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Nuvation Energy Low-Voltage BMS

Installation Guide

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Important Safety Information

The content in this document must be followed in order to ensure safe operation of Nuvation Energy BMS.

Do **NOT** connect the `J7: Current Shunt / +V Power` connector to the Battery Controller until all other connections have been made.

Properly insulate or remove any unused wires. Unused wires can couple excessive system noise into Nuvation Energy BMS which can disrupt communication and lead to undesirable behaviors.

Please be aware of high voltages present in your system and follow all necessary safety precautions.

The provided module enclosures are not fire enclosures.

Depending on battery chemistry, there might be a nominal voltage per cell which adds up in series and is always present. There are many different battery chemistries with different current capacities, and so high voltage with high current capacity may be present while connecting Nuvation Energy BMS. You must use proper electrical safety precautions when handling any part of Nuvation Energy BMS.

Neither Nuvation Energy or any of its employees shall be liable for any direct, indirect, incidental, special, exemplary, personal or consequential harm or damages (including, but not limited to, procurement or substitute goods or services; loss of use, data, or profits; or business interruption) however caused and on any theory of liability, whether in contract, strict liability, or tort (including negligence or otherwise) arising in any way out of the use of this product.

Nuvation Energy BMS relies on your system charger to charge the battery cells; do not leave your charger off while Nuvation Energy BMS is powered from the stack for prolonged periods of time. Nuvation Energy BMS should be shut down when the system is in storage to minimize the drain on the cells.

1. Introduction

Thank you for choosing Nuvation Energy BMS.

Low-Voltage Battery Controller is an enterprise-grade battery management system with features that extend battery life, ensuring battery safety, and cell balancing.

You can take advantage of the highly configurable browser-based user interface and custom-tune Low-Voltage Battery Controller to your specific target application.

1.1. About this Guide

This *Nuvation Energy Low-Voltage BMS: Installation Guide* provides wiring instructions to connect your Low-Voltage Battery Controller to your system.

Once you have successfully completed the installation process, please follow instructions in the *Operator Interface Manual* for accessing and configuring the Nuvation Energy BMS Operator Interface for the Battery Controller.

We thrive on your feedback and what we build is driven by your input. Please submit support tickets to support@nuvationenergy.com.

2. System Overview

The Nuvation Energy Low-Voltage BMS is a complete battery management system that provides cell balancing and charge management for virtually any battery chemistry using a Battery Controller. The Battery Controller is designed for input voltage of 11-60 V DC. It can manage up to 12 or 16 battery cells in series, and can be expanded to manage additional cells with a Nuvation Energy Cell Interface module.

An example 12 or 16 channel configuration is shown in Figure 1. This configuration requires a single Battery Controller.

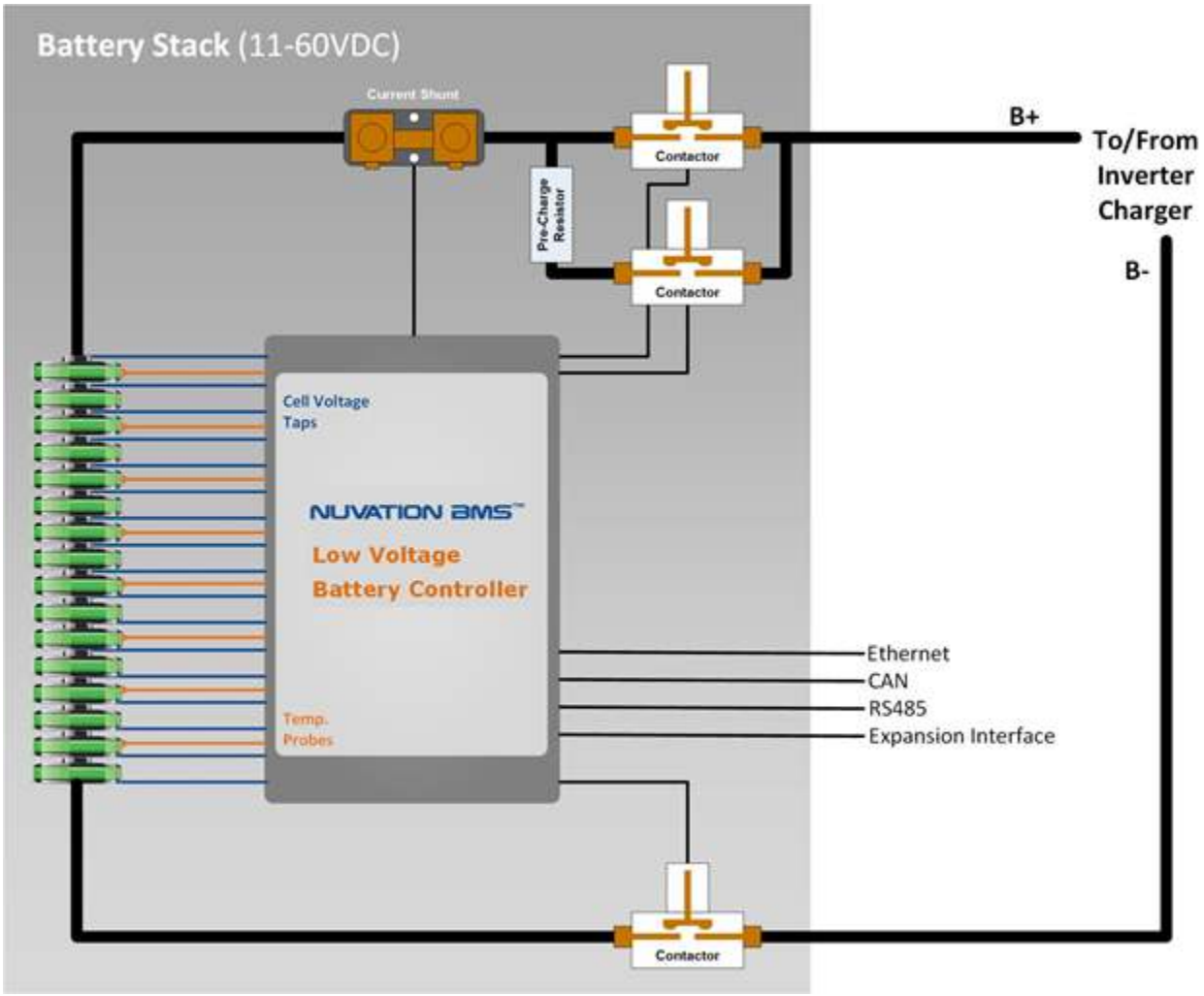


Figure 1. Nuvation Energy Low-Voltage BMS System Overview

An example 24-channel configuration is shown in Figure 2. This configuration requires a Battery Controller and a Cell Interface. Please see Section 4.1 for more details.

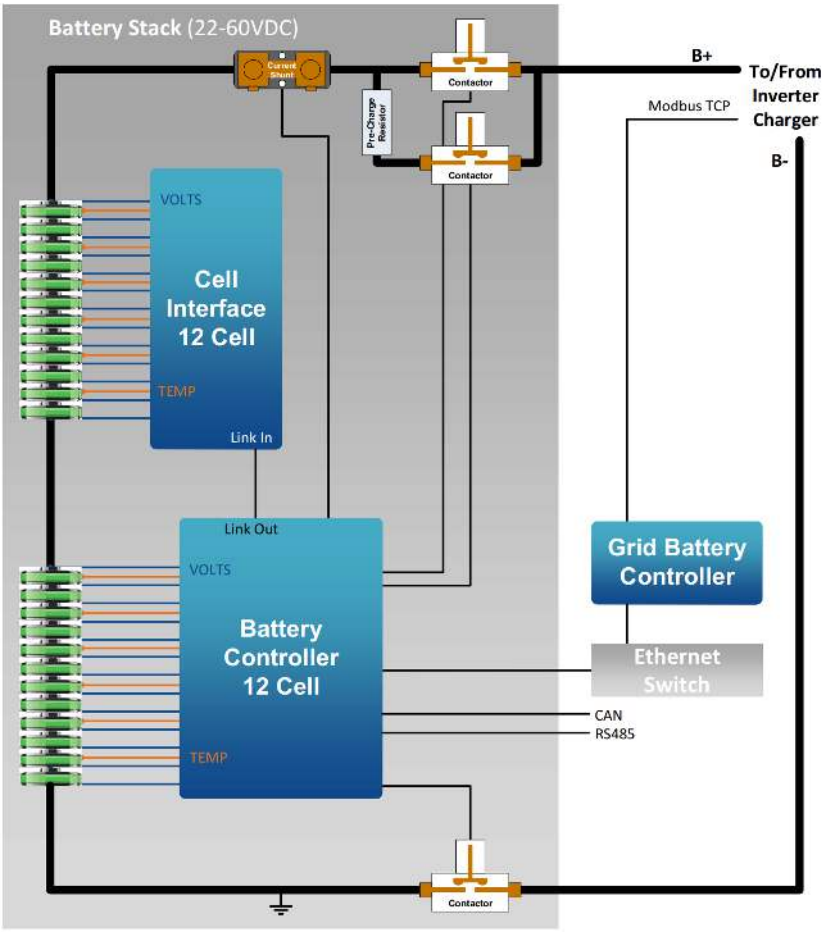


Figure 2. Low-Voltage BMS System Overview: 24-channel Application

3. Battery Controller

3.1. Overview

The Nuvation Energy Low-Voltage Battery Controller safely manages up to 12 or 16 cells by measuring cell voltage, temperature and current and applying software decision-making to control contactors, communicate with energy storage controllers, and interface with general purpose I/O.

The Battery Controller is able to operate as a stand-alone battery management system, requiring no additional Nuvation Energy BMS modules to manage a stack of up to 12 or 16 cells. Nuvation Energy Cell Interface may be used to increase the stack size in systems that are rated less than 60 V DC.

The Battery Controller is available in two models:

- The NUV300-BC-12 which can monitor up to 12 series-connected cells
- The NUV300-BC-16 which can monitor up to 16 series-connected cells

3.2. GPIO Block

The GPIO and control inputs are accessible at the `J5: Control / GPIO connector`.

The general-purpose outputs from the Battery Controller are implemented using optical MOSFET switches. These outputs are non-polarized, presenting an on-resistance of typically 2 Ω and capable of carrying 400 mA of DC or RMS current when activated. Figure 3 shows a high level circuit diagram for the GPO pins.

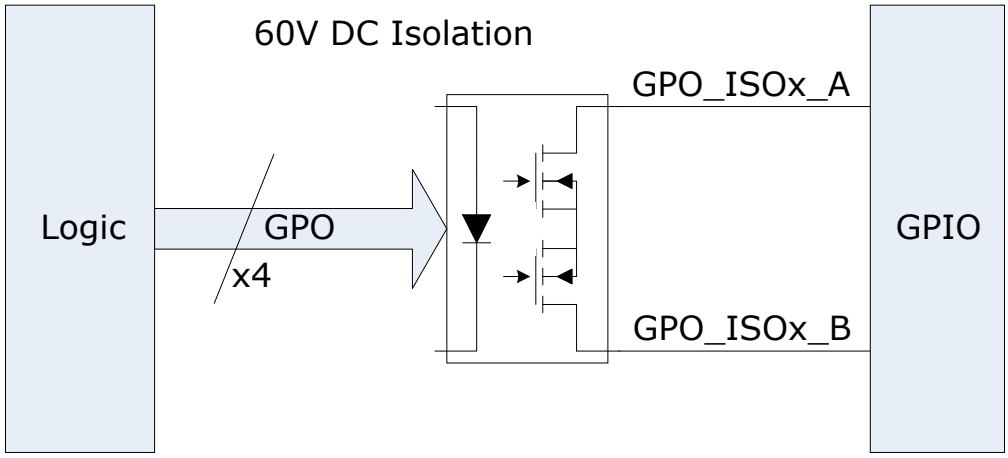


Figure 3. GPIO Circuit Diagram

The general-purpose and specific-purpose (`FAULT_CLEAR`, `FACTORY_RESET`, `SHUTDOWN`) inputs to the Battery Controller are implemented using optical isolation components. The current source for these inputs is provided in the Battery Controller and each input is activated by providing a simple contact closure to the common point.

The *BMS Enable* input differs slightly from the other specific-purpose inputs. This control requires a contact closure between the `BMS_ENABLE#` and `VBOT` signals and must not be referenced to the common point of the other inputs. It is used to start the Battery Controller after it has been shut down due to

activation of the SHUTDOWN input, low battery, or some other condition invoked under software control. BMS_ENABLE# is pulled up to the battery stack positive (potentially 60 V away from VBOT) so the switch/external controller must be tolerant of the maximum battery stack voltage.

3.3. CAN Bus and RS485 / Modbus RTU Block

The CAN Bus communication channel is available on the J3: CAN connector. The RS485 / Modbus RTU communication channel is available on the J4: RS485 / Modbus RTU connector.

These communication channels are isolated from the battery stack and share their common reference with each other, with the general-purpose I/O, and with the specialized control inputs. A 120 Ω bus termination is required on each end of the bus for these communication channels. Termination is not provided within the Battery Controller on stock production units.

3.4. Power Supply, Current Shunt, and Contactor Drivers

Operating power, including primary power source for operating the contactor coils, is connected to the Battery Controller at two connectors: positive to the J7: Current Shunt / +V Power connector, and negative to the J6: Contactors / -V Power connector.

The current shunt, which is connected in series with the battery stack at the positive end, connects its sense points to the Battery Controller at the J7: Current Shunt / +V Power connector.

Up to 4 system contactors may be connected and controlled by the Battery Controller, connecting to the Battery Controller at the J6: Contactors / -V Power connector.

3.5. Mechanical Dimensions

The overall dimensions of the Battery Controller are 220 mm X 125 mm X 30 mm. Extra space should be provided around the module to allow for easy installation/maintenance.

Dimensions in the diagram below are shown in inches

The Battery Controller should be securely mounted in a vertical orientation, in an environment that permits free movement of air through all ventilation slots for convection cooling. The Cell Connections connector (J1) should be facing up or to the left. If it is to be used with a battery chemistry such as lead-acid, which does not require balancing, the Battery Controller may be mounted horizontally, with the ventilation slots oriented upwards. It is not advisable to mount the Battery Controller on the underside of a horizontal surface.

The Low-Voltage Battery Controller weighs approximately 400 g.

