Battery Emulation for Space Systems





Charger

Battery Emulation, Charge/Discharge Managenment



Battery Emulation

Battery Emulation, Solar Emulation



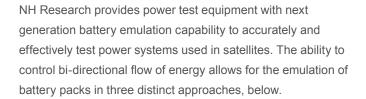
Power Distribution & Management

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.

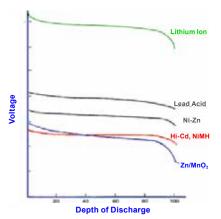


- 1 Set constant voltage to mimic a battery state of charge.
- 2 Set series resistance to emulate battery degradation and simulate voltage dynamics due to changes in current.
- 3 Emulate any battery's discharge curves using a simple to use test sequencer such as Enerchron® Test Executive to load variances in specific sequences.

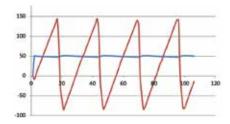
Multi-million dollar satellite systems require constant simulation and testing of both the batteries used in space along with power components such as inverters, converters, auxiliary loads, and actuators that would need to be tested in various conditions including over-limit, and under-limit variances. 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.



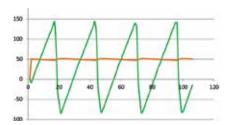
Image Source: Next generation Space Satellite from Lockheed Martin



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

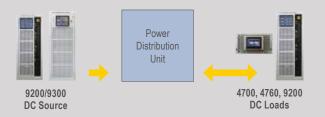
NHR's energy storage test solutions provide a bi-directional approach with the speed and accuracy to emulate real world conditions. Being able to simulate the battery system and the power draws of the satellite actuators ensures maximum reliability with systems testing.

- 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)

