9200 Series
Battery Module/Pack Test System

NH Research, Inc.

Automated Characterization, Power Cycling & Life-Cycle Testing of Battery Modules & Packs

Key Features

- Best configuration flexibility
- Custom waveform/profile generation
- Microsecond voltage, current & mode transition times
- Built-in digital measurements with charting & scope displays
- 3 test system control options including a Touch-Panel interface
- Expandable from 12 to 252kW with 40, 120, 240 or 600V bi-directional DC loads
- 87% efficiency of discharge power returned to AC mains
- Multiple safety layers to protect battery being tested
- Battery emulation & burn-in applications

Battery Test Applications

The 9200 Battery Test System is designed for all battery chemistries including lead-acid, nickel-cadmium and lithium-ion. The 9200 is ideally suited for applications where maximum tester configuration flexibility is needed to adapt to a broad range of battery voltage, current and power requirements now and in the future. Another good fit is where high-speed set and measurement are necessary to better characterize battery transient performance. A third application is where easier and faster test program creation is desired. All applications benefit from the 9200 discharge power recycling capability, which results in both a cooler test environment and system cost recovery in a few years. Other 9200 applications such as battery emulation, battery charger test and power supply burn-in are covered in supplemental product bulletins.

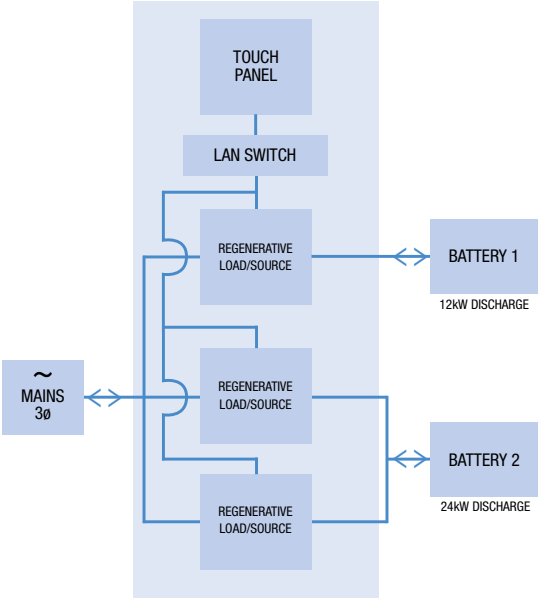

Figure 1 - Independent testing of 2 different types of batteries

Highly Flexible Tester-per-Channel Design

9200 Testers are configured with independent, 12kW DC bi-directional loads that can be dynamically programmed both within a cabinet and from cabinet-to-cabinet to run in parallel or independently. This capability provides for simultaneous testing a number of smaller batteries each with a different test plan, power level and start/stop times. Alternately, a higher power battery can be tested by connecting the loads in parallel. The simplified diagram to the left illustrates *(Fig. 1)* how loads can be configured to run both in parallel and independently at the same time. For a laboratory or production facility that has a wide mix of batteries to test, this configuration flexibility provides optimizing tester usage at all times.

Recycle Discharge Power Back onto the AC Line

Up to 87% of the energy that ends up as waste heat during battery discharge can be saved by converting it back to electrical power that precisely matches the facility AC line. The savings attainable here can provide payback of the entire test system within a few years. Further advantages are a cooler work

environment, smaller air conditioning capacity, elimination of elaborate water cooling systems plus the good will created through being recognized as a "green" neighbor investing to minimize their carbon footprint.

Broad Operating Envelopes

Battery cycling testers are best evaluated on operating power envelopes rather than simply maximum kilowatts. The reasoning here is that users often do not know what combination of voltage and current they will be required to test in the future. Consequently, the broadest operating envelope provides the best insurance that future test requirements will be met *(Fig. 2)*. All NH Research, Inc. (NHR) bi-directional loads have an exceptionally broad operating envelope just for that reason.

