



Next Generation Battery Test Solutions



NH Research: Industry Leader in Battery Test

NH Research (NHR) is an industry leader in battery module and pack test solutions for the electric vehicle, energy storage, aerospace and defense, renewable energy, and industrial markets. Our comprehensive battery test solutions include hardware and software at the instrument, systems, and enterprise level.

NHR customers include OEMs, Tier 1, 2, 3 suppliers and manufacturers, universities, government, and testing labs, worldwide.

At NHR, **we're your partner in test**. We provide high performance, easy to use, safe, and reliable solutions for the entire product life cycle from R&D to production, in-use, and end of life. Our in-house battery test experts and network of solution partners have extensive application expertise to help you develop a fully integrated solution. Whether you're a beginner, intermediate or advanced in battery test, we'll elevate your battery test to the next level.



Electric Vehicles & E-mobility



Electric Flight

**We Simplify Battery Test
So You Can Get to Market Faster**



Energy Storage Systems



Fuel Cells

The NHR Advantage



**Best in Class
Performance**



Ease of Use



**Modular
Scalable Power**



**Reduced
Testing Time**

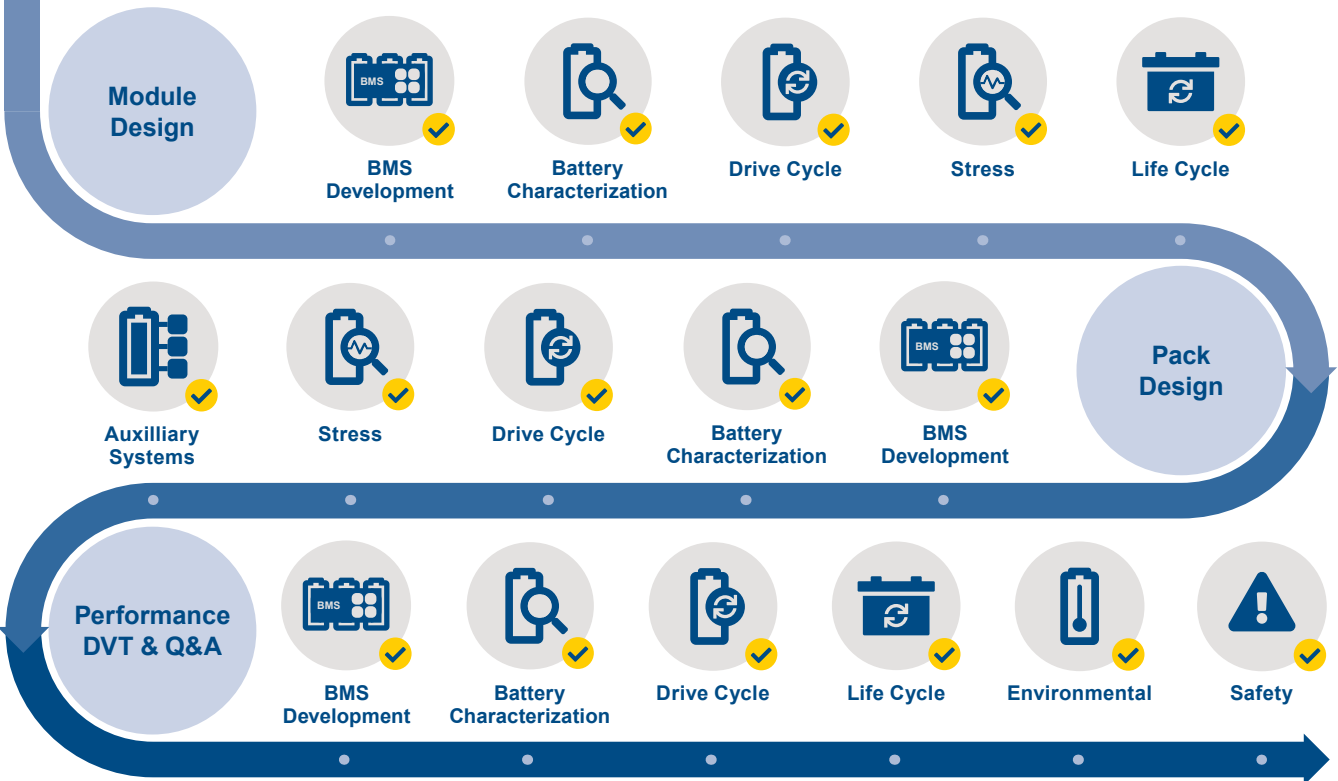


**Improved
Safety**

Common R&D Battery Tests



R&D Process





Battery Test Involves More Than Cycling Batteries

Testing battery modules and packs involve more than just battery cycling. More often than not, testing a battery involves software and a controller to automate the test steps and integrate additional devices needed to communicate with the battery.

