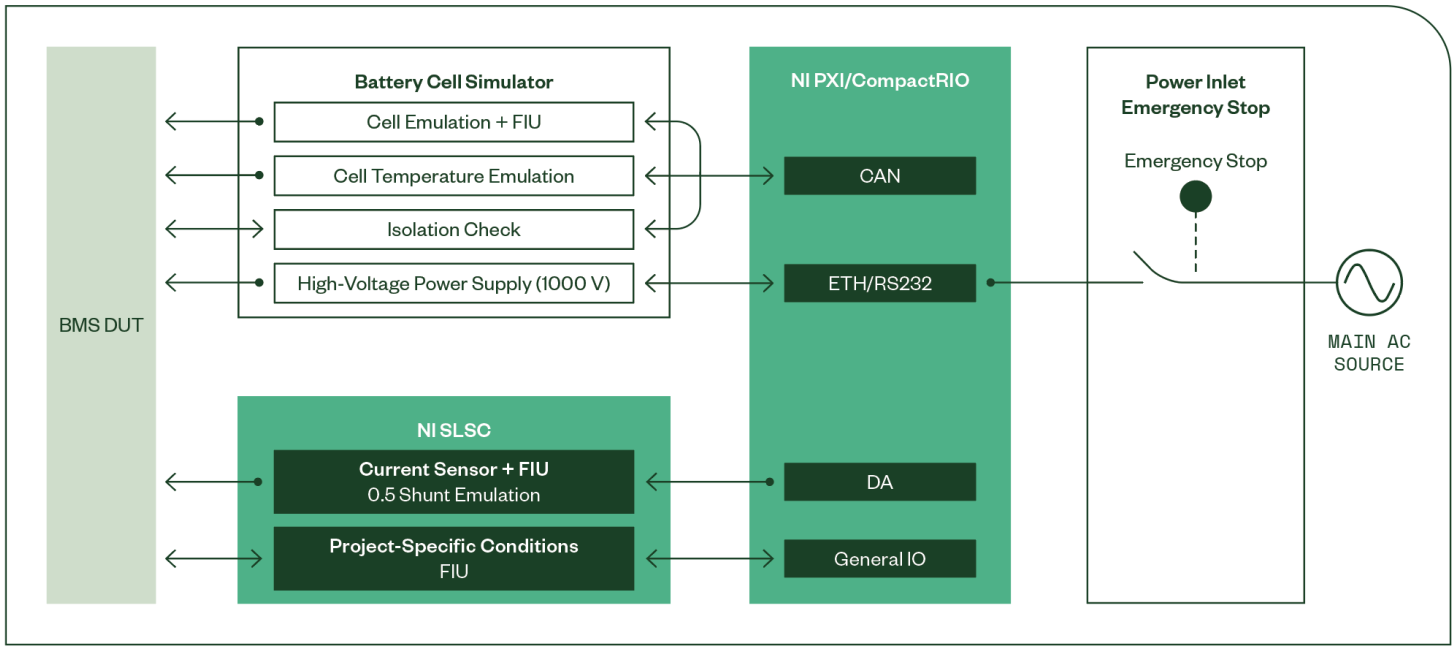
Emulate 12 battery cells with high-precision Battery Cell Simulator (BCS) unit connected through CAN interface module, and easily add more channels to keep up with new test requirements.

02

Integrate battery models to simulate the different discharge characteristics of most battery types, such as NiMH and Li-Ion, and connect to third-party equipment for real-time test execution.

03

Leverage vast integration and custom engineering expertise of NI partners to add extra protection, shunt emulation, breakout boxes, and other controls to your BMS validation test system.

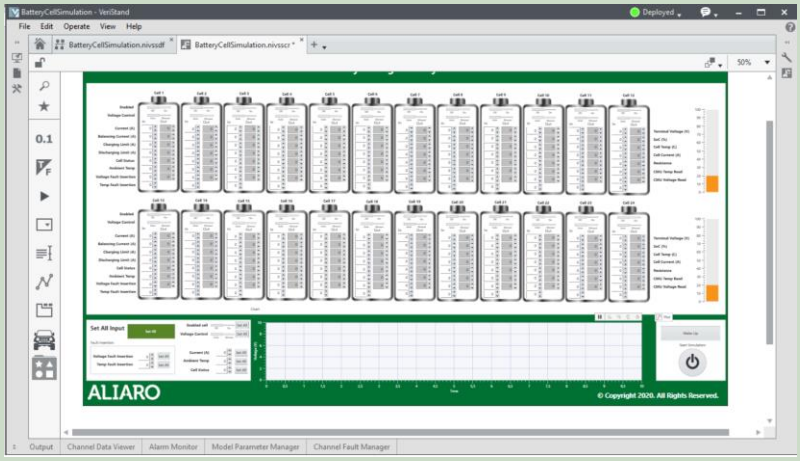


BMS HIL TEST SOLUTIONS ON THE NI PLATFORM ARE DELIVERED BY OPAL-RT, ALIARO AND OTHER NI PARTNERS.