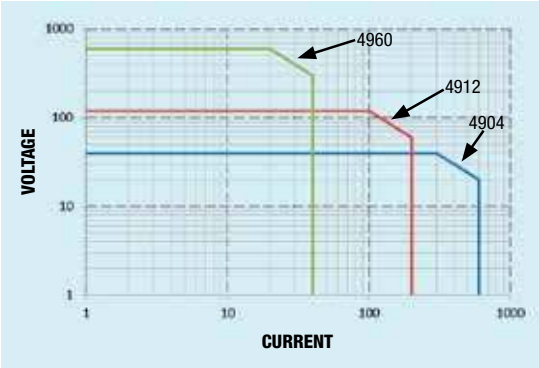

Figure 2 - Discharge Operating Envelope

Digital Measurements, Scope Display & Charting Capability Built-In

A vast amount of precision measurement information is provided by the high-speed digitization of analog measurement signals within each load. One example is the simultaneous measurements of voltage, current, amp-hours and watt-hours that are continuously available. The extent of this measurement information minimizes the need for supplemental instruments added to the test system. Another benefit is that waveforms can now be displayed in real-time much like an oscilloscope and also charted *(Fig. 3)*. Reports can incorporate such waveforms to document how the battery-under-test behaved during certain transient conditions.

Figure 3 - Chart Recorder

Microsecond Current, Voltage & Mode Transitions

9200 loads are able to simulate demanding real-world transient conditions through hyper- fast, slew-rate-controlled settings and Macros. Macros are mini-programs up to 1000 steps that for speed purposes will execute within the load rather than PC. In combination with the 1.2Ms/sec digitized waveform captures *(Fig. 4)*, a unique fast transient simulation and resulting UUT waveform display/record is provided. Macros can be saved to a library and then called by the PC test program when needed.

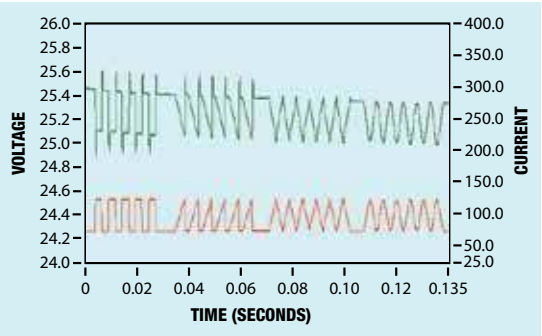

Figure 4 - High Speed Waveform Set (Red) & Capture (Green)

Programmable Bi-Directional Power

Each test channel is an 8kW source, a 12kW sink and operates as a fully programmable power supply, load, or battery. All of these operating modes support constant-voltage (CV), constant-current (CC), and constant-power (CP) regulation *(Fig. 5)*. More than one regulation mode may be enabled at the same time, creating standard charge profiles like CCCV and CPCV.

Resistance provides a programmable series resistor emulating voltage effects caused by resistance found in wire harnesses, protection circuits, or batteries.

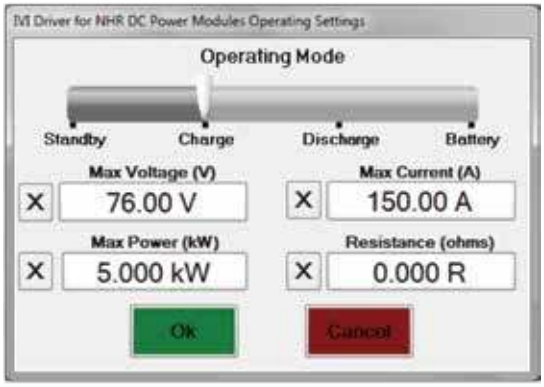

Figure 5 - Power Supply, Electronic Load, & Programmable Battery Modes

Multiple Safety Features to Protect the Battery Under Test

Each test channel provides programmable safety limits *(Fig. 6)* to prevent damage that could occur caused by operator error, programming errors, external or internal faults. When a safety limit is triggered, the test channel opens its output contactors isolating the test channel from the battery-under-test and prevents further operation until the test channel fault is cleared. These programmable safety limits can be set through the Touch-Panel manual interface, programmatically through LabVIEW, and other programming languages.

Figure 6 - Safety Settings

Each test channel also provides a separate interlock input that can be connected to an external test fixture. The test channel will open its output contactors isolating it if the interlock input is triggered. And, when this isn't enough to catch a fault, the user can abort testing and disconnect the battery/ module through an emergency power-off switch prominently mounted on the front of the cabinet.

Enerchron® Test Executive

The Enerchron Test Executive is an industry leading test controller that makes battery test program generation faster, easier and more intuitive than ever before. A key structural element of this advanced test controller is adaptive test program creation that provides for the use of variables, such as C-Rates, instead of hard-coded values. Variables allow information from any source to dynamically change the test program. With this capability, programs can be written from an industry standard or test procedure in that same language to become templates. Then, individual battery information is input and processed for a complete test program. There is never a need to rewrite the template again, only add new battery information.

