# Battery Emulation for Space Systems

NH Research

**Charger**

*Battery Emulation, Charge/Discharge Managenment*

**Battery Emulation**

*Battery Emulation, Solar Emulation*

**Power Distribution & Management**

*Battery Emulation, AC-DC, DC-DC Power Converter/Inverter Auxiliary Loads, Actuators, Electrical Systems*

**Battery Test**

*Life Cycle, Performance, Charge/Discharge, BMS Development*

As battery technology continues to improve, the demand for higher performing energy storage in space satellite and military missile systems is increasing. Battery emulation can be a valuable and productive approach by dramatically reducing test time, providing more repeatable results, and creating a safer test environment. A satellite has unique power requirements through its lifetime in space including power generation, energy storage and the management of various power sources. Common test platforms for next generation satellites require the ability to emulate various battery capacities with bidirectional source and load capability. The ability to test energy flow in both directions enables a wide range of testing scenarios. Battery emulation is critical for satellite testing applications including: charger systems, power source management, power distribution and battery test.

NH Research provides power test equipment with next generation battery emulation capability to accurately and effectively test power systems used in satellites. The ability to control bi-directional flow of energy allows for the emulation of battery packs in three distinct approaches, below.

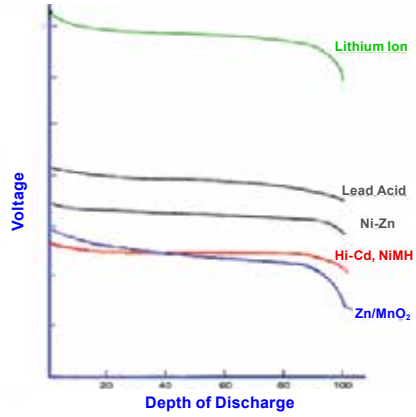
1. Set constant voltage to mimic a battery state of charge.

2. Set series resistance to emulate battery degradation and simulate voltage dynamics due to changes in current.

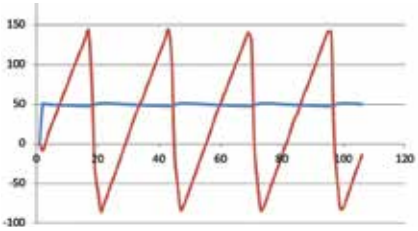
3. Emulate any battery's discharge curves using a simple to use test sequencer such as Enerchron® Test Executive to load variances in specific sequences.

Multi-million dollar satellite systems require constant simulation and testing of both the batteries used in space along with power components such as inverters, converters, auxiliary loads, and actuators that would need to be tested in various conditions including over-limit, and under-limit variances. NHR's battery emulators offer modular configurations, expandable power, integrated safety, wider operating envelopes, built-in measurements, and faster transient response-times for today's and tomorrow's products. NHR's advanced test solutions enable the testing of battery-tied components in the most efficient way by offering a true battery emulator for high powered applications.

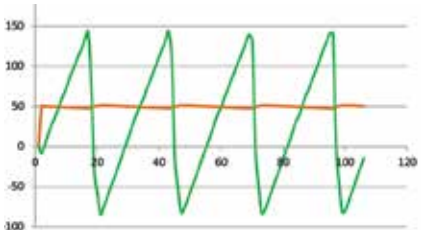
***Image Source:*** *Next generation Space Satellite from Lockheed Martin*




*Various Battery Chemistries can be profiled into NHR's Battery Emulators*



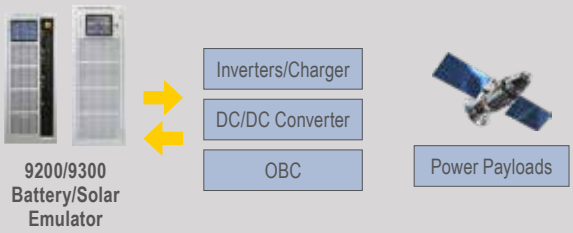
*A. Cycle testing with real 48V battery**



*B. Cycle testing with 48V battery emulator**

** Customer results show a 70% reduction in total test time by replacing real batteries using battery emulation.*

## Charger & Converter Testing




### Battery Emulation to Test Converter/Inverters/OBC

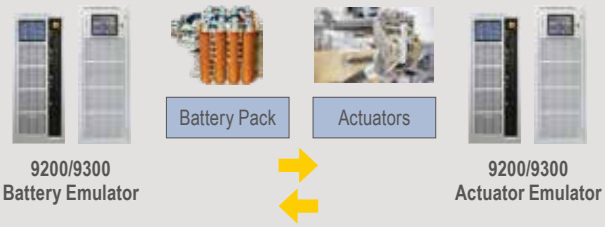
**NHR's Bi-directional Battery Emulators** simulate batteries or photovoltaics (PV) panels for testing inverters, chargers, OBC, and DC/DC converters. Safely test charging by emulating batteries with different voltage, current and power level combinations.