NHR Battery Test Systems Easily Integrate with your Existing Assets or Future Test Requirement Set-ups

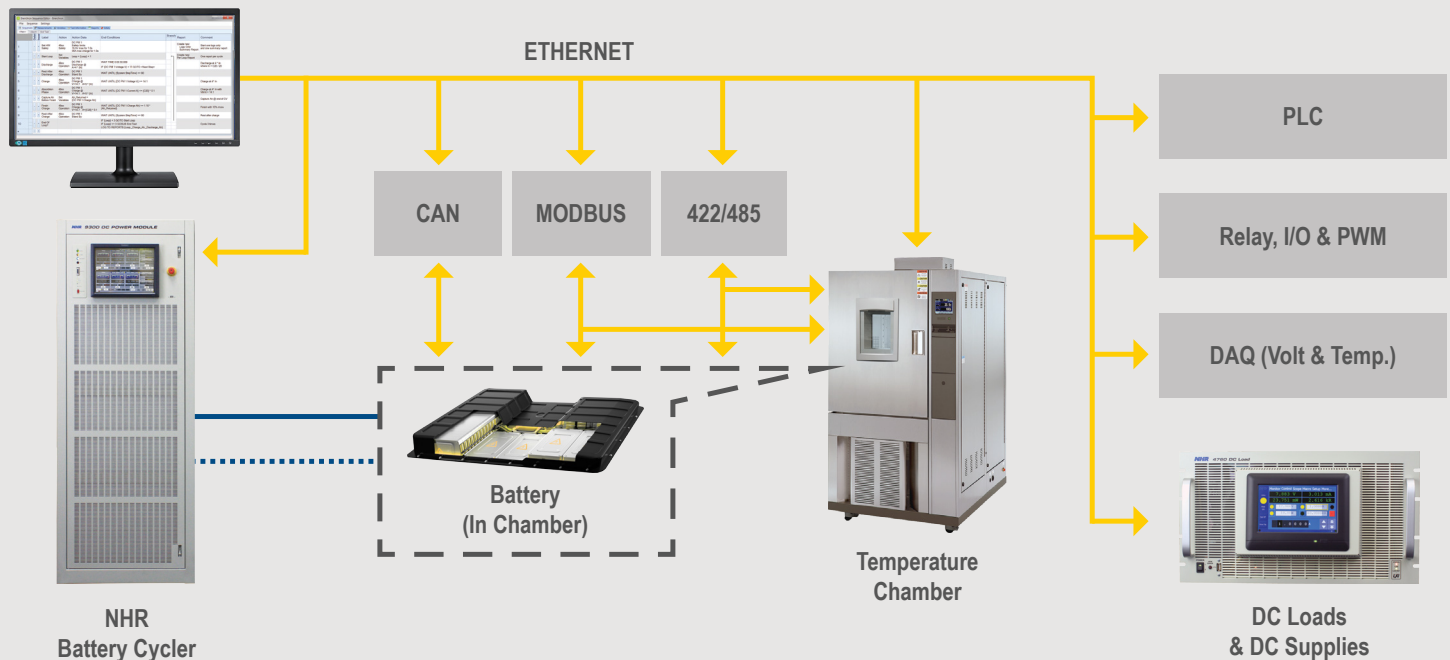


Figure 1: A battery test environment typically involves additional components such as communication modules, temperature chambers and chillers, and other power sources which factors into test requirements.

The Industry's Most Flexible, Modular, Off-the-Shelf Battery Test Systems

NHR's Regenerative Battery Test Systems address the increasing power levels of battery modules and packs used in the electric vehicles and renewable energy storage industries.

