

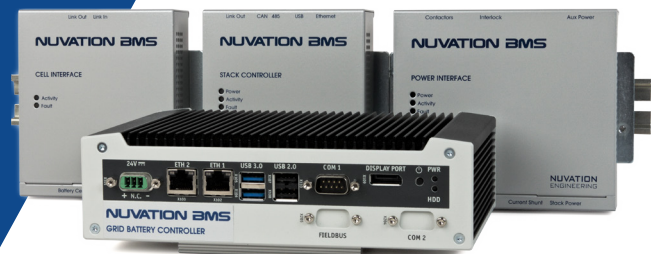
# NUVATION ENERGY



## Nuvation High-Voltage BMS™

A utility-grade battery management system for energy storage

- Maximizes Battery Safety
- Increases Reliability and Uptime
- Data Analytics Gateway
- Enables Remote Management
- Battery Chemistry Configurable



[nuvationenergy.com](http://nuvationenergy.com)







# High-Reliability Battery Management Products

Nuvation battery management systems are designed with modular architectures to enable cost-and performance-optimized scaling. They can be used to manage a range of configurations and voltages, from 12 VDC battery stacks to megawatt-scale systems up to 1250 VDC.





## Battery Chemistry Agnostic

Nuvation BMS™ supports most cell chemistries, including Li-Ion (e.g. LiCoO<sub>2</sub>, LiFePO<sub>4</sub>, LiFeYPO<sub>4</sub>, LiMn<sub>2</sub>O<sub>4</sub>, LiMnO<sub>2</sub>, LiNiCoAlO<sub>2</sub>, LiNiMnCoO<sub>2</sub>, LiPo), Lead-Acid, Zinc, Nickel-Metal Hydride, and others.

## Enables Extended Battery Warranties

Nuvation BMS™ enables battery manufacturers to extend their product warranties by monitoring the battery to ensure it is being operated within product specifications.

## From the Lab to the Field

With over 1000 configurable settings, the same Nuvation BMS™ software and hardware can be used during both battery system development and deployment in the field.

## A highly configurable battery management system for high-voltage applications

Nuvation High-Voltage BMS™ was designed to manage utility-scale energy storage systems up to 1250 VDC and to meet the external communication requirements of smart grids. Designed in conformance with MESA (Modular Energy Storage Architecture) Open Standards for Energy Storage ([mesastandards.org](http://mesastandards.org)), this commercial-grade battery management system meets industry-recognized interoperability standards for utility-scale batteries and inverters.

- **Extends Battery Life** – Communicates with power conversion systems to deliver optimal charge cycling. Modbus TCP supports MESA storage models for connection to power conversion systems as well as to other external systems through multiple concurrent client connections
- **Ensures Pack-Level Safety** – Identifies cells that need servicing or replacement or are being operated outside of manufacturer specifications. Initiates preventive action to protect the battery and ensure safe operation
- **Supports Data Analytics** – Streams measurements and control signals to external server for real-time view and trend data analytics capture
- **Enables Remote Management** – Provides access to ESS management tools from any PC or mobile device. View system performance, make system-wide BMS configuration changes, take down or bring up stacks, update firmware across the entire battery via one interface
- **Highly Configurable** – Over 1000 low-level fine tuning controls enable battery performance optimization and on-the-fly experimentation

The image displays a variety of Nuvation BMS modules. In the foreground, a **GRID BATTERY CONTROLLER** is shown with a digital display showing '33.1' and 'N.C.'. It features ports for ETH 2, ETH 1, USB 3.0, USB 2.0, CAN 1, DISPLAY PORT, FAN, and RS485. Below the ports are terminals for FIELDBUS and CAN 2. In the background, other modules are visible: a **CELL INTERFACE** with Activity and Fault LEDs, a **STACK CONTROLLER** with Power, Activity, and Fault LEDs, a **POWER INTERFACE** with Power, Activity, and Fault LEDs, and a **Control Board** with Control Signal and Stack Power connections. All modules are branded with the **NUVATION BMS** logo and **NUVATION ENGINEERING** text.

