NUVATION
ENERGY

Nuvation Low-Voltage BMS™

An 11-60 VDC battery management system with utility-grade software

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

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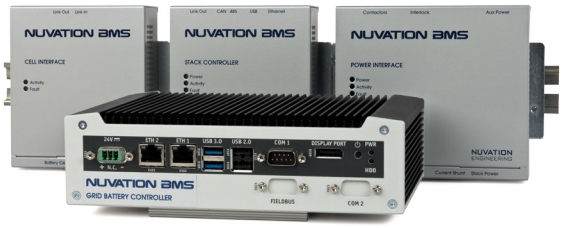
High-Reliability Battery Management Products

Nuvation battery management systems are designed for 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. $LiCoO_2$, $LiFePO_4$, $LiFeYPO_4$, $LiMn_2O_4$, $LiMnO_2$, $LiNiCoAlO_2$, $LiNiMnCoO_2$, 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 low-voltage applications

This enterprise-grade battery management system supports applications such as behind the meter and telecom backup power systems as well as electric vehicles and mobile robots. Built on the same hardware and software platform as Nuvation High-Voltage BMS™ for grid-attached energy storage, this low-voltage BMS has been built to stringent reliability standards and provides unparalleled user access and control.

- **Extends Battery Life** – Communicates with power conversion systems to deliver optimal charge cycling
- **Ensures Battery Safety** – Identifies cells that need servicing or replacement or are being operated outside manufacturer specifications. Initiates preventive action to protect the battery and ensure safe operation
- **Balances Cells** – Provides passive balancing for lithium-ion and other battery chemistries
- **Browser-Based User Interface** – Platform agnostic (Windows®, Linux®, iOS®, mobile) operator interface allows user to view system performance, take down or bring up stack(s), view faults and warnings, update BMS firmware
- **Highly Configurable** – Over 1000 configuration settings deliver highly optimized battery performance on a wide range of battery platforms, and enable custom-tuning of the BMS for target applications
- **Customizable** – Nuvation can add client-specific support and functionality to the BMS to deliver additional features without additional hardware
- **Built-In Wireless Support** – Coming soon: Optional built-in Wi-Fi and Bluetooth support, no external modules required