ALIARO

OPAL-RT TECHNOLOGIES

> Testing a BMS in real time is not a very high technical challenge in terms of real-time simulation, but the safety and reliability, repeatability of tests, flexibility, and openness of the solution made the full difference for us.
>
> **Julie Darrah**
> Senior Engineer, IAV Automotive Engineering



Customer Needs

01

Perform emulation of battery cell modules and units, thermistors, battery types, power electronics, and others.

02

Conduct multiple fault insertion tests and failure mode simulation in real-time.

03

Implement ECU communications and sensor simulation on BMSs over different buses.

THE NI AND PARTNERS ADVANTAGE

- Shorten test plan implementation time integrating off-the-shelf components from NI and other market leaders specialized in BMS test
- Test BMS under extenuating safety conditions with NI's real-time test software and native simulation model integration
- Add every signal, real or simulated, to your BMS test system with minimum incremental cost thanks to NI's platform scalability and openness
- Ensure timely delivery of the test system combining NI global footprint with vast Partner expertise

KEY SPECIFICATIONS	
Number of Cells Per Emulation	12 per emulator, scalable to 200
Fault Insertion Bus Support	CAN, LIN, Automotive Ethernet
Battery Cell Simulator (BCS) Support	Comemso, SLSC (Aliaro)
Cell Module Unit Simulation	Supported (Opal-RT)
Communication buses	CAN, Automotive Ethernet
Electrical Failure Simulation	Broken wire, short circuit, polarity reversal

Battery Cell Production Test

The manufacturing of safe, reliable, and top-performing electric vehicle (EV) batteries demands rigorous testing, from formation to aging and assembly. The growing consumer demand for EVs and their promise of zero emissions is forcing battery manufacturers and OEMs to accelerate production without sacrificing precision, repeatability, and traceability.

Modern battery packs and modules contain hundreds and even thousands of battery cells, exponentially multiplying the risk of failure. As the industry strives towards zero defects, manufacturing test and the insights that come from the test data, make the difference between battery performance, and recalls.

A Solution that Evolves with You

NI has proven solutions for battery cell production that help EV battery cell manufacturers deliver safety and performance through high-quality, deterministic, and scalable PXI-based test systems for three critical test in manufacturing:

01

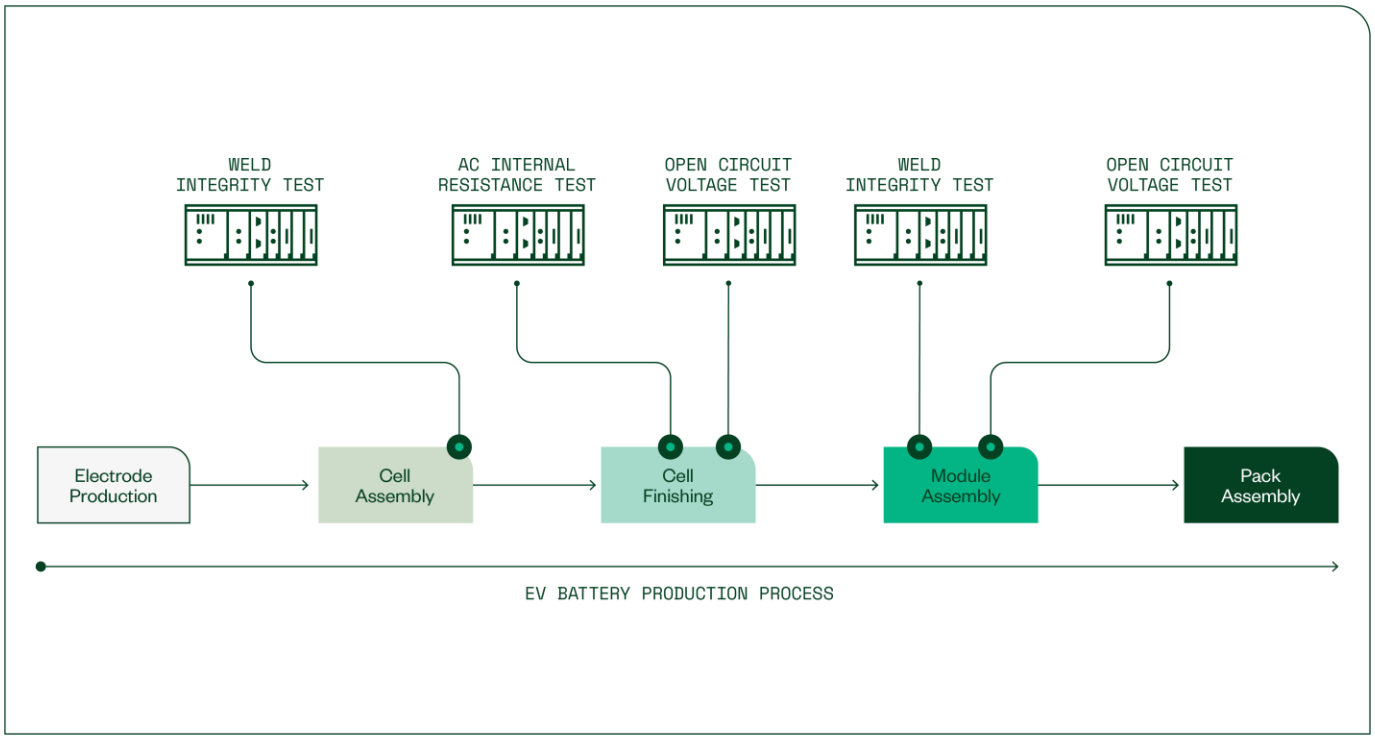
Weld Integrity (Laser Weld Impedance)