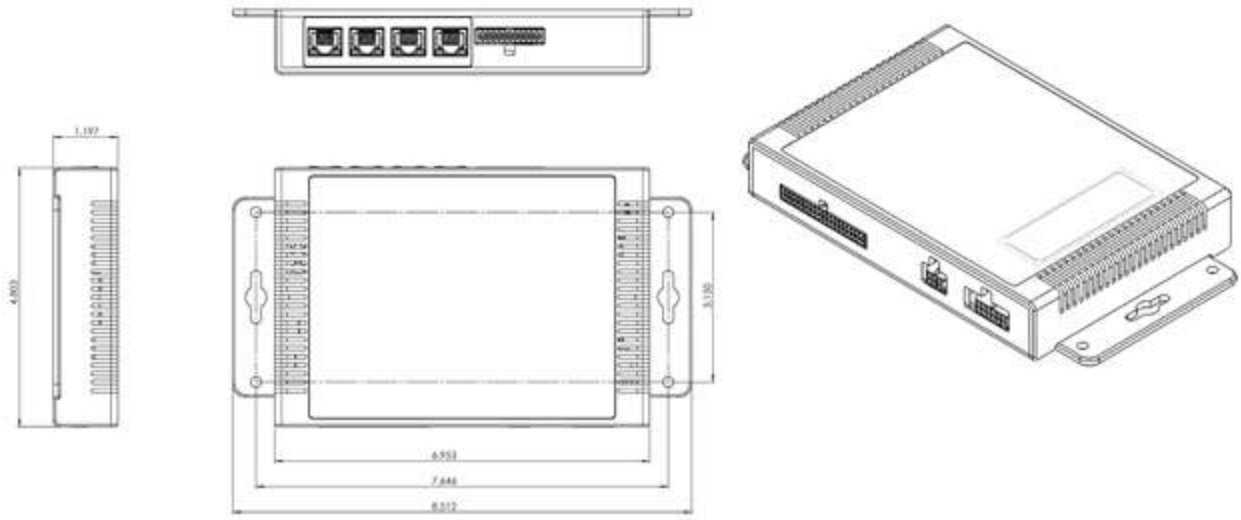


Figure 4. Mechanical Drawing of Battery Controller

3.6. Electric Connections

3.6.1. Overview

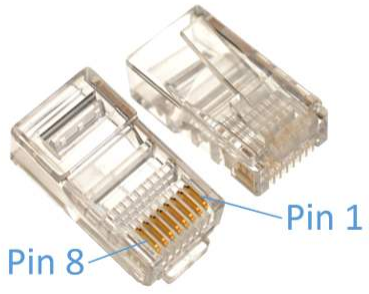
The Battery Controller module has eight connectors. Each connector is described in the following sections in detail.

3.6.2. J1: Link Out

In certain situations, it may be required to monitor more than 16 cells in series, such as with 2V lead-acid cells. This connector is used to connect to an additional Cell Interface module to manage more cells and thermistors. See Section 4.1 for installation instructions for the Cell Interface.

Table 1 describes a typical compatible plug for the `J1: Link Out` jack.

Table 1. RJ-45 Plug Details



Conec 391J00039X	
Manufacturer	Conec
Housing	391J00039X

Housing material	Polycarbonate UL94V-0
Circuits	8
Crimp terminal	insulation displacement
Wire gauge range	AWG24-26 stranded or solid

The `Link Out` interface connector is a standard RJ45 Cat5e rated jack. This interface is used to connect the Battery Controller module to an expansion Cell Interface module to provide monitoring for additional battery cells and thermistors.

Table 2. Link Out Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	No Connect	Not Connected	No Connect
2	No Connect	Not Connected	No Connect
3	No Connect	Not Connected	No Connect
4	No Connect	Not Connected	No Connect
5	No Connect	Not Connected	No Connect
6	No Connect	Not Connected	No Connect
7	LINKBUS_N	Link Bus differential pair negative	Cell Interface
8	LINKBUS_P	Link Bus differential pair positive	Cell Interface

3.6.3. J2: Ethernet / Modbus TCP

The Ethernet / Modbus TCP jack is a standard RJ45 Cat5e rated jack. This interface is used as the primary means of connecting an external system to the Battery Controller to configure the operating parameters, observe the status, and perform maintenance such as firmware upgrades.

Table 1 describes a typical compatible plug for the `J2: Ethernet / Modbus TCP` jack.

Table 3. Ethernet / Modbus TCP Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	TD_P	Transmit differential pair positive	External Equipment
2	TD_N	Transmit differential pair negative	External Equipment
3	RD_P	Receive differential pair positive	External Equipment
4	NUL45	Unused; connected to Pin 5 and terminated	External Equipment
5	NUL45	Unused; connected to Pin 4 and terminated	External Equipment
6	RD_N	Receive differential pair negative	External Equipment
7	NUL78	Unused; connected to Pin 8 and terminated	External Equipment
8	NUL78	Unused; connected to Pin 7 and terminated	External Equipment

3.6.4. J3: CAN

The CANBus 2.0 connector is a standard RJ45 Cat5e rated jack. This interface provides an isolated

CANBus 2.0 port.

CANBus termination is not provided within the Battery Controller on stock production units. Standard 120 Ω termination must be installed at each end of the CANBus network.

Table 1 describes a typical compatible plug for the `J3: CAN` jack.

Table 4. CANBus RJ45 Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	CAN_P	CAN bus differential pair positive	External Equipment
2	CAN_N	CAN bus differential pair negative	External Equipment
3	COMIO	Common reference shared with GPIO	External Equipment
4	No Connect	Not Connected	No Connect
5	No Connect	Not Connected	No Connect
6	No Connect	Not Connected	No Connect
7	COMIO	Common reference shared with GPIO	External Equipment
8	No Connect	Not Connected	No Connect

3.6.5. J4: RS485 / Modbus RTU

The RS-485 connector is a standard RJ45 Cat5e rated jack. This interface provides an isolated RS-485 (Modbus-RTU) port.

RS485 termination is not provided within the Battery Controller on stock production units. Standard 120 Ω termination must be installed at each end of the Modbus-RTU network.

Table 1 describes a typical compatible plug for the `J4: RS485 / Modbus RTU` jack.

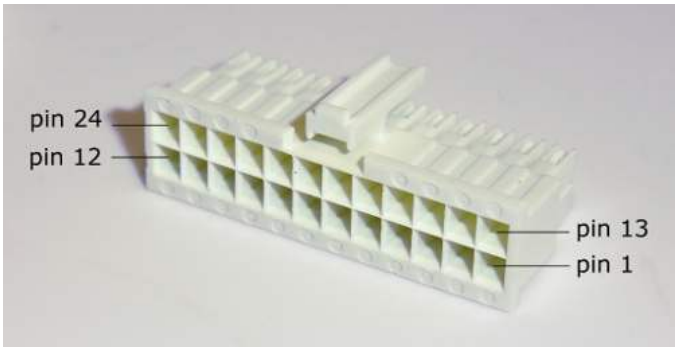
Table 5. RS485 / Modbus RJ45 Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	No Connect	Not Connected	No Connect
2	No Connect	Not Connected	No Connect
3	No Connect	Not Connected	No Connect
4	MODBUS_P	MODBUS differential pair positive	External Equipment
5	MODBUS_N	MODBUS differential pair negative	External Equipment
6	No Connect	Not Connected	No Connect
7	No Connect	Not Connected	No Connect
8	COMIO	Common reference shared with GPIO	External Equipment

3.6.6. J5: Control / GPIO

Table 6 describes the recommended plug and crimp terminals to be used with the `J5: Control / GPIO connector`.

Table 6. J5: Control / GPIO plug housing and terminal details



Samtec IPD1-12-D	
Manufacturer	Samtec Inc
Housing	IPD1-12-D
Housing material	Nylon (Zytel® PA66) UL94V-2
Circuits	24
Crimp terminal	CC79R-2024-01-L
Wire gauge range	AWG20-24 stranded

This interface provides connections to isolated general purpose inputs and outputs, and also specific function inputs that can be used to:

- Enable the power supply
- Invoke or force a system shutdown
- Clear system faults
- Invoke a factory reset

The functionalities of the general purpose inputs and outputs are configured by the end-user to match their needs.

Table 7. GPI, GPO, and Special Function Connector Pin Assignment

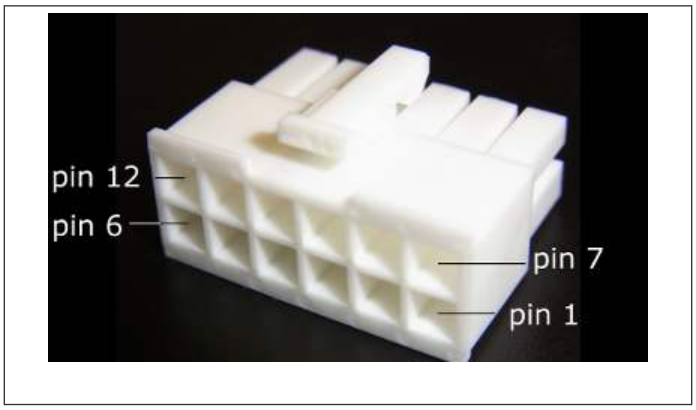
Pin	Connection	Description	Connected to Device
1	GPO_ISO0_A	Digital Output 0	External Equipment
2	GPO_ISO1_A	Digital Output 1	External Equipment
3	GPO_ISO2_A	Digital Output 2	External Equipment
4	GPO_ISO3_A	Digital Output 3	External Equipment
5	+5V_GPIO_ISO	Isolated +5V I/O Power Supply	External Equipment
6	GPI_ISO0_K	Input detector 0	External Equipment
7	GPI_ISO1_K	Input detector 1	External Equipment
8	GPI_ISO2_K	Input detector 2	External Equipment
9	GPI_ISO3_K	Input detector 3	External Equipment
10	FAULT_CLEAR#	Momentary to COMIO to clear faults	Processor GPI via logic elements

Pin	Connection	Description	Connected to Device
11	FACTORY_RESET#	Hold to COMIO during startup to perform a factory reset	Processor GPI via logic elements
12	BMS_ENABLE#	Momentary to VBOT to enable BMS; Hold to VBOT to defeat Shutdown	Power supply enable gate
		NOTE: different reference from other inputs	
13	GPO_ISO0_B	Digital Output 0	External Equipment
14	GPO_ISO1_B	Digital Output 1	External Equipment
15	GPO_ISO2_B	Digital Output 2	External Equipment
16	GPO_ISO3_B	Digital Output 3	External Equipment
17	COMIO	Isolated I/O Power Supply Common Reference	External Equipment
18	COMIO	Isolated I/O Power Supply Common Reference	External Equipment
19	COMIO	Isolated I/O Power Supply Common Reference	External Equipment
20	COMIO	Isolated I/O Power Supply Common Reference	External Equipment
21	COMIO	Isolated I/O Power Supply Common Reference	External Equipment
22	COMIO	Isolated I/O Power Supply Common Reference	External Equipment
23	SHUTDOWN#	Momentary to COMIO to invoke shutdown; Hold to COMIO to force shutdown	Processor GPI via logic elements, hard shutdown (no software) via logic elements with longer press
24	VBOT		VBOT

3.6.7. J6: Contactors / -V Power

Table 8 describes the recommended plug and crimp terminals to be used with the `J6: Contactors / -V Power` connector.

Table 8. J6: Contactors / -V Power plug housing and terminal details



Molex 39-01-2125	
Manufacturer	Molex Incorporated
Housing	39-01-2125
Housing material	Nylon UL94V-0
Circuits	12
Crimp terminal	39-00-0073
Wire gauge range	AWG18-24 stranded

This interface is used to drive up to 4 external contactor coils and to select their power source. The negative operating power is provided in a fused connection to this connector (fuses not provided).

Connecting to Contactor Coils

The Battery Controller provides coil drivers for contactor coils up to 24 V DC. The internal 24 V power supply of the Battery Controller may be used to power the coils if the following conditions are satisfied:

- 24 V coils are connected
- The worst-case coil inrush current is below 1.5 A
- The sum of all connected coil currents is less than 1 A

To use the internal power supply, connect together pins 11 (`+VCOIL`) and 12 (`+24V`) of J6 to deliver +24 V to the `+VCOIL` input. Pin 5 (`VCOIL_RETURN`) is left disconnected and should be insulated to prevent shorts.

Other coil voltages in the 12V-24 V range and total currents of up to 1.5 A per coil may be supported through the use of an external DC power source. Such a supply must be connected between `+VCOIL` (pin 11) and `VCOIL_RETURN` (pin 5) of `J6`.

As depicted in Figure 14, if an external power supply is used to power the Battery Controller instead of the battery stack, the `VCOIL_RETURN` (pin 5) connection of `J6` must be externally connected to the bottom of the battery stack. If using a dedicated external power supply to power the contactor coils, connect the common return of that supply to this pin.

Coil back-EMF protection is provided by the Battery Controller that clamps at 40 V. External clamping diodes of lower voltages may be connected if required.

The bottom of the attached battery stack is internally connected to the common return path for all contactor coils (pins 1~5 of `J6`). It is recommended that no ground connection be made at the coils to avoid creating an inadvertent ground fault or ground loop.

Contactor coils are to be connected between the `COILn_HI` and COM pins of `J6` as required. When the Battery Controller activates a contactor, the `COILn_HI` output is driven to a `VCOIL` voltage level.

Unused contactor coil wires should be properly insulated or removed. Refer to Figure 13 and Figure 14 for use of the `VPOWER` connection at `J6`.

Contactor coils, internal and external supply connections to `J6` are shown in Figure 5 and Figure 6.