Another key concept is the use of plug-ins, which provides specific enhancements to Enerchron in order to expand testing capabilities. Plug-ins may include new test algorithms, test channels, measurement channels, control of a temperature chamber, or new battery communication protocols. These two features are only a few of the great many advances Enerchron offers. An on-line demonstration of this entire application can be arranged with your local sales representative.

Three Control Options

Each 9200 cabinet, which contains up to three 12kW loads, has a Touch-Panel that controls and displays voltage, current, power along with other settings, limits and test status *(Fig. 7)*. This Touch-Panel provides the ability to create, run, monitor, chart and report battery charge/discharge profiles without writing any code. The Touch-Panel can be used to manually control the operating modes or program a simple, time- based, test profile that can be saved for repeated use.

Figure 7 - Three Channel Monitor Panel

Another control option is the NHR Enerchron® Test Executive hosted on the embedded or external PC. This is best suited for running long-term tests and includes a data collection option.

The third option is where user can utilize their own PCs and test software to communicate with the 9200 through its IVI drivers. This works well in instances where the customer has already written test programs and doesn't want to replicate all this work.

Battery Emulation & Burn-In Applications

A Battery Emulation Mode is provided within Enerchron for testing certain power electronic systems that now utilize a real battery to source and load the product-under-test. In this Emulation Mode, the test channel will source and sink current as needed to maintain voltage regulation. Having a programmable battery emulator provides a more consistent testing capability for products such as chargers, regenerative braking systems, and on board DC/DC converters.

Another 9200 application is DC power supply burn-in. While this type of testing utilizes only the regenerative load capability of the 9200, the electricity savings created by recycling 87% of input power back into the facility AC line pays for the tester in a few years. This is especially true for higher-power DC supplies typically used by mission critical applications that require extensive burn-in testing.