02

Battery AC Internal Resistance (AC-IR)

03

Open Circuit Voltage (OCV)



Battery Cell Production Test Needs

01

Weld Integrity Test
Confirm weld seam quality by measuring resistance and making pass/fail decisions within ranges of 0.1 mW

Test Requirements
- Precise, fast, and repeatable 4-wire resistance measurements with high channel counts and current generation capability from 100 mA to 2A
- Test rig with precise probe control at high speeds

02

Battery AC Internal Resistance (AC-IR)
Measure impedance after formation to ensure battery quality by applying a small AC signal and detecting resistive and reactive components of measured voltage

Test Requirements
- Measure sub-mW impedance at 1 kHz on shipping and acceptance inspection lines
- Meet production throughput without sacrificing measurement repeatability
- Scalable integration of other measurements such as temperature

03

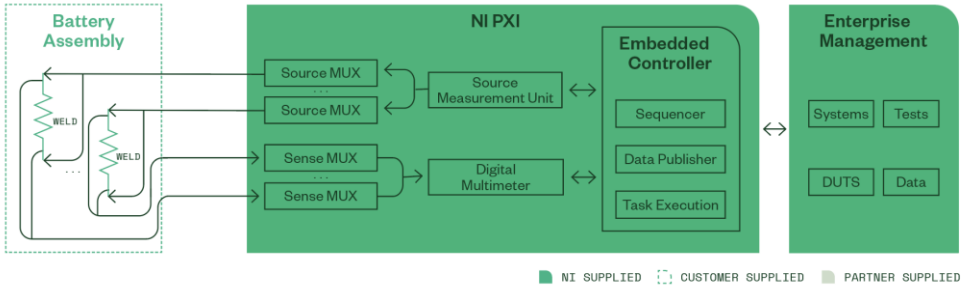
Open Circuit Voltage (OCV)
Detect micro-shorts that occur during cell aging process by monitoring OCV variation

Test Requirements
- Repeatable measurements within mV to quickly detect potential defects
- Reliable test performance continuously running up to several weeks
- Fast test time in high channel count setups

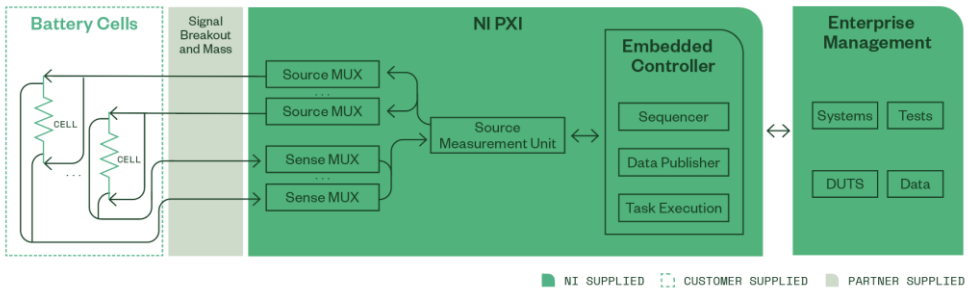
NI Solution for Battery Cell Production Test