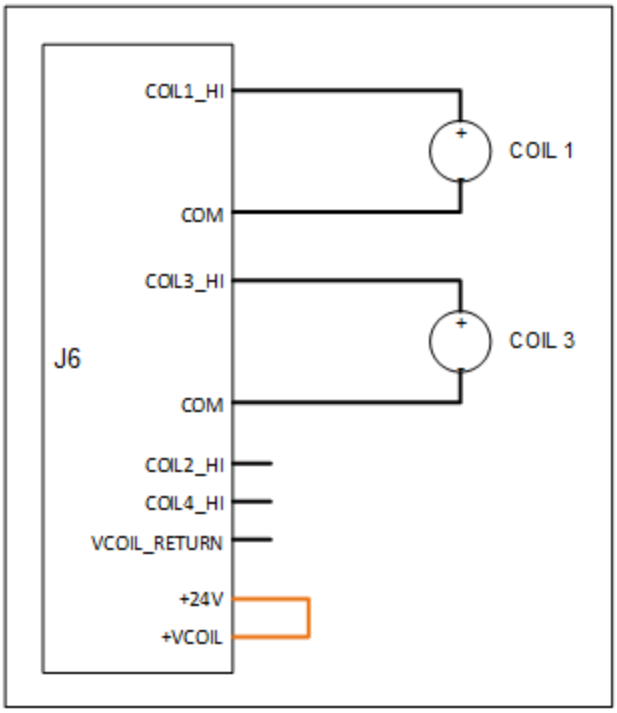


Figure 5. Connection to J6: Two 24V contactor coils powered from internal supply

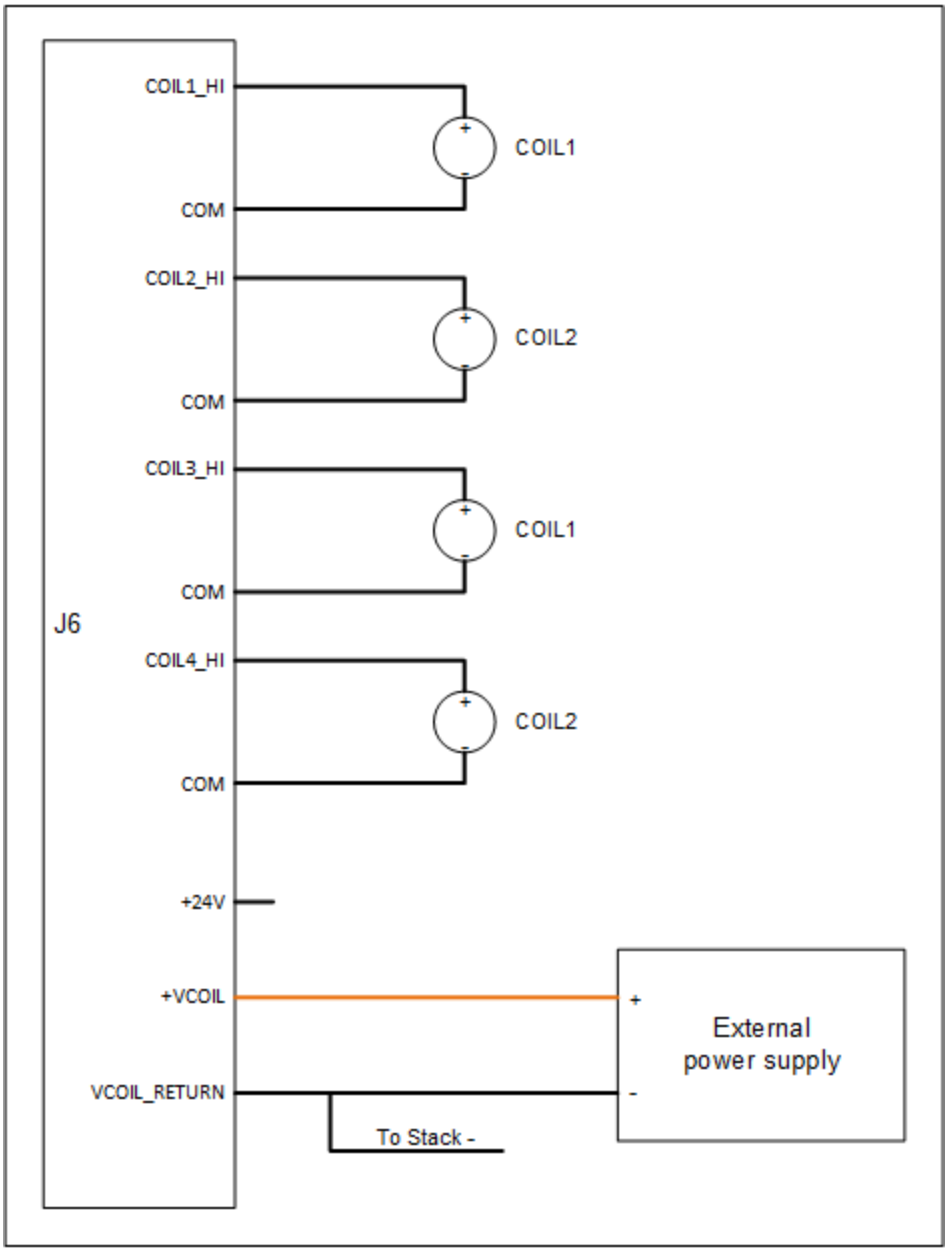


Figure 6. Connection to J6: Four contactor coils powered from external supply

Table 9. Stack Power Return and Contactors Connector Pin Assignment

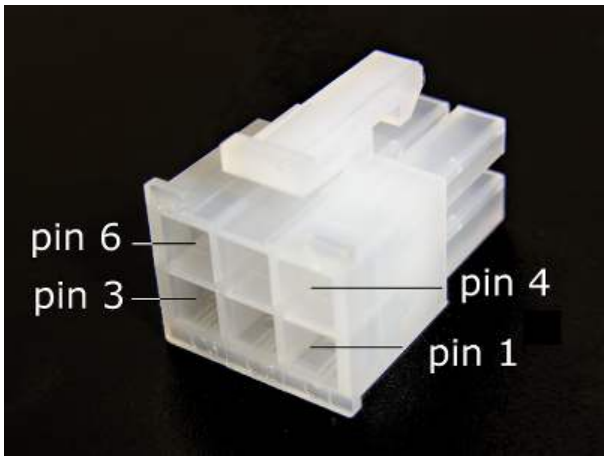
Pin	Connection	Description	Connected to Device
1	COM	Negative Coil 1	Contactor 1 negative coil connection
2	COM	Negative Coil 2	Contactor 2 negative coil connection
3	COM	Negative Coil 3	Contactor 3 negative coil connection
4	COM	Negative Coil 4	Contactor 4 negative coil connection

Pin	Connection	Description	Connected to Device
5	VCOIL_RETURN	Negative reference for external supply	External Power Supply. Refer to Figure 13 and Figure 14 for additional requirements
6	-VPOWER	Power return of Battery Controller	Bottom of Stack
7	COIL1_HI	Positive Coil 1	Contactor 1 positive coil connection
8	COIL2_HI	Positive Coil 2	Contactor 2 positive coil connection
9	COIL3_HI	Positive Coil 3	Contactor 3 positive coil connection
10	COIL4_HI	Positive Coil 4	Contactor 4 positive coil connection
11	+VCOIL	12~24V Contactor Coil Power Supply	Connect to external power supply, or to pin 12 if driving contactor coil from internal power supply
12	+24V	Internal Power Supply	Connect to pin 11 if driving contactor coils from internal power supply

3.6.8. J7: Current Shunt / +V Power

Table 10 describes the recommended plug and crimp terminals to be used with the `J7: Current Shunt / +V Power` connector.

Table 10. J7: Current Shunt / -V Power plug housing and terminal details



Molex 39-01-2065	
Manufacturer	Molex Incorporated
Housing	39-01-2065
Housing material	Nylon UL94V-0
Circuits	6

Crimp terminal	39-00-0073
Wire gauge range	AWG18-24 stranded

This interface is used to connect the current shunt to the Battery Controller. The positive operating power is provided in a fused connection to this connector (fuses not provided).

This connection must only be made after all other connections to the Battery Controller have been made.

Connecting to a Current Shunt

The Battery Controller requires the shunt to be on the high side (positive end) of the battery stack. The VSHUNT_REF signal is used to compensate for the voltage drop in the sense wires as well as to provide the positive reference for measuring the overall voltage of the stack. VSHUNT_BAT and VSHUNT_LOAD carry the differential voltage measurement from the shunt. VSHUNT_BAT must be closest to the battery cells and VSHUNT_LOAD must be closest to the Stack Fuse so that the measured current has the correct polarity. To minimize outside interference, twist VSHUNT_LOAD and VSHUNT_BAT together to form a twisted pair, then run all 3 wires close together.

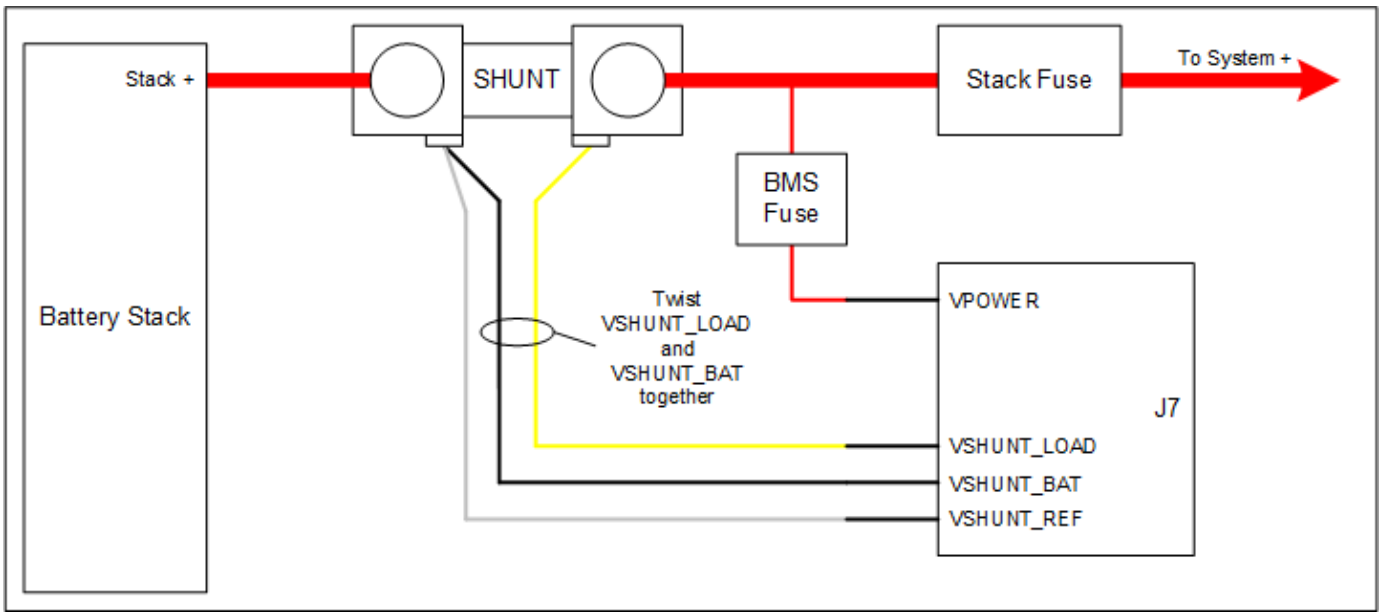


Figure 7. Current shunt and Power fuse connection to J7

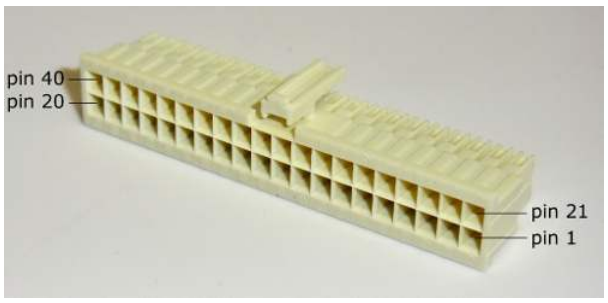
Table 11. Current Shunt Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	+VPOWER	Main power supply input	Positive end of the stack or other power source
2	No Connect	Not Connected	No Connect
3	No Connect	Not Connected	No Connect
4	VSHUNT_LOAD	Differential voltage input; Load side	Load side of current shunt
5	VSHUNT_BAT	Differential voltage input; Battery side	Battery side of current shunt
6	VSHUNT_REF	Voltage reference for voltage measurement	Battery side of current shunt

3.6.9. J8: Cell Voltage / Temperature

This interface is used to connect the battery cell voltage sense wires as well as up to eight 10 kΩ NTC thermistors to the Battery Controller module.

Table 12. J8: Cell Voltage / Temperature plug housing and terminal details



Samtec IPD1-20-D	
Manufacturer	Samtec Inc
Housing	IPD1-20-D
Housing material	Nylon (Zytel® PA66) UL94V-2
Circuits	40
Crimp terminal	CC79R-2024-01-L
Wire gauge range	AWG20-24 stranded

Battery Cell Connections

The following two models of the Battery Controller are available, supporting a variety of cell counts and voltage ranges:

NUV300-BC-12: Connected cells are monitored internally by a single functional block. This functional block requires a minimum stack voltage of 11 V to operate and measure its input voltages. The total voltage across the stack can be up to 60 V. Unused cell tap wires should be connected to the last cell in the stack. See Figure 8 and Figure 9 for examples of how to connect cells to the NUV300-BC-12.

NUV300-BC-16: Connected cells are monitored internally by two functional blocks, each measuring

eight cells (C0 to C8 and C8 to C16). Each functional block requires a minimum of 11 V across it to operate and measure its input voltages. The total voltage across the stack can be up to 60 V. See Figure 10, Figure 11 and Figure 12 for examples of how to connect cells to the NUV300-BC-12.

Groups do not need to contain the same number of cells but the maximum and minimum voltage limits must be met, as stated in Table 13.

Table 13. Battery Controller supported cell connections

Battery Controller	Cell groups	Max cell inputs per group	Max cell voltage per input	Max total voltage across group	Max total voltage across all groups	Min voltage per group
NUV300-BC-12	1	12	5V	60V	60V	11V
NUV300-BC-16	2	8	5V	40V	60V	11V

The same style of connector is used for cell voltage and temperature sensor connection in both the NUV300-BC-12 and NUV300-BC-16. The names of the pins for the J8 connector are given in Table 14.

Table 14. Battery Cell Voltage and Temperature Probes connector pin assignment

Pin	Connection	Description	Connected to Device
1	TPROBE1	External Temperature Probe Input 1	10 kΩ NTC Thermistor
2	VBOT_TEMP	External Temperature Probe Reference 1	10 kΩ NTC Thermistor
3	TPROBE2	External Temperature Probe Input 2	10 kΩ NTC Thermistor
4	VBOT_TEMP	External Temperature Probe Reference 2	10 kΩ NTC Thermistor
5	TPROBE3	External Temperature Probe Input 3	10 kΩ NTC Thermistor
6	VBOT_TEMP	External Temperature Probe Reference 3	10 kΩ NTC Thermistor
7	TPROBE4	External Temperature Probe Input 4	10 kΩ NTC Thermistor
8	VBOT_TEMP	External Temperature Probe Reference 4	10 kΩ NTC Thermistor
9	TPROBE5	External Temperature Probe Input 5	10 kΩ NTC Thermistor
10	VBOT_TEMP	External Temperature Probe Reference 5	10 kΩ NTC Thermistor
11	TPROBE6	External Temperature Probe Input 6	10 kΩ NTC Thermistor
12	VBOT_TEMP	External Temperature Probe Reference 6	10 kΩ NTC Thermistor
13	TPROBE7	External Temperature Probe Input 7	10 kΩ NTC Thermistor
14	VBOT_TEMP	External Temperature Probe Reference 7	10 kΩ NTC Thermistor
15	TPROBE8	External Temperature Probe Input 8	10 kΩ NTC Thermistor
16	VBOT_TEMP	External Temperature Probe Reference 8	10 kΩ NTC Thermistor
17	NC	No connect	
18	NC	No connect	
19	NC	No connect	
20	NC	No connect	
21	NC	No connect	
22	NC	No connect	

Pin	Connection	Description	Connected to Device
23	VCELL16	Cell 16 voltage sense	Connect to positive terminal of Cell 15
24	VCELL15	Cell 15 voltage sense	Connect to positive terminal of Cell 14
25	VCELL14	Cell 14 voltage sense	Connect to positive terminal of Cell 13
26	VCELL13	Cell 13 voltage sense	Connect to positive terminal of Cell 12
27	VCELL12	Cell 12 voltage sense	Connect to positive terminal of Cell 11
28	VCELL11	Cell 11 voltage sense	Connect to positive terminal of Cell 10
29	VCELL10	Cell 10 voltage sense	Connect to positive terminal of Cell 9
30	VCELL9	Cell 9 voltage sense	Connect to positive terminal of Cell 8
31	VCELL8	Cell 8 voltage sense	Connect to positive terminal of Cell 7
32	VCELL7	Cell 7 voltage sense	Connect to positive terminal of Cell 6
33	VCELL6	Cell 6 voltage sense	Connect to positive terminal of Cell 5
34	VCELL5	Cell 5 voltage sense	Connect to positive terminal of Cell 4
35	VCELL4	Cell 4 voltage sense	Connect to positive terminal of Cell 3
36	VCELL3	Cell 3 voltage sense	Connect to positive terminal of Cell 2
37	VCELL2	Cell 2 voltage sense	Connect to positive terminal of Cell 1
38	VCELL1	Cell 1 voltage sense	Connect to positive terminal of the lowest cell in the 12 or 16 cell module
39	VCELL0	Bottom of stack reference	Connect to negative terminal of the lowest cell in the 12 or 16 cell module
40	VSTACK_SENSE	Voltage sense reference	Connect to negative terminal of the lowest cell in the 12 or 16 cell module

Connecting to a Battery Controller - 12 channel (NUV300-BC-12)

Refer to Table 14 for the pin name assignment of the cell voltage and temperature sensor connector J8 for the NUV300-BC-12.