Key Features

- Modular and Scalable Power
- Wide Operating Envelope
- Fast Response Times
- Flexible, Easy Control & Integration
- Multiple Layers of Safety Built-In
- Accurate Battery Emulation Mode
- Energy Savings



Image: Single 9300 & 9200 Cabinet

The All-in-One Test Solution

NHR's Battery Test Systems are the ideal all-in-one test solution for EV components and systems. These multi-functional units serve as a battery cycler, bidirectional DC source and load, and battery emulator in one mobile-friendly asset. Ideal test applications include the battery/fuel cell, electric powertrain, EVSE/OBC, DC converter, fast charger, and V2G.

Applications

- Battery Module and Pack Test for All Chemistries
- Fuel Cell, Super Capacitor and Ultra-capacitor Testing
- Life Cycle Testing
- Engineering Characterization, Design Validation
- Production, End of Line Testing
- Drive Cycle Simulation Testing: FUDS, SFUDS, GSFUDS, DST, and ECE-15L
- Microgrid , Energy Storage Systems, Inverter, UPS, Generator, and Flywheel Testing
- Battery /DC Emulation: Vehicle Drivetrain, Solar PV, Spacecraft Simulation

	9200 Series	9300 Series
Applications	Mid-Voltage, Module Level	High Voltage, Pack Level
Power	12kW up to 252kW	100kW up to 2.4MW
Maximum Channels In Parallel	21 Channels	24 Channels
Voltage Options	40V, 120V, 600V	Dual Range 600 V, 1200 V
Maximum Current	Up to 12,600A	Up to 7,992A
Modes	CC, CV, CP, Series-CR	CC, CV, CP, Series-CR
Loading Modes	Charge/Discharge, Load, Battery Emulation	Charge/Discharge, Load, Battery Emulation

1 Modular and Scalable Power

NHR's Battery Test Systems are designed for fully independent operation and can be paralleled, increasing the maximum power and current capability to the level required. This modular expansion allows you to scale power as needed.

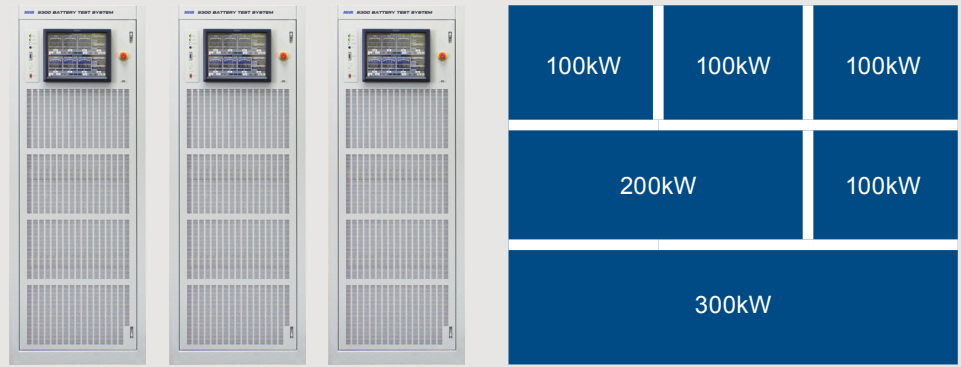


Figure 2: Modular configuration options for a 300 kW system. The 9300 Series can be paralleled up to 2.4 MW

2 Wide Operating Envelope

New electric transportation architectures operate between 800/1000 VDC to enable faster DC charging. The 9300 has a dual power range that covers both lower (up to 600 V) and higher power (up to 1200 V+) applications using a single product. Unlike custom built solutions, the 9300 provides maximum flexibility in voltage and power, providing full power from 300 V – 1,200 V+.