- Cost-effective, compact, precise, and high throughput PXI configurations comprising of Source Measure Units, High Speed Multiplexers and Voltage Measurement Modules
- Scalability from 32 to 64 channels per system in a small footprint
- Integration with production test tools such as TestStand test executive, SystemLink® for enterprise data and systems management
- Service programs for maximum equipment availability and uptime

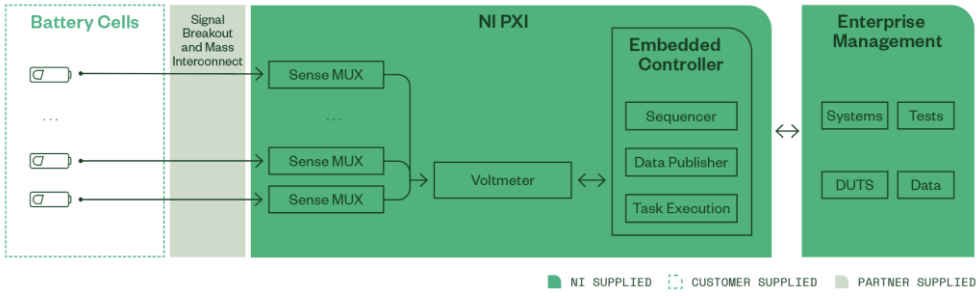
01



02



03



SIgnal-Level Inverter HIL

Testing hybrid and electric vehicle inverters for software and electrical functionality at the signal level with a closed loop simulator. Using a simulator instead of dynamometer lets you test sooner in the design process, test cheaper, and achieve greater test coverage because of the physical limitations of dynos. Systems need to be iterated on quickly to manage rapidly evolving DUTs and meet time to market requirements.

A Solution that Evolves with You

01

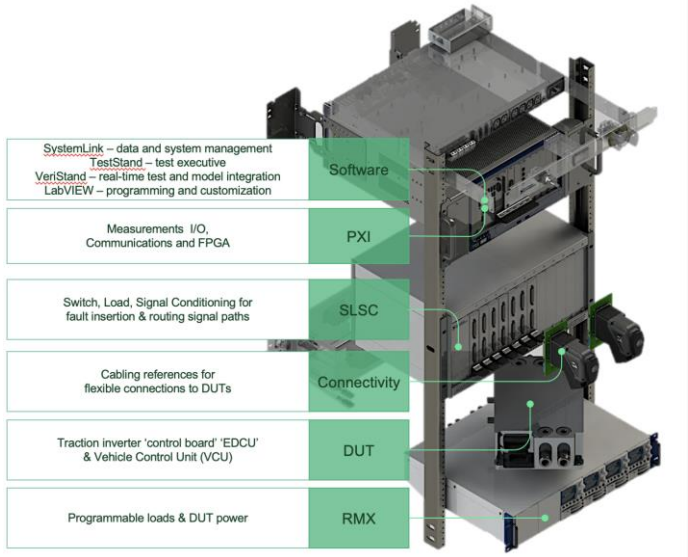
FPGA + RT CPU Model Simulation.
Co-simulate 3rd party models, including MathWorks Simulink®, on NI COTS FPGA and RT CPU simultaneously.

02

Multi-DUT Configurations.
Test 1, 2 or 4 DUTs in a single rack with signal conditioning and fault insertion.