Model 9200 Individual Power Module Specifications

	Model 4904			Model 4912			Model 4924			Model 4960		
Functional Capability												
Operating States	Charge (Source), Discharge (Load), Standby, Battery											
Charge/Discharge Modes	Constant-Voltage(CV), Current (CC), Power (CP), Resistance (CR)											
Charging Envelope	0 - 40V, 8kW, 600A			0-120V, 8kW, 200A			0-240V, 8kW, 100A			0-600V, 8kW, 40A		
Discharging Envelope	1 - 40V, 12kW, 600A			4-120V, 12kW, 200A			6-240V, 12kW, 100A			10-600V, 12kW, 40A		
Slew Rate	0.011V/S - 30kV/S, 0.0165A - 600kA/S			0.033V/S - 120kV/S, 0.055A - 200kA/S			0.066V/S - 240kV/S, 0.027A - 100kA/S			0.165V/S - 600kV/S, 0.011A/S-40kA/S		
Current Change Time	Less than 5mS											
Current Reverse Time	Less than 10mS											
Parallelability	Synchronous control for up to 12 channels (144kW)											
Macro Test Profiles												
Development Source	Touch-Panel, Import from Excel or User's System Controller											
Maximum Steps	1000											
Minimum Time Delay	50uS											
Maximum Step Delay	1mS - 7 Days											
Programming	Range	Accuracy[1]	Res.[1]	Range	Accuracy[1]	Res.[1]	Range	Accuracy[1]	Res.[1]	Range	Accuracy[1]	Res.[1]
Voltage	0-40V	0.1% + 0.1%	0.005%	0-120V	0.1% + 0.1%	0.005%	0-240V	0.1% + 0.1%	0.005%	0-600V	0.1% + 0.1%	0.005%
Current	±600A	0.2% + 0.2%	0.005%	±200A	0.2% + 0.2%	0.005%	±100A	0.2% + 0.2%	0.005%	±40A	0.2% + 0.2%	0.005%
Power	±8/-12kW	0.4% + 0.4%	0.005%	±8/-12kW	0.4% + 0.4%	0.005%	±8/-12kW	0.4% + 0.4%	0.005%	±8/-12kW	0.4% + 0.4%	0.005%
Resistance	0 - 34Ω	2%	0.005%	0 - 100Ω	2%	0.005%	0 - 200Ω	2%	0.005%	0 - 500Ω	2%	0.005%
Slew Rate												
Voltage	0.011V/s – 80V/ms			0.033V/s – 240V/ms			0.066V/s – 480V/ms			0.165V/s – 600V/ms		
Current	0.17A/s – 3000A/ms			0.055A/s – 1000A/ms			0.027 A/s – 500A/ms			0.011 A/s – 40A/ms		
Resistance	0.01Ω/s – 34Ω/ms			0.028Ω/s – 100Ω/m			0.056Ω/s – 200Ω/m			0.14Ω/s – 500Ω/ms		
Power	2W/s – 8kW/s			2W/s – 8kW/s			2W/s – 8kW/s			2W/s – 8kW/s		
Test Measurement (4-Wire)	Range	Accuracy[1]	Res.[1]	Range	Accuracy[1]	Res.[1]	Range	Accuracy[1]	Res.[1]	Range	Accuracy[1]	Res.[1]
Voltage, DC Average	0 -40V	0.05% + 0.05%	0.005%	0 -120V	0.05% + 0.05%	0.005%	0 - 240V	0.05% + 0.05%	0.005%	0 -600V	0.05% + 0.05%	0.005%
Current, DC Average, Amp-Hr	0 - 600A	0.1% + 0.1%	0.005%	0 - 200A	0.1% + 0.1%	0.005%	0 - 100A	0.1% + 0.1%	0.005%	0 - 40A	0.1% + 0.1%	0.005%
Power, Ah, kWh	± 12kW	0.2% + 0.2%	0.005%	± 12kW	0.2% + 0.2%	0.005%	± 12kW	0.2% + 0.2%	0.005%	± 12kW	0.2% + 0.2%	0.005%
Time	1ms - 1Yr	0.1%	0.005%	1ms - 1Yr	0.1%	0.005%	1ms - 1Yr	0.1%	0.005%	1ms - 1Yr	0.1%	0.005%
Control												
Local User Interface	Touch-Panel with graphic meters and controls plus Macro development/execution screens											
Ext. System Communication	LAN (Ethernet)											
Drivers (Win XP or Win 7)	LabVIEW, IVI-COM, IVI-C											
Analog Current Monitor	0 to +10V charge/0 to -10V discharge											
Analog Voltage Monitor	0 to +10V full scale voltage											
Safety												
Isolation AC Input	1000V AC to DC Output / 1000V AC Input to chassis											
Isolation UUT Input	600V UUT to chassis			1000V UUT to chassis			1000V UUT to chassis			1000V UUT to chassis		
Programmable Safety Limits	Over-Voltage (OV) / Under-Voltage (UV), Over-Current (OC), Over-Power (OP)											
Internal Protection	Over/Under-Voltage, Over-Current, Over-Power, Internal Over-Temperature											
Interlocks	External user input, emergency stop, and rear service door											
Watchdog Timer	Continuously monitors control communications											
Physical												
Test Channel Connectors	Buss Bars			Anderson EBC A32			Anderson EBC A32			Anderson SBS75X		
Cabinet[2] Dimensions	72" H x 28" W x 31" D											
Cabinet Weight (3 Channels	1475 Lbs											
Operating Temperature	0 - 35°C full power											
Input Power[3] per Module	3 Ø, 50 - 60Hz, 200VAC/30A, 208VAC/29A, 220VAC/28A, 380VAC/21A or 480VAC/17A											
Calibration	Semi-Automatic , closed cover with standard lab equipment											

[1] All Accuracies are % of Set + % of Range, All Resolutions are % of Range unless otherwise indicated, [2] Standard cabinet contains 1,2 or 3 Modules, [3] Input Voltage set at placement of order

Ordering Information

Typical Configurations	9200-4904-36	9200-4912-36-2	9200-4924-36-3	9200-4960-36-3	9200-4960-36-4
Number of Test Channels[3] Maximum Test Power	3 @ 12kW 36kW	6 @ 12kW 72kW	9 @ 12kW 108kW	9 @ 12kW 108kW	12 @ 12kW 144kW
Power Modules Voltage Maximum Current	4904 40V 1800A	4912 120V 1200A	4924 240V 700A	4960 600V 360A	4960 600V 480A
Number of Cabinets Floor Space Required Cabinet Height	One 28"W x 31"D 72"	Two 56"W x 31"D 72"	Three 84"W x 31"D 72"	Three 84"W x 31"D 72"	Four 112"W x 31"D 72"
Part Number Construction	9200-4912-36-2 4912 – Power Module Selection 36 – kW per cabinet (1 module = 12kW, 2 modules = 24kW, 3 modules = 36kW) 2 – Number of Cabinets				

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