The Nuvation High-Voltage BMS™ modules that manage a battery stack include a Stack Controller, Power Interface, and Cell Interface. A typical single-stack system configuration includes one Stack Controller, one Power Interface, and one or more Cell Interfaces connected in series. This modular architecture supports battery pack voltages as high as 1250 VDC. Cell Interface modules can manage up to 16 cells each. One Stack Controller can manage up to 48 Cell Interface modules. The Grid Battery Controller (GBC) manages multi-stack battery configurations by aggregating the Stack Controllers and managing all cells and stacks as a single unified battery.

The diagram illustrates the architecture of a Battery Stack system. On the left, a vertical stack of seven battery modules is shown, each connected to a 'Cell Interface' block. These interfaces are connected to a 'Stack Controller' block via a 'Link Bus'. The 'Stack Controller' is also connected to a 'Power Interface' block and a 'Control & Measurement' block. The 'Stack Controller' has three output lines: 'CAN', 'Modbus RTU', and 'Modbus TCP'. The 'Control & Measurement' block is connected to a 'Grid-Tied Inverter Charger' block via 'B+' and 'B-' lines. The 'Grid-Tied Inverter Charger' is connected to 'Grid Power (AC)' and has a 'Modbus TCP' connection to an 'Ethernet Switch'. This 'Ethernet Switch' is connected to a 'Grid Battery Controller' block via 'Ethernet'. The 'Grid Battery Controller' is also connected to an 'Ethernet Switch' via 'Ethernet'. This second 'Ethernet Switch' is connected to three 'Additional Battery Stacks' via 'Ethernet'.





## Nuvation Energy NvERS™ Software

Nuvation Energy Reliability System™ ("NvERS") Software includes battery management and user control software as well as platform-agnostic (i.e. Windows®, Linux®, iOS®, mobile) performance data reporting and administrator controls.

- Monitor State of Charge (SOC) and State of Health (SOH)
- Ensure optimal battery performance
- View battery performance statistics
- Change configuration settings
- Perform BMS software updates
- Check that all data is propagating correctly through the system

### User-Friendly Operator Interface

Platform-agnostic user interface provides at-a-glance view of:

- **Provides Unified View of Entire Battery** – Access diagnostics and performance data of the entire single- or multi-stack battery
- **Provides Remote Access** – For off-site data analytics and to view or adjust battery operation remotely from a central site. Accessible via Internet browser on PC or mobile device
- **Enables System-Wide Updating** – Can make system-wide BMS configuration changes, update firmware across the entire battery via one interface
- **SOC and SOH** – Displays State of Charge and State of Health for the entire battery
- **Real-Time View** – Streams measurements and control signals for real-time display and recording
- **Statistics View** – Provides pack-level voltage, temperature, and current statistics for all cells
- **Faults and Warnings** – Aggregated for system-wide overview, plus detail drill-down for battery pack diagnostics





## Technical Specifications

### Grid Battery Controller

For large-scale multi-stack battery configurations, the GBC manages all cells and stacks across the entire battery and enables remote monitoring, management, and maintenance of the battery from a single device. Configured in compliance with MESA (Modular Energy Storage Architecture) Open Standards for Energy Storage, the GBC is designed specifically for integration with utility-scale batteries and inverters.

- Collects pack-level voltage, temperature, and current statistics for all cells, SOC and SOH, system-wide faults, warnings, and battery pack diagnostics for the entire battery
- Provides a single entry point to all measurement and control points in the BMS
- Ensures that measurements, control signals, and other data are propagating properly through the entire system
- Streams real-time data to external servers for analytics and trend data capture
- Multi-socket Ethernet interface allows concurrent operation of both local and remote operator panels, data analytics streaming, and Modbus TCP inverter control
- Configurable CAN bus interface for connection to inverters and chargers
- MESA-compliant Modbus TCP for connection to power conversion systems
- Assigns IP addresses to stack controllers automatically to simplify battery bring-up
- Pushes firmware and configuration updates to all BMS modules across entire battery



### Stack Controller

The Stack Controller monitors and controls all Cell Interfaces in a single battery stack. The built-in Stack Bus receives power and communication from the Power Interface. The Link Bus provides power and communication for all connected Cell Interfaces. Ethernet, CAN, and RS-485 (Modbus RTU) connections are included. No high-voltage or high-current interfaces are present on the Stack Controller, making this module easy and safe to connect to for service operations.