Connecting to the NUV300-BC-12 is very straightforward since all connected cells belong to a single

group.

It is important to connect all cells in ascending voltage order, such that the negative terminal of the most negative (bottom) cell connects to `VCELL0` of `J8`, and the positive terminal of each cell connects in ascending voltage order to `VCELL1`, `VCELL2`, etc. If fewer than 12 cells are connected, then the top cell and all unused cell inputs between the top cell and `VCELL12` must be connected to `VCELL12`. Inputs `VCELL13` through `VCELL16` may be left disconnected, as shown in Figure 9.

Use a separate wire to connect input `VSTACK_SENSE` to the negative end of the most negative (bottom) cell.

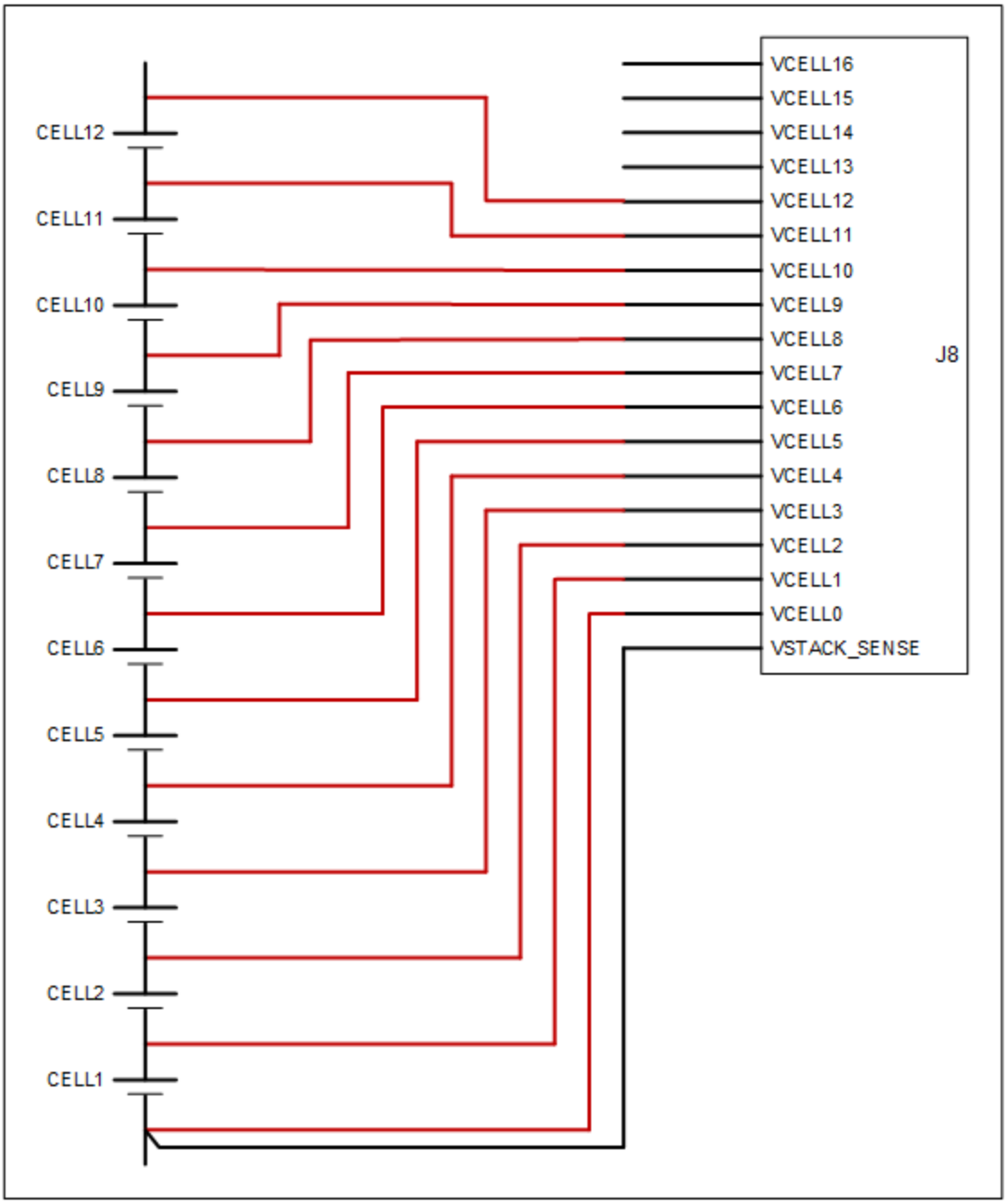


Figure 8. NUV300-BC-12: Connecting 12 cells to J8

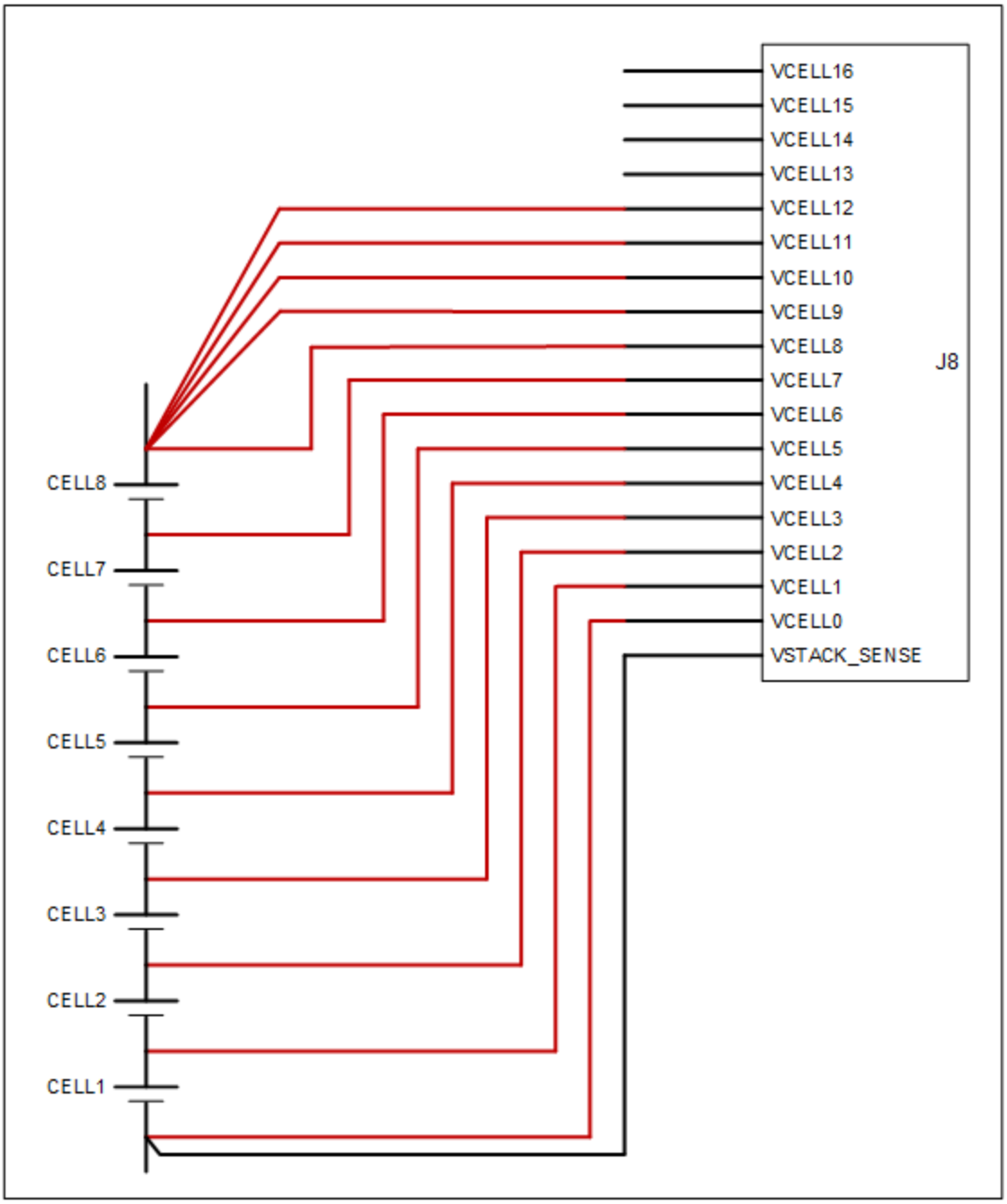


Figure 9. NUV300-BC-12: Connecting 8 cells to J8

Connecting to a Battery Controller - 16 channel (NUV300-BC-16)

Refer to Table 14 for the pin name assignment of the cell voltage and temperature sensor connector J8 for the NUV300-BC-16.

The NUV300-BC-16 requires division of the connected cells into two groups. Each group is comprised of a sequentially-connected subset of the connected cells and the groups may be of different cell counts to a maximum of eight cells per group.

It is important to connect all cells in ascending voltage order, such that the negative terminal of the most negative (bottom) cell of the more negative group connects to VCELL0 of J8, and the positive terminal of each cell in that group connects in ascending voltage order to VCELL1, VCELL2, etc. If fewer than 8 cells are connected in the more negative group, then that group's top cell and all unused cell inputs between the group's top cell and VCELL8 must be connected to VCELL8.

Recognizing that the positive terminal of the top cell of the more negative group always connects to the negative terminal of the bottom cell of the more positive group and to VCELL8, the positive terminals of the cells in the more positive group must connect in ascending voltage order to VCELL9, VCELL10, etc. If fewer than 8 cells are connected in the more positive group, then that group's top cell and all unused cell inputs between the group's top cell and VCELL16 must be connected to VCELL16.

Figure 10 shows the connection of 16 cells to a NUV300-BC-12. It is recommended to use a NUV300-BC-12 for an 11-cell stack, but if a NUV300-BC-16 must be used, an example of the correct connection of 11 cells to a NUV300-BC-16 is presented in Figure 11. A less desirable connection example is shown in Figure 12 which assumes 3 cells are sufficient to provide the required 11 V minimum to the lower group.

Use a separate wire to connect input VSTACK_SENSE to the negative end of the most negative (bottom) cell of the more negative group.