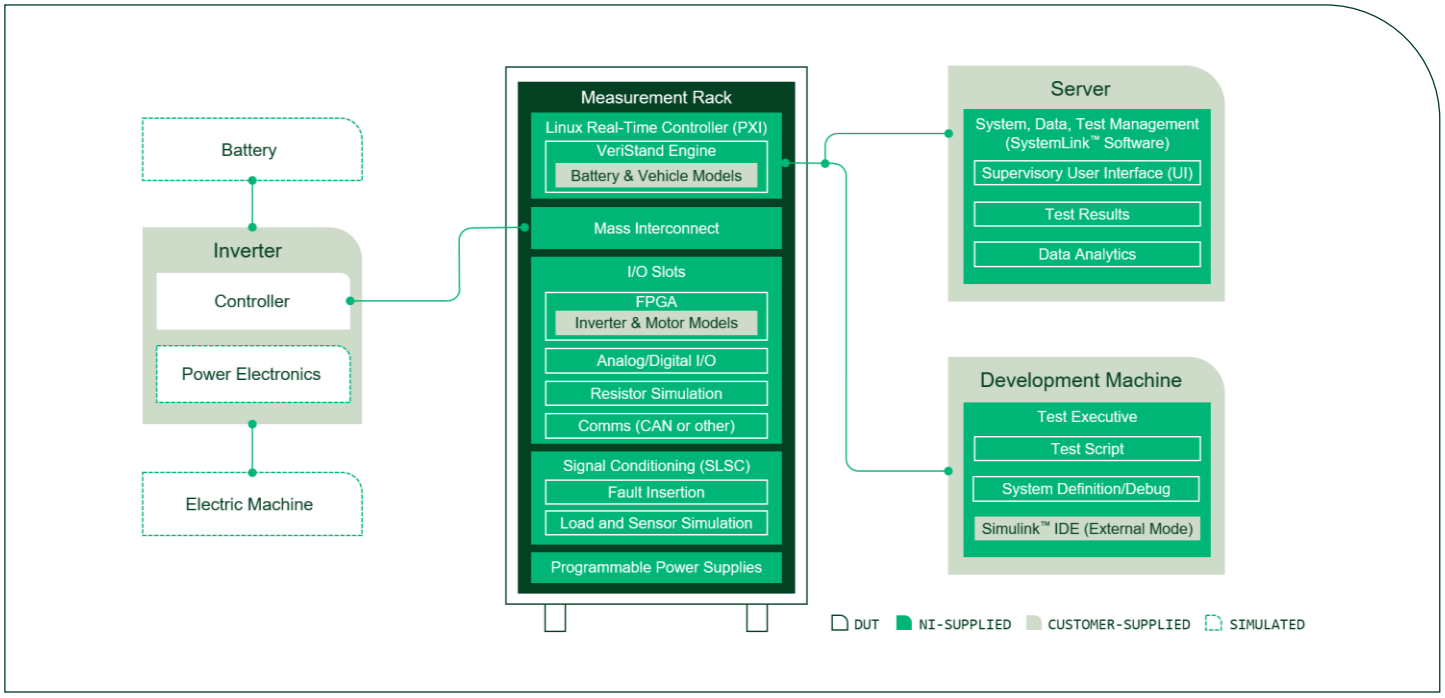
03

Systems and data management.
Facilitate large tester fleet deployments. Make the most of test data.



> By adopting FPGA-based simulation using the NI hardware and software platforms, we achieved the simulation speed and model fidelity required for verification of an electric motor ECU. We reduced test time to 1/20 of the estimated time for equivalent testing on a dynamometer.
>
> **Mr. Tomohiro Morita**
> Subaru

NI Inverter Test System Architecture



Customer Needs

01

Power electronics simulation running at least 100x faster than inverter switching frequency to achieve high accuracy.

02

Validate ECU performance over a wide range of parameter variations to achieve full test coverage.

03

Verify ECU functionality in range of conditions and faults, including extreme environments not easily created or replicated in the real world.

THE NI ADVANTAGE

- NI's open and flexible platform-based approach means you can own the test system IP and make changes quickly rather than being solely reliant on a third-party vendor.
- Run motor and electrical models at up to 4 MHz loop rates to achieve sufficient model accuracy for testing the inverter in simulation.
- Deploy quickly using existing models, tools, and workflows. Test systems need to be up and running quickly with fast delivery schedules.
- Fault insertion in hardware for opens and shorts and software for network messages.

SIGNAL LIST				
Signal Description	+/- 10V with FIU	4	2	1
Motor Phase Current (3-Phase)	+/- 10V with FIU	4	2	1
Motor Phase Voltage (Vab, Vbc)	+/- 10V with FIU	4	2	1
Resolver (1 Differential AI, 2 Differential AO)	0 to 50V with FIU	4	2	1
Inverter Gate Drive PWM Inputs (6 Inputs)	-	6	5	3
CAN or LIN	10 to 1M Ohm	16	16	0
Resistor Channels (100hm – 1MOhm)	0 to 30V 0 to 12A	2	1	0
RMX Power Supplies	0 to 60V 0 to 7A	2	1	1
RMX Power Supplies	+/- 10V with FIU	4	2	1

Power-Level Inverter HIL

Power-level hardware-in-the-loop (pHIL) testing extends traditional signal-level HIL to include testing of the power electronics circuits on EV traction inverters in a closed-loop simulator. By emulating the power components in an EV powertrain, traction inverter validation engineers can extend their testing capabilities to cover a wider range of test scenarios and faults safely in a controlled environment.

pHIL testing is a lower-cost alternative to dyno test and mitigates the need for the EV motor, plus it allows for replication of scenarios not easily reproduced with in-vehicle testing (e.g. single wheel slipping on icy road). Systems need to be iterated on quickly to manage rapidly evolving DUTs and meet time to market requirements.

