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Nuvation Energy High-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** energize the system until all connections to the Cell Interface and Power Interface modules have been made.

Insulated handling is required of any connector carrying potentials over 600 V DC relative to chassis.

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.

Nuvation Energy High-Voltage BMS is an enterprise-grade battery management system with features that extend battery life, ensuring pack-level safety, data-analytics, and remote management.

You can take advantage of the highly configurable browser-based user interface and custom-tune Nuvation Energy BMS to your specific target application.

1.1. About this Guide

This *Nuvation Energy High-Voltage BMS: Installation Guide* provides wiring instructions to connect your Nuvation Energy High-Voltage BMS 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.

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 High-Voltage BMS family includes several modules that operate together as a complete system. Available modules are listed below.

Table 1. High-Voltage BMS Modules

Model	Module Name
NUV100-SC	High-Voltage Stack Controller
NUV100-PI-HE	High-Voltage Power Interface
NUV100-CI-12-1	Cell Interface - 12 channel
NUV100-CI-16-1	Cell Interface - 16 channel
NUV100-CI-4M12-1	Cell Interface - 12V 4 channel

Generally, a single High-Voltage BMS system uses 1 Stack Controller, 1 Power Interface, and 1 or more Cell Interface modules. An example configuration is shown in Figure 1

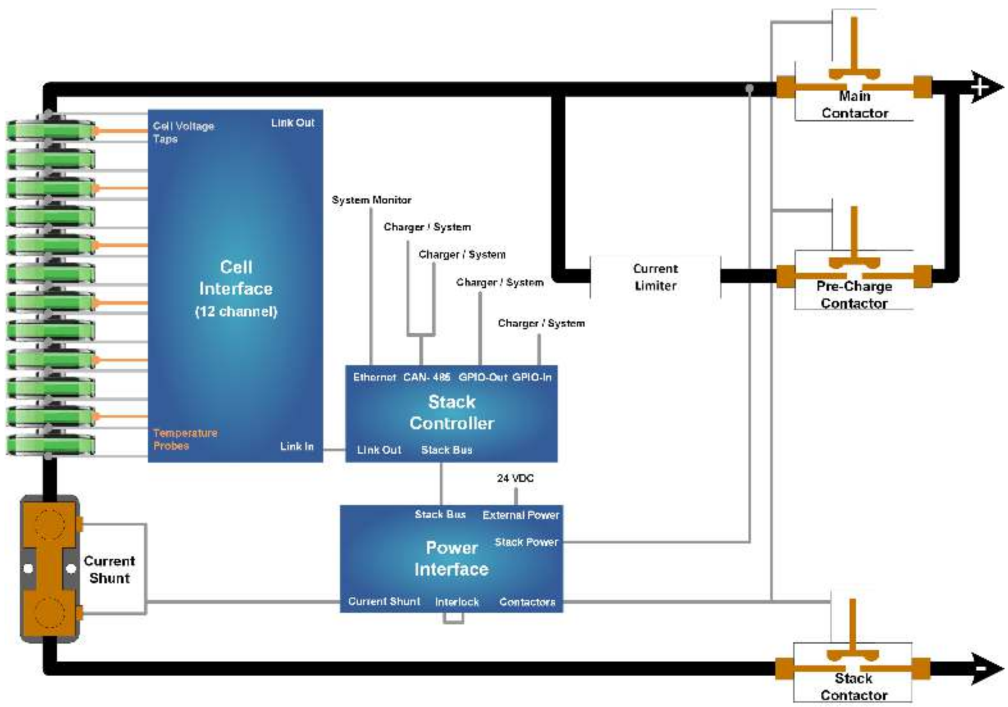


Figure 1. Nuvation Energy High-Voltage BMS System Overview

3. High-Voltage Stack Controller

3.1. Overview

The High-Voltage Stack Controller module monitors and controls all Cell Interface modules in a single battery stack. The built-in Stack Bus receives power and communication from the Power Interface module. The Link Bus provides power and communication for all connected Cell Interface modules. Ethernet, CAN and RS-485 (Modbus) 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.

There is only one model of the Stack Controller, the NUV100-SC.

3.2. Mechanical Dimensions

The overall dimensions of the Stack Controller are 104.4 mm X 121.58 mm X 40.6 mm.

It comes standard with DIN clips that enable the Stack Controller module to be securely mounted to EN50022-compliant DIN rails. The clips add an extra 19.6 mm to the overall width of the Stack Controller module, bringing it from 104.4 mm to 124 mm. The clips also hold the module approximately 7 mm away from the inside lip of the DIN rail.

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

The Stack Controller weighs approximately 525 g.

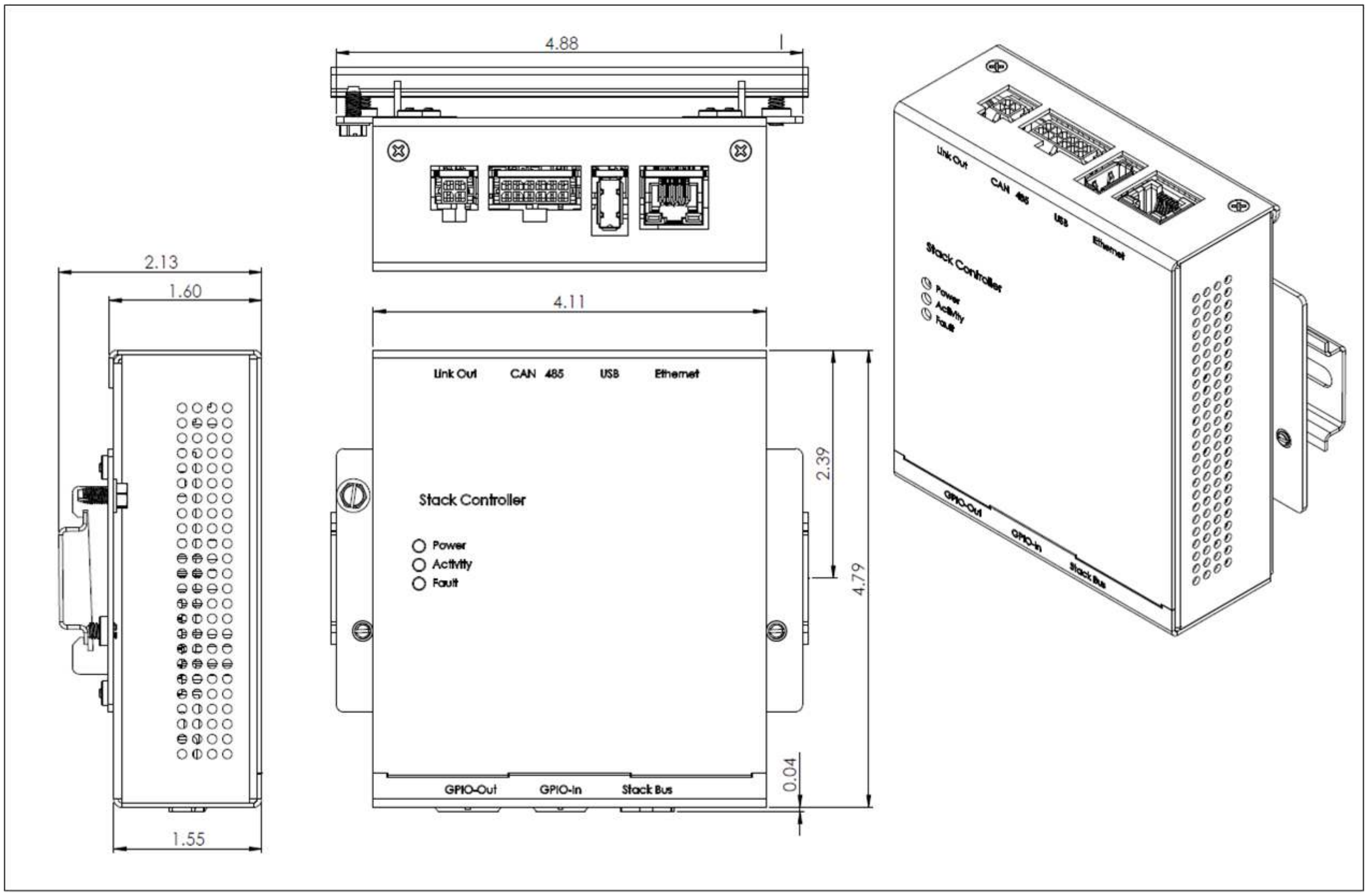


Figure 2. Mechanical Drawing of Stack Controller

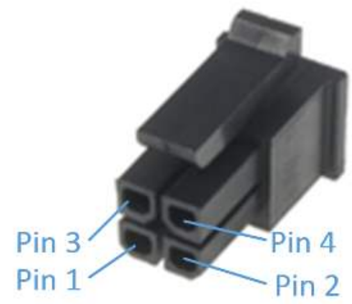
3.3. Electrical Connections

The Stack Controller module has 7 connectors. Each connector is described in the following sections in detail.

3.3.1. Link Out

The Link Out connector provides power and communication to the Cell Interface modules. The amount of current supplied by this connector is the sum of current consumed by all Cell Interface modules in the system. Connect the Cell Interface module which is measuring the most negative cell in the stack to this connector.

Table 2. Link Out: Molex Micro-Fit 3.0 Connector



Molex 43025-0400	
Manufacturer	Molex Incorporated
Housing	43025-0400
Housing material	Nylon UL94V-0
Circuits	4
Crimp terminal	43030-0002
Wire gauge range	AWG20-24 stranded

Table 3. Link Out Connector Pin Assignment

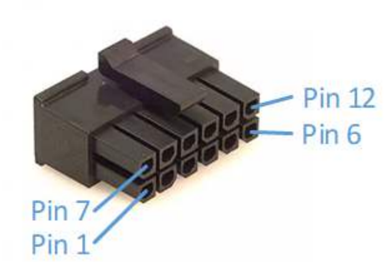
Pin	Connection	Description	Connected to Device
1	VBUS	DC power from Stack Controller, with Fault Pilot Signal	Cell Interface
2	COM	Power return from Stack Controller	Cell Interface
3	IPA	Link Bus differential pair plus	Cell Interface
4	IMA	Link Bus differential pair minus	Cell Interface

3.3.2. CAN 485

The CAN 485 connector contains both isolated CAN and non-isolated RS-485 (Modbus) connections. Isolated CAN requires 5.5-12 Vdc sourced from an external power supply to operate. 120 Ω termination for CAN is added by connecting pins 3 and 9 together. 150 Ω termination for Modbus is added by connecting pins 6 and 12 together.

Keep the termination wire length short for best results. Connect external equipment to this connector.

Table 4. CAN 485: Molex Micro-Fit 3.0 Connector



Molex 43025-1200	
Manufacturer	Molex Incorporated
Housing	43025-1200
Housing material	Nylon UL94V-0
Circuits	12
Crimp terminal	43030-0002
Wire gauge range	AWG20-24 stranded

Table 5. CAN 485 Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	-V_isoCAN	Power return from Pin 7	External Equipment
2	CAN_N	CAN bus differential pair negative	External Equipment
3	EXTCAN_TERM1	Termination Resistor; Short to Pin 9 to add 120Ω bus termination	CAN 485 Connector
4	COM	Power return from SC	External Equipment
5	MODBUS_N	MODBUS differential pair negative	External Equipment
6	EXTMOD_TERM1	Termination Resistor; Short to Pin 12 to add 150Ω bus termination	CAN 485 Connector
7	+12V_isoCAN	+5.5~12Vdc isolated CAN bus power	External Equipment
8	CAN_P	CAN bus differential part positive	External Equipment
9	EXTCAN_TERM2	Termination Resistor; Short to Pin 3 to add 120Ω bus termination	CAN 485 Connector
10	+VSYS	+24Vdc Power supply	External Equipment
11	MODBUS_P	MODBUS differential pair positive	External Equipment
12	EXTMOD_TERM2	Termination Resistor; Short to Pin 6 to add 150Ω bus termination	CAN 485 Connector

3.3.3. Ethernet

The Ethernet connector is a standard RJ45 Ethernet jack. Connect external equipment to this connector.