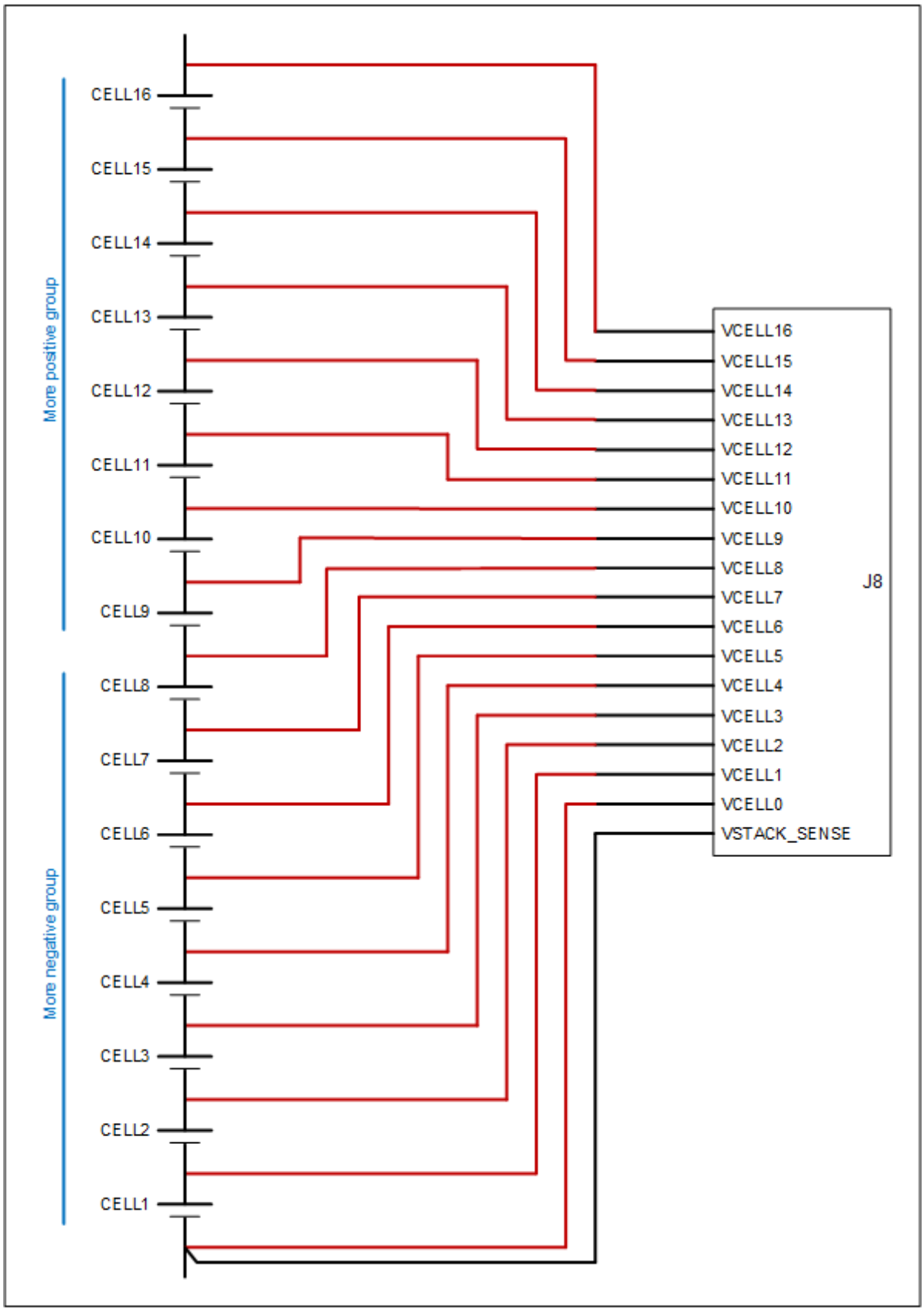


Figure 10. NUV300-BC-16: Connecting 16 cells to J8

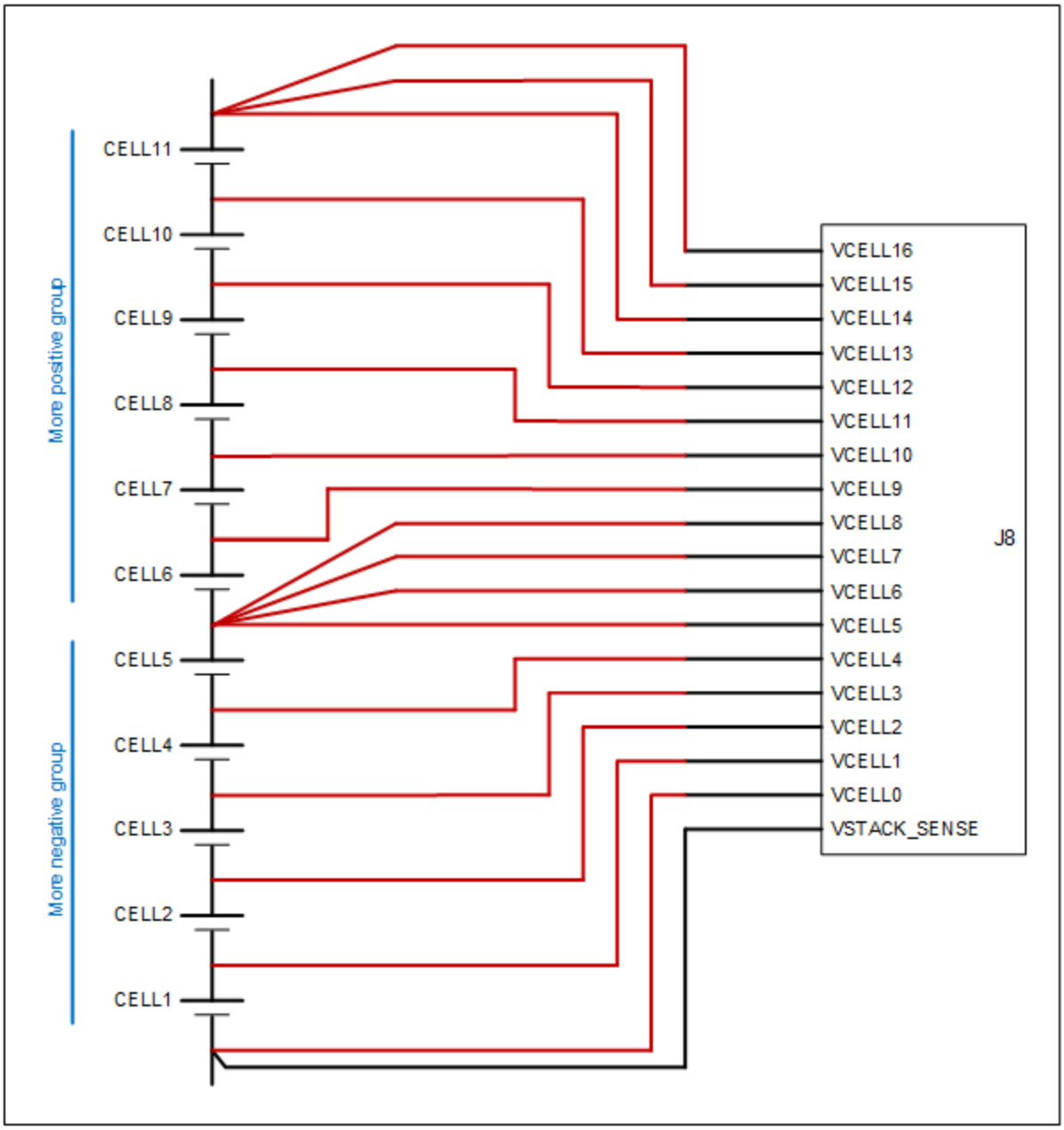


Figure 11. NUV300-BC-16: Preferred method of connecting 11 cells to J8

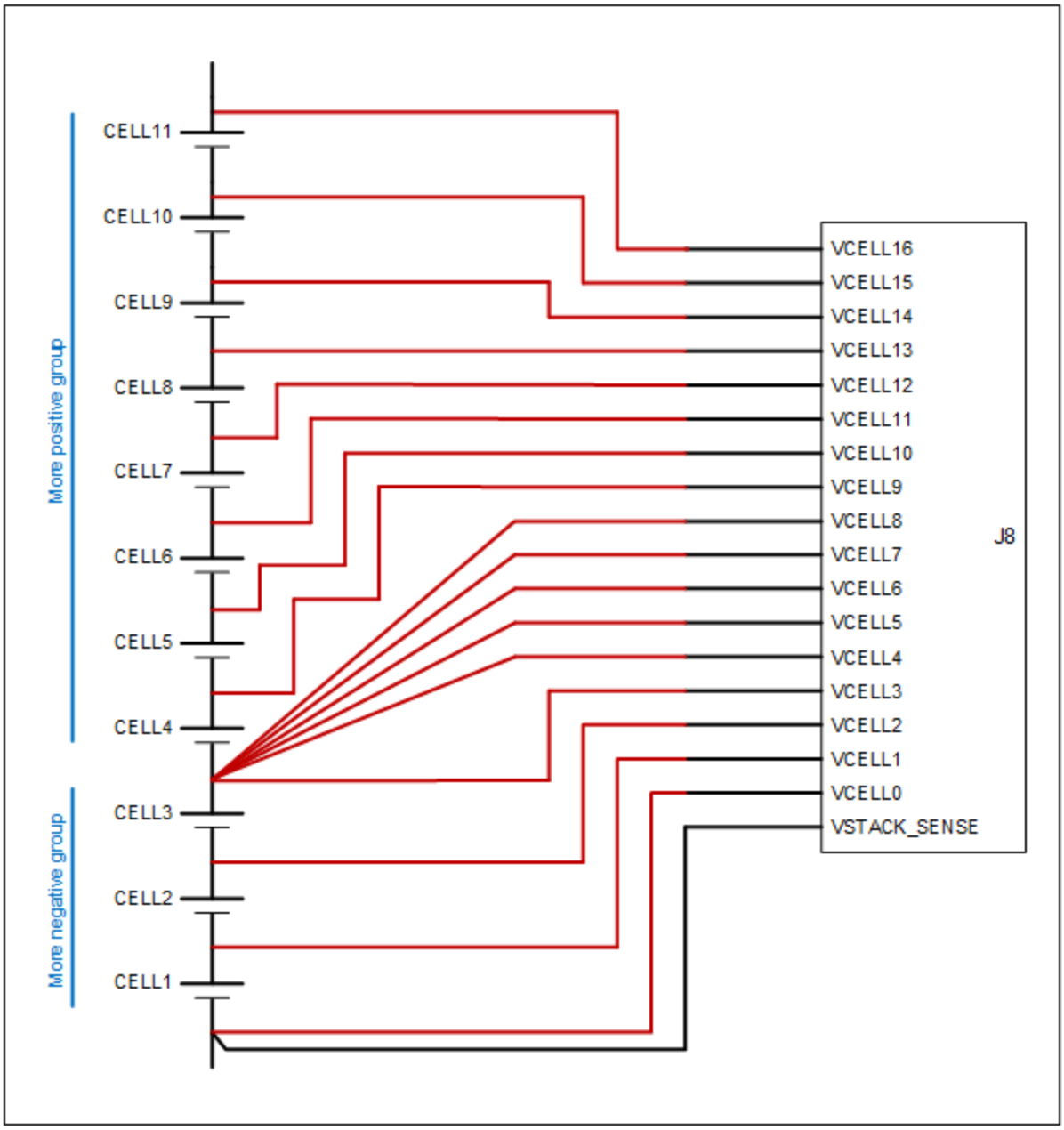


Figure 12. NUV300-BC-16: Less optimal method of connecting 11 cells to J8

Temperature Sensor Connections

Refer to Table 14 for the pin name assignment of the temperature sensor connections for the cell voltage and temperature sensor connector J8.

The Battery Controller supports monitoring of up to eight temperature channels for measuring cell temperature.

The sensors supported are negative temperature coefficient (NTC) thermistor type, with a 25° C resistance of 10 kΩ. Thermistors supplied with the wiring harnesses may be one of the sensors listed in Table 15. Refer to the *Software Reference Manual* for instructions on how to configure the Battery

Controller to use other thermistors.

Table 15. Thermistor details

Manufacturer	Part number	Type	R25	Range
Murata Electronics	NXFT15XH103FA2B100	NTC thermistor	10kΩ	-40° C ~ 125° C
US Sensor	USP10982	NTC thermistor	10kΩ	-55° C ~ 80° C

Thermistors are 2-leaded non-polarized devices. One lead of each sensor is to be connected to the `TPROBEn` pin of connector `J8`, where `n` denotes the channel on which that sensor's signal is measured. The other lead of each sensor is to be connected to one of the `VBOT_TEMP` pins of connector `J8`. Unused temperature input wires should be properly insulated or removed.

3.7. Grounding and Fusing

The Battery Controller enables connection to a series-connected stack of monitored cells up to a total voltage of 60 V. The lowest potential (the negative end) of the connected stack also serves as the common return for the contactor coils as well as the reference for the Battery Controller internal circuitry and power supply. Any connection to earth or chassis ground must be made outside of the Battery Controller.

The contactor coils return to the same potential as the most negative end of the attached stack regardless of whether this point is connected to ground.

An earth or chassis ground connection may be made to any single point in the connected cell stack as required by the application. The cell stack may also be left isolated from earth or chassis. Fusing of the cell stack where it connects to provide operating power to the Battery Controller is required externally.

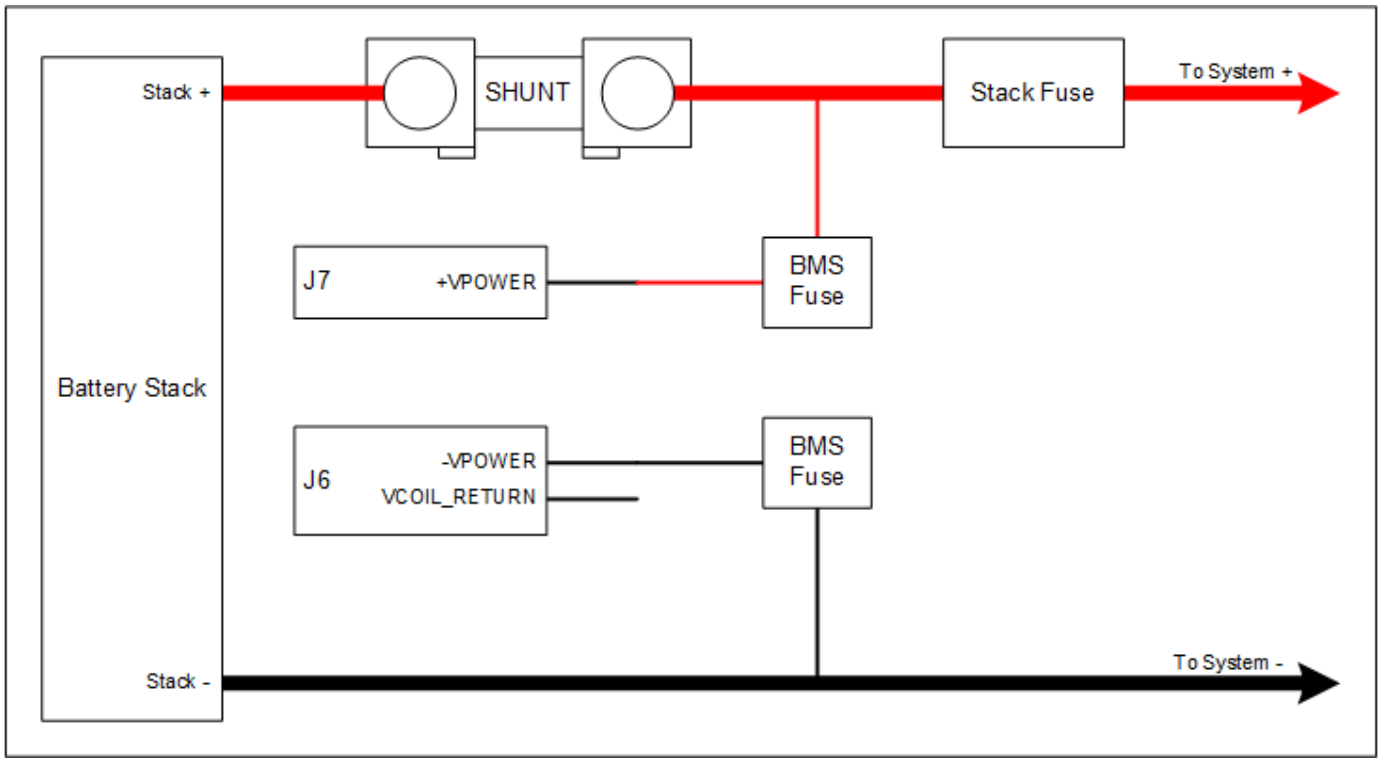


Figure 13. Connection example for powering the Battery Controller from cells

If the load side of the current shunt is grounded:

- A fuse is required at the negative power connection point only, in line with the connection to pin 6 of the `J6: Contactors / -V Power` connector
- Connect pin 6 of the `J6: Contactors / -V Power` connector through a fuse to the negative end of the stack
- Connect pin 1 of the `J7: Current Shunt / +V Power` connector directly to the load side of the current shunt, or to ground

If the most negative end of the stack is grounded:

- A fuse is required at the positive power connection point only, in line with the connection to pin 1 of the `J7: Current Shunt / +V Power` connector
- Connect pin 1 of the `J7: Current Shunt / +V Power` connector through a fuse to the load side of the current shunt
- Connect pin 6 of the `J6: Contactors / -V Power` connector directly to the negative end of the stack, or to ground

If no ground connection exists within the stack or if a ground connection is made somewhere other than at an end:

- Fuses are required at both the positive and negative power connection points to the Battery Controller, in line with each of pin 1 of the `J7: Current Shunt / +V Power` connector and pin 6 of the `J6: Contactors / -V Power` connector

- Connect pin 1 of the `J7: Current Shunt / +V Power` connector through a fuse to the load side of the current shunt
- Connect pin 6 of the `J6: Contactors / -V Power` connector through a fuse to the negative end of the stack

Fuses are not supplied and must be selected based on the operating voltage range of the connected battery stack. Use the following table as a guide to select either one or two fuses of the same capacity.