Customer Needs

01

Emulate all characteristics of a PMSM or induction motor at full power in all four quadrants.

02

Run motor and electrical models at 100 kHz or faster loop rates to achieve sufficient model accuracy for testing the inverter in simulation.

03

Deploy quickly using existing models, tools, and workflows. Test systems need to be up and running quickly with fast delivery schedules.

04

Fault insertion in hardware for opens and shorts and software for network messages.

05

Scale with future test requirements.

D&V + NI Solution

01

NI PXI high speed serial modules can link the FPGA directly to the D&V emulators with fiber optic cable, ensuring full power can be delivered and manipulated at the necessary loop rates.

02

Readily deploy models from a variety of electrical modeling environments like SimPowerSystems, PSIM, and MultiSIM directly to NI FPGA PXI modules allowing for reuse of existing models and accelerated development.

03

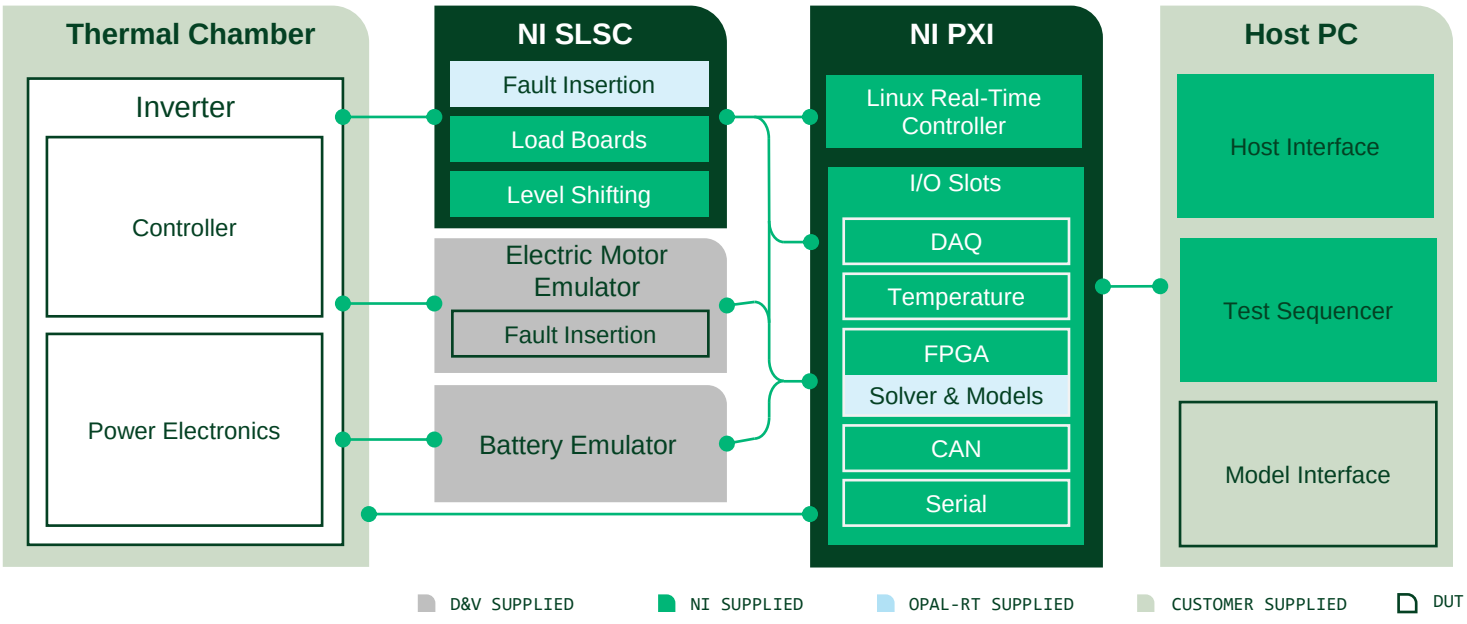
Open, short, and ground hardware fault insertion are implemented with NI SLSC or on D&V's emulators while software faults can be implemented directly in the FPGA.