- Battery emulation sinks & sources to maintain voltage regulation
- Built in safety isolation relays & contactors
- Allow testing of over limit & under-limit conditions

**NHR's Bi-directional DC Source** for battery emulation

- 9200 Series - 12 kW modules, parallel up to 21 channels (40, 120, 600 V)
- 9300 Series - 100 kW modules up to 2.4 MW, Dual range (600 V, 1200 V)

## Battery Emulation for Spacecraft Simulation




### Battery System & Actuator Emulation

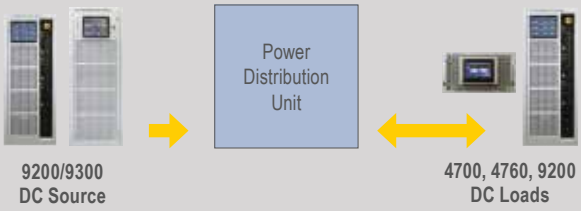
NHR's energy storage test solutions provide a bi-directional approach with the speed and accuracy to emulate real world conditions. Being able to simulate the battery system and the power draws of the satellite actuators ensures maximum reliability with systems testing.

- Battery emulation sinks & sources to maintain voltage regulation
- Isolated input & output paths for multiple layers of safety

**Scalable Bi-directional DC Source** with fast transient speed

- **9200 Series -** 12 kW modules, parallel up to 21 channels (40, 120, 600 V)
- **9300 Series -** 100 kW modules up to 2.4 MW, Dual range (600 V, 1200 V)
- **9200/9300 Series** - Regenerative DC load mode (discharge) > 90%

## Power Management & Satellite Payload Testing




### AC, DC Loads & Sources

NHR offers AC & DC electronic power solutions for testing satellite electrical systems such as satellite payloads, auxiliary loads, switches, electric actuators, PDUs, and Power Conditioning Systems (PCS). Safely test PDUs which route multiple high power sources and loads throughout the satellite.

- Modular power configuration for various payloads
- Fast transient capabilities
- Built in safety isolation relays & contactors
- Allow testing of over limit & under-limit conditions

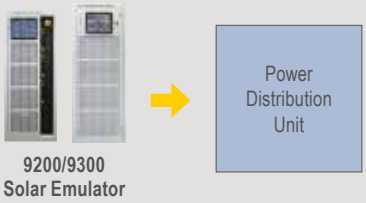
**Bi-directional DC Source** for Battery Emulation

- **9200 Series** - 12 kW modules, parallel up to 21 channels (40, 120, 600 V)
- **9300 Series** - 100 kW modules up to 2.4 MW, Dual range (600 V, 1200 V)

**DC Load** for transient and accessory load inrush simulation

- **4700/4760** - 120 VDC & 600 VDC
- **9200/9300 Series** - Regenerative DC load mode (discharge) > 90%

## Solar Emulator for Spacecraft Simulation




### Solar Emulator

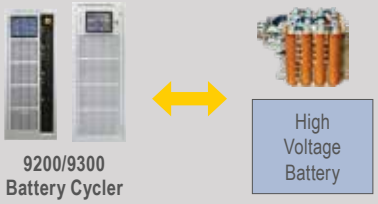
NHR's battery emulators provide emulation of energy storage systems including solar PV arrays. Testing satellites with actual solar arrays is not practical due to the operating conditions. Solar emulation reduces testing time and ensures repeatable results.

- Solar emulation sinks & sources to maintain voltage regulation
- Built in safety isolation relays & contactors
- Allow testing of various solar conditions

**Bi-directional DC Source** for Battery Emulation

- **9200 Series** - 12 kW modules, parallel up to 21 channels (40, 120, 600 V)
- **9300 Series** - 100 kW modules up to 2.4 MW, Dual range (600 V, 1200 V)

## Battery Testing




### Battery Cycler

NHR's battery test systems enable scalable power and flexible configurations for rigorous life-cycle, flight cycle, and performance testing with built-in safety.

- Modular power configuration for traditional & electrical systems
- Fast transient capabilities
- Easy third-party integration & data management (optional software)
- Allow testing of over limit & under-limit conditions

**High Performance Battery Cycler** with fast transient speed

- **9300 Series** - 100 kW modules up to 2.4 MW, Dual range (600 V, 1200 V)
- **9200 Series** - 12 kW modules, parallel up to 21 channels (40, 120, 600 V)

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