Fuse current ratings	
12 V Battery (9-16 V)	8.0 A
24 V Battery (18-32 V)	4.0 A
36 V Battery (27-48 V)	2.5 A
48 V Battery (36-60 V)	2.0 A

3AB/3AG fast-response cartridge fuses and in-line fuse holders are commonly used for this application

An external 9-60 V DC power source may be used (instead of the connected battery stack) to power the Battery Controller and power the contactor coils. The positive of this source must connect through a fuse to pin 1 of the `J7: Current Shunt / +V Power` connector and the negative of this source must connect through a fuse to pin 6 of the `J6: Contactors / -V Power` connector. In this situation, pin 5 of the `J6: Contactors / -V Power` connector must be connected directly to the most negative end of the stack. This will connect the negative of the external power source to the most negative end of the attached stack, so caution must be exercised when choosing the power source to ensure that this is acceptable and safe.

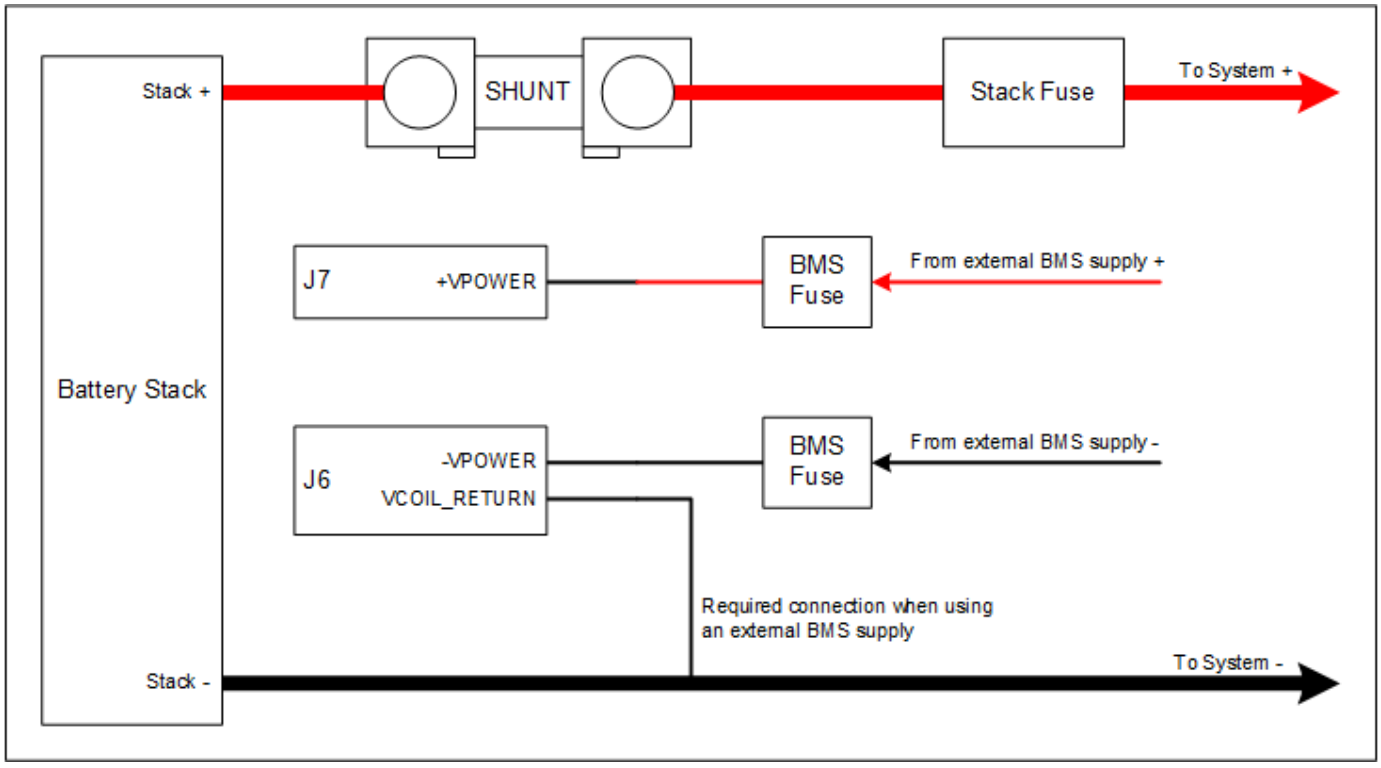


Figure 14. Connection example for powering the Battery Controller from external DC power source

4. Cell Interface Expansion Module

4.1. Scaling to over 16 channels

A Nuvation Energy Cell Interface may be used as an expansion module on Low-Voltage BMS systems which are less than 60 V, but have more cells than supported by the base Battery Controller module (i.e. 16 cells).

For example, on a 24 cell system of 2V lead-acid cells (total stack of 48 V), a 12-channel Battery Controller and 12-channel Cell Interface maybe be use to manage the 24 cells.

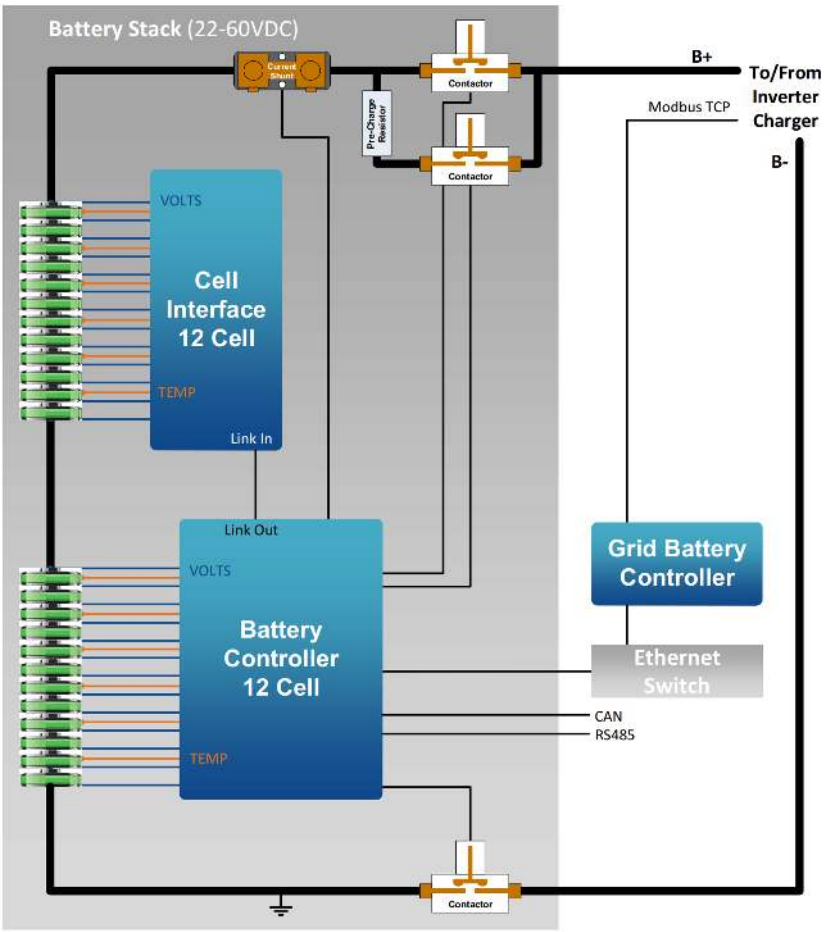


Figure 15. Low-Voltage BMS System Overview: 24-channel Application

> The Nuvation Energy Low-Voltage Battery Controller system should not be used with a battery stack that exceeds 60 V DC during normal operation.
>
> Please see Section 4.1.1 below for safety considerations.

The Cell Interface connects to the battery cells and temperature sensors. It monitors and balances the cells, sends cell data to the Battery Controller, and prevents overheating or overcharging of cells.

Table 16 below shows the available Cell Interface configurations and the corresponding Battery

Controller configurations which support them.

Table 16. Supported Cell Interface to Battery Controller system pairings

Cell Interface	Supported Battery Controller
Cell Interface - 12 channel	Battery Controller - 12 channel
Cell Interface - 16 channel	Battery Controller - 16 channel
Cell Interface - 12V 4 channel	Not supported

Nuvation Energy Cell Interface datasheet is available online at https://www.nuvationenergy.com/technical-resources.

4.1.1. Safety Considerations

The Battery Controller's I/O ports (Ethernet, CAN, RS485, GPIO, Link Out) are SELV (Safety Extra Low Voltage) rated to 60 V. For example, a system using more than 16 cells of 2V lead-acid could exceed the 60 V maximum of the Battery Controller module during the equalization phase of the charge profile.

To maintain the SELV rating of the Battery Controller I/O ports, the negative terminal of the battery stack must be connected to earth ground. This prevents high voltage from propagating out of the I/O ports in the very unlikely event of an internal failure with the current shunt interface. This requirement also means that any device connected to the Battery Controller must reference its signals to earth ground, as any signal referenced to the top of the battery stack would exceed the 60 V limit of the Battery Controller.

4.2. Mechanical Overview

The overall dimensions of the Cell Interface are 104.4 mm X 121.58 mm X 40.6 mm.

The Cell Interface is available in a bulkhead-mountable enclosure as shown in Figure 16. The enclosure has five metal walls, leaving the bottom of the unit fully exposed. It must be mounted to a metal bulkhead panel such that the panel covers the exposed bottom side.

The NUV100-CI-12-1 and NUV100-CI-16-1 variants produce up to 24 W and 32 W, respectively, during cell balancing. A portion of this heat is transferred to the bulkhead.

Extra space should be provided around the module to allow for easy installation/maintenance.

The standard Cell Interface, Bulkhead weighs approximately 450 g.

The Cell Interface contains high-voltage signals reaching as high as 1250 V DC. Care must be taken when mounting the PCB into a metal enclosure to ensure that the metal walls remain a safe distance from the exposed conductor on the PCB.

Using 1250 V DC as an example, the metal walls of the enclosure must be at least 4.2 mm from the nearest exposed conductor and must not touch the PCB or any component on the PCB, including the connector housings.

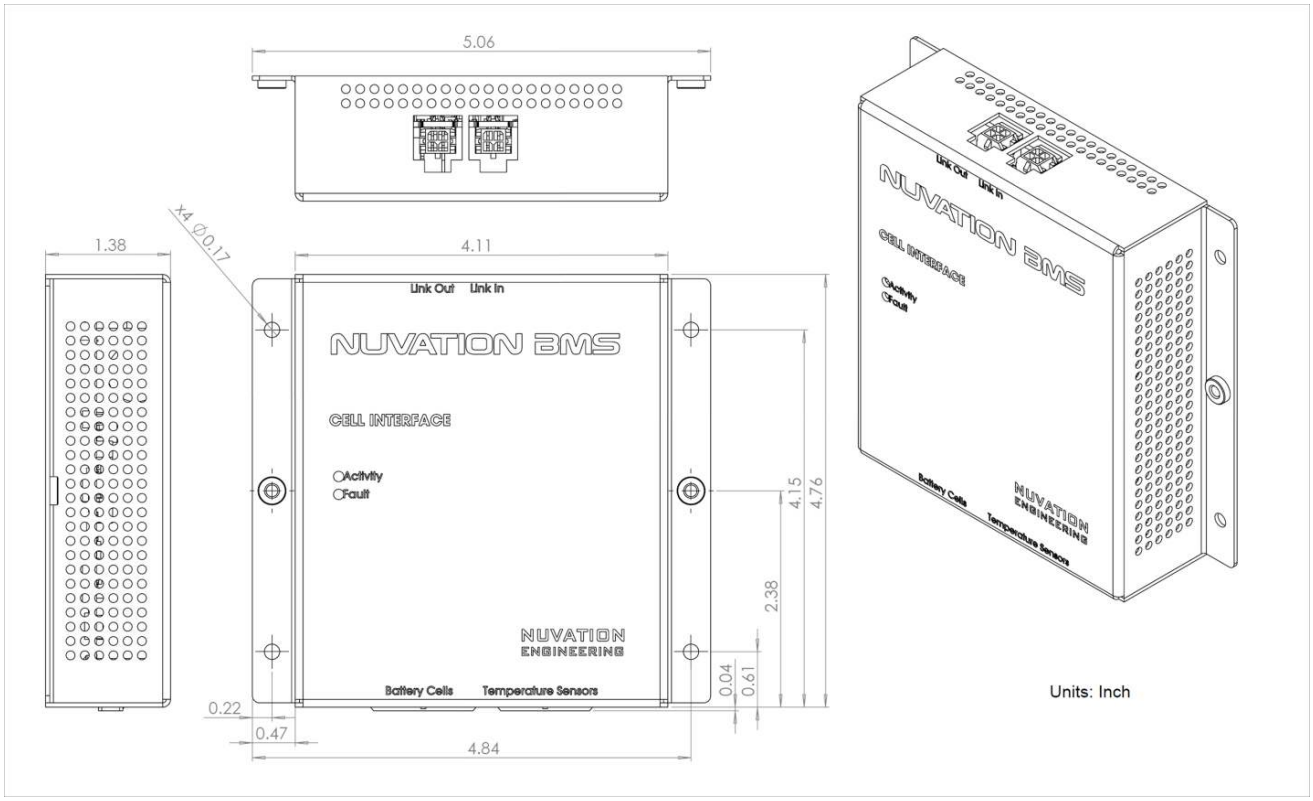


Figure 16. Mechanical Drawing of Cell Interface with Bulkhead Enclosure

4.2.1. Optional DIN rail mounting Kit

For applications requiring DIN rail mounting, the Cell Interface may be ordered with the Cell Interface Mounting Bracket (Bulkhead-to-DIN) kit. This kit is sold separately, and includes a metal plate and the necessary hardware to securely mount the standard Cell Interface module to EN50022-compliant DIN rails, as shown in Figure 17.

The Mounting Bracket kit assembly adds an extra 14.2 mm to the overall width of the Cell Interface module, bringing it from 104.4 mm to 118.6 mm. The kit assembly holds the module approximately 7 mm away from the inside lip of the DIN rail.