Table 6. Ethernet Connector Pin Assignment

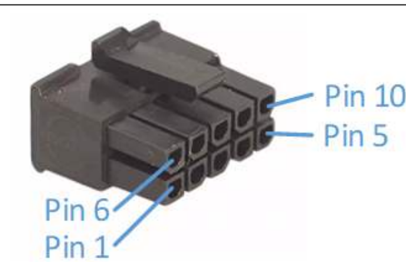
Pin	Connection	Description	Connected to Device
1	TD_P	Transmit differential pair positive	External Equipment
2	TD_N	Transmit differential pair negative	External Equipment
3	RD_P	Receive differential pair positive	External Equipment
4	NUL45	Unused; connected to Pin 5 and terminated	External Equipment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

3.3.4. GPIO-Out

The GPIO-Out connector provides 4 general-purpose outputs. 4 independent solid-state relays are used to connect `*_A` pins to their corresponding `*_B` pins. Each output is rated for 60 V DC, 400 mA max., and the signals connected to each output must be within 50 V DC from chassis/earth ground. There is no polarity dependency between `*_A` and `*_B` pins.

Connect external equipment to this connector.

Table 7. GPO: Molex Micro-Fit 3.0 Connector



Molex 43025-1000	
Manufacturer	Molex Incorporated
Housing	43025-1000
Housing material	Nylon UL94V-0
Circuits	10
Crimp terminal	43030-0002
Wire gauge range	AWG20-24 stranded

Table 8. GPO 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

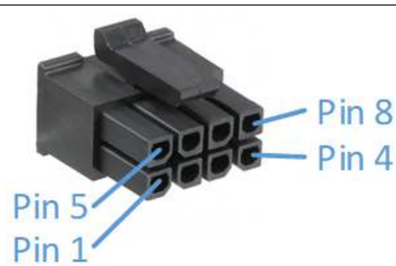
Pin	Connection	Description	Connected to Device
5	COM	Power return from SC	External Equipment
6	GPO_ISO0_B	Digital Output 0	External Equipment
7	GPO_ISO1_B	Digital Output 1	External Equipment
8	GPO_ISO2_B	Digital Output 2	External Equipment
9	GPO_ISO3_B	Digital Output 3	External Equipment
10	No Connect	Not Connected	No Connect

3.3.5. GPIO-In

The GPIO-In connector provides 4 general-purpose inputs. 4 independent detector circuits are used, driven by an on-board +5 V source. Each detector's input is connected to its corresponding pin, and paired with a COM reference pin per input. When switched on by an external connection, each input will source about 12 mA to COM.

Connect external equipment to this connector. Connect a pin to its corresponding COM to turn the input on.

Table 9. GPI: Molex Micro-Fit 3.0 Connector



Molex 43025-0800	
Manufacturer	Molex Incorporated
Housing	43025-0800
Housing material	Nylon UL94V-0
Circuits	8
Crimp terminal	43030-0002
Wire gauge range	AWG20-24 stranded

Table 10. GPI Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	COM	Power return from Stack Controller for GPI0	External Equipment
2	COM	Power return from Stack Controller for GPI2	External Equipment
3	COM	Power return from Stack Controller for GPI3	External Equipment
4	COM	Power return from Stack Controller for GPI4	External Equipment
5	GPI_ISO0_K	Input detector 0	External Equipment
6	GPI_ISO1_K	Input detector 1	External Equipment

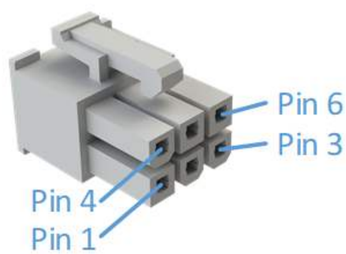
Pin	Connection	Description	Connected to Device
7	GPI_ISO2_K	Input detector 2	External Equipment
8	GPI_ISO3_K	Input detector 3	External Equipment

3.3.6. Stack Bus

The Stack Bus connector accepts power and provides a communication channel from the Power Interface. The Stack Bus provides 42 mA to the Stack Controller plus the summation of current consumed by all Cell Interface modules in the system (25 mA per CI-12 or 31 mA per CI-16). 120 Ω termination must be added by connecting pins 1 and 4 together with a short length of wire (see Table 12).

Connect the Power Interface module to this connector.

Table 11. Stack Bus: Molex MiniFit Jr Connector



Molex 39-01-2065	
Manufacturer	Molex Incorporated
Housing	39-01-2065
Housing material	Nylon UL94V-0
Circuits	6
Crimp terminal	39-00-0181
Wire gauge range	AWG20-24 stranded

Table 12. Stack Bus Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	TERM1	Termination Resistor; Short to Pin 4 to add 120Ω bus termination	Stack Bus Connector
2	STACKBUS_N	Stack bus differential pair negative	Power Interface
3	+VSYS	+24V Power Supply	Power Interface
4	TERM2	Termination Resistor; Short to Pin 1 to add 120Ω bus termination	Stack Bus Connector
5	STACKBUS_P	Stack bus differential pair positive	Power Interface
6	COM	Power return from SC	Power Interface

4. Nuvation Energy Cell Interface

4.1. Overview

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

There are three models of the Cell Interface.

- The NUV100-CI-12-1, Cell Interface - 12 channel can monitor up to 12 series-connected cells
- The NUV100-CI-16-1, Cell Interface - 16 channel can monitor up to 16 series-connected cells
- The NUV100-CI-4M12-1, Cell Interface - 12V 4 channel can monitor up to 4 series-connected 12V lead-acid cells

4.2. Mechanical Dimensions

4.3. 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 3. 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.

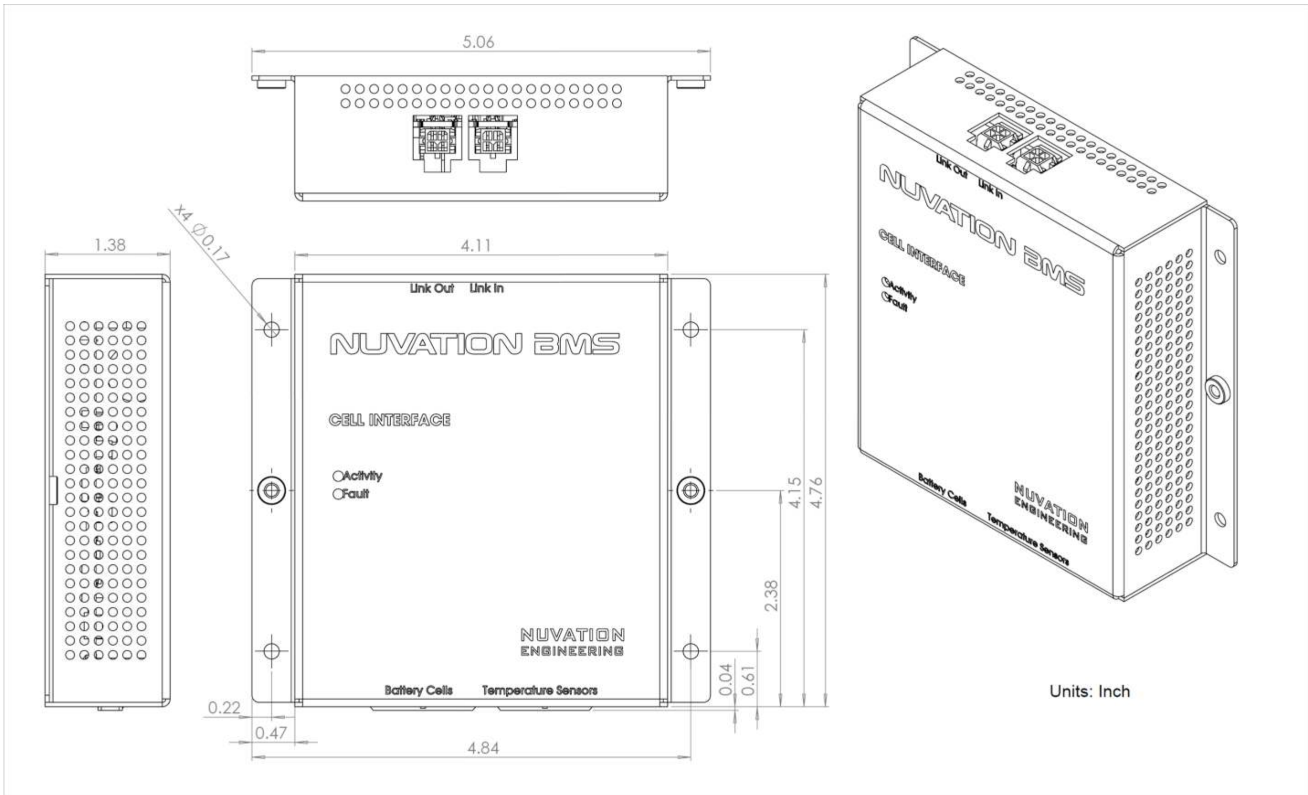


Figure 3. Mechanical Drawing of Cell Interface with Bulkhead Enclosure

4.3.1. 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 4.

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 4.