THE D&V ADVANTAGE

- Lower operating costs through smaller footprint recirculating electric motor emulators
- Future-proof test systems through scalable I/O and power electronics
- Reduce time to first test with D&V integration expertise

D&V ELECTRIC MOTOR AND DC EMULATOR

D&V Electronics pHIL Inverter Test Block Diagram



EMULATOR SPECIFICATIONS	150500-1	250500-2	275960-1	550960-2
Emulated Motor Quantity	1	2	1	2
Cabinet Quantity	1	1	1	2 or 3
Motor Type	Synchronous PM or Induction, 3-phase/emulator (6-phase in parallel)			
Max Continuous Power (kW)	150kW/emulator; 250kW parallel		275kW/emulator; 550kW parallel	
AC Continuous Current	350Arms/emulator; 700Arms in parallel connection			
Fundamental Frequency	DC to 1500Hz			
Motor Voltage	0 to 365 VAC RMS L-L		0 to 700 VAC RMS L-L	
Scalability	Parallel up to 4 emulators - 1400Arms, 1200ADC, Up to 1.1MW			
DC Emulator Voltage	Up to 500 VDC		Up to 960 VDC	
DC Emulator Bandwidth	3Hz up to 20kHz (with choice of DC power supply)			

Electric Vehicle Dynamometer (eDyno)

Combining cutting edge control technology with fast switching power electronics, NI's highly flexible, fast, and high-precision motor drives boost performance and productivity of development and test by allowing engineers to seamlessly switch between real-world and digital twin test benches for a more comprehensive, and safer, validation of EV Drive Units.

A Solution that Evolves with You

01

Model-based approach. Detect issues sooner and iterate faster, avoiding expensive bench test time and accidental downtime.

02

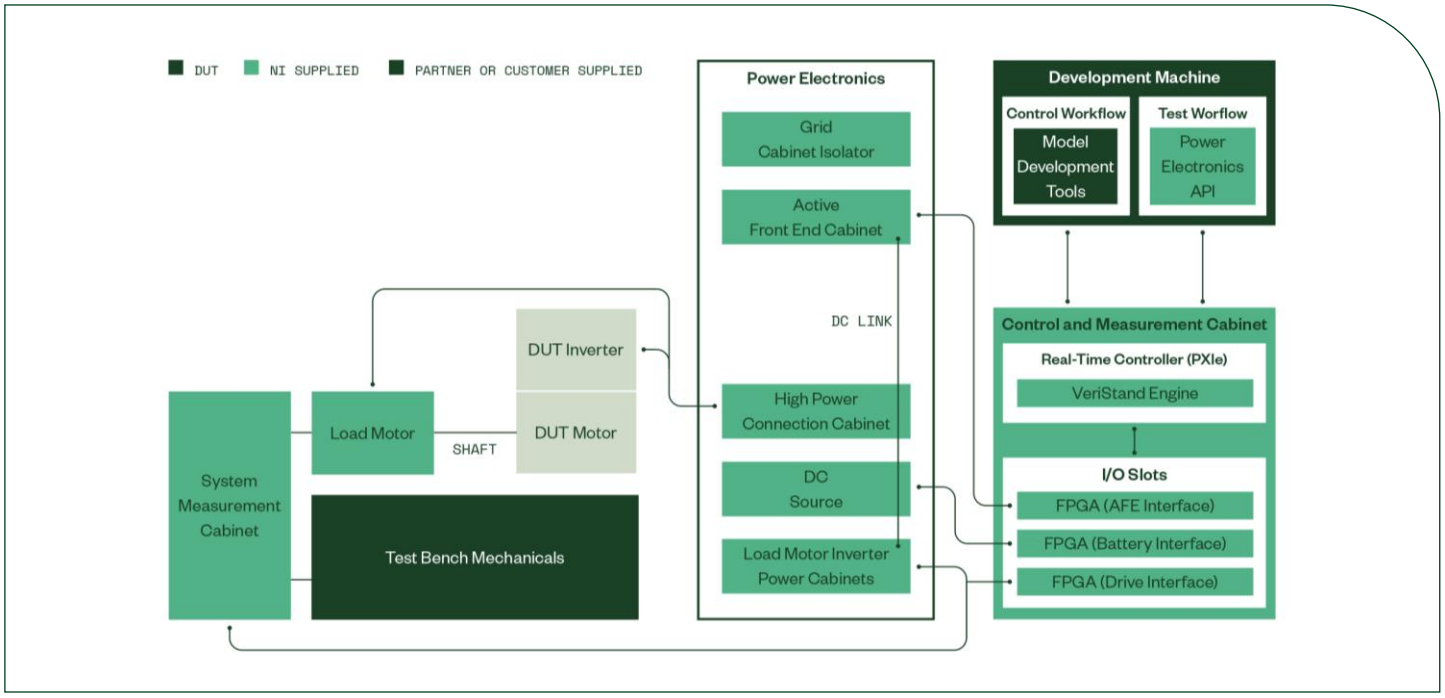
Scalable power and measurement. Control multiple motors with high precision using synchronized models executing at 20kHz+.