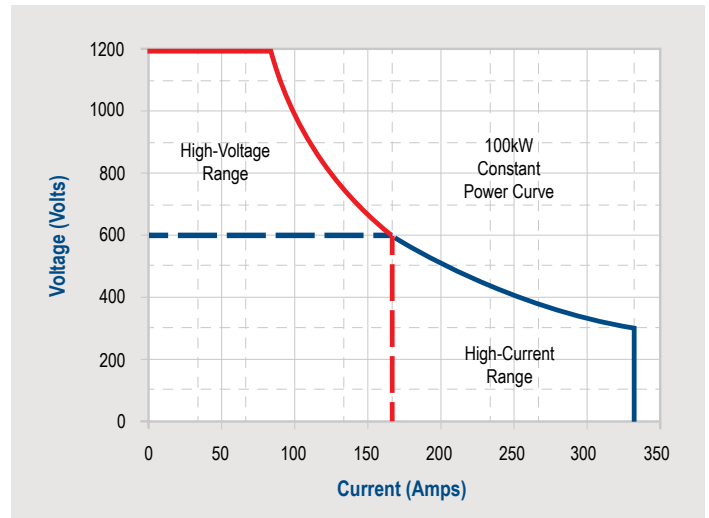
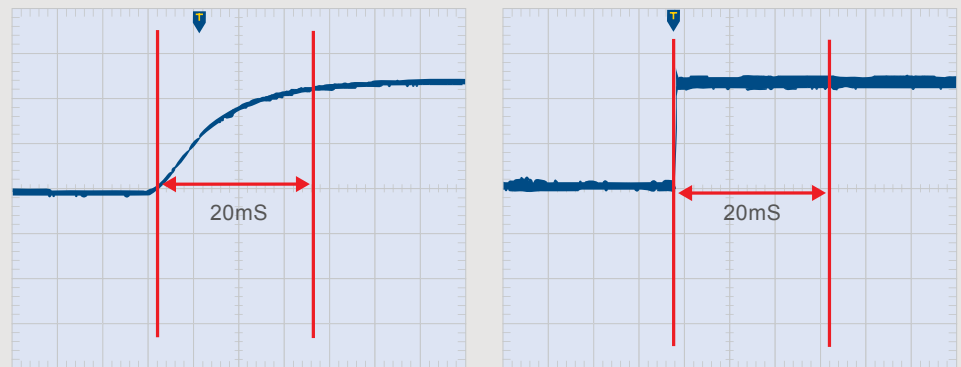


Figure 3: Wide operating envelope means full power available from 300 V – 1,200 V+.

3 Fast Response Times

Voltage and current transitions, or slew rates, of the test system must be faster than the battery under test to emulate real-world settings.

NHR Battery Test Systems have fast response times for hardware and software to meet real-world conditions and command speeds with accuracy.



Slow rise-time of typical DC supply

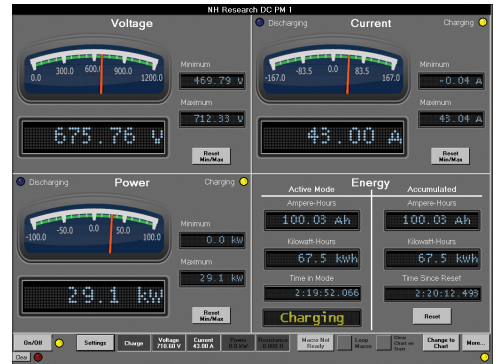
Sub-millisecond rise time of NHR

Figure 4: Fast Response times simulate real-world conditions

4 Flexible Control and Automation Options

Engineers need to have multiple ways to control the battery test instrument. Depending on the specific need, an engineer may choose to **1)** directly access the drivers for in-house programming, **2)** use a solution provider, or **3)** use NHR's Enerchron Test Executive Software.

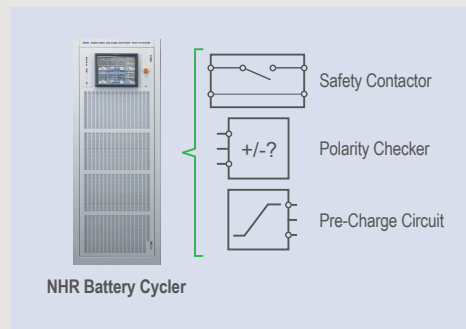
NHR Battery Test Systems can be easily integrated into existing test platforms or serve as the power stage for new test platforms. We provide fully documented drivers using either IVI or SCPO languages along with examples, applications, and integration support.



5 Multiple Layers of Safety Built-in

NHR provides multiple layers of integrated hardware and software protection. The safety contactor, reverse polarity checker, and pre-charge circuit are built into the hardware.

Additional safety features are also fully integrated in to the automation system as shown in **Figure 5**. There are no hidden fees or added costs.