MESA
Open Standards for Energy Storage

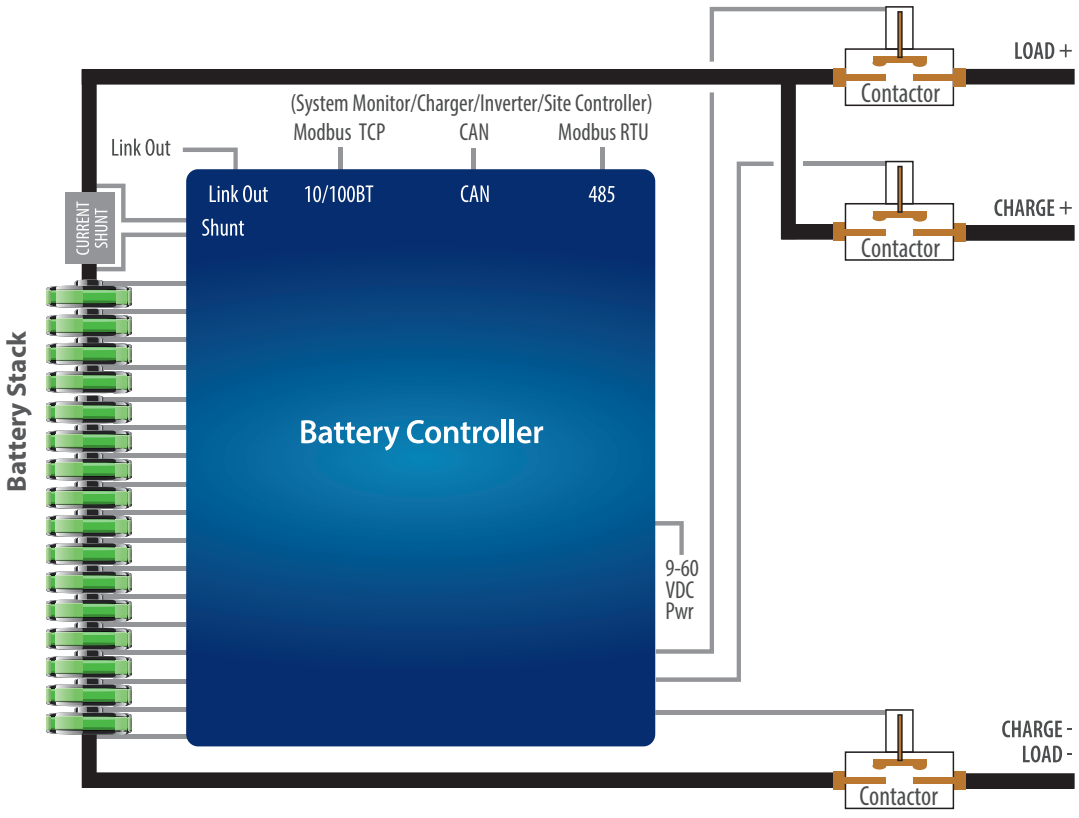
MESA Conformance

Nuvation BMS™ is conformant with the MESA-Device/Sunspec Energy Storage Model. MESA (mesastandards.org) conformant products share a common communications interface that exposes all the data and control points required for operating an energy storage system. This enables Nuvation BMS™ to be integrated with other MESA-conformant energy storage hardware or software without the need for custom middleware.

MESA

Technical Specifications

- Supports total stack voltage ranging from 11-60 VDC
- Cell voltage taps support up to 16 cells
- Supports up to eight temperature sensors
- External communications support for Modbus TCP, Modbus RTU, and CAN
- Multiple stacks can be connected in parallel using an additional hardware module
- Monitors battery stack current via an external temperature-compensated inline current shunt for high accuracy
- Controls up to four contactors
- Includes protection from overvoltage and reverse battery connection
- Four general purpose inputs and four general purpose outputs
- Supports firmware upgrades over Ethernet



51.2V 16s LFP Single Stack System with Charger and Contactors

Nuvation Energy NvERS™ Software

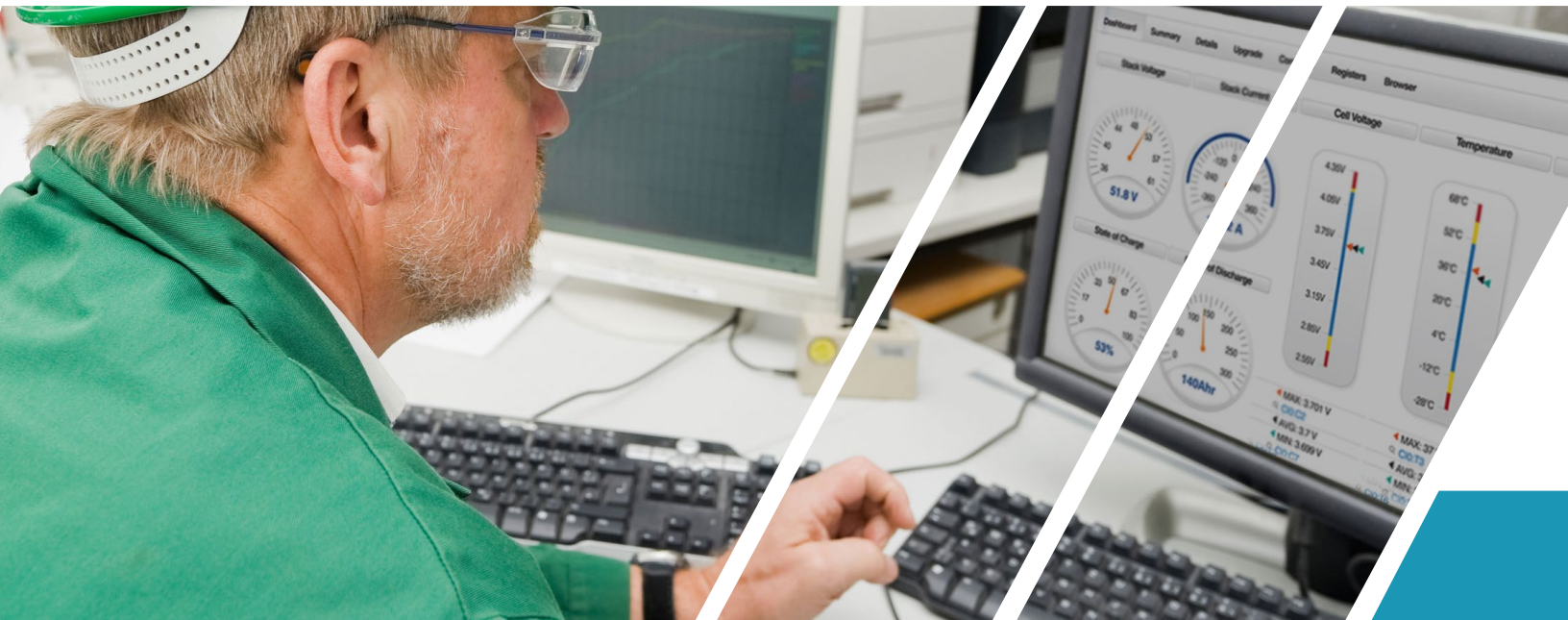
Nuvation Energy Reliability System™ ("NvERS") Software includes battery management and user control software as well as platform-agnostic (i.e. Windows®, Linux®, iOS®, mobile) performance data reporting and administrator controls.