03

Enhanced data management, mining, and viewing. Remote access to assess the test and test asset quickly.

Flanders Make e-Powertrain Lab

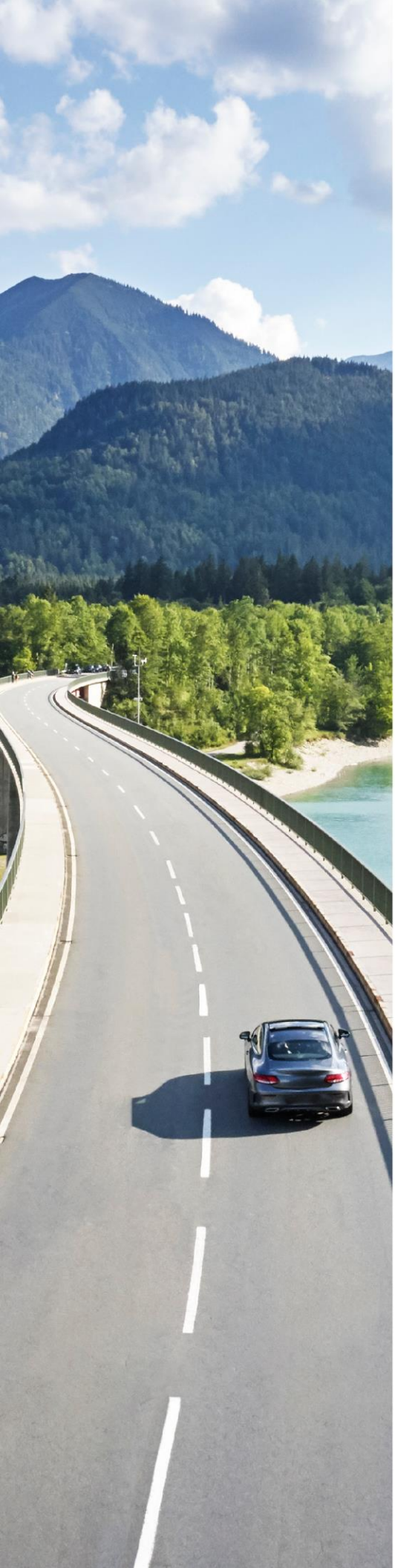
NI eDyno Test System Architecture



THE NI ADVANTAGE

- Easy setup and tuning of load motors and DUTs
- Integration with Simulink™ External Mode for streamlined iterations through model parameter tuning
- Open drive technology supports a wide range of high-speed, low-inductance, motors with arbitrary number of phases
- Scalable technology supports motor power outputs from 10kW to 700kW
- High-speed, system-wide synchronization for accurate, multi-motor motion control
- Test bench digital twin technology to facilitate test development and validate test performance with real-time execution of Matlab/Simulink™ models for advanced control prototyping

Dyno System Variants	
High-Speed Dyno System	**High-Torque Dyno System**
100 to 700 kW shaft power depending on cabinet count	100 to 500kW shaft power depending on cabinet count
Maximum stall torque 460 Nm	Maximum stall torque 1,200 Nm
Maximum torque 695 Nm	Maximum torque 1,400 Nm
Up to 25,000 RPM operation	Up to 18,000 RPM operation
1,200 V/1,000 A DC source for DUT	
20 kHz + control for easy setup and debug	
100 kHz torque and speed setpoint updates	
Less than 0.01% of current ripple	



System Integration on Your Terms

NI offers a variety of solution integration options customized to your application-specific requirements. You can use your own internal integration teams for full system control or leverage the expertise of our worldwide network of Alliance Partners to obtain a turnkey system.

Contact your account manager or call or email us to learn more about how NI can help you increase product quality and accelerate test timelines at (888) 280-7645 or **info@ni.com**.

NI Services and Support

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- Repair and Calibration
- Global Support
- Prototyping and Feasibility Analysis
- Training and Certification

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