Additional Safety Features

- Emergency Power Off (EPO)
- External Wired Interlock
- Programmable H/W Limits
- Communication Watchdog
- In-sequence Logic (S/W)
- Additional Monitoring (S/W)

Figure 5: All NHR safety features are built-in, providing full safety and control throughout the test environment

6 Accurate Battery Emulation

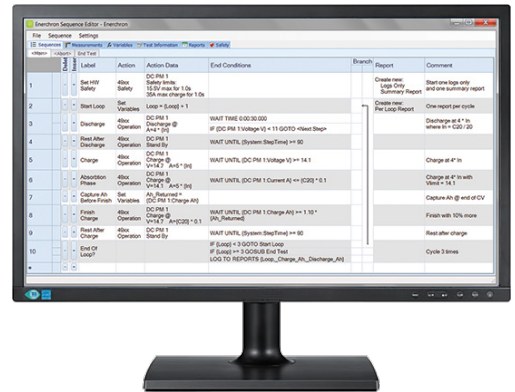
NHR Battery Test Systems have a unique Battery Emulation mode. This mode implements a programmable series resistance with low capacitance built into the hardware (versus only the software). This ensures accurate testing of real world conditions. As in a real battery, the test channel will source and sink current as needed to maintain voltage regulation. Battery emulation is ideal for testing electric powertrains, chargers, and regenerative braking systems, on board DC/DC converters and DC power supply burn-in.



Enerchron® Test Executive

Simplify and Accelerate Battery Test Automation

Enerchron is a powerful but easy to use test executive created for battery testing to simplify and accelerate your test automation. It's a comprehensive battery test environment that includes integration with H/W and S/W tools. Enerchron is your shortest path to market. Enerchron breaks the mold of traditional battery cycling software through its unique variable-based formulas.



Key Features

- Dramatically reduce software development and post-processing time
- Streamline your battery test process and workflow
- Increase productivity and eliminate errors and repeated tests
- Save time, money and resources
- Reduce stress and testing difficulties
- Stay on schedule and budget
- Get to market faster

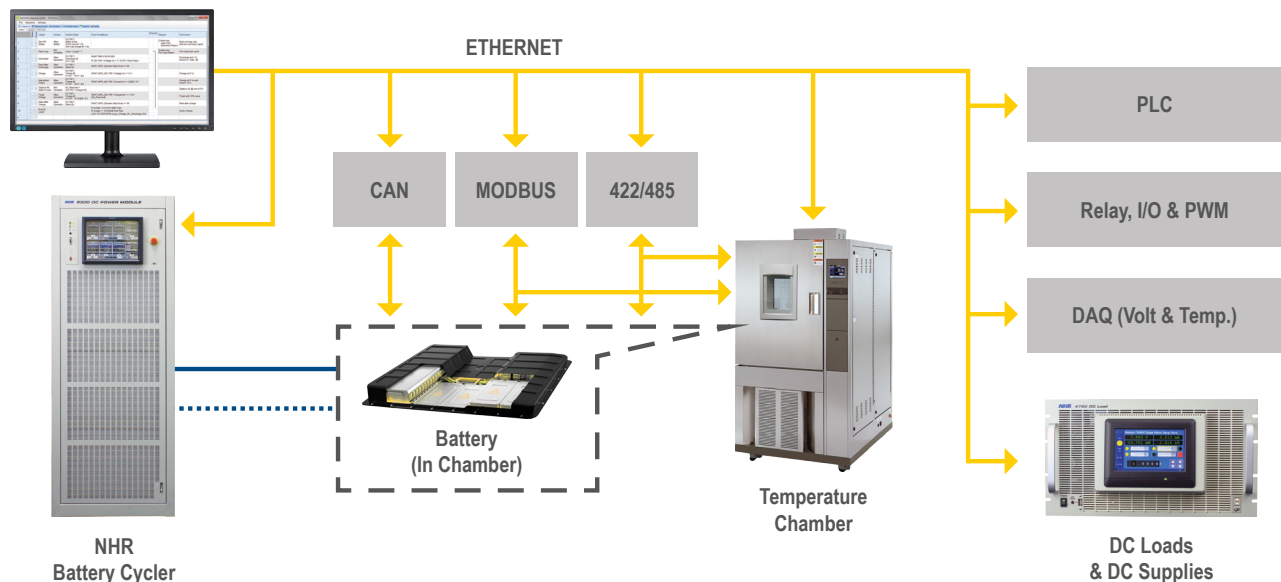


Figure 6: Enerchron test executive provides a comprehensive battery test environment that includes integration with H/W & S/W tools.