- Master controller for the BMS stack
- Communicates with systems outside of the BMS via Modbus TCP (Ethernet), Modbus RTU (RS-485), or CAN bus
- Provides State of Charge and State of Health tracking
- Supports firmware upgrades via Ethernet
- Includes Link Bus interface to Cell Interface module(s)
- Includes Stack Bus interface to Power Interface module
- LEDs provide Power, Activity, and Fault status



## Safety and Reliability

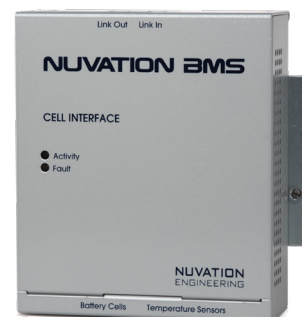
Dual independent processors, one in the Stack Controller and one in the Power Interface, monitor each other to identify potential unsafe/faulty operation in the BMS. Each processor utilizes independent hardware channels which may be configured to open the contactors in the event that one processor fails, to prevent battery cell damage and unsafe operation.



## Cell Interface

The Cell Interface connects to the battery cells and temperature sensors to monitor and balance the cells and sends cell data to the Stack Controller to prevent overheating, overcharging, and overdischarging. Communication and power are provided over the Link Bus.

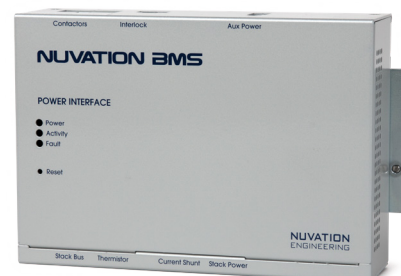
- Stackable architecture supports using multiple Cell Interfaces to support hundreds of cells in series
- Includes internal temperature monitoring of the module plus 8 external sensor inputs for the cells
- Galvanically isolated serial communications between Cell Interfaces and the Stack Controller protect the system from electromagnetic interference and enable floating battery architectures and highly accurate voltage readings
- Up to 60 VDC per Cell Interface
- Provides passive balancing up to 300mA
- Daisy chain architecture; no addressing switches to set
- LEDs provide Activity and Fault status
- Monitors voltage of each cell
- A single module manages up to 12 or 16 cells (depending on the model)



## Power Interface

The Power Interface connects directly to high-voltage and high-current components. It provides system power from an external power input, power conditioning for all Nuvation BMS™ modules, and power for the contactors. The Stack Controller controls all operations on the Power Interface via the Stack Bus.

- Provides operating power for the system, sourced from a 24 VAC/VDC input, which allows full functionality even with fully discharged battery cells
- Monitors stack current via an external temperature-compensated inline current shunt for high accuracy
- Monitors battery stack voltage
- External equipment interlock connector provides contactor enable and E-stop contactor disconnect functions
- LEDs provide Power, Activity, and Fault status
- Includes coil drivers for 4 contactors; 24 VDC provided for contactor coils, optional external coil power input for voltage flexibility



## Customization Options

For clients who need additional customization, Nuvation's BMS engineering team provides system integration services and client-specific customizations such as higher or lower stack voltage input, different connector types, custom form factors, ruggedized enclosures such as IP65, added display capability, hardware and software additions, and support for any other special requirements.



## About Nuvation Energy

Nuvation Energy leverages the power engineering and product design expertise of Nuvation Engineering and our relationships with leading component vendors to deliver high quality energy storage solutions to our clients. In operation since 1997, Nuvation Engineering has completed over 800 electronic design projects. We create highly complex products for environments such as deep sea exploration, space systems, military vehicles, scientific research, and manufacturing facilities.

Nuvation Energy customers are supported by a team of senior power electronics and BMS design engineers who provide hands-on support with system integration and configuration, firmware update roll-outs, and custom energy management engineering services. Our project management and design methodologies have been refined over two decades and include internally developed toolsets and supply chain management processes.

All product development is performed in Canada and the United States.



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