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

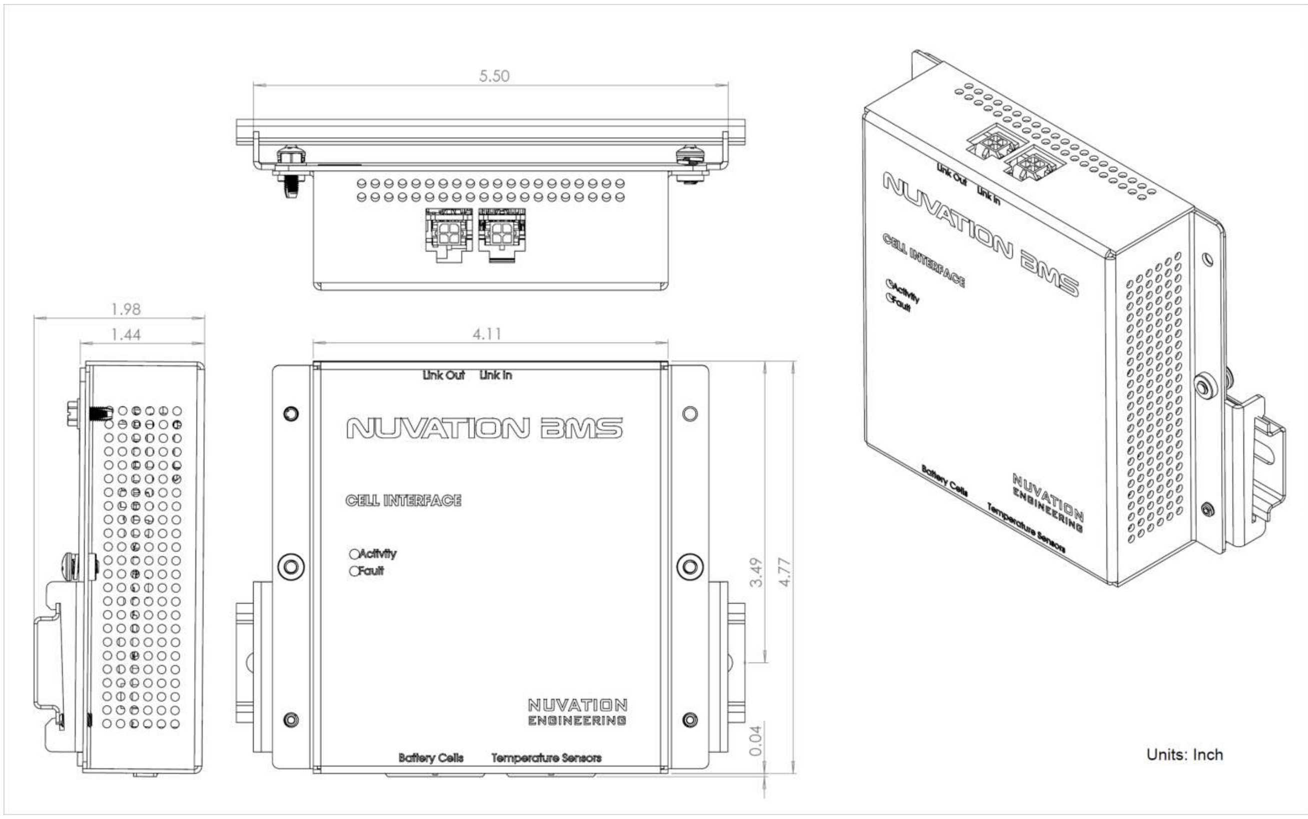


Figure 4. Mechanical Drawing of Cell Interface with Cell Interface Mounting Bracket (Bulkhead-to-DIN)

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 5.

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

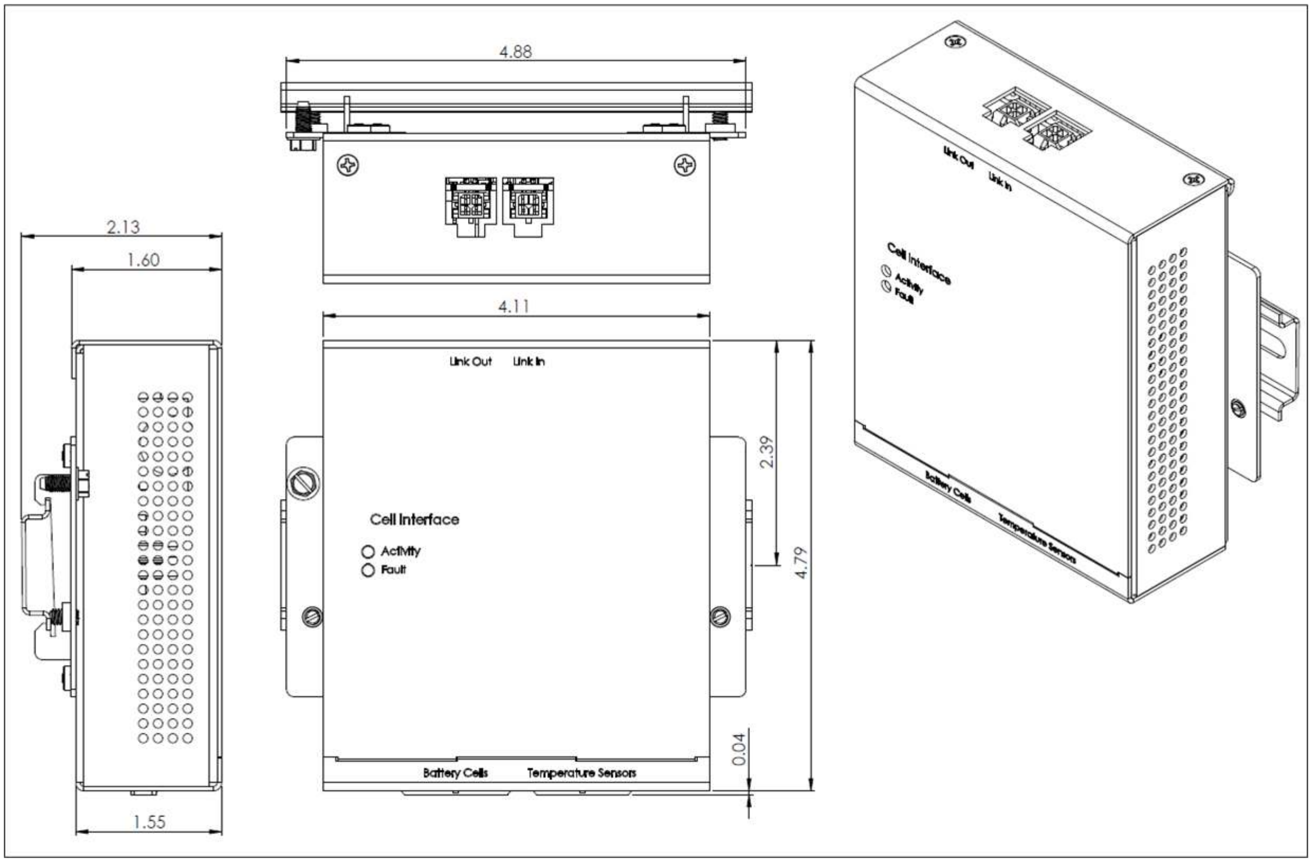


Figure 5. Mechanical Drawing of Cell Interface with DIN Enclosure (NRND)

4.4. Electrical Connections

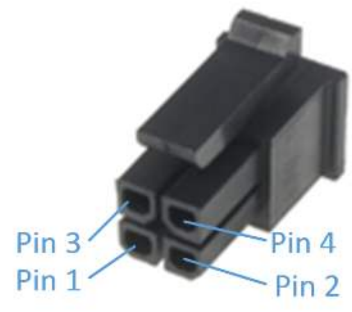
The Cell Interface module has 4 connectors. Each connector is described in the following sections in detail.

4.4.1. Link Out

The Link Out connector provides power and communication to the Cell Interface modules above this Cell Interface. The amount of current supplied by this connector is the sum of current consumed by all Cell Interface modules above this Cell Interface.

Connect the Cell Interface that is measuring the next series-connected cell above the most positive cell connected to this connector.

Table 13. Link Out: Molex Micro-Fit 3.0 Connector



Molex 43025-0400	
Manufacturer	Molex Incorporated
Housing	43025-0400
Housing material	Nylon UL94V-0
Circuits	4
Crimp terminal	43030-0002
Wire gauge range	AWG20-24 stranded

Table 14. Link Out Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	VBUS	DC power from Stack Controller, with Fault Pilot Signal	Cell Interface
2	COM	Power return from Stack Controller	Cell Interface
3	IPA	Link Bus differential pair plus	Cell Interface
4	IMA	Link Bus differential pair minus	Cell Interface

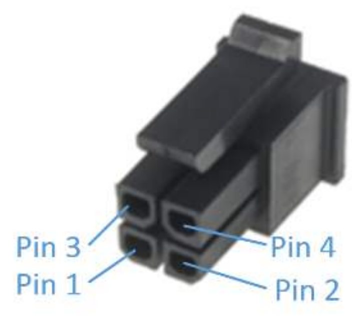
4.4.2. Link In

The Link In connector provides power and communication to this Cell Interface from the Cell Interface modules below this Cell Interface, or from the Stack Controller if this Cell Interface is measuring the most negative cell in the stack.

The amount of current sourced into this connector is the sum of current consumed by this Cell Interface and all those above it (which amounts to all Cell Interface modules if this Cell Interface is measuring Cell 1).

Connect to the Link Out connector on the Cell Interface that is measuring the previous series-connected cell below this Cell Interface to this connector, or connect the Stack Controller to this connector if this Cell Interface is measuring the bottom cell in the stack.

Table 15. 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	43030-0002
Wire gauge range	AWG20-24 stranded

Table 16. Link In Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	VBUS	DC power from Stack Controller, with Fault Pilot Signal	Cell Interface
2	COM	Power return from Stack Controller	Cell Interface
3	IPA	Link Bus differential pair plus	Cell Interface
4	IMA	Link Bus differential pair minus	Cell Interface

4.4.3. Battery Cells

The Battery Cells connector provides cell voltage input and a means for balancing the cells. The cable wire should be rated for at least 750mA to survive worse-case current.

Pins 8, 16, 17, and 18 are `No Connect` in the Cell Interface - 12 channel model. Pins 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16, and 17 are `No Connect` in the Cell Interface - 12V 4 channel model.

All unused voltage inputs should be tied to the next highest potential voltage sense input. In this way, all pins should be connected with the exception of pins 8, 16, 17 and 18 in the Cell Interface - 12 channel model and pins 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16, and 17 in the Cell Interface - 12V 4 channel model.

Connect the battery cell voltage sense leads to this connector.

Table 17. 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

Table 18. Cell Interface - 12 channel Battery Cell Connector Pin Assignment

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	No Connect	Not Connected	No Connect
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

Pin	Connection	Description	Connected to Device
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	No Connect	Not Connected	No Connect
17	No Connect	Not Connected	No Connect
18	No Connect	Not Connected	No Connect

The following is an example wiring guide for a Cell Interface - 12 channel with 12 cells and 8 cells

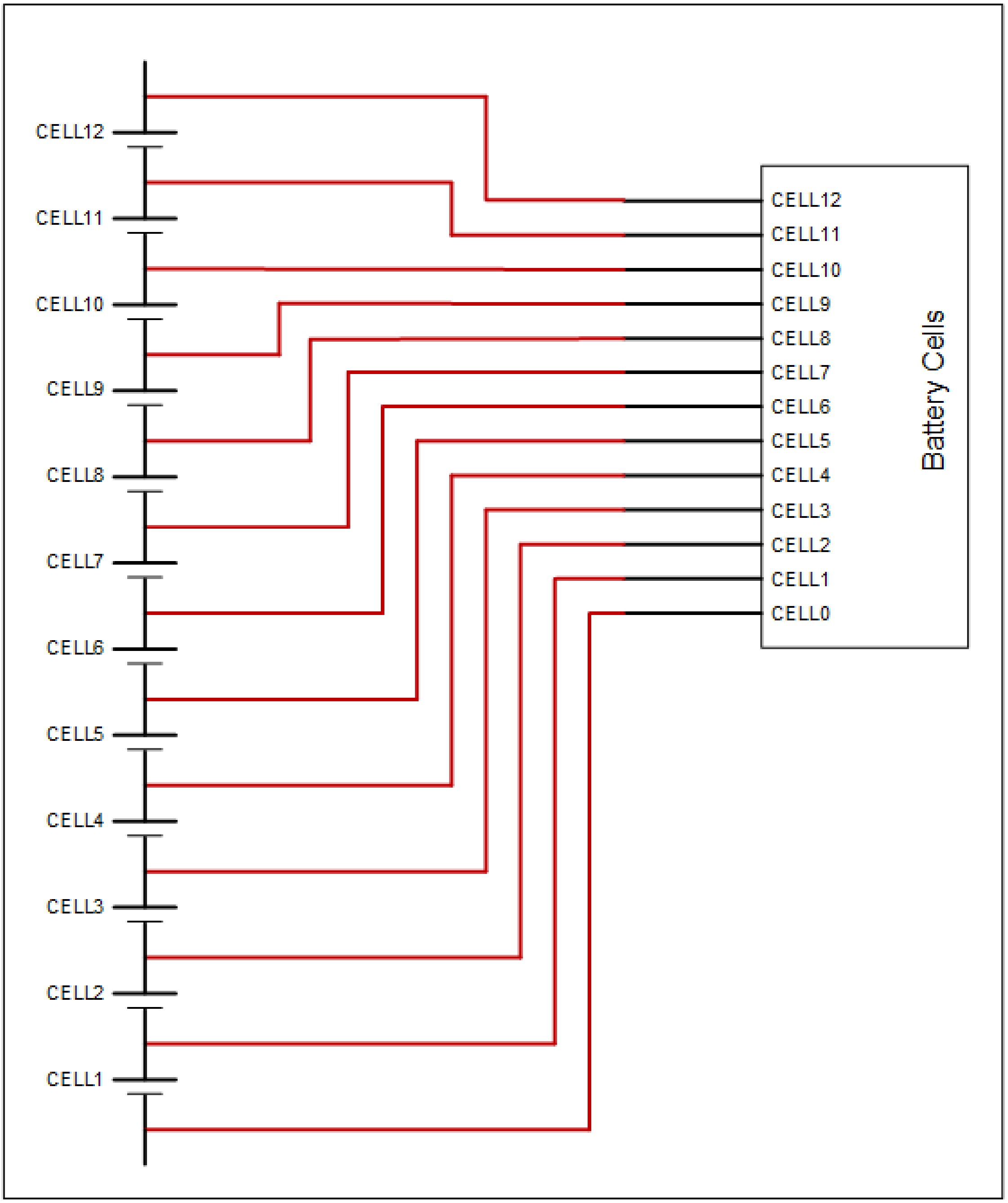


Figure 6. Example wiring 12 cells in a Cell Interface - 12 channel

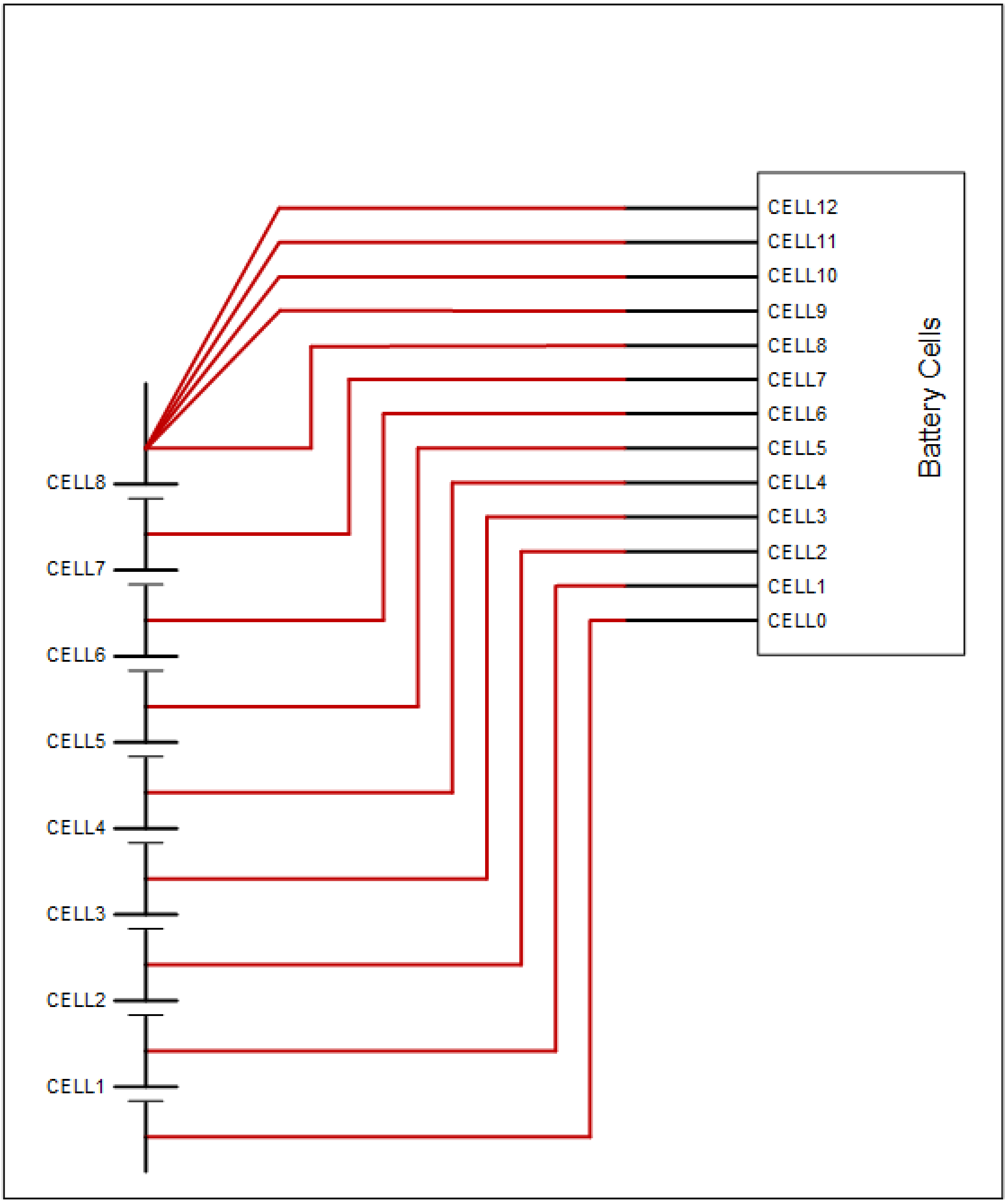


Figure 7. Example wiring 8 cells in a Cell Interface - 12 channel

Battery Cell Connecter for Cell Interface - 16 channel

Table 19. Cell Interface - 16 channel Battery Cell Connector Pin Assignment

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

Pin	Connection	Description	Connected to Device
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

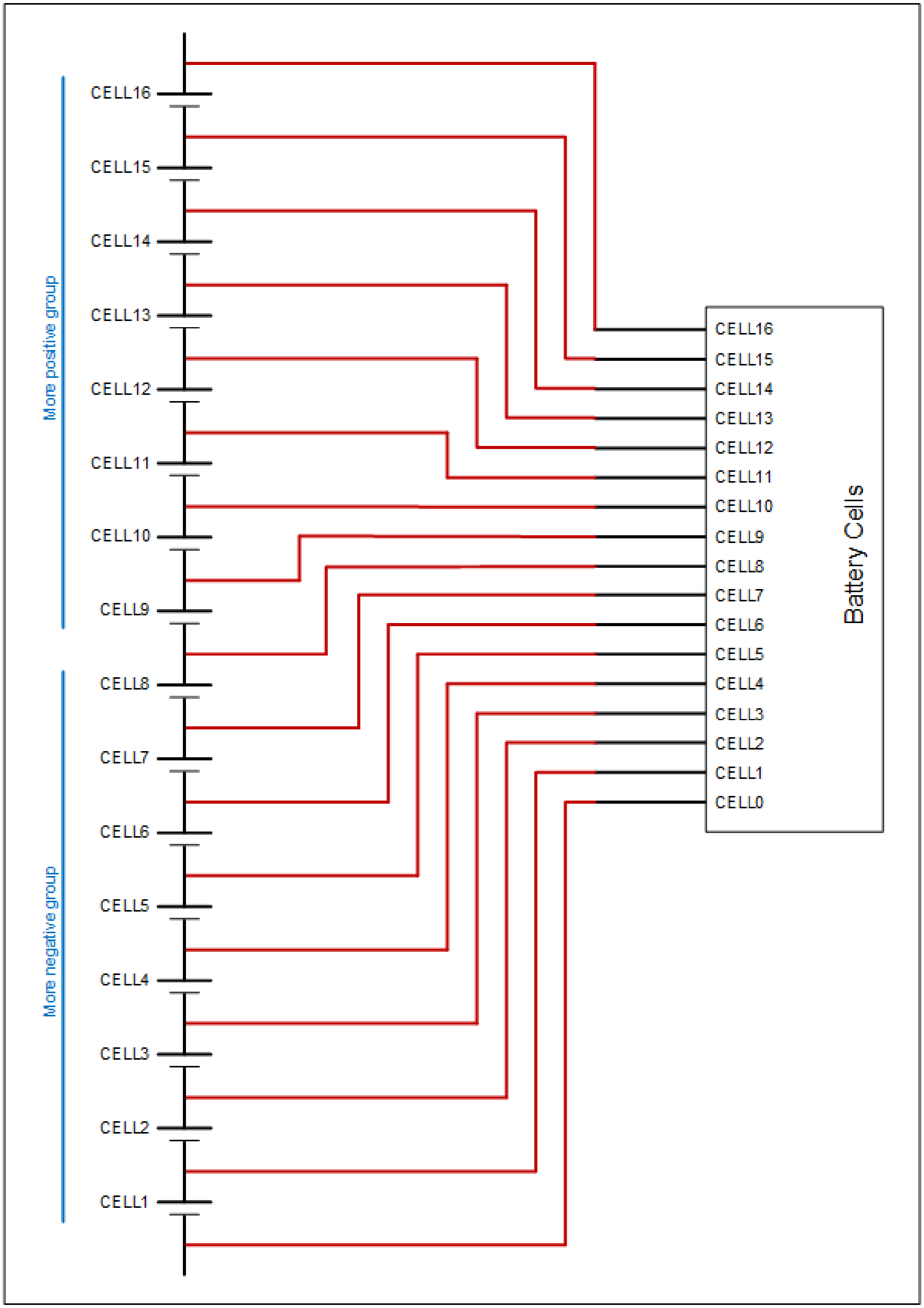


Figure 8. Example wiring 16 cells in a Cell Interface - 16 channel

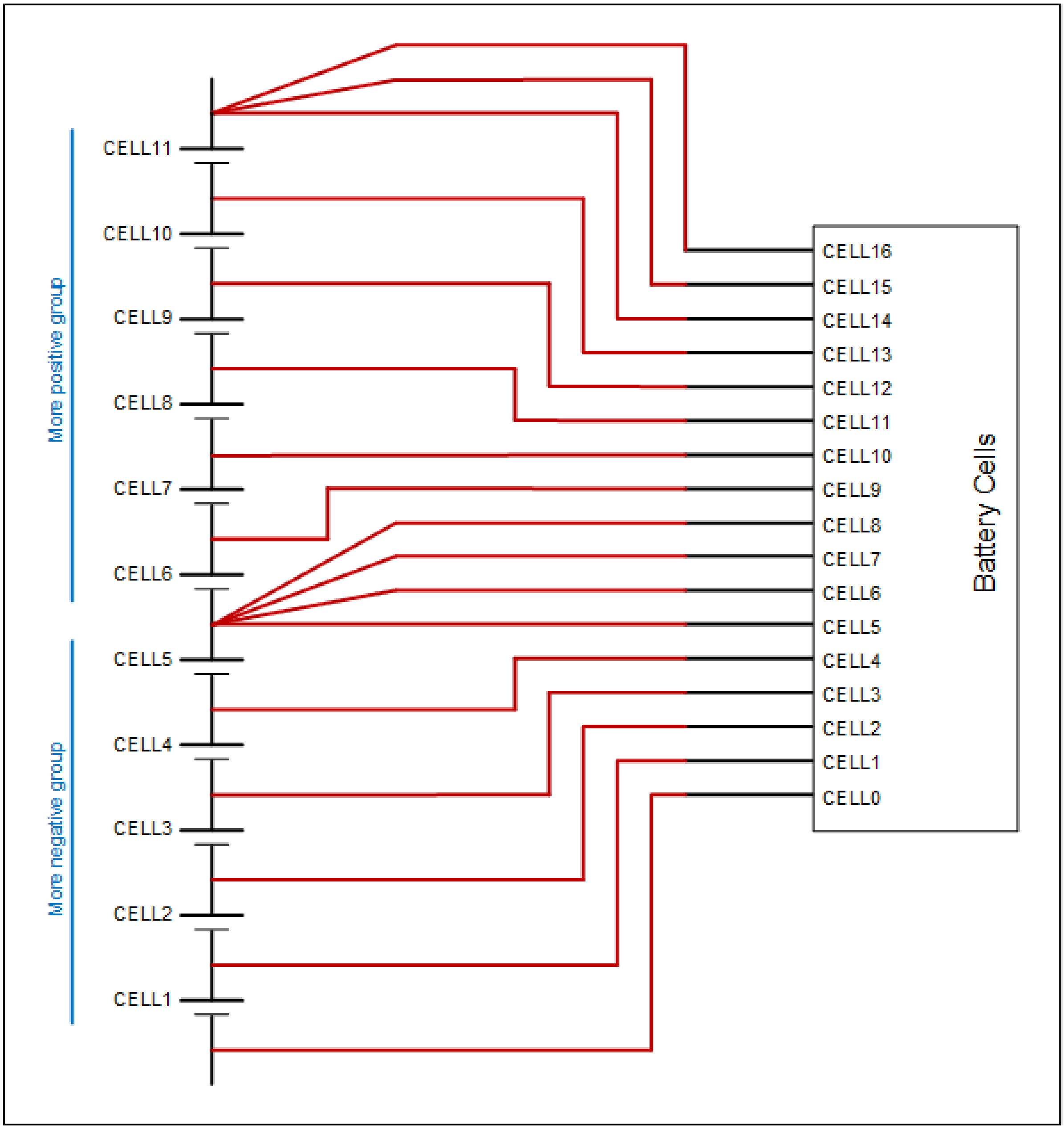


Figure 9. Example wiring 11 cells in a Cell Interface - 16 channel

Battery Cell Connecter for Cell Interface - 12V 4 channel

Table 20. Cell Interface - 12V 4 channel Battery Cell Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	CELL0	Bottom reference of Cell Interface	Connect to negative terminal of the lowest cell (Cell 1)
2	No Connect	Not Connected	No Connect
3	CELL4	Cell 1 voltage sense	Connect to positive terminal of the lowest cell (Cell 1)

Pin	Connection	Description	Connected to Device
4	No Connect	Not Connected	No Connect
5	CELL8	Cell 2 voltage sense	Connect to positive terminal of Cell 2
6	No Connect	Not Connected	No Connect
7	CELL1	Cell 3 voltage sense	Connect to positive terminal of Cell 3
8	No Connect	Not Connected	No Connect
9	No Connect	Not Connected	No Connect
10	No Connect	Not Connected	No Connect
11	No Connect	Not Connected	No Connect
12	No Connect	Not Connected	No Connect
13	No Connect	Not Connected	No Connect
14	No Connect	Not Connected	No Connect
15	No Connect	Not Connected	No Connect
16	No Connect	Not Connected	No Connect
17	No Connect	Not Connected	No Connect
18	CELL16	Cell 4 voltage sense	Connect to positive terminal of Cell 4

The following is an example wiring guide for a Cell Interface - 12V 4 channel with 4 cells and 3 cells

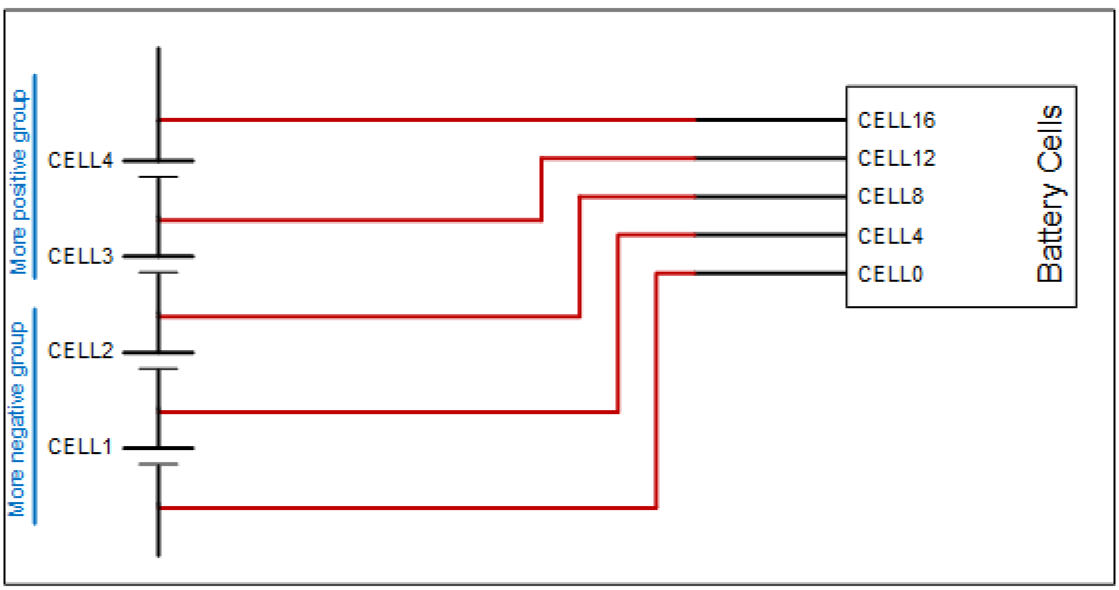


Figure 10. Example wiring 4 cells in a Cell Interface - 12V 4 channel

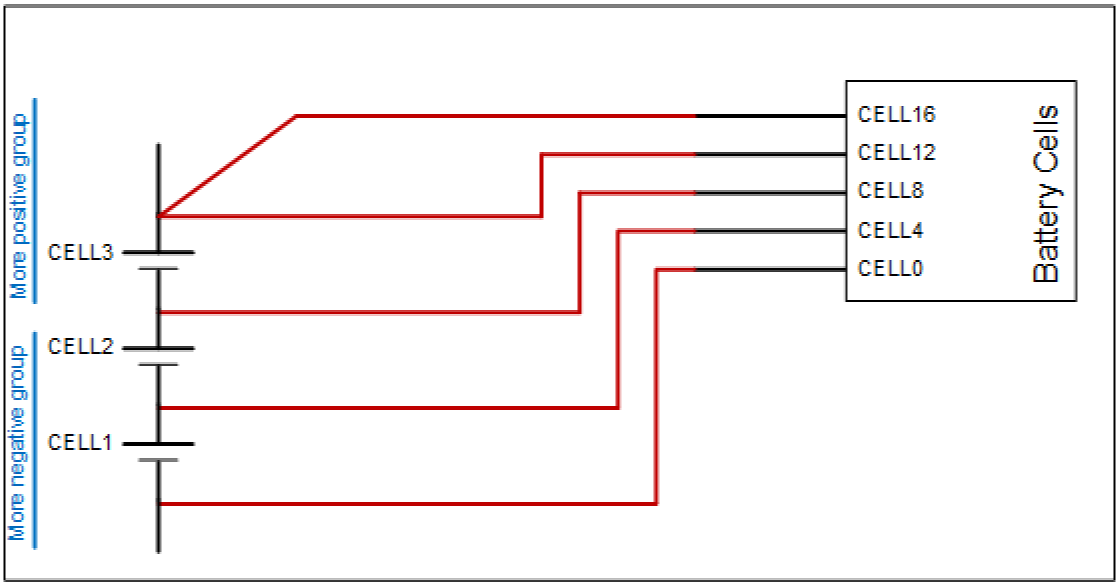


Figure 11. Example wiring 3 cells in a Cell Interface - 12V 4 channel

4.5. 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 21. 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 22. 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. High-Voltage Power Interface

5.1. Overview

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

There is only one model of the Power Interface, the NUV100-PI-HE.

5.2. Mechanical Dimensions

The overall dimensions of the Power Interface are 174.40 mm X 121.58 mm X 48.60 mm.

It comes standard with DIN clips that enable the Power Interface module to be securely mounted to EN50022-compliant DIN rails. The clips add an extra 19.6 mm to the overall width of the Power Interface, bringing it from 174.40 mm to 194 mm. The clips also hold the module approximately 7 mm away from the inside lip of the DIN rail.

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

> The Power Interface can contain high-voltage signals. It is possible to have signals 1250 V DC away from earth ground. Care must be taken when mounting the PCB into a metal enclosure to ensure the metal walls remain the correct distance from the exposed conductor on the PCB. Using the 1250 V DC as an example, the metal walls must be at least 4.2 mm from the nearest exposed conductor and not touch the PCB or any component on the PCB, including the connector housings.

The Power Interface weighs approximately 915 g.

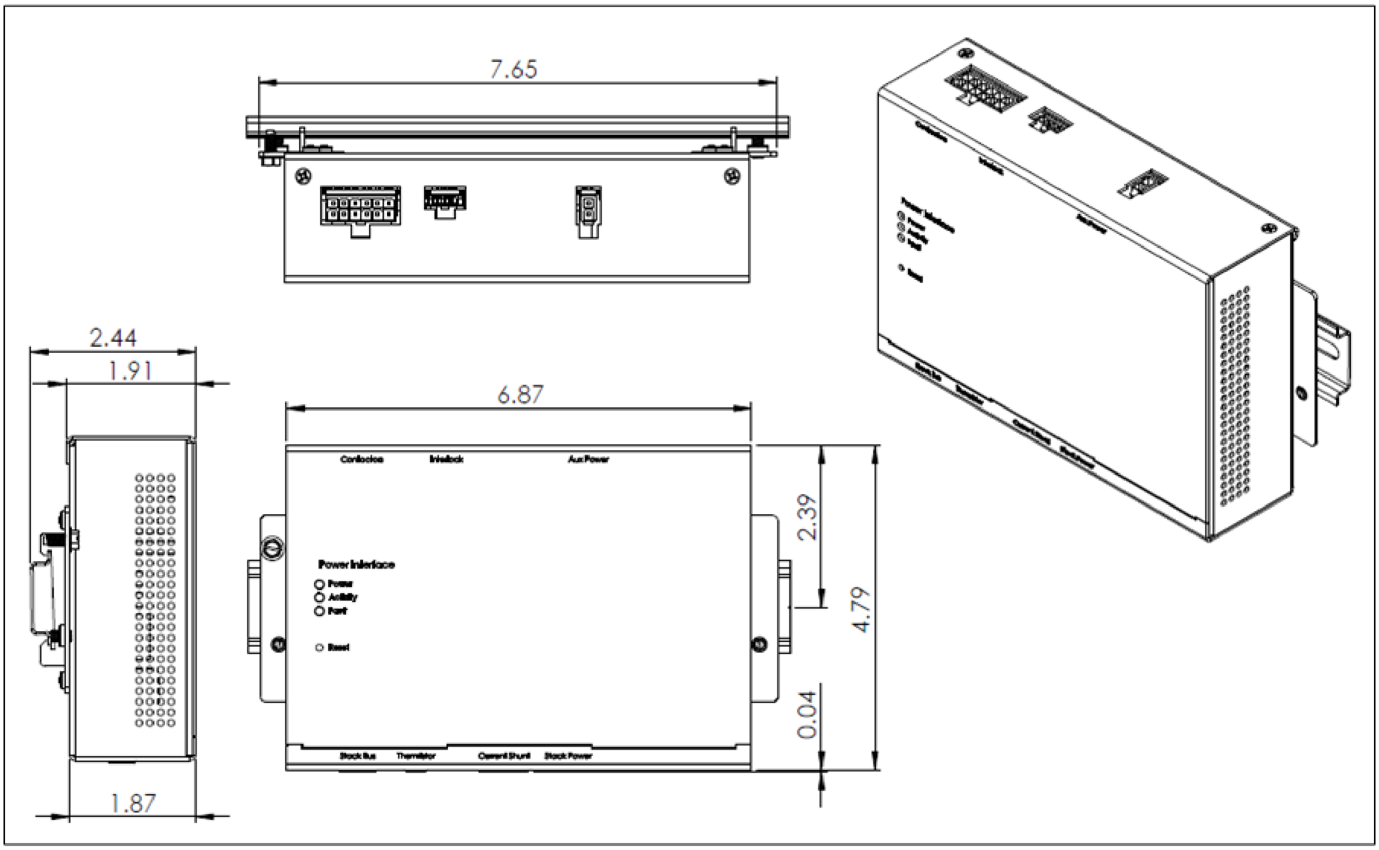


Figure 12. Mechanical Drawing of Power Interface

5.3. Electrical Connections

The Power Interface module has seven connectors. Each connector is described in the following sections in detail.

5.3.1. Contactors

The Contactor connector is a 12-pin Mini-Fit® Jr. Molex connector. This interface is used to provide or select contactor coil operating power, either from an external power supply (40 V max), or from a loop-back connection from the BMS internal 24 V (nominal) source.

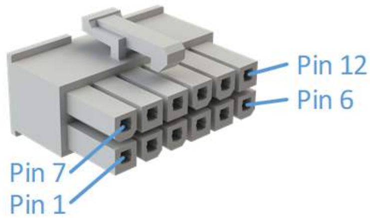
The Contactors connector also connects to up to 4 external contactor coils. Each output is capable of sourcing a maximum of 2.8 A continuously.

If coil operating power is provided from an external power source, the sum of all 4 output currents must not exceed 5 A continuous. If coil operating power is provided from the internal power source, the sum of all 4 output currents must not exceed 2.8 A or 2.9 A minus 31.7 mA per Cell Interface connected in the system, whichever is lower.

Coil high-side drive and return outputs are provided at the connector. The return is referenced to the Power Interface chassis. Contactor coil back-EMF is internally clamped at 40 V.

Connect up to 4 high-current contactor coils to this connector.

Table 23. Contactors: Molex MiniFit Jr Connector



Molex 39-01-2125	
Manufacturer	Molex Incorporated
Housing	39-01-2125
Housing material	Nylon UL94V-0
Circuits	12
Crimp terminal	39-00-0181
Wire gauge range	AWG18-24 stranded

Table 24. Contactor Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	COIL1_HI	Positive Coil 1	Contactor 1 positive coil connection
2	COIL2_HI	Positive Coil 2	Contactor 2 positive coil connection
3	COIL3_HI	Positive Coil 3	Contactor 3 positive coil connection
4	COIL4_HI	Positive Coil 4	Contactor 4 positive coil connection
5	No Connect	Not Connected	No Connect
6	COM	Negative reference for external supply	External Power Supply
7	COM	Negative Coil 1	Contactor 1 negative coil connection
8	COM	Negative Coil 2	Contactor 2 negative coil connection
9	COM	Negative Coil 3	Contactor 3 negative coil connection
10	COM	Negative Coil 4	Contactor 4 negative coil connection
11	+VINT	PI Power Supply	Connect to Contactors connector Pin 12 if driving contactor coil from Power Interface power supply
12	+VCOIL	12~24V Contactor Coil Power Supply	Connect to external power supply or Contactors connector Pin 11 if driving contactor coil from Power Interface power supply

The following is an example 2 contactor implementation with 24 V coils that are powered from the PI:

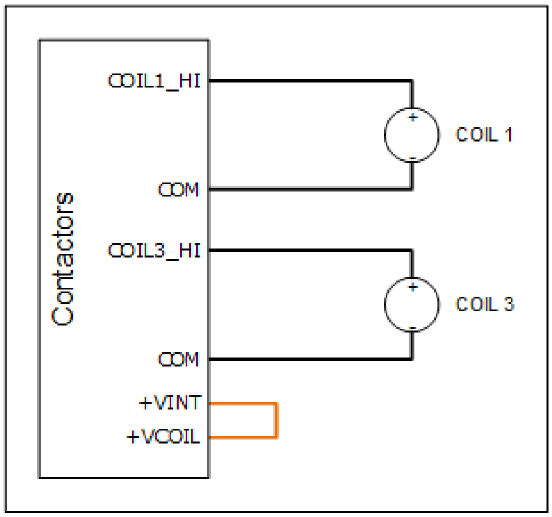


Figure 13. Example 2-coil wiring

The following is an example 4 contactor implementation that is powered from an external power supply:

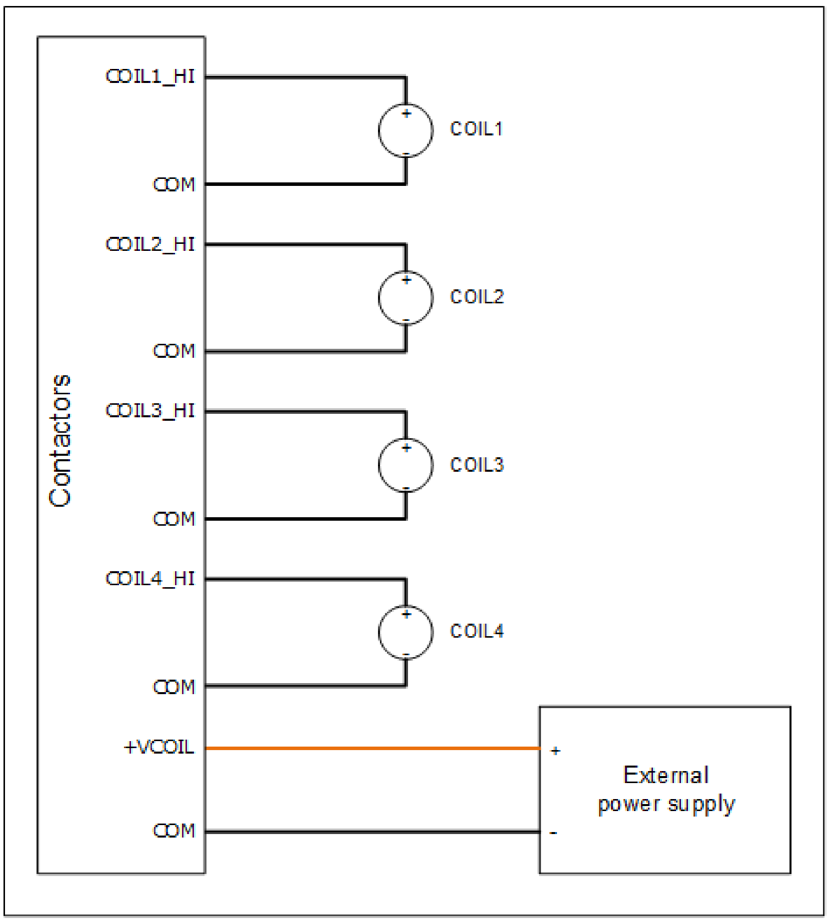


Figure 14. Example externally powered 4-coil wiring

5.3.2. Interlock

The Interlock connector provides a means to set the high-current contactor behavior, as outlined in the table below. Using a physical switch/relay instead of a jumper is a convenient way to implement an interlock switch that de-energizes the system contactors. It is recommended to connect pins 2 and 3 as this will enable the hardware redundant fault signaling feature to de-energize system contactors in the event of a Power Interface failure.

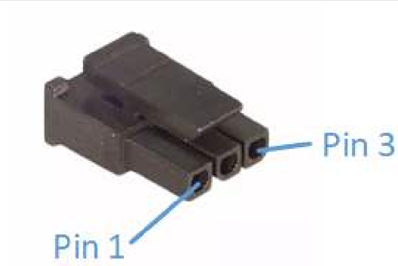
Table 25. Interlock Options

Interlock Connection		Function
1 & 3	**2 & 3**	
open	open	System contactors are de-energized
open	closed	System contactors are controlled by Nuvation Energy BMS software, but de-energized if hardware-based fault signaling detects a fault
closed	either open or closed	System contactors are controlled by Nuvation Energy BMS software; hardware-based fault signaling mechanism will not de-energize system contactors

> Pin 3 is electrically connected to chassis ground

Connect a jumper or external interlock switch to this connector.

Table 26. Interlock: Molex Micro-Fit Connector



Molex 43645-0300	
Manufacturer	Molex Incorporated
Housing	43645-0300
Housing material	Nylon UL94V-0
Circuits	3
Crimp terminal	43030-0002
Wire gauge range	AWG20-24 stranded

Table 27. Interlock Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	R_OVERRIDE_ENA#	Active-low; Allows Nuvation Energy BMS software to control contactors	Interlock Connector Pin 3
2	R_DRV_ENA#	Active-low; Allows internal hardware fault detection to override Nuvation Energy BMS software control of contactors	Interlock Connector Pin 3
3	COM	Power return from Power Interface	Interlock Connector Pin 1 or Pin 2

5.3.3. External Power

The External Power connector accepts power from an external power supply. This is the sole power source for Nuvation Energy BMS. The external supply can be either 16-24 V AC or 13-34 V DC and must be isolated from chassis and COM grounds. There is no polarity dependency between `PWR_A` and `PWR_B` pins.

Connect an external power supply to this connector.

Table 28. External Power: Molex MiniFit Jr Connector

Molex 39-01-2025	
Manufacturer	Molex Incorporated
Housing	39-01-2025
Housing material	Nylon UL94V-0
Circuits	2
Crimp terminal	39-00-0181
Wire gauge range	AWG18-24 stranded

Table 29. External Power Connector Pin Assignment

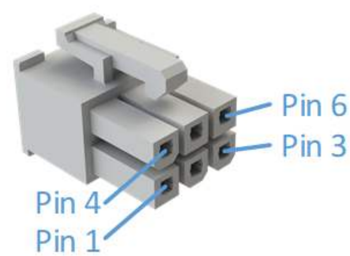
Pin	Connection	Description	Connected to Device
1	PWR_A	External Power Supply Input	External Power Supply
2	PWR_B	External Power Supply Input	External Power Supply

5.3.4. Stack Bus

The Stack Bus connector provides power and communication to the Stack Controller module. The Stack Bus provides 42 mA to the Stack Controller plus the summation of current consumed by all Cell Interface modules in the system (up to 25 mA per Cell Interface - 12 channel or 31 mA per Cell Interface - 16 channel). 120 Ω termination must be added by connecting pins 1 and 3 together with a short length of wire.

Connect the Stack Controller to this connector.

Table 30. Stack Bus: Molex MiniFit Jr Connector



Molex 39-01-2065	
Manufacturer	Molex Incorporated
Housing	39-01-2065
Housing material	Nylon UL94V-0
Circuits	6
Crimp terminal	39-00-0181
Wire gauge range	AWG18-24 stranded

Table 31. Stack Bus Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	TERM1	Termination Resistor; Short to Pin 4 to add 120Ω bus termination	Stack Bus Connector
2	STACKBUS_N	Stack bus differential pair negative	Stack Controller
3	+VSYS	+24V Power Supply	Stack Controller
4	TERM2	Termination Resistor; Short to Pin 1 to add 120Ω bus termination	Stack Bus Connector
5	STACKBUS_P	Stack bus differential pair positive	Stack Controller
6	COM	Power return from Power Interface	Stack Controller

5.3.5. Thermistor

Contact Nuvation Energy for support if temperature compensation of the high-current shunt is desired for your specific application.

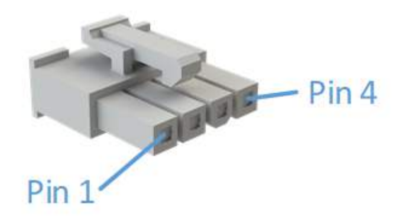
> Nuvation Energy can be contacted via support@nuvationenergy.com.

5.3.6. Current Shunt

The Current Shunt connector provides a current shunt input for current measurement of the high-voltage stack. For best results, minimize the cable length used between the shunt and the connector. Use a twisted pair for the differential shunt voltage sense wires. The differential voltage across the shunt must never exceed 1V under any circumstance. Choose the resistance value accordingly.

Connect the current shunt to this connector.

Table 32. Current Shunt: Molex MiniFit Jr Connector

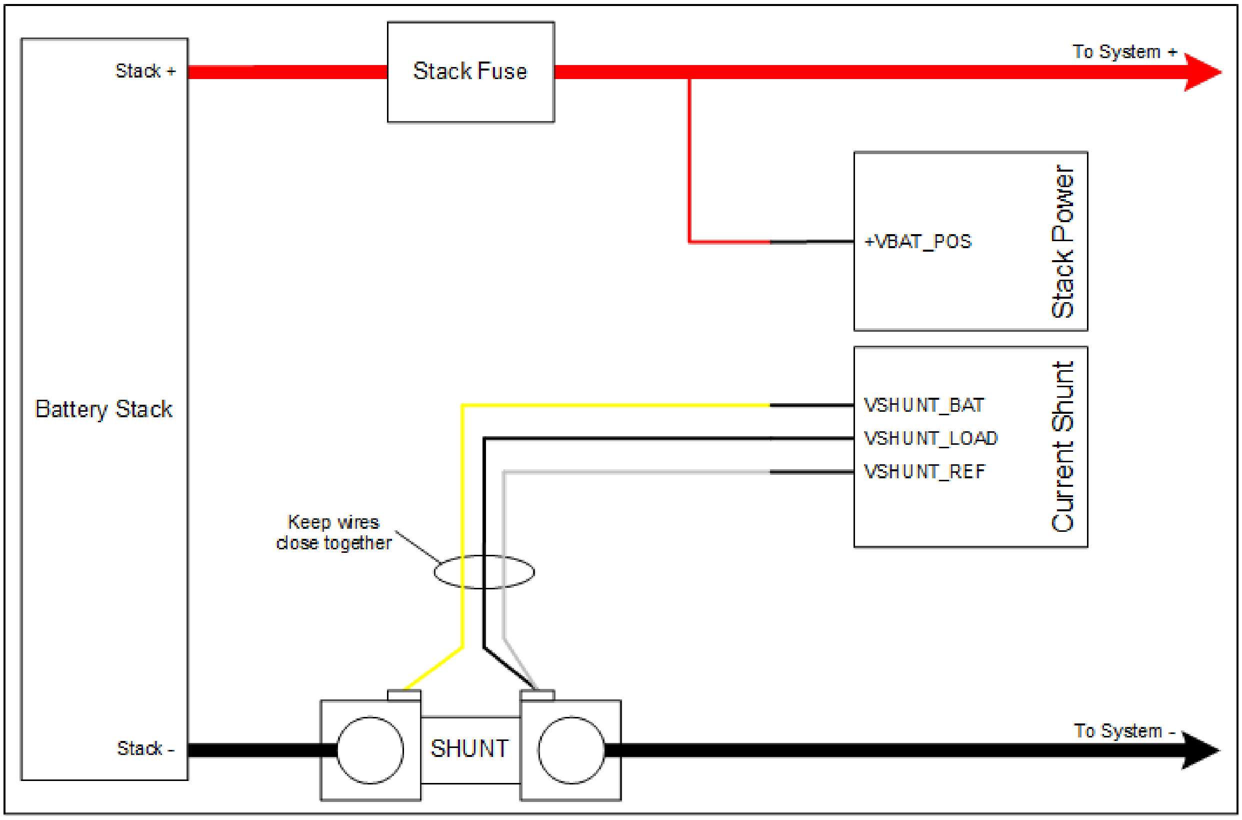


Molex 39-01-4041	
Manufacturer	Molex Incorporated
Housing	39-01-4041
Housing material	Nylon UL94V-0
Circuits	4
Crimp terminal	39-00-0181
Wire gauge range	AWG18-24 stranded

Table 33. Current Shunt Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	No Connect	Not Connected	No Connect
2	VSHUNT_REF	Voltage reference for voltage measurement	Load side of current shunt
3	VSHUNT_LOAD	Differential voltage input; Load side	Load side of current shunt
4	VSHUNT_BAT	Differential voltage input; Battery side	Battery side of current shunt

An example high-current shunt wiring diagram is shown below:

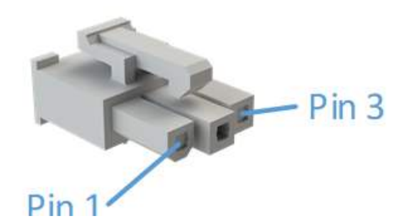


5.3.7. Stack Power

The Stack Power connector is used to provide an overall stack voltage measurement.

Connect the overall battery stack positive terminal to this connector.

Table 34. Stack Power: Molex MiniFit Jr Connector



Molex 39-01-4031	
Manufacturer	Molex Incorporated
Housing	39-01-4031
Housing material	Nylon UL94V-0
Circuits	3
Crimp terminal	39-00-0181
Wire gauge range	AWG18-24 stranded

Table 35. Stack Power Connector Pin Assignment

Pin	Connection	Description	Connected to Device
1	+VBAT_POS	Overall Stack Positive	Connect to most positive terminal of the battery stack
2	No Connect	Not Connected	No Connect
3	No Connect	Not Connected	No Connect

6. Nuvation Energy BMS: Best Practices

This section describes important concepts which need special attention to achieve a reliable installation.

6.1. Grounding

It is assumed that Nuvation Energy BMS will be attached electrically to an earth or local chassis ground point, via the DIN rail grounding provision (#8-32 , ¼" Hex-head drive, earth grounding screw), and the mounting brackets on Nuvation Energy BMS component enclosures.

Voltages and signals on the Stack Bus and Link Bus cables are chassis/earth ground referenced. In addition, the Stack Controller module's USB port, non-isolated RS485, and GPIO-In signals; and the Power Interface module's Contactor coils and Interlock signals are chassis/earth ground referenced.

All connections to the battery stack are isolated from chassis ground. This includes the Current Shunt, Thermistor, and Stack Power connections on the Power Interface; and the Battery Cells and Temperature Sensors connections on the Cell Interface, and Ethernet and CAN interfaces on the Stack Controller.

It is acceptable, as may be required in some cases, for the battery stack to be ground-referenced at some single point. However, a 24 V RMS AC or 24 V DC power supply connected to the Power Interface module's External Power connection must be isolated from earth/chassis ground, with a working isolation voltage of at least 60 V RMS for all Power Interface models.

Protective earthing conductors must be attached to each DIN enclosure at the designated ground screw location on the DIN clip. Furthermore, the DIN rail itself should be connected to earth ground. 14 AWG wire with a jacket color appropriate for indicating it is a protective earthing conductor must be used.

An example of this grounding scheme is shown below:

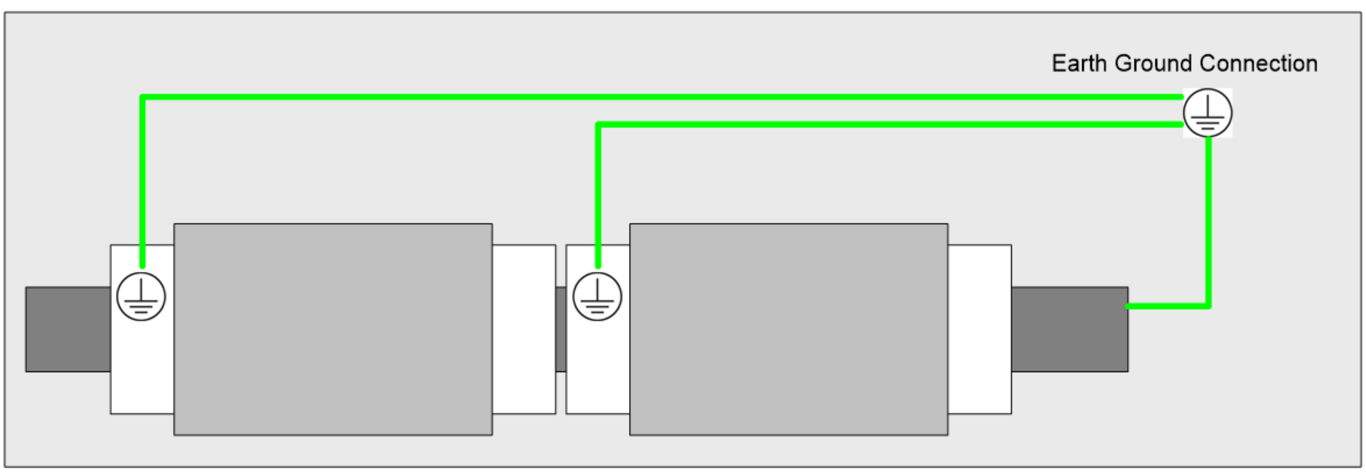


Figure 15. Example Earth Ground Wiring Diagram

6.2. Excess Cable Management

During the first prototype system build, it is possible to encounter cable lengths that are too long for your system. Leaving the excess cable length unmanaged can result in a messy system installation.

If reducing the cable length is not feasible or if there is no time to physically modify the lengths, a common solution is to wrap the excess cable length in a coil and fasten the wire loop in the cabinet. This basic tactic has the undesirable effect of creating an air-core transformer which will couple EMI into the cable extremely well.

The best solution to cable length management is to bundle the excess length in a figure-8 pattern. This prevents the bundle from turning into an air-core transformer since the direction of current in one side of the figure-8 turns opposite to the current in the other side. It is recommended to use the figure-8 method if physically reducing the cable length is not possible.