Enerlab™ Enterprise Lab Management Software

Enerlab is a top-level enterprise software solution that monitors, controls and manages battery test systems using Enerchron. It is designed to improve productivity, utilization and efficiency while ensuring safety by providing real-time access and control to lab and test information.

Key capabilities include live camera views and full control of test programs, as well as customizable dashboards and reporting tools. Enerlab provides a way to remotely manage all battery test stations within a facility, on a single dashboard from one browser.

Key Features

- Simplify operator usage to a single screen
- Ensure safety with live camera views of labs
- Start, stop & abort tests remotely
- Track utilization & status of test program
- Manage schedule queue of test programs
- Create customized dashboards
- Maximize equipment (CAPEX) utilization & schedule
- Track weekly & in-test trends (charting feature)

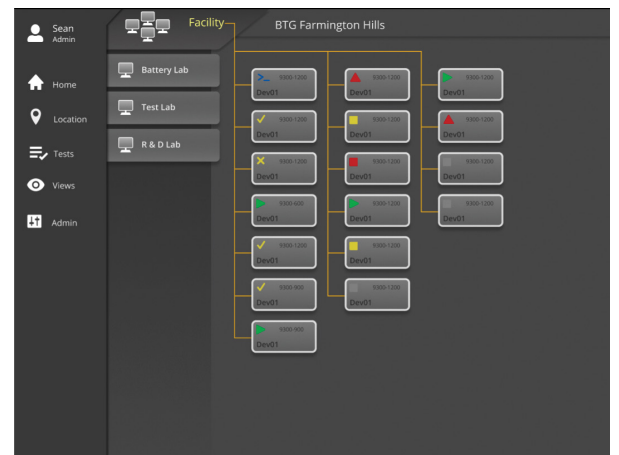
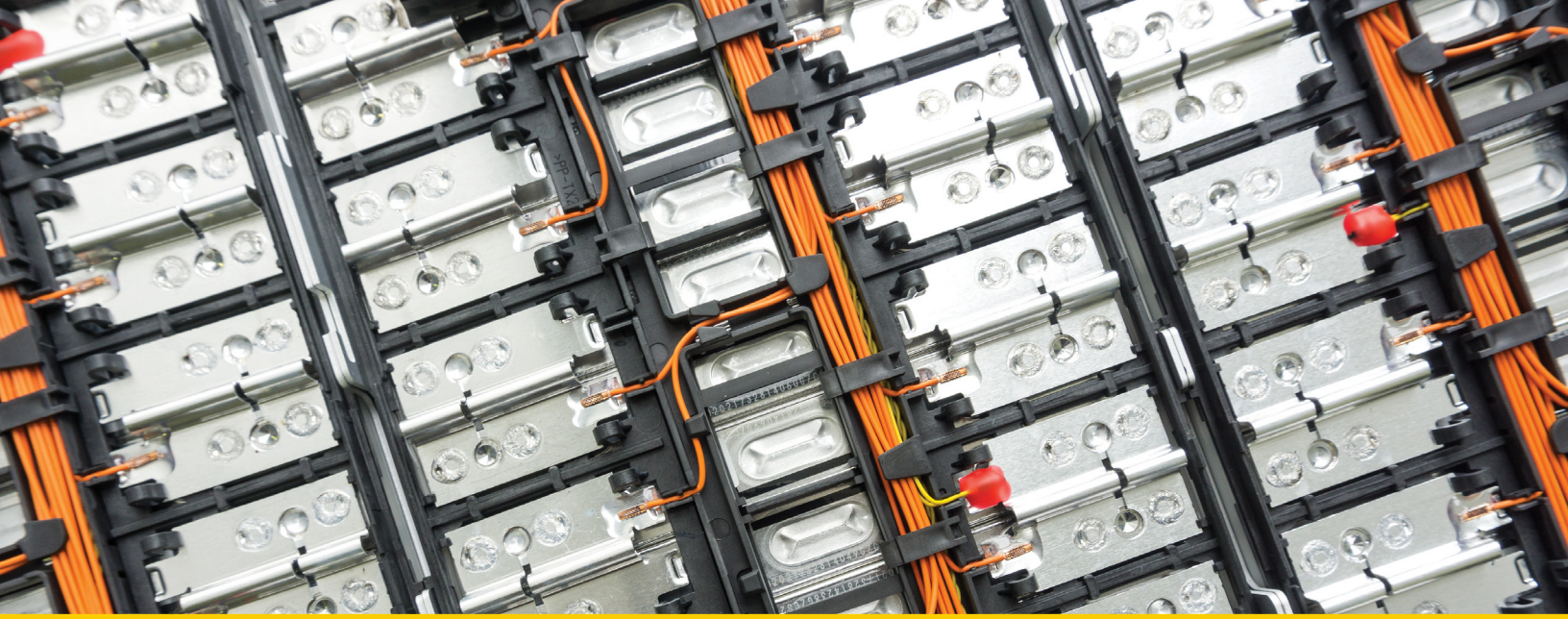