- 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



Target Applications

Nuvation Low-Voltage BMS™ is designed for high-reliability energy storage applications. It includes robust communications support and can be easily integrated into battery packs.

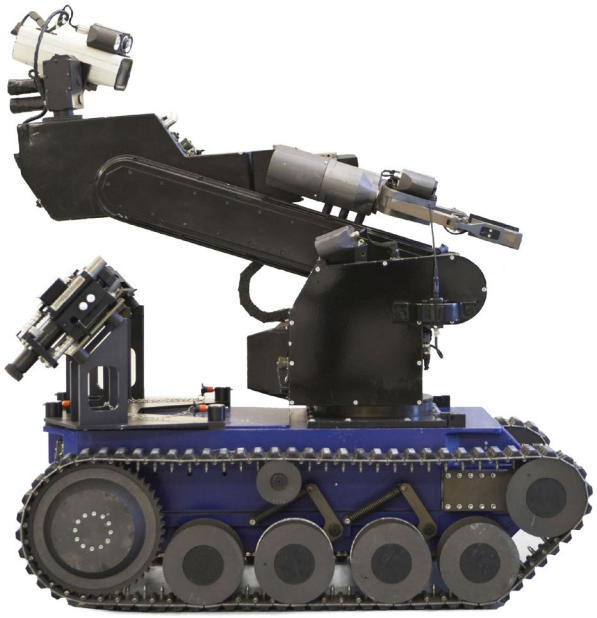
Telecom Backup Power

Interfaces to the BMS are isolated from the battery, which enables the BMS to be integrated with any battery pack regardless of its grounding topology.

Nuvation Low-Voltage BMS™ is chemistry-agnostic and can be used to manage lead-acid battery charging to optimize cell life, as well as to perform remote monitoring of the energy storage unit. This reduces the need to send service personnel to remote telecom towers simply to test the health of the backup battery. Nuvation BMS can identify cells in need of replacement, which is viewable from any computing device or monitoring station.

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.



Mobile Robots

Nuvation BMS™ can connect and disconnect power path contactors, which eliminates the need to include a separate power path controller in the mobile robot.

It also includes user-configurable GPIO (general purpose input / output) that can communicate with a variety of subsystems and be used to control status indicators, or perform functions such as disconnecting the contactors after the battery is fully charged.

Safety and Reliability

Dual independent processors 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.

Specialty Vehicles

Nuvation Low-Voltage BMS can be used to manage both the traction batteries and auxiliary energy storage systems of specialty vehicles. It is available without the enclosure to simplify integration into the vehicle battery system, or Nuvation Energy can create a custom enclosure for a specific target configuration.

The non-proprietary CAN interface can be integrated with most vehicle CAN interfaces, enabling the integration of Nuvation BMS with vehicle chargers, dashboard gauges, motor controllers, etc.

Behind-the-Meter Energy Storage

Nuvation Low-Voltage BMS™ can manage multiple battery stacks by connecting a BMS module to each stack to enable parallelization. This highly optimized approach to parallel stack management enables the cost-efficient scaling of storage applications from kilowatt-hours to megawatt-hours.

Conformance with the MESA-Device Specifications / SunSpec Energy Storage Model means that Nuvation BMS™ can be easily connected to and communicate with other SunSpec-conformant products such as inverters and solar chargers without the need for any custom middleware.

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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