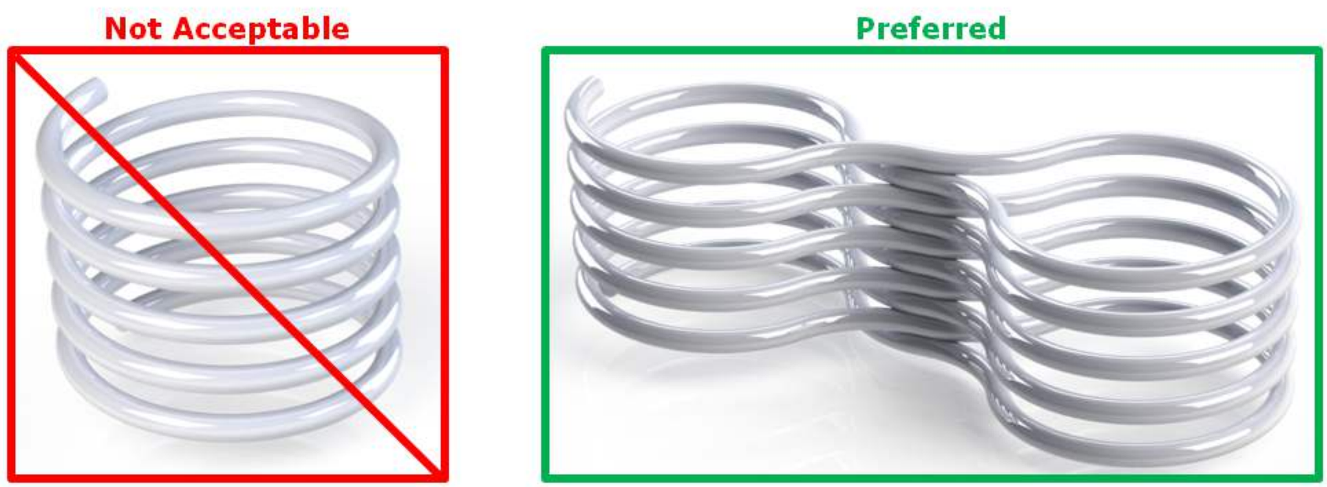


Figure 16. Excess Cable Management Examples

6.3. System Noise

High-power inverters generate a lot of system noise, especially on the DC bus. This is due to the industry standards for AC harmonics and EMC on the grid-side which require the DC bus to help filter out the harmful emissions. Unfortunately, that means the battery cells, and the High-Voltage BMS, experience extreme levels of noise.

The most harmful emissions on the DC bus are between the DC bus and earth. This is due to the slew-rate of the switching devices implemented in the inverter (usually IGBTs). The slew-rate is impacted by a many elements, and the emissions can be minimized by carefully grounding the installation so that the return-path for the high-frequency switching noise can be kept small.

The High-Voltage BMS has various faults and informative registers to determine if the system has a high level of noise that is impacting the battery management system.

The communication faults are:

```
sc_fault_linkbus_wdt.trig
sc_fault_stackbus_rxwdt.trig
sc_fault_stackbus_txwdt.trig
sc_fault_pi_afe_wdt.trig
sc_fault_controller_wdt.trig
```

The informative communication error registers are:

```
sc_linkbus_packets.operation_read_errors
sc_linkbus_packets.operation_validate_errors
sc_stackbus.rxerrrate
sc_stackbus.txerrrate
pi_afe.rx_err_rate
pi_afe.tx_err_rate
```

The system controller heartbeat should also be coming through as expected, and can be verified by reading the register:

```
sc_controller_heartbeat.value
```

In a correctly wired system, a communication fault points to elevated system noise that is disrupting communications. If the system grounding scheme cannot be improved, there are still a few techniques within Nuvation Energy BMS or the battery area to try to decrease the amount of noise.

6.3.1. DC Filtering

A DC filter can be installed between the DC bus and the inverter or between each DC battery stack and the common DC bus in a multi-stack system. Schaffner FN 2200 is an example DC filter which has been known to decrease the amount of harmful emissions on the DC bus. An example filter installation is shown below:

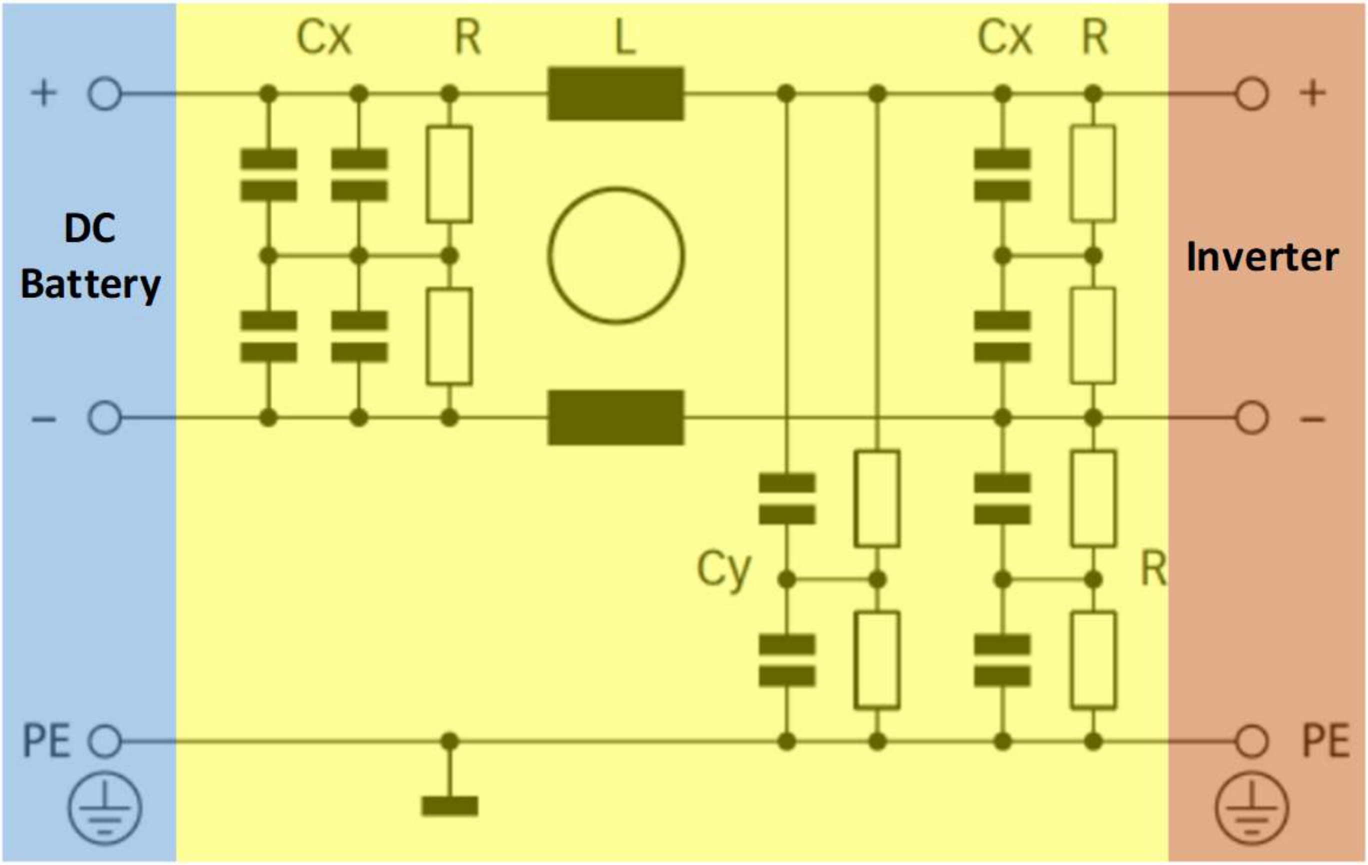


Figure 17. Example DC Filter Schematic

When using DC filters, please be aware that it shunts high-frequency noise to earth. If the inverter is not driving an insulated neutral system, there will be high current pulses flowing in the system earth which can trip ground fault detectors. It might be necessary to install an isolation transformer between the inverter and the grid to remove the high current pulses.

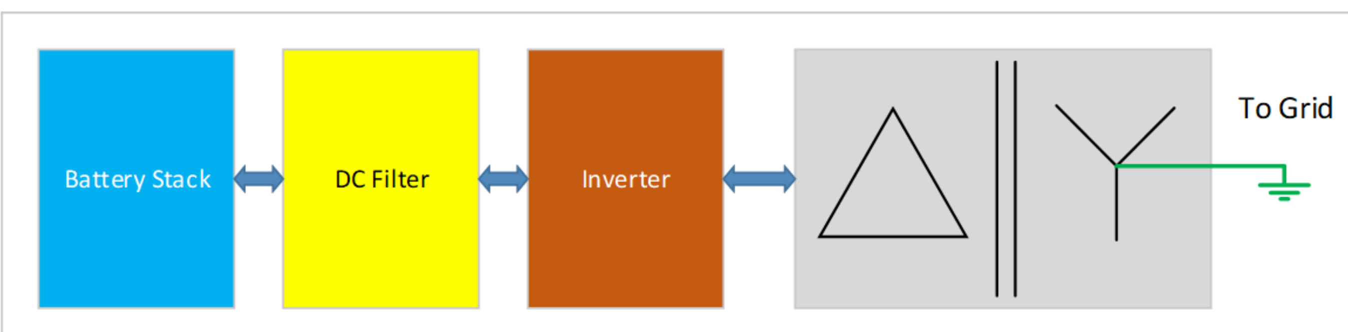


Figure 18. Example Isolation Transformer Installation Diagram

6.3.2. Stack Controller Grounding

If `sc_stackbus` communication faults are occurring, it might be alleviated by providing a dedicated ground connection for the Stack Controller. In the typical installation, the Stack Controller is grounded through the Power Interface via the Stack Bus cable. By providing a direct connection to ground, any noise entering the Stack Controller from the Link Bus cable will not flow through the Stack Bus cable.

Connect one of the following pins to earth:

- Link Out pin 2
- CAN485 pin 4
- GPIO-Out pin 5
- GPIO-In pin 1, 2, 3 or 4

6.3.3. Link Bus Power

While the communication interface between the Stack Controller and the Cell Interface is a daisy-chain, the power supplied to the Cell Interface from the Stack Controller is a bus. This results in the power twisted pair in the Link Bus cable carrying power up the entire length of the chain. This provides a decent medium to couple system noise into the Link Bus which can result in `sc_linkbus` communication faults.

In systems where the cells can provide the necessary minimum operating voltage to the Cell Interface, Link Bus power can be disabled if the observed impact on performance is acceptable. The power twisted pair must be disconnected in the Link Bus cable, so all Link Out and Link In connectors on the Stack Controller and Cell Interface must have pins 1 and 2 unpopulated. Also, the High-Voltage BMS must be configured to disable power to the Link Bus, by setting this register to 0:

```
sc_linkbus.power_mode = 0
```

Appendix A: Factory Reset

Overview

In the unlikely event Nuvation Energy BMS becomes inaccessible due to a forgotten password or invalid network configuration; a factory reset operation must be performed to restore the system to the default settings.

Reset to Factory Defaults

Follow the steps below to reset Nuvation Energy BMS to factory defaults:

1. Disconnect the `External Power` from the Power Interface
2. Disconnect the `Link Bus cable` from the Stack Controller
3. Connect the `Factory Reset cable` to the `Link Bus connector` on the Stack Controller

> If a `Factory Reset cable` is unavailable, connect an external 18-24V DC power supply to the `Link Bus connector` on the Stack Controller.
>
> Pin 1 on the `Link Bus connector` is positive and Pin 2 is negative

4. Observe a blinking activity LED on the Stack Controller
5. Connect `External Power` to the Power Interface
6. Disconnect the `Factory Reset cable` from the Stack Controller
7. Wait for the blinking activity LED on the Stack Controller to stop blinking
8. Reconnect the `Link Bus cable` to the Stack Controller

Nuvation Energy BMS should now be reset to the factory firmware version, default password, and default network configuration.

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.