The Mounting Bracket offsets the Cell Interface module from the center of the DIN rail approximately 30 mm upwards as shown in Figure 17.

A Cell Interface with the Mounting Bracket weighs approximately 540 g.

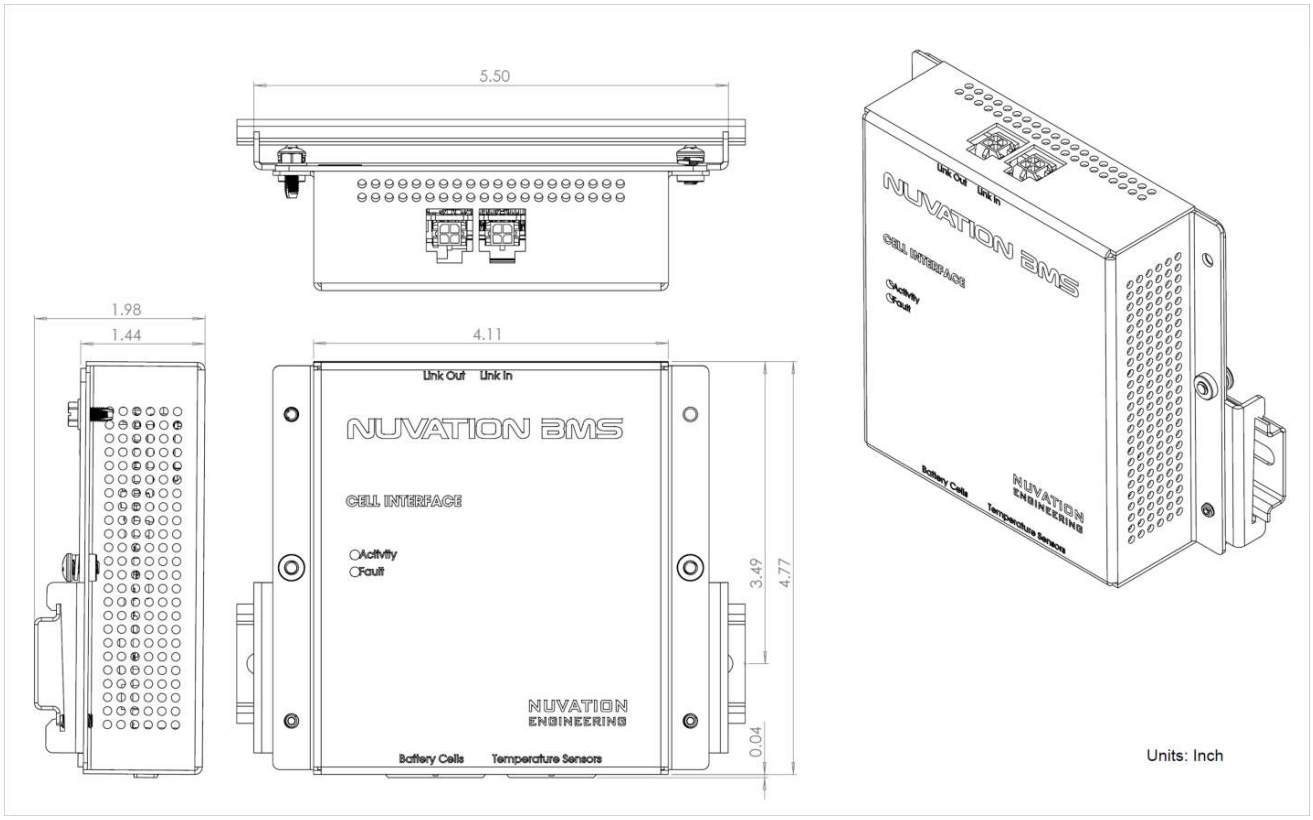


Figure 17. Mechanical Drawing of Cell Interface with Cell Interface Mounting Bracket (Bulkhead-to-DIN)

NRND variant with DIN rail mounting

The older Cell Interface, DIN Mount variant has been discontinued and is NRND (not recommended for new design). New designs should use Cell Interface, Bulkhead variant with the Cell Interface Mounting Bracket (Bulkhead-to-DIN) kit. The information below is provided for the purpose of updating DIN rail mechanical designs.

The clips add an extra 19.6 mm to the overall width of the standard Cell Interface module, bringing it from 104.4 mm to 124 mm. The clips also hold the module approximately 7mm away from the inside lip of the DIN rail. The DIN enclosure vertically centers the module over the DIN rail, as shown in Figure 18.

A Cell Interface with DIN mountable enclosure weighs approximately 540 g.

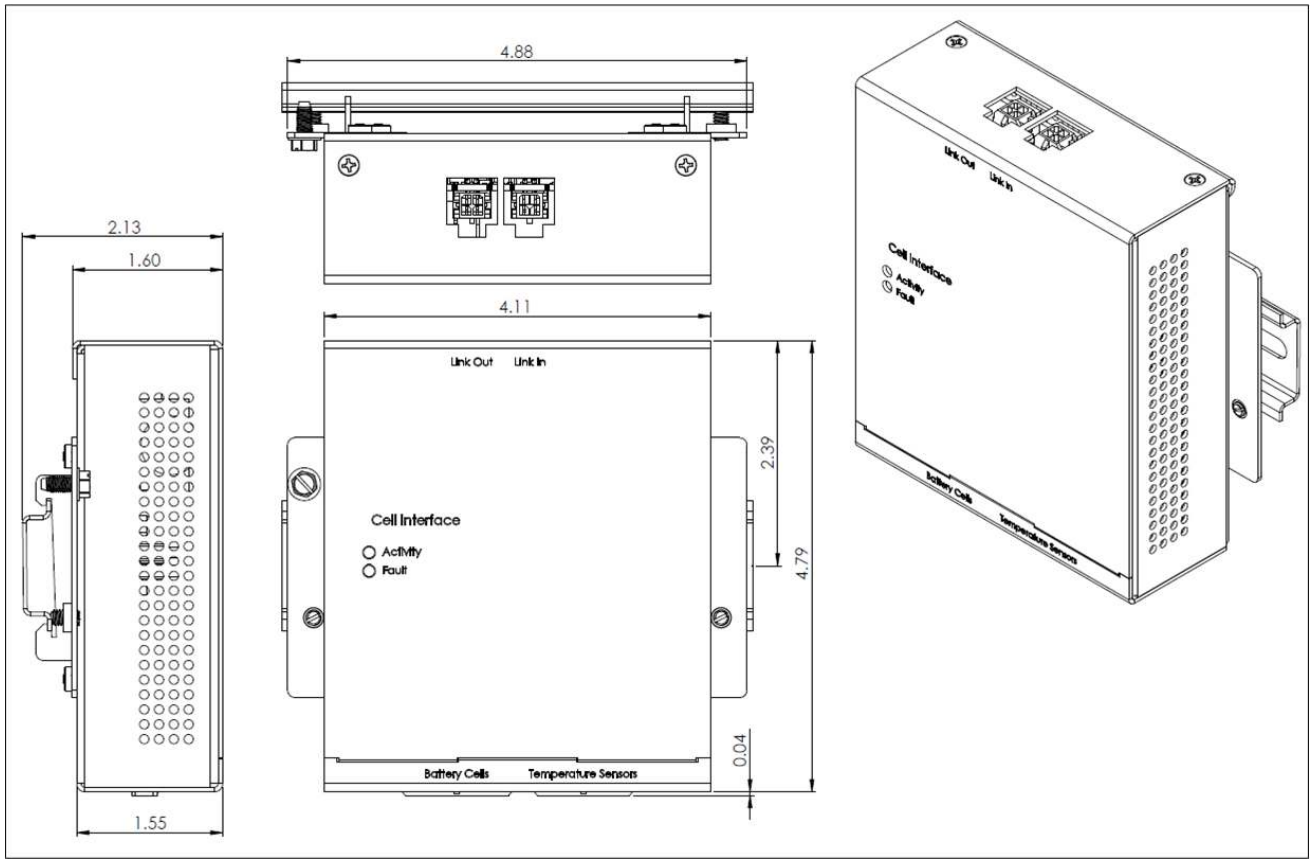


Figure 18. Mechanical Drawing of Cell Interface with DIN Enclosure (NRND)

4.3. Electrical Connections

The Cell Interface module has 4 connectors. Each connector is described in the following sections in detail.

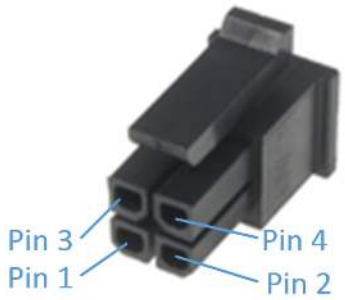
4.3.1. Link Out

For Low-Voltage applications, this connector is not used.

4.3.2. Link In

The `Link In` interface on the Cell Interface module connects to the `J1: Link Out interface` on the Battery Controller.

Table 17. Link In: Molex Micro-Fit 3.0 Connector



Molex 43025-0400	
Manufacturer	Molex Incorporated
Housing	43025-0400
Housing material	Nylon UL94V-0
Circuits	4
Crimp terminal	43030-0006
Wire gauge range	AWG26-30 stranded

If 24 AWG stranded wire is used with the RJ45 plug, use crimp terminal 43030-0002 instead.

Table 18. Link In Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	No Connect	Not Connected	No Connect
2	No Connect	Not Connected	No Connect
3	LINKBUS_P	Link Bus differential pair positive	Battery Controller
4	LINKBUS_N	Link Bus differential pair negative	Battery Controller

4.3.3. Battery Cells

The Battery Cells connector provides cell voltage input and a means for balancing the cells.

The battery cell voltage sense leads connect to this connector. Recommended plug and crimp terminals to be used with the Cell Interface: `Battery Cells` connector are listed below:

Table 19. Battery Cells: Molex Micro-Fit 3.0 Connector

Molex 43025-1800	
Manufacturer	Molex Incorporated
Housing	43025-1800
Housing material	Nylon UL94V-0
Circuits	18
Crimp terminal	43030-0002
Wire gauge range	AWG20-24 stranded

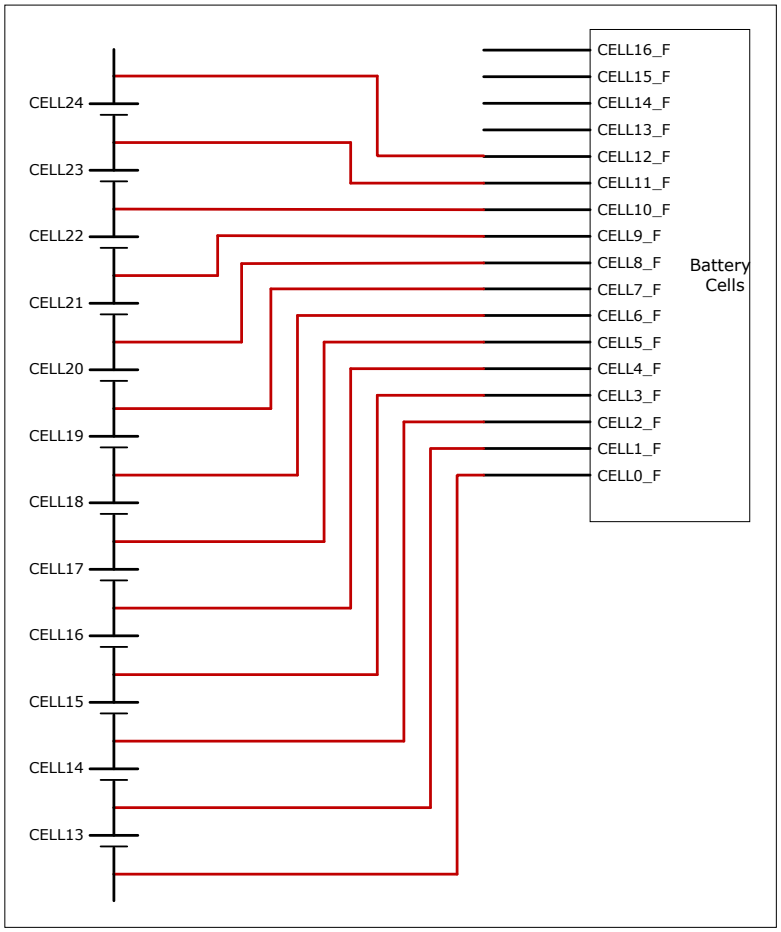
Battery Cell Connecter for Cell Interface - 12 channel

The `Battery Cells` interface on the Cell Interface connects to the top 12 cells in the stack according to the pin-out stated in the table below. Note that pins 8, 16, 17, and 18 are `No Connect` in the Cell Interface - 12 channel model.

Pin	Connection	Description	Connected to Device
1	CELL0_F	Bottom reference of CI	Connect to negative terminal of the lowest cell (Cell 0) in the upper 12 cell module
2	CELL2_F	Cell 2 voltage sense	Connect to positive terminal of Cell 1
3	CELL4_F	Cell 4 voltage sense	Connect to positive terminal of Cell 3
4	CELL6_F	Cell 6 voltage sense	Connect to positive terminal of Cell 5
5	CELL8_F	Cell 8 voltage sense	Connect to positive terminal of Cell 7
6	CELL10_F	Cell 10 voltage sense	Connect to positive terminal of Cell 9
7	CELL12_F	Cell 12 voltage sense	Connect to positive terminal of Cell 11
8	CELL14_F	Not Connected	No Connect

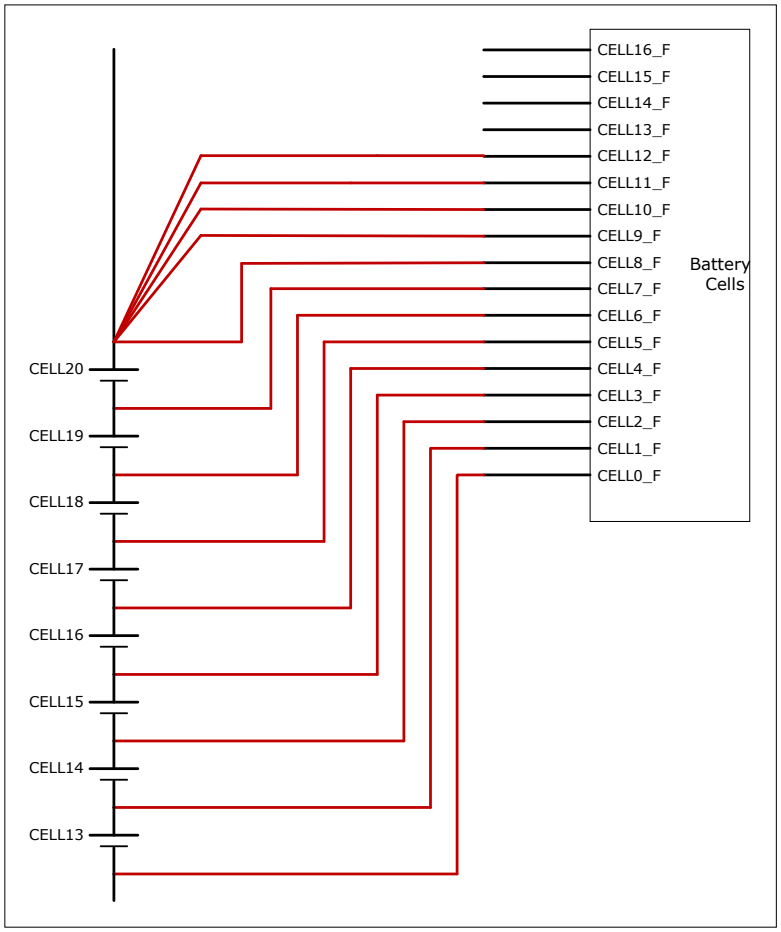
Pin	Connection	Description	Connected to Device
9	No Connect	Not Connected	No Connect
10	CELL1_F	Cell 1 voltage sense	Connect to positive terminal of the lowest cell (Cell 0) in the upper 12 cell module
11	CELL3_F	Cell 3 voltage sense	Connect to positive terminal of Cell 2
12	CELL5_F	Cell 5 voltage sense	Connect to positive terminal of Cell 4
13	CELL7_F	Cell 7 voltage sense	Connect to positive terminal of Cell 6
14	CELL9_F	Cell 9 voltage sense	Connect to positive terminal of Cell 8
15	CELL11_F	Cell 11 voltage sense Connect to positive terminal of Cell 10	16
CELL13_F	Not Connected	No Connect	17
CELL15_F	Not Connected	No Connect	18

Wiring the upper 12 cells in a Cell Interface - 12 channel



Wiring a 20-cell stack

When fewer than 24 cells are required, connect unused inputs to the positive terminal of the top cell in the stack. An example of a 20-cell stack is shown below.