Figure 7: Customizable user dashboards for all projects and test stations facility-wide.



Next Generation Battery Test Solutions for R&D

Battery testing raises many challenges because it is complex, time-consuming, data intensive and can be hazardous. Testing without the right equipment and software tools can delay projects, increase safety risks and hinder productivity.

Below are key considerations for selecting NHR's battery test solution.

1 Advanced Hardware Performance ▶

Ensure accurate, scalable and repeatable test results.

- Fast response times to emulate real-world settings (Voltage and Current)
- Modular and scalable power address future power requirements
- Wide operating envelope optimizes configuration and testing opportunities

2 Multiple Layers of Safety ▶ *Protect the user, equipment, UUT, and facility.*

- Built-in hardware and software protections prevents safety hazards

3 The Power of Choice ▶ *Multiple options to control the instrument and manage test results.*

- Multiple programming languages to write your own software
- Enerchron Test Executive provides comprehensive battery test solution
- Solution providers can easily integrate systems with NHR's open control mechanism

4 Easy, Flexible Integration and Control ▶

Control the entire battery test environment.

- Easy integration with third party tools such as software communication interfaces, temperature chambers, DAQ systems, PLM, etc.

5 Powerful Automation & Enterprise Software ▶

Simplify and accelerate battery test.

- Enerchron provides unique variable-based programming to reduce software development time and complexity
- Enterprise lab software to monitor, control and manage test systems

6 Worldwide Support ▶ *Get the support you need before, during and after purchase.*

- In-house domain battery test expertise
- Technical support services available including calibration, maintenance, and repair

The Power of Choice: Flexible and Easy Control and Integration

We give you the power of choice. Unlike other providers on the market, NHR Battery Test Systems are designed with multiple control options so that you can write your own software, work with a solution provider, or select NHR's Enerchron test executive for a fully integrated solution.

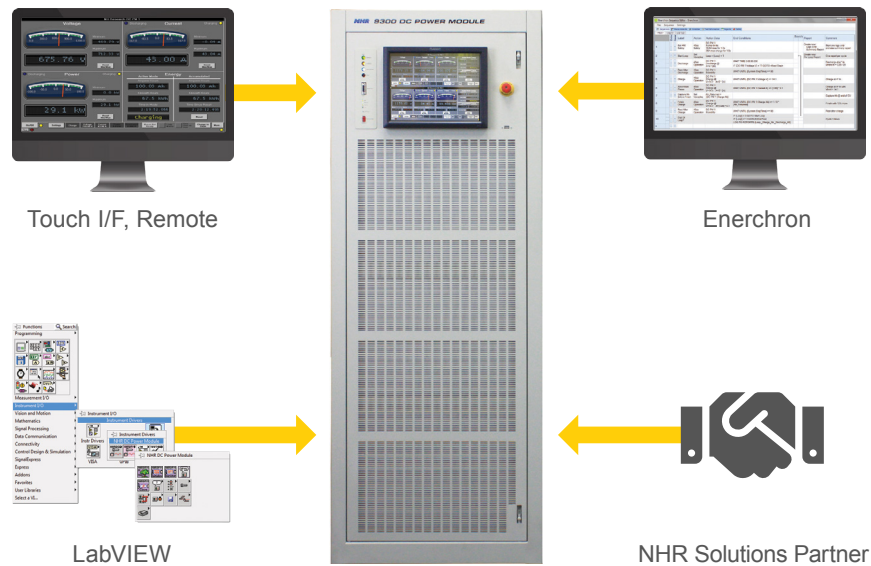


Figure 8: Multiple control options ensure easy and flexible integration within test environment.

NHR's Comprehensive Battery Test Solutions

NHR battery test solutions include advanced performance hardware, test executive software, and enterprise lab remote management software. Our validated network of solution providers also offers additional services as required.

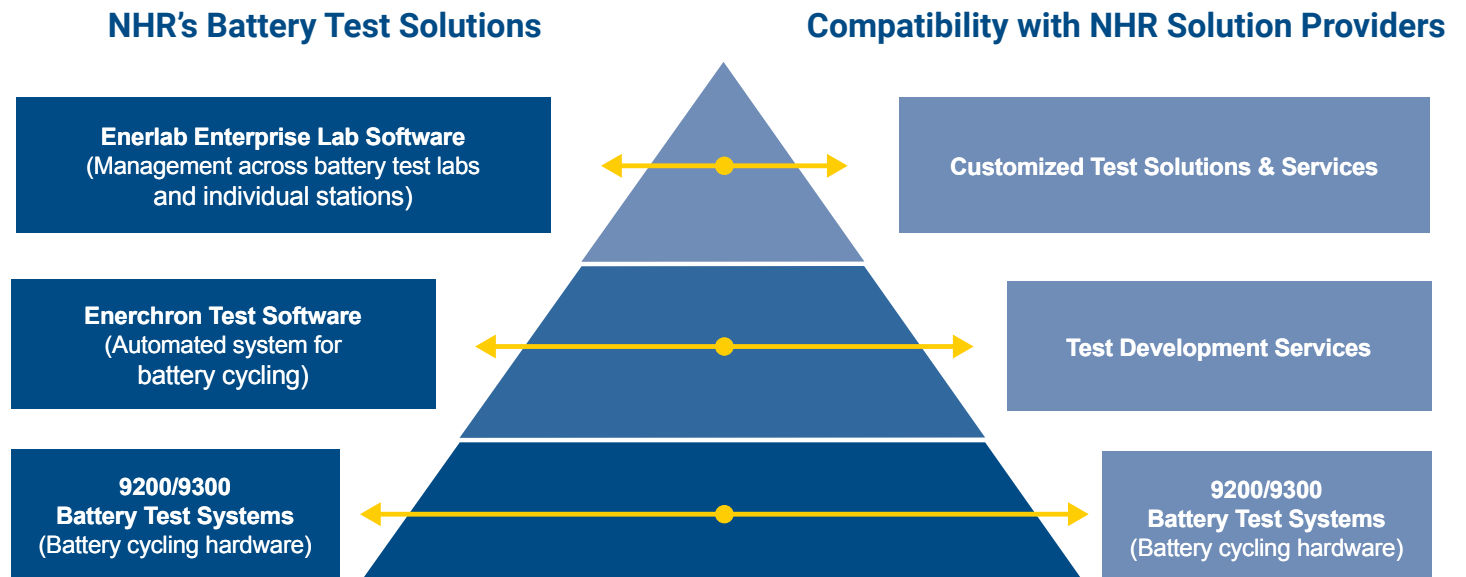





Figure 9: NHR battery test systems are highly flexible to meet your evolving test requirements.



Worldwide Customer Support

NHR is committed to providing reliable and responsive support to our customers. We maintain sales and service with fully staffed technical resources, diagnostic tools and replacement parts to resolve problems quickly anywhere in the world.

NHR Life-Cycle Support Stages	
	<p>Design & Manufacture</p> <p>These services and solutions shorten the design time, create efficiencies in processes and facilities, and get your production up and running fast.</p>
	<p>Commission, Maintain & Repair</p> <p>We'll help ensure the reliability of your NHR test equipment, the integrity of your test set-up, and promote workplace safety.</p>
	<p>Upgrade & Enhance</p> <p>Our service solutions extend equipment life, accelerate business workflow, and help maximize safety.</p>

Enabling Electrification

Your Partner in Test

