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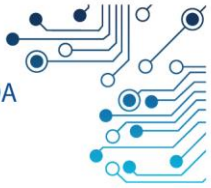

Nuvation BMS™ Implementation Guide

2017-01-31, Rev. 1.0

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System Overview

Nuvation BMS™ is generally comprised of the following modules:

- 1 Stack Controller
- 1 Power Interface
- 1 or more Cell Interfaces

An example configuration is shown in Figure 1.

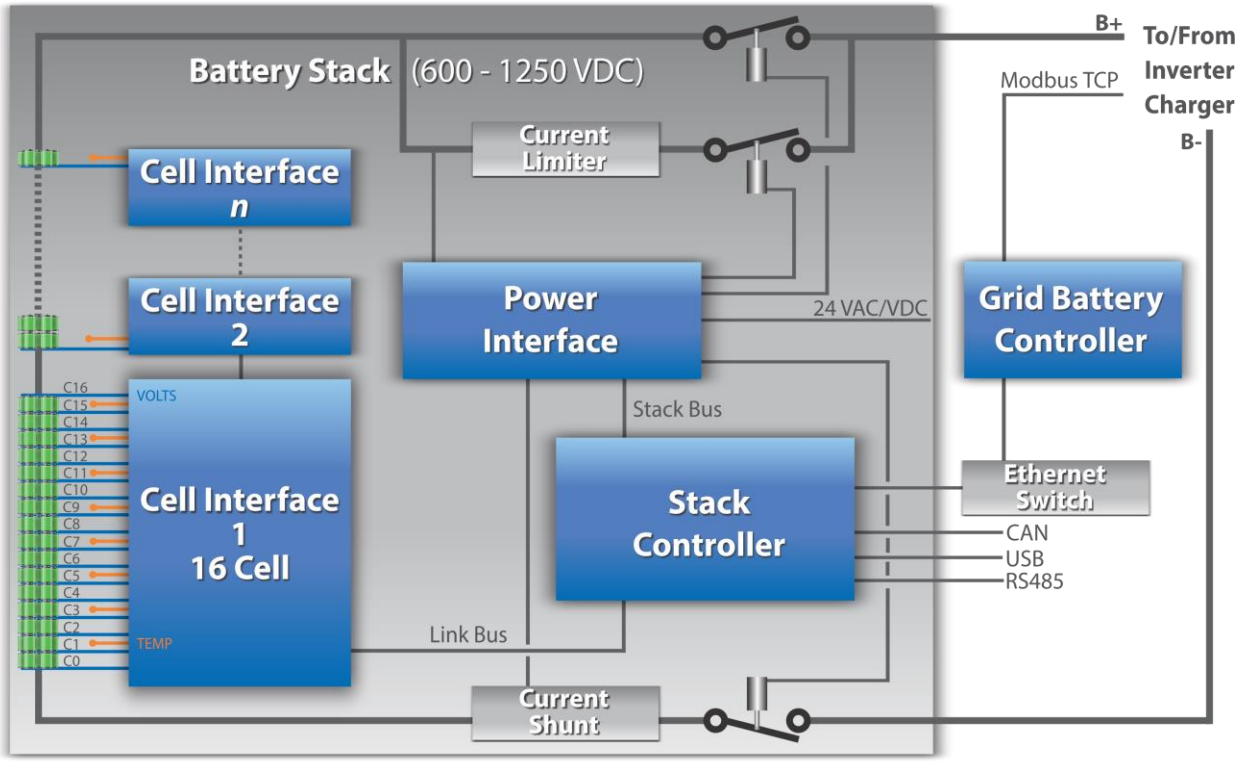

Figure 1: Nuvation BMS™ Example System Diagram

Important safety notes:

1. **All connections to the Cell Interface and Power Interface BMS modules must be connected first before energizing the system.**
2. **Non-barehand handling of any connector carrying potentials over 600Vdc relative to chassis is required.**
3. **Provided enclosures are not fire enclosures.**

When multiple stacks are connected in parallel to form a large system, a Grid Battery Controller is required to aggregate information from each Stack Controller in the system and to provide a unified interface to the large battery system. An example configuration is shown in Figure 2.

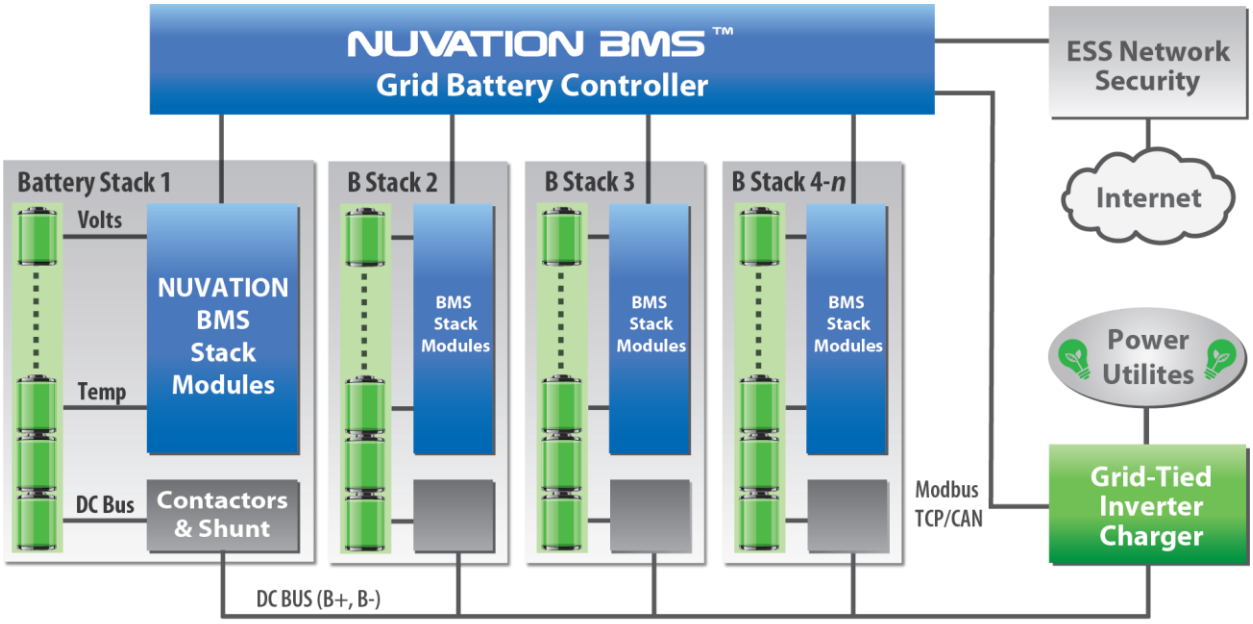

Figure 2: Grid Battery Controller Example System Diagram

Nuvation BMS Modules

This section describes each module in detail.

In the following sections, where Molex connectors are named, reference must be made to the manufacturer's data sheet to verify pin number assignment.

Stack Controller

The Stack Controller (SC) 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, RS485 (Modbus) and USB connections are included. No high-voltage or high-current interfaces are present on the SC, making this module easy and safe to connect to for service operations.

There is only one model of the SC.

The following is a functional block diagram of the SC showing the internal connections:

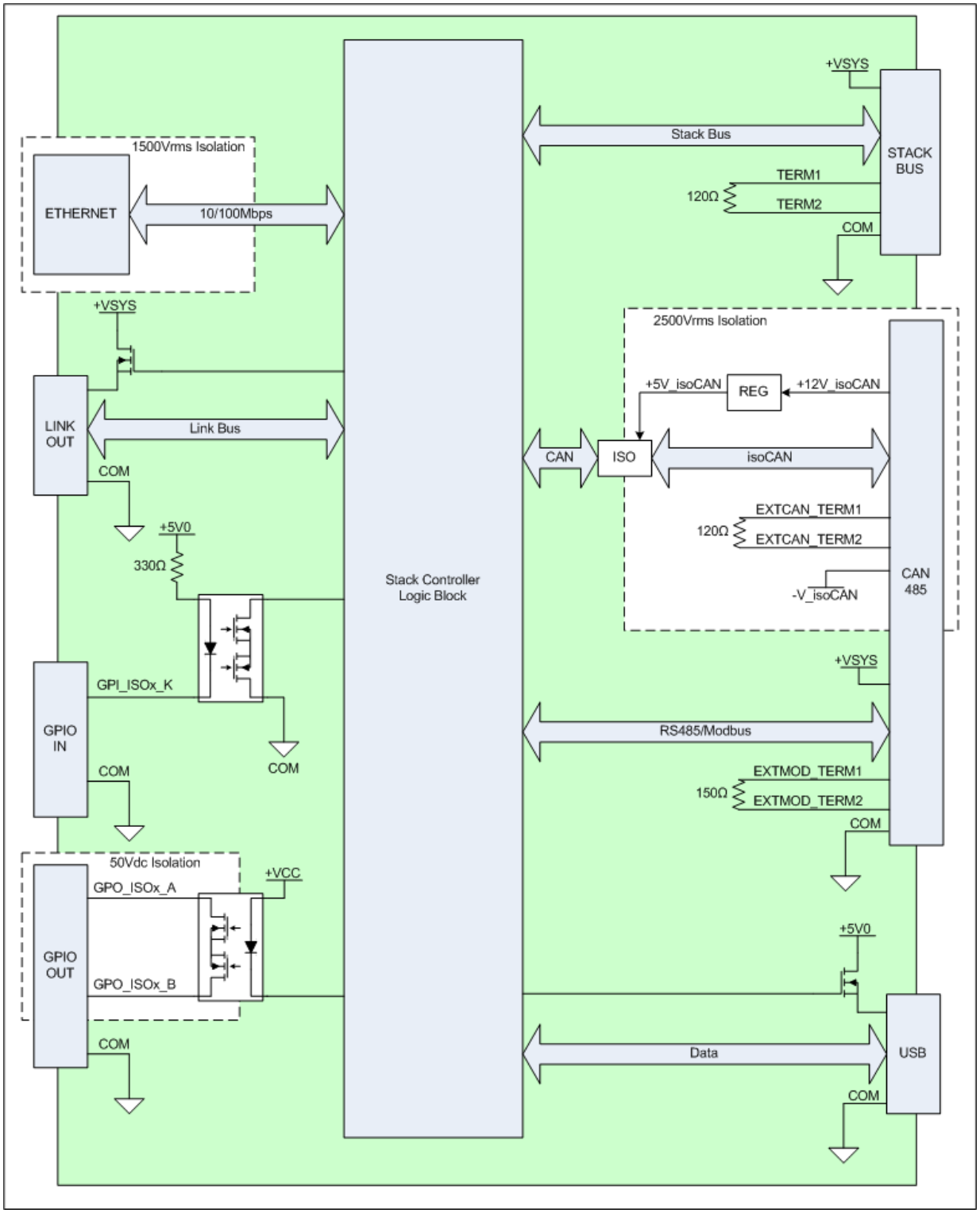

Figure 3: Stack Controller Block Diagram

Mechanical Dimensions

The overall dimensions of the SC are 104.4mm X 121.58mm X 40.6mm. It comes standard with DIN clips that enable the SC module to be securely mounted to EN50022-compliant DIN rails. The clips add an extra 19.6mm to the overall width of the SC module, bringing it from 104.4mm to 124mm. The clips also hold the module approximately 7mm away from the inside lip of the DIN rail. Extra space should be provided around the module to allow for easy installation/maintenance.

A more detailed mechanical drawing of the SC module is provided in Appendix A: Detailed Mechanical Drawings.

Electrical Connections

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

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 Cell 0 to this connector.

Connector Part Number	43025-0400
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 4POS 20-24AWG GOLD

Figure 4: Molex Micro-Fit 3.0 Connector for Connection to Link Bus

Table 1: Link Bus Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	PWR	-	VBUS	DC power from SC, with Fault Pilot Signal	Cell Interface
2	PWR	-	COM	Power return from SC	Cell Interface

Pin	Type	I/O	Connection	Description	Connected to Device
3	I/O	-	IPA	Link Bus differential pair plus	Cell Interface
4	I/O	-	IMA	Link Bus differential pair minus	Cell Interface

CAN 485

The CAN 485 connector contains both isolated CAN and non-isolated RS485 (Modbus) connections. Connect external equipment to this connector.

Connector Part Number	43025-1200
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 12POS 20-24AWG GOLD

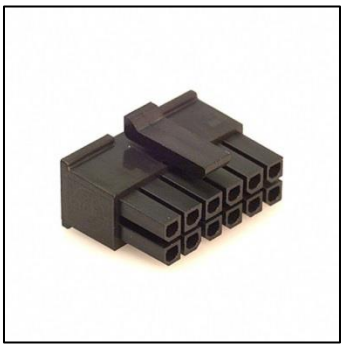

Figure 5: Molex Micro-Fit 3.0 Connector for Connection to External CAN and MODBUS

Table 2: CAN 485 Connector Pin Assignment

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

Pin	Type	I/O	Connection	Description	Connected to Device
12	I/O	-	EXTMOD_TERM2	Termination Resistor; Short to Pin 6 to add 150Ω bus termination	CAN 485 Connector

USB

The USB connector is a standard USB host A-type connector. Connect external equipment to this connector.

Table 3: USB Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	PWR	-	+5V_USB	+5V Power supply	External Equipment
2	I/O	-	USB_CONN_D_N	Data -	External Equipment
3	I/O	-	USB_CONN_D_P	Data +	External Equipment
4	PWR	-	COM	Power supply return from Pin 1	External Equipment

Ethernet

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

Table 4: Ethernet Connector Pin Assignment

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

GPIO-Out

The GPIO-Out connector provides four (4) general-purpose outputs. Four (4) independent solid-state relays are used to connect *_A pins to their corresponding *_B pins. Each output is rated for 60VDC, 200mA max., and the signals connected to each output do not need to be chassis/earth ground referenced. There is no polarity dependency between *_A and *_B pins. Connect external equipment to this connector.

Connector Part Number	43025-1000
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 10POS 20-24AWG GOLD

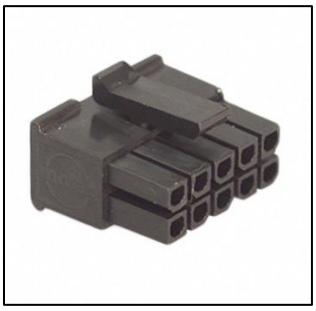

Figure 6: Molex Micro-Fit 3.0 Connector for General Connection to External Equipment

Table 5: GPIO-Out Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	Output	O	GPO_ISO0_A	Digital Output 0	External Equipment
2	Output	O	GPO_ISO1_A	Digital Output 1	External Equipment
3	Output	O	GPO_ISO2_A	Digital Output 2	External Equipment
4	Output	O	GPO_ISO3_A	Digital Output 3	External Equipment
5	PWR	-	COM	Power return from SC	External Equipment
6	Output	O	GPO_ISO0_B	Digital Output 0	External Equipment
7	Output	O	GPO_ISO1_B	Digital Output 1	External Equipment
8	Output	O	GPO_ISO2_B	Digital Output 2	External Equipment
9	Output	O	GPO_ISO3_B	Digital Output 3	External Equipment
10	NC	-	No Connect	Not Connected	No Connect

GPIO-In

The GPIO-In connector provides four (4) general-purpose inputs. Four (4) independent detector circuits are used, driven by an on-board +5V 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 12mA to COM. Connect external equipment to this connector; connect a pin to its corresponding COM to turn the input on.

Connector Part Number	43025-0800
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated

Description	CONN RECEPTACLE 8POS 20-24AWG GOLD

Figure 7: Molex Micro-Fit 3.0 Connector for General Connection to External Equipment

Table 6: GPIO-In Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	PWR	-	COM	Power return from SC for GPI0	External Equipment
2	PWR	-	COM	Power return from SC for GPI2	External Equipment
3	PWR	-	COM	Power return from SC for GPI3	External Equipment
4	PWR	-	COM	Power return from SC for GPI4	External Equipment
5	Input	I	GPI_ISO0_K	Input detector 0	External Equipment
6	Input	I	GPI_ISO1_K	Input detector 1	External Equipment
7	Input	I	GPI_ISO2_K	Input detector 2	External Equipment
8	Input	I	GPI_ISO3_K	Input detector 3	External Equipment

Stack Bus

The Stack Bus connector accepts power and provides a communication channel from the Power Interface module. The Stack Bus provides 42mA to the SC plus the summation of current consumed by all Cell Interface modules in the system (25mA per CI-12 or 31mA per CI-16). Connect the Power Interface module to this connector.

Connector Part Number	39-01-2065
Crimp Part Number	39-00-0181
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 6POS 18-24AWG GOLD

Figure 8: MiniFit Jr Connector for Connection to Stack Bus

Table 7: Stack Bus Connector Pin Assignment

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

Cell Interface

The Cell Interface (CI) module connects to the battery cells and temperature sensors to monitor and balance the cells, and sends cell data to the SC, to prevent overheating or overcharging.

There are two models of the CI. The CI-12 can monitor up to 12 series-connected cells. The CI-16 can monitor up to 16 series-connected cells.

Mechanical Dimensions

The overall dimensions of the CI are 104.4mm X 121.58mm X 40.6mm. It comes standard with DIN clips that enable the CI module to be securely mounted to EN50022-compliant DIN rails. The clips add an extra 19.6mm to the overall width of the CI module, bringing it from 104.4mm to 124mm. The clips also hold the module approximately 7mm away from the inside lip of the DIN rail. Extra space should be provided around the module to allow for easy installation/maintenance.

The CI can also come in a bulkhead-mountable enclosure.

A more detailed mechanical drawing of the CI module is provided in Appendix A: Detailed Mechanical Drawings.

Electrical Connections

The CI module has four connectors. Each connector is described in the following sections in detail.

Link Out

The Link Out connector provides power and communication to the CIs above this CI. The amount of current supplied by this connector is the sum of current consumed by all CIs above this CI. Connect the CI that is measuring the next series-connected cell above Cell12 to this connector.

Connector Part Number	43025-0400
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 4POS 20-24AWG GOLD

Figure 9: Molex Micro-Fit 3.0 Connector for Connection to Link Bus

Table 8: Link Bus Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	PWR	-	VBUS	DC power from SC, with Fault Pilot Signal	Cell Interface
2	PWR	-	COM	Power return from SC	Cell Interface
3	I/O	-	IPA	Link Bus differential pair plus	Cell Interface
4	I/O	-	IMA	Link Bus differential pair minus	Cell Interface

Link In

The Link In connector provides power and communication to this CI from the CIs below this CI, or from the SC if this CI is measuring Cell 0. The amount of current sourced into this connector is the sum of current consumed by this CI and all those above it (which amounts to all CIs if this CI is measuring Cell 0). Connect to the *Link Out* connector on the CI that is measuring the next series-connected cell below this CI to this connector, or connect the SC to this connector if this CI is measuring Cell 0.

Connector Part Number	43025-0400
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 4POS 20-24AWG GOLD

Figure 10: Molex Micro-Fit 3.0 Connector for Connection to Link Bus

Table 9: Link Bus Connector Pin Assignment

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

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 CI-12 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 CI-12 model. Connect the battery cell voltage sense leads to this connector.

Connector Part Number	43025-1800
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 18POS 20-24AWG GOLD

Figure 11: Molex Micro-Fit 3.0 Connector for Connection to Battery Cells

Table 10: Battery Cells Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	Analog	I	CELL0_F	Bottom reference of CI	Connect to negative terminal of the lowest cell (Cell 0) in the 12 or 16 cell module
2	Analog	I	CELL2_F	Cell 2 voltage sense	Connect to positive terminal of Cell 1
3	Analog	I	CELL4_F	Cell 4 voltage sense	Connect to positive terminal of Cell 3
4	Analog	I	CELL6_F	Cell 6 voltage sense	Connect to positive terminal of Cell 5
5	Analog	I	CELL8_F	Cell 8 voltage sense	Connect to positive terminal of Cell 7
6	Analog	I	CELL10_F	Cell 10 voltage sense	Connect to positive terminal of Cell 9
7	Analog	I	CELL12_F	Cell 12 voltage sense	Connect to positive terminal of Cell 11
8	Analog	I	CELL14_F	Cell 14 voltage sense	Connect to positive terminal of Cell 13
9	NC	-	No Connect	Not Connected	No Connect
10	Analog	I	CELL1_F	Cell 1 voltage sense	Connect to positive terminal of the lowest cell (Cell 0) in the 12 or 16 cell module
11	Analog	I	CELL3_F	Cell 3 voltage sense	Connect to positive terminal of Cell 2
12	Analog	I	CELL5_F	Cell 5 voltage sense	Connect to positive terminal of Cell 4
13	Analog	I	CELL7_F	Cell 7 voltage sense	Connect to positive terminal of Cell 6
14	Analog	I	CELL9_F	Cell 9 voltage sense	Connect to positive terminal of Cell 8
15	Analog	I	CELL11_F	Cell 11 voltage sense	Connect to positive terminal of Cell 10
16	Analog	I	CELL13_F	Cell 13 voltage sense	Connect to positive terminal of Cell 12
17	Analog	I	CELL15_F	Cell 15 voltage sense	Connect to positive terminal of Cell 14
18	Analog	I	CELL16_F	Cell 16 voltage sense	Connect to positive terminal of Cell 15

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 10kΩ NTC thermistors to this connector.

Connector Part Number	43025-1600
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 16POS 20-24AWG GOLD

Figure 12: Molex Micro-Fit 3.0 Connector for Connection to Temperature Sensors

Table 11: Temperature Sensors Connector Pin Assignment

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

Power Interface

The Power Interface (PI) module connects directly to high-voltage and high-current components. It accepts Stack and external power inputs, provides power conditioning for all Nuvation BMS modules and power for the contactors. The SC controls all operations on the PI via the Stack Bus.

There are four models of the PI. The PI model used is dependent on the total stack voltage of the battery system being monitored.

Table 12: Power Interface Models

PI Model	Stack Power Input Voltage Range [VDC]		
A	30	–	120
B	70	–	280
C	160	–	640
D	370	–	1250

The following is a functional block diagram of the PI showing the internal connections:

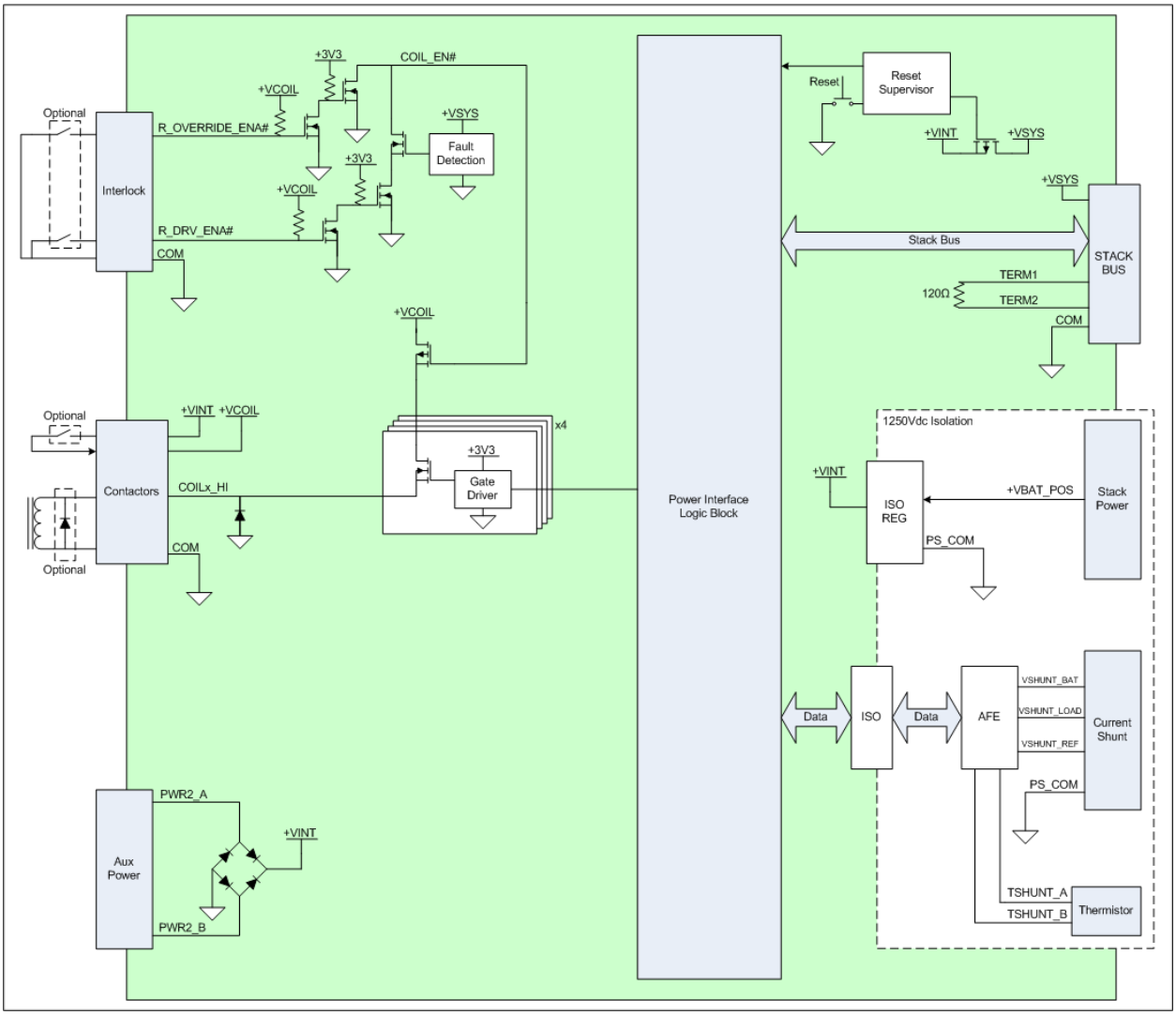

Figure 13: Power Interface Block Diagram

Mechanical Dimensions

The PI Model A and Model B have the same mechanical dimensions. PI Model C and Model D are slightly larger.

PI Model A/B

The overall dimensions of the PI Model A and Model B are 135.40mm X 121.58mm X 48.60mm. It comes standard with DIN clips that enable the PI module to be securely mounted to EN50022-compliant DIN rails. The clips add an extra 19.6mm to the overall width of the PI module, bringing it from 135.40mm to 155mm. The clips also hold the module approximately 7mm away from the inside lip of the DIN rail. Extra space should be provided around the module to allow for easy installation/maintenance.

A more detailed mechanical drawing of the PI Model A and Model B module is provided in Appendix A: Detailed Mechanical Drawings.

PI Model C/D

The overall dimensions of the PI Model C and Model D are 174.40mm X 121.58mm X 48.60mm. It comes standard with DIN clips that enable the PI module to be securely mounted to EN50022-compliant DIN rails. The clips add an extra 19.6mm to the overall width of the PI module, bringing it from 174.40mm to 194mm. The clips also hold the module approximately 7mm away from the inside lip of the DIN rail. Extra space should be provided around the module to allow for easy installation/maintenance.

A more detailed mechanical drawing of the PI Model C and Model D module is provided in Appendix A: Detailed Mechanical Drawings.

Electrical Characteristics

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

Contactors

The Contactors connector provides high-current outputs for controlling high-current contactors. Each output is capable of sourcing maximum continuous 2.8A. When powering the contactor drivers from +VINT, the combined current cannot be more than 3A minus 25mA for the PI, minus 42mA for the SC and minus the combined current consumed by the CIs (22mA per CI). If powering the contactor drivers from an external power source via +VCOIL, the combined current cannot be more than 2.8A continuously. Connect up to four (4) high-current contactor coils to this connector.

Connector Part Number	39-01-2125
Crimp Part Number	39-00-0181
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 12POS 18-24AWG GOLD

Figure 14: MiniFit Jr Connector for Connection to Contactors

Table 13: Contactors Connector Pin Assignment

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

Interlock

The Interlock connector provides a means to set the high-current contactor behaviour, as outlined in Table 14. Using a physical switch/relay instead of a jumper is a convenient way to implement an interlock switch that de-energizes the system contactors.

Table 14: Interlock Options

Interlock Connection		Function
1 & 3	2 & 3	
open	open	System contactors are de-energized
open	closed	System contactors are controlled by BMS software, but de-energized if hardware-based fault signaling detects a fault
closed	open or closed (does not matter)	System contactors are controlled by BMS software; hardware-based fault signaling mechanism will not de-energise system contactors
Note: Pin 3 is electrically connected to chassis ground.		

Connect a jumper or external interlock switch to this connector.

Connector Part Number	43645-0300
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 3POS 20-24AWG GOLD

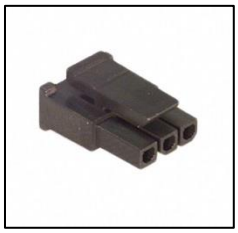

Figure 15: Molex Micro-Fit 3.0 Connector for Connection to Interlock

Table 15: Interlock Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	I/O	I	R_OVERRIDE_ENA#	Active-low; Allows BMS software to control contactors	Interlock Connector Pin 3
2	I/O	I	R_DRV_ENA#	Active-low; Allows internal hardware fault detection to override BMS software control of contactors	Interlock Connector Pin 3
3	PWR	-	COM	Power return from PI	Interlock Connector Pin 1 or Pin 2

Aux Power

The Aux Power connector accepts power from an external power supply to allow the BMS to function without deriving its power directly from the battery stack. An external power supply

is also required if the battery stack voltage is expected to drop below the Stack Power minimum input voltage (as determined by the model of Power Interface used in the system – refer to Table 12). The external supply can be either 9-24VAC or 13-34VDC and must be isolated from chassis and COM grounds. Connect an external power supply to this connector.

Connector Part Number	39-01-2025
Crimp Part Number	39-00-0181
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 2POS 18-24AWG GOLD

Figure 16: MiniFit Jr Connector for Connection to Aux Power

Table 16: Aux Power Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	PWR	-	PWR2_A	External Power Supply Input	External Power Supply
2	PWR	-	PWR2_B	External Power Supply Input	External Power Supply

Stack Bus

The Stack Bus connector provides power and communication to the SC module. The Stack Bus provides 42mA to the SC plus the summation of current consumed by all CI modules in the system (up to 25mA per CI12 or 31mA per CI-16). Connect the SC module to this connector.

Connector Part Number	39-01-2065
Crimp Part Number	39-00-0181
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 6POS 18-24AWG GOLD

Figure 17: MiniFit Jr Connector for Connection to Stack Bus

Table 17: Stack Bus Connector Pin Assignment

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

Thermistor

The Thermistor connection provides an NTC thermistor input for temperature measurement of the high-current shunt. The temperature of the current shunt is used to improve the accuracy of the current measurement by correcting the offset measurement error. Connect a 10kΩ NTC thermistor to this connector.

Connector Part Number	43645-0200
Crimp Part Number	43030-0002
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 2POS 20-24AWG GOLD

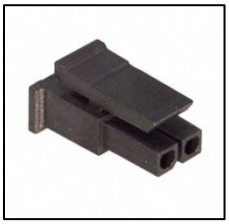

Figure 18: Molex Micro-Fit 3.0 Connector for Connection to Thermistor

Table 18: Thermistor Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	Analog	I	TSHUNT_A	External Temperature Probe Input 1	10kΩ NTC Thermistor
2	Analog	I	TSHUNT_B	External Temperature Probe Reference 1	10kΩ NTC Thermistor

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.

Connector Part Number	39-01-4041
Crimp Part Number	39-00-0181
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 4POS 18-24AWG GOLD

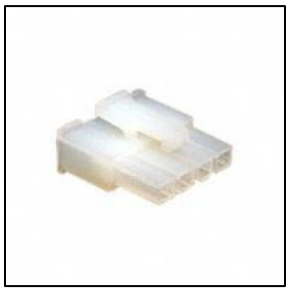

Figure 19: MiniFit Jr Connector for Connection to Current Shunt

Table 19: Current Shunt Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	PWR	-	PS_COM	Stack Power Supply return from PI	Load side of current shunt
2	PWR	-	VSHUNT_REF	Voltage reference for voltage measurement	Load side of current shunt

Pin	Type	I/O	Connection	Description	Connected to Device
3	Analog	I	VSHUNT_LOAD	Differential voltage input; Load side	Load side of current shunt
4	Analog	I	VSHUNT_BAT	Differential voltage input; Battery side	Battery side of current shunt

Stack Power

The Stack Power connector accepts power from the high-voltage battery stack. This connection is required even if powering the system from Aux Power as an overall stack voltage measurement and ground fault detection requires this connection to the stack positive terminal. Connect the overall battery stack positive terminal to this connector.

Connector Part Number	39-01-4031
Crimp Part Number	39-00-0181
Manufacturer	Molex Incorporated
Description	CONN RECEPTACLE 3POS 18-24AWG GOLD

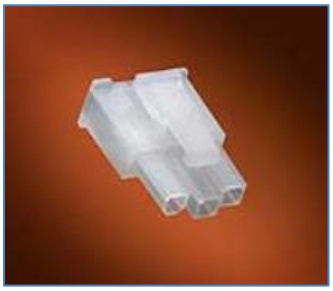

Figure 20: MiniFit Jr Connector for Connection to Stack Power

Table 20: Stack Power Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	PWR	-	+VBAT_POS	Overall Stack Positive	Connect to most positive terminal of the battery stack
2	NC	-	No Connect	Not Connected	No Connect
3	NC	-	No Connect	Not Connected	No Connect

Grid Battery Controller

The Grid Battery Controller (GBC) aggregates information from each SC in the system and presents a unified interface to the large battery system. The GBC provides two crucial battery-level software interfaces for large, multi-stack battery applications:

1. Modbus TCP:
    - Unified view of the entire battery conforming to open energy standards.
    - Conforms to MESA Models: S801, S802 and S803
    - Used directly by inverters and other grid infrastructure implementing the MESA standard
2. Web-based configuration and diagnostics:
    - Hosts web-based tools that can be accessed from common web browsers
    - Used to provision firmware upgrades, configure settings and view diagnostic information for the entire battery system

A few key system-level features that are also provided are:

- System-wide statistics for voltages, temperature and currents
- Current tapering algorithms for multi-stack battery systems
- SOC/SOH algorithms for multi-stack battery systems
- NTP client for BMS time synchronization

The GBC uses a Linux-based operating system with special provisions in place to guarantee the performance and responsiveness required for real-time inverter control.

Mechanical Dimensions

The overall dimensions of the GBC are 210mm X 140mm X 58mm. It comes standard with DIN clips that enable the GBC to be securely mounted to EN50022-compliant DIN rails. A keep-out area is required around the unit to provide adequate air flow for cooling purposes. Extra space should be provided around the connectors to allow for easy installation and maintenance.

A more detailed mechanical drawing of the GBC is provided in Appendix A: Detailed Mechanical Drawings.

Electrical Connections

The GBC has standard connectors excluding the power connector.

DC Power Connector

The DC power connector provides power to the GBC. The power supply tolerates an input voltage between 19.2V and 28.8V. At 24V, it will consume no more than 2.5A. Connect an external power supply to this connector.

Connector Part Number	1841909
Manufacturer	Phoenix Contact
Description	DSUB PSC 1.5/3-F 3POS 16-28AWG TIN

Figure 21: MINI-COMBICON DSUB Connector for Connection to DC Power

Table 21: DC Power Connector Pin Assignment

Pin	Type	I/O	Connection	Description	Connected to Device
1	PWR	-	+24V	External Power Supply Input Positive	Connect to external 24Vdc power supply positive
2	NC	-	No Connect	Not Connected	No Connect
3	PWR	-	GND	External Power Supply Input Negative	Connect to external 24Vdc power supply negative

Nuvation BMS Cabling Details

This section describes the cabling details of the common cable assemblies used in this system. IMPORTANT NOTE: All drawings are provided as examples only.

Grounding

It is assumed that the Nuvation BMS will be attached electrically to an earth or local chassis ground point, via the DIN rail grounding provision, and the mounting brackets on the BMS component enclosures.

Voltages and signals on the Stack Bus and Link Bus cables are chassis/earth ground referenced. In addition, the Stack Controller's USB port, non-isolated RS485, and GPIO-In signals; and the Power Interface'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 24VRMS AC or 24VDC power supply connected to the Power Interface's Aux Power connection must be isolated from earth/chassis ground, with a working isolation voltage of at least 60Vrms 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. 14AWG 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:

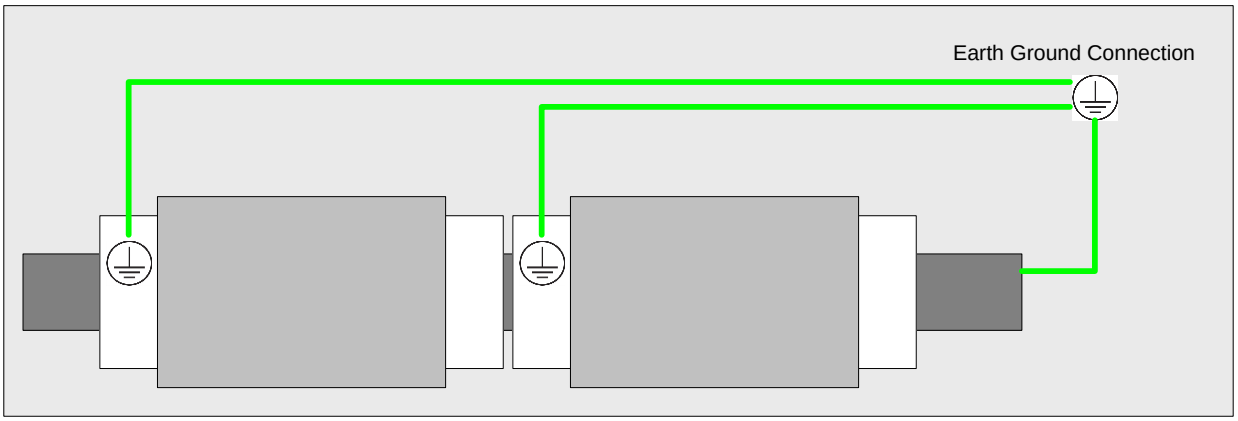

Figure 22: Example Earth Ground Wiring Diagram

Link Bus

The Link Bus cable cannot be longer than 100m. The wire gauge of the +VBUS and COM signals needs to be sufficient for the current that will flow through it. 22AWG, 1m long cable is sufficient for up to 40 CI-12s or CI-16s.

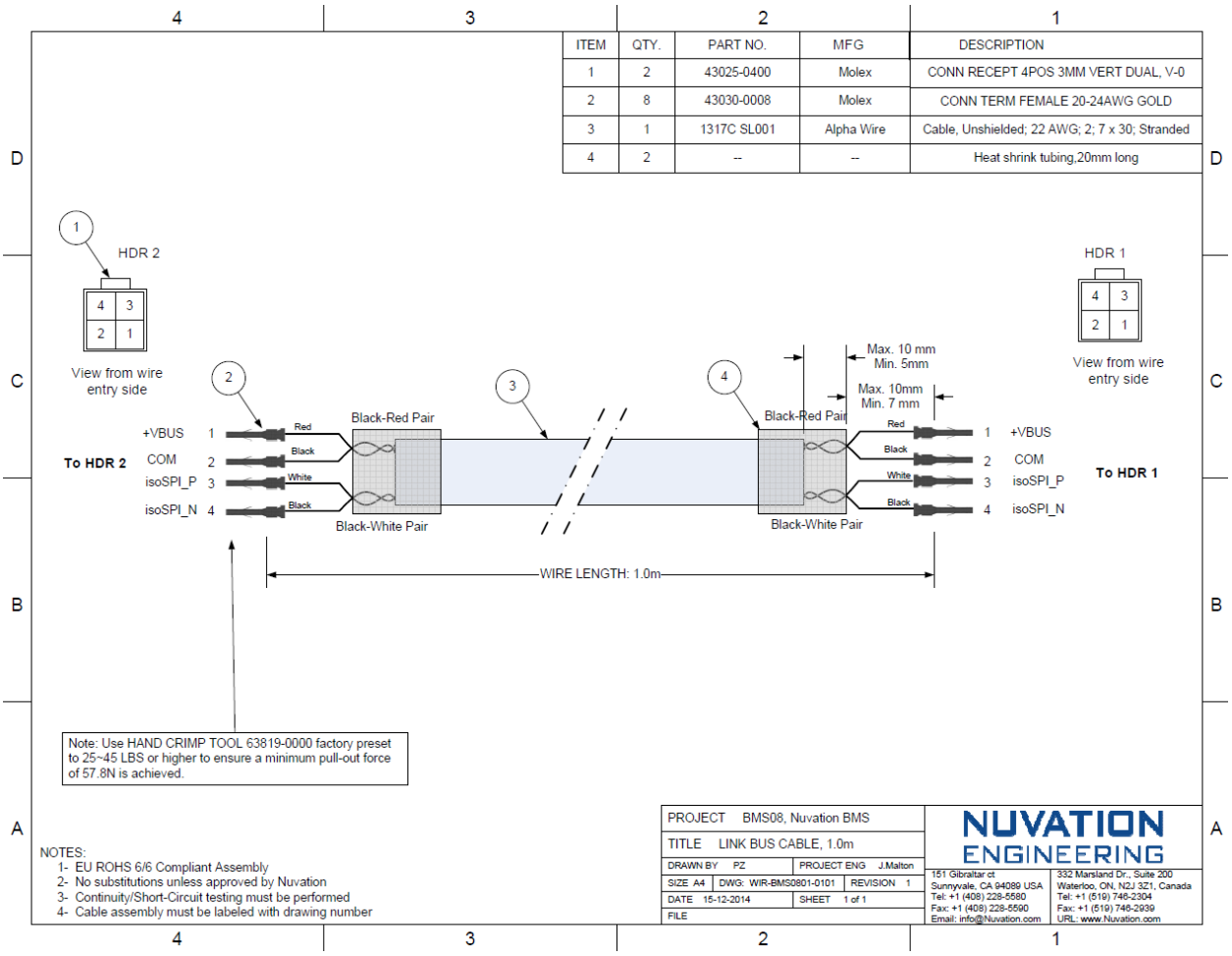

Figure 23: Example Link Bus Cable Drawing

Stack Bus

The Stack Bus cable cannot be longer than 40m. The wire gauge of the +VSYS and COM signals needs to be sufficient for the current that will flow through it. 22AWG, 1m long cable is sufficient for up to 40 CI-12s or CI-16s.

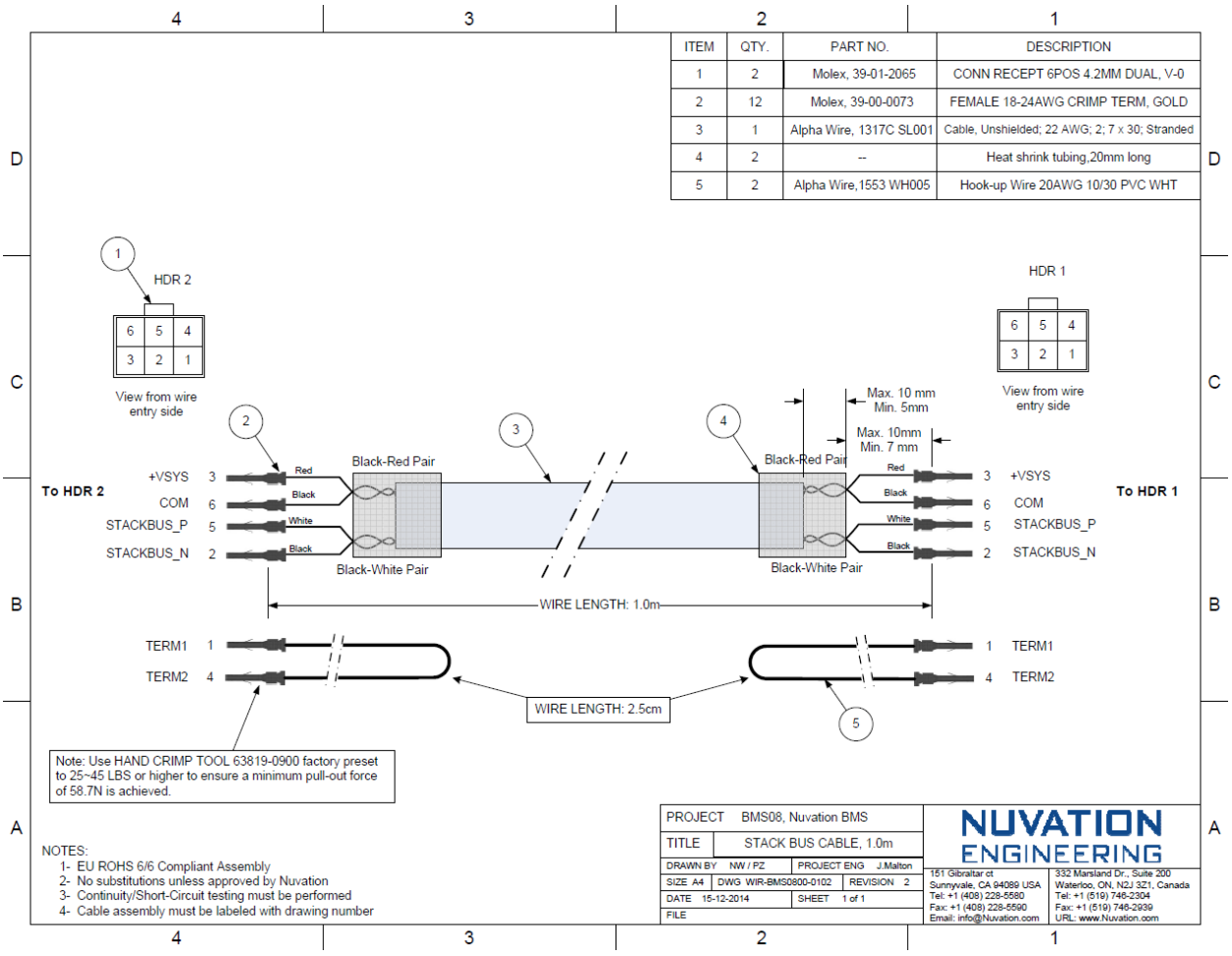

Figure 24: Example Stack Bus Cable Drawing

Current Shunt

The Current Shunt cable length should be minimized. The wire gauge of the PS_COM signal needs to be sufficient for the current that will flow through it. 24AWG, 0.5m long cable is sufficient in most cases.

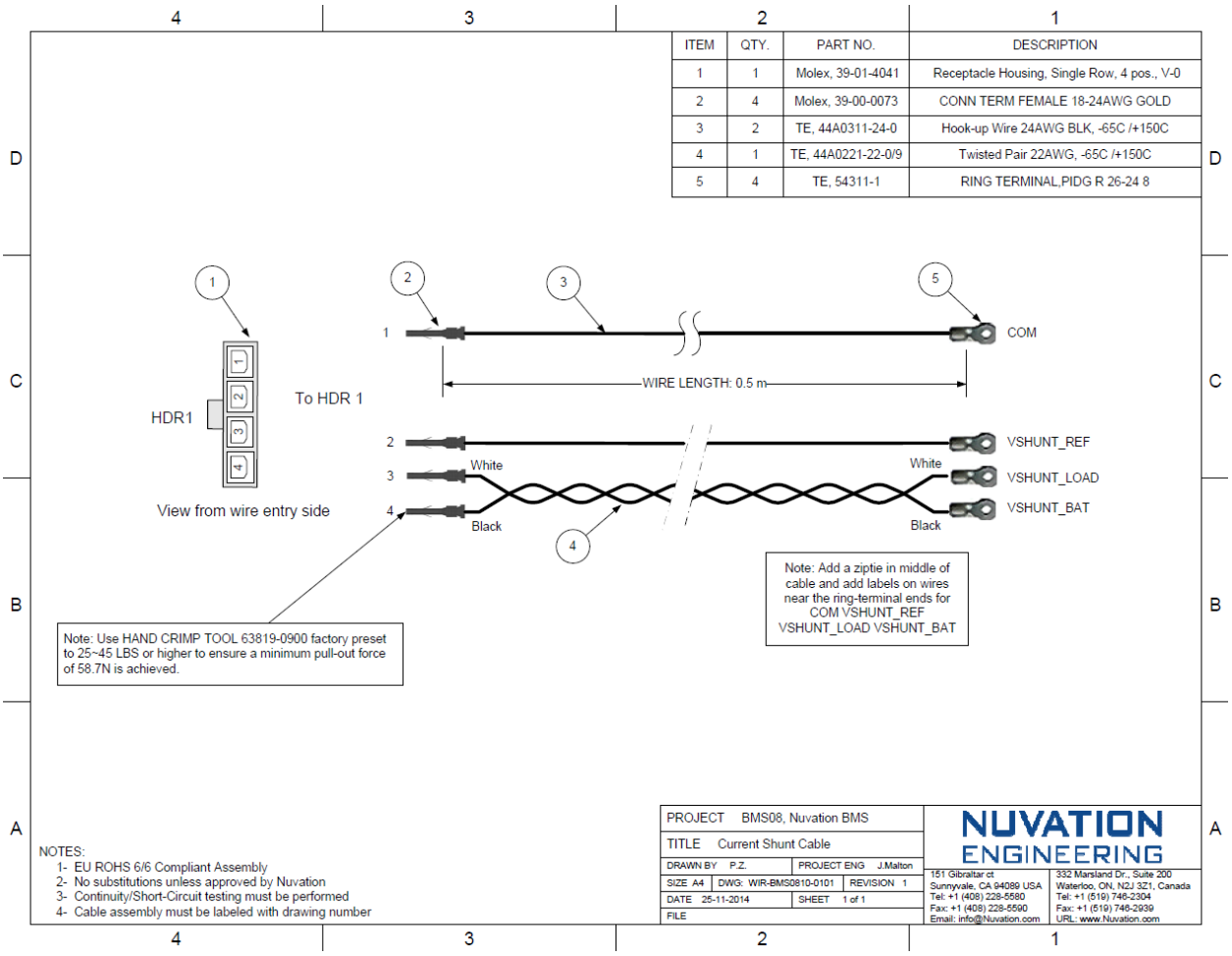

Figure 25: Example Current Shunt Cable Drawing

Thermistor

The Thermistor cable length should be minimized to reduce voltage drop and minimize susceptibility to system noise.

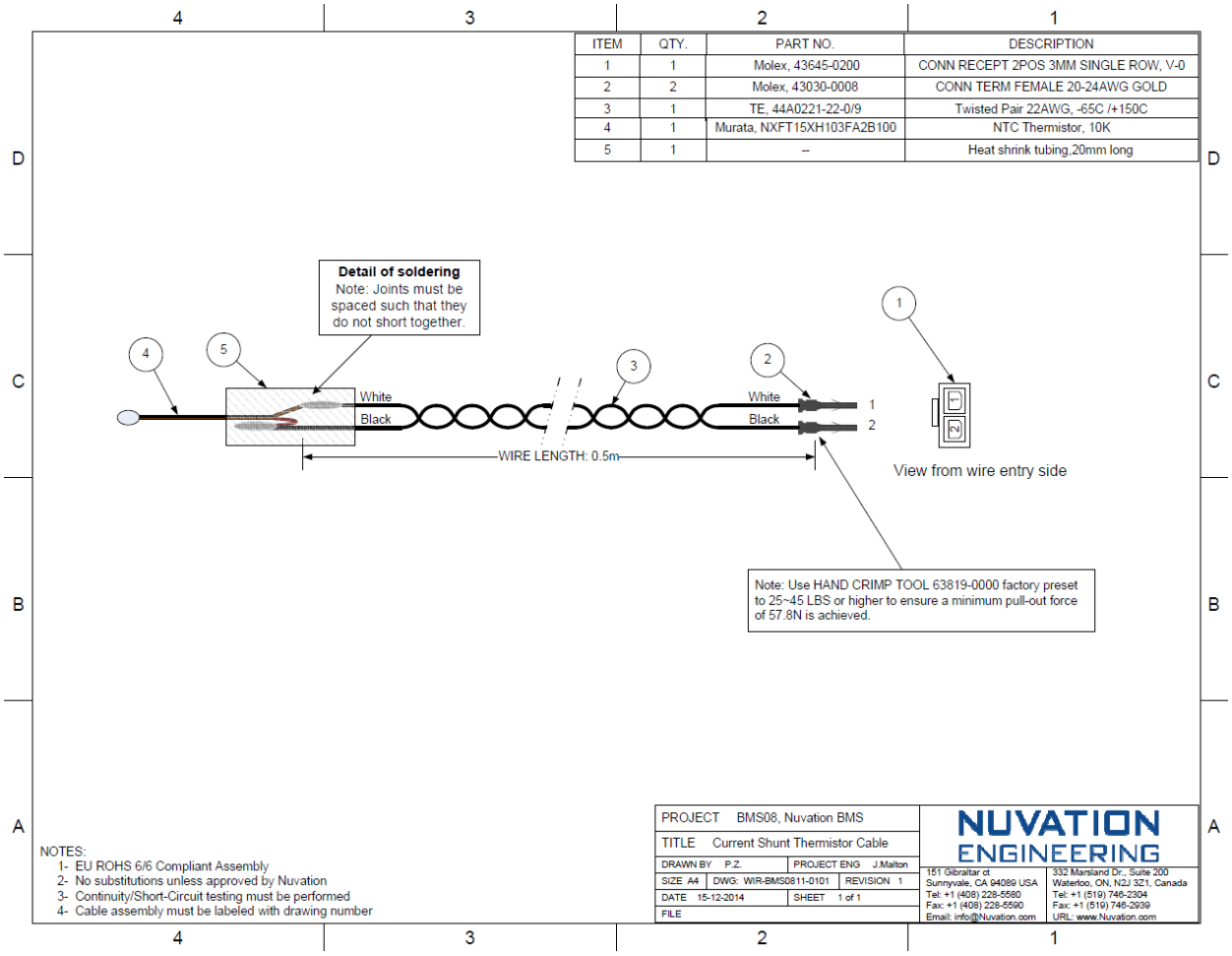

Figure 26: Example Thermistor Cable Drawing

Appendix A: Detailed Mechanical Drawings

Stack Controller

Stack Controller with Enclosure

Weight: 525g

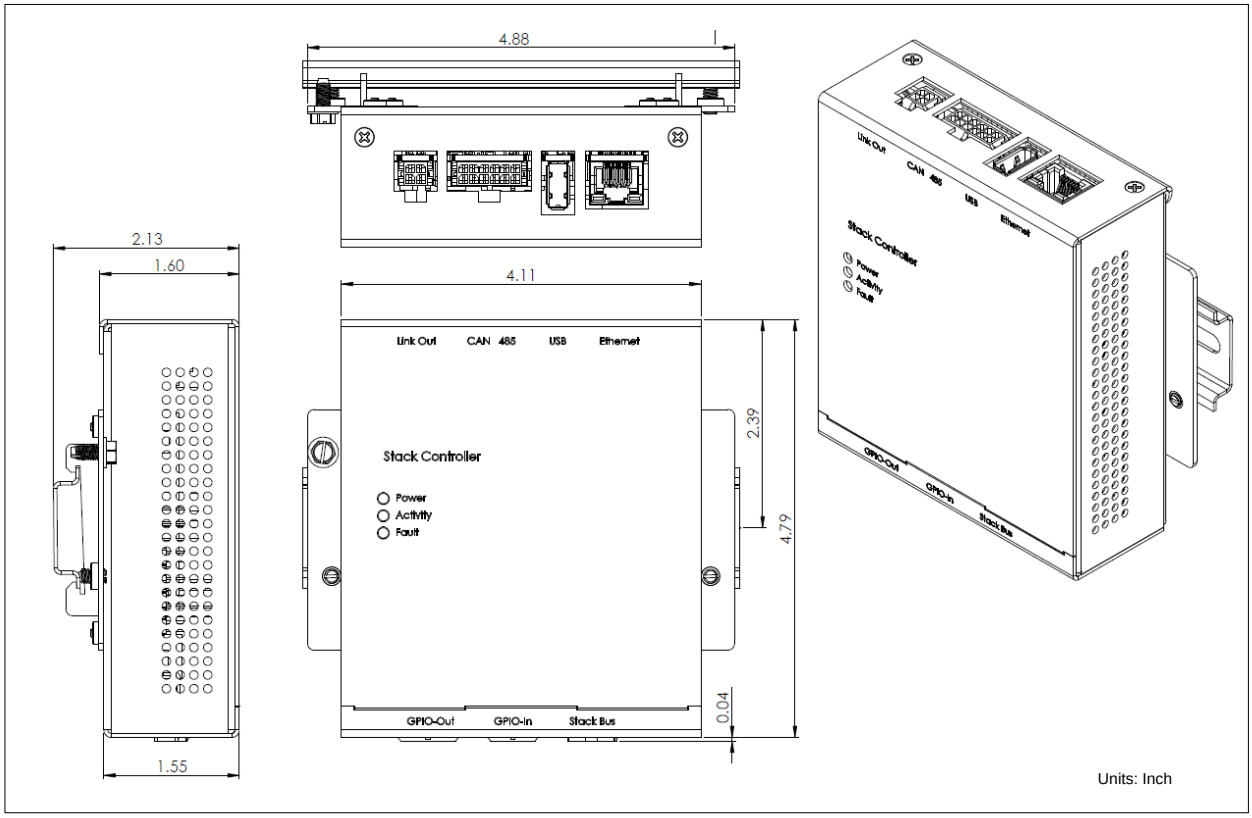

Figure 27: Stack Controller Mechanical Drawing

Stack Controller without Enclosure

The Stack Controller PCB does not contain high-voltage signals, all signals are 24Vdc or less with respect to earth ground. If mounting the PCB in a metal enclosure, use standard design approaches to prevent the metal walls from making contact with the PCB or with components on the PCB.

Weight: 75g

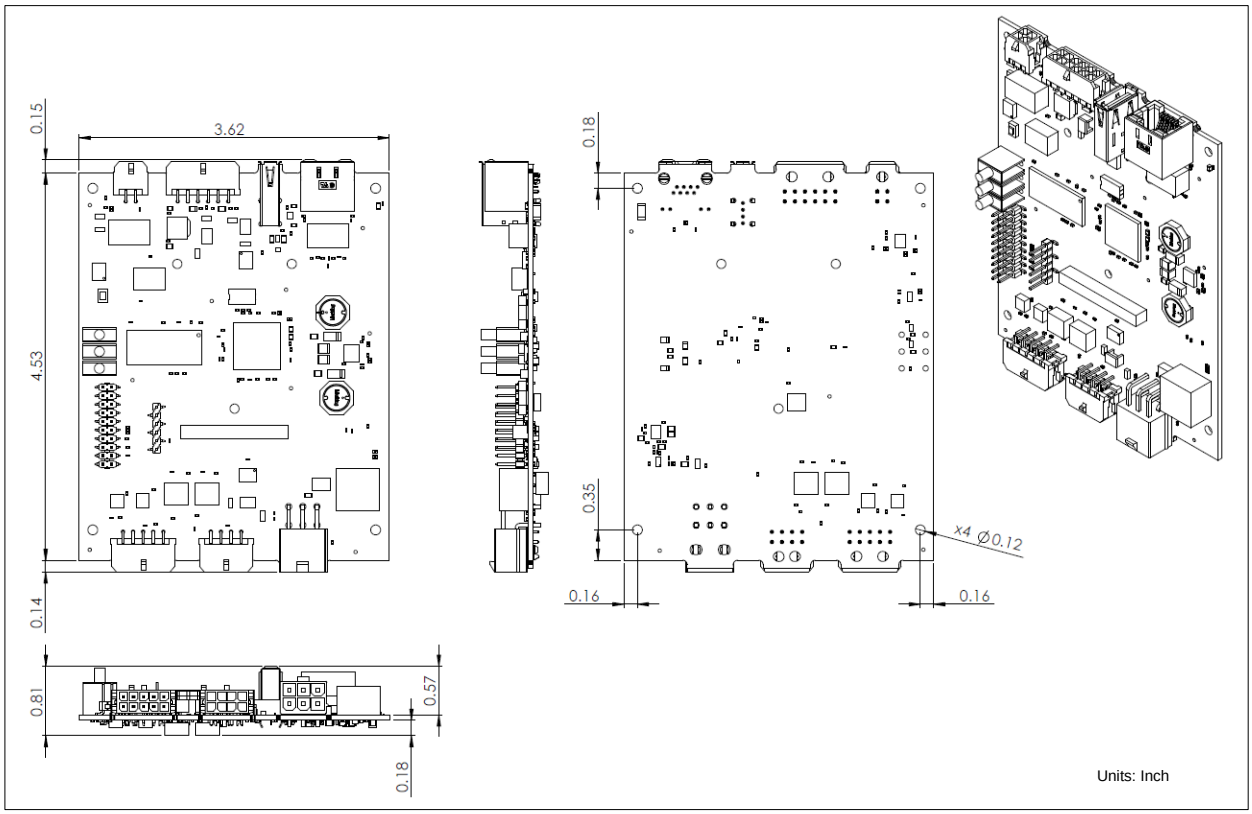

Figure 28: Stack Controller PCB Mechanical Drawing

Cell Interface

Cell Interface with Enclosure

Weight: 540g