Battery Cell Connecter for Cell Interface - 16 channel

Pin	Connection	Description	Connected to Device
1	CELL0	Bottom reference of Cell Interface	Connect to negative terminal of the lowest cell (Cell 1)
2	CELL2	Cell 2 voltage sense	Connect to positive terminal of Cell 2
3	CELL4	Cell 4 voltage sense	Connect to positive terminal of Cell 4
4	CELL6	Cell 6 voltage sense	Connect to positive terminal of Cell 6
5	CELL8	Cell 8 voltage sense	Connect to positive terminal of Cell 8
6	CELL10	Cell 10 voltage sense	Connect to positive terminal of Cell 10
7	CELL12	Cell 12 voltage sense	Connect to positive terminal of Cell 12
8	CELL14	Cell 14 voltage sense	Connect to positive terminal of Cell 14
9	No Connect	Not Connected	No Connect
10	CELL1	Cell 1 voltage sense	Connect to positive terminal of the lowest cell (Cell 1)
11	CELL3	Cell 3 voltage sense	Connect to positive terminal of Cell 3
12	CELL5	Cell 5 voltage sense	Connect to positive terminal of Cell 5
13	CELL7	Cell 7 voltage sense	Connect to positive terminal of Cell 7
14	CELL9	Cell 9 voltage sense	Connect to positive terminal of Cell 9
15	CELL11	Cell 11 voltage sense	Connect to positive terminal of Cell 11
16	CELL13	Cell 13 voltage sense	Connect to positive terminal of Cell 13
17	CELL15	Cell 15 voltage sense	Connect to positive terminal of Cell 15
18	CELL16	Cell 16 voltage sense	Connect to positive terminal of Cell 16

The following is an example wiring guide for a Cell Interface - 16 channel with 16 cells and 11 cells

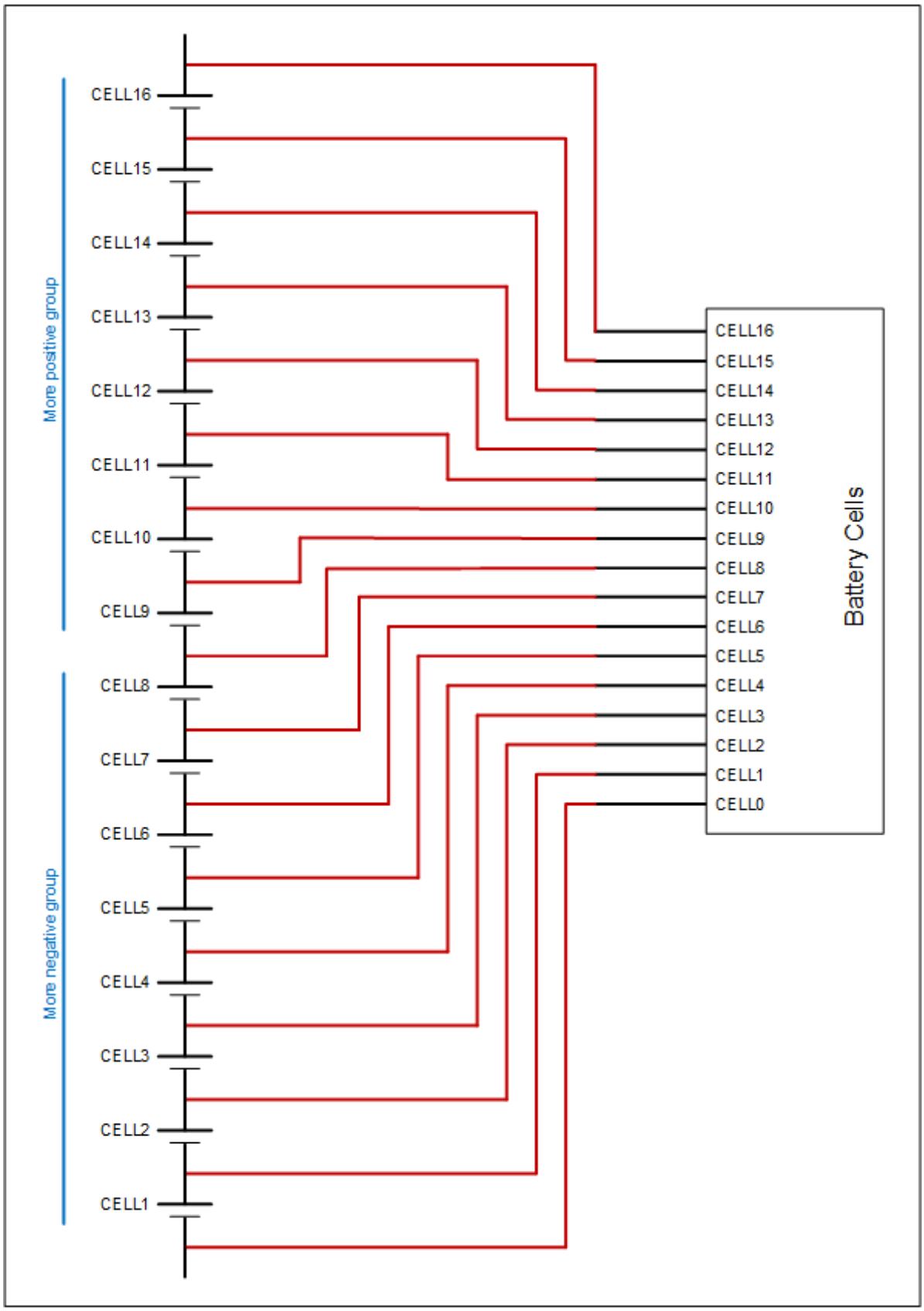


Figure 19. Example wiring 16 cells in a Cell Interface - 16 channel

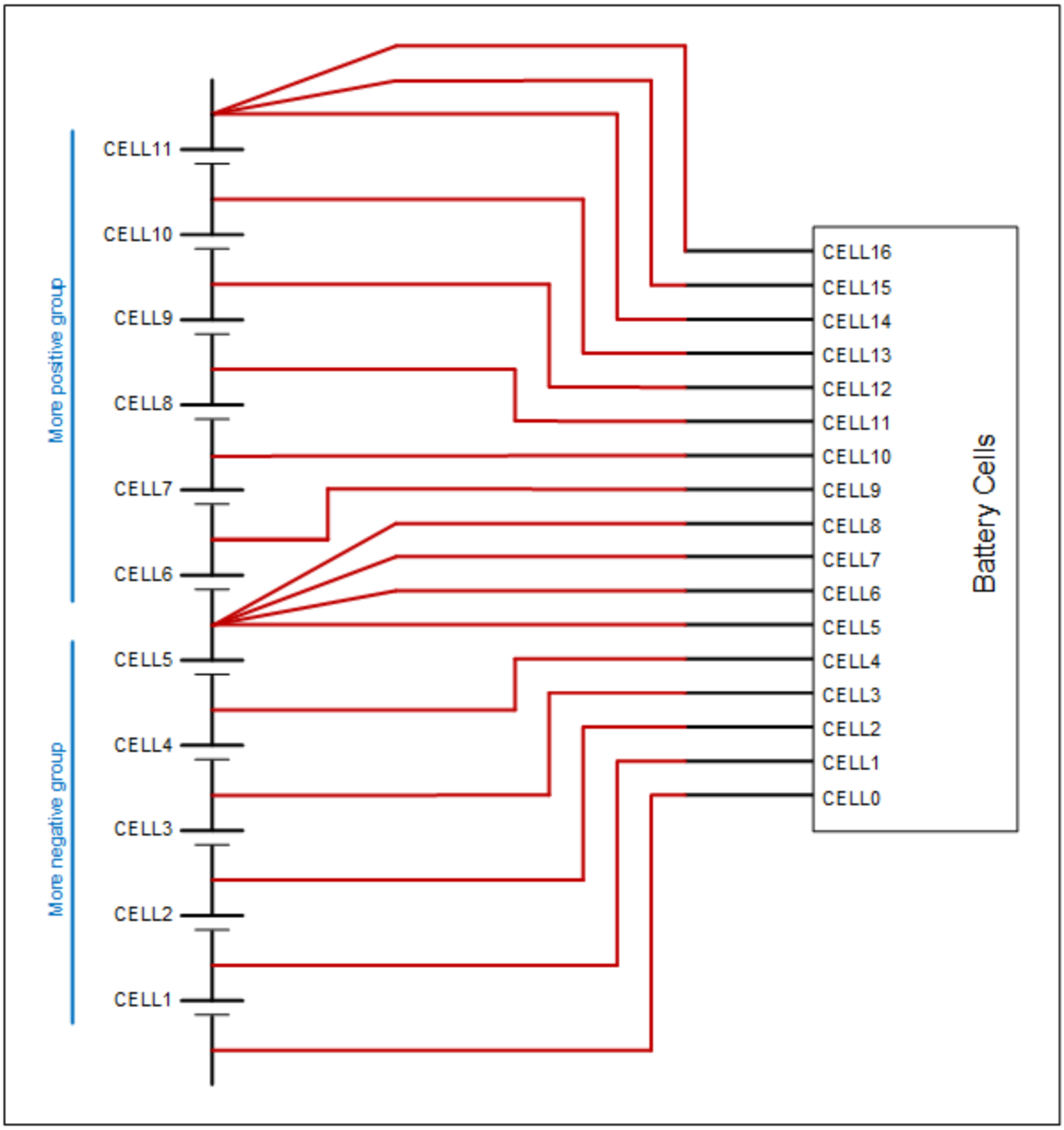


Figure 20. Example wiring 11 cells in a Cell Interface - 16 channel

4.3.4. Temperature Sensors

The Temperature Sensors connector provides NTC thermistor inputs for temperature measurement of the cells and/or surrounding area. All signals are referenced to Pin 1 of the `Battery Cells` connector. The thermistors must be isolated from the cell voltage terminals in such a way that they will not make an electrical connection to a cell terminal in the event of vibration/failures.

Connect 10 kΩ NTC thermistors to this connector.

Table 20. Temperature Sensors: Molex Micro-Fit 3.0 Connector

Molex 43025-1600	
Manufacturer	Molex Incorporated
Housing	43025-1600
Housing material	Nylon UL94V-0
Circuits	16
Crimp terminal	43030-0002
Wire gauge range	AWG20-24 stranded

Table 21. Temperature Sensors Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	VBOT	External Temperature Probe Reference 1	10 kΩ NTC Thermistor
2	VBOT	External Temperature Probe Reference 2	10 kΩ NTC Thermistor
3	VBOT	External Temperature Probe Reference 3	10 kΩ NTC Thermistor
4	VBOT	External Temperature Probe Reference 4	10 kΩ NTC Thermistor
5	VBOT	External Temperature Probe Reference 5	10 kΩ NTC Thermistor
6	VBOT	External Temperature Probe Reference 6	10 kΩ NTC Thermistor
7	VBOT	External Temperature Probe Reference 7	10 kΩ NTC Thermistor
8	VBOT	External Temperature Probe Reference 8	10 kΩ NTC Thermistor
9	TEMP1_R	External Temperature Probe Input 1	10 kΩ NTC Thermistor
10	TEMP2_R	External Temperature Probe Input 2	10 kΩ NTC Thermistor
11	TEMP3_R	External Temperature Probe Input 3	10 kΩ NTC Thermistor
12	TEMP4_R	External Temperature Probe Input 4	10 kΩ NTC Thermistor
13	TEMP5_R	External Temperature Probe Input 5	10 kΩ NTC Thermistor
14	TEMP6_R	External Temperature Probe Input 6	10 kΩ NTC Thermistor
15	TEMP7_R	External Temperature Probe Input 7	10 kΩ NTC Thermistor
16	TEMP8_R	External Temperature Probe Input 8	10 kΩ NTC Thermistor

5. Software Configuration

Once the Battery Controller installation is complete, please follow the instructions in the *Operator Interface Manual* (available online at https://www.nuvationenergy.com/technical-resources) to complete the software configuration.

5.1. Enabling Battery Controller expansion with Cell Interface module

For Battery Controller systems using a Cell Interface expansion, the config file will need to be updated to support the expansion. Please refer to the *Software Reference Manual*, available online at https://www.nuvationenergy.com/technical-resources, for more details. A reference example is provided below.

Example: The following example applies to a 24-channel system - i.e. 12-channel Battery Controller with a 12-channel Cell Interface. This sets the upper 12 cells and additional 8 thermistors installed in the BMS.

Starting with the example configuration provided for the standard `NUV300-BC12` system, the following registers need to be adjusted to enable the added cell and thermistor inputs:

```
sc_linkbus.cicount = 2
cell[0:11:16:2].installed = 1
therm[0:7:8:2].installed = 1
```

From time to time Nuvation Energy will make updates to Nuvation Energy BMS in response to changes in available technologies, client requests, emerging energy storage standards, and other industry requirements. The product specifications in this document, therefore, are subject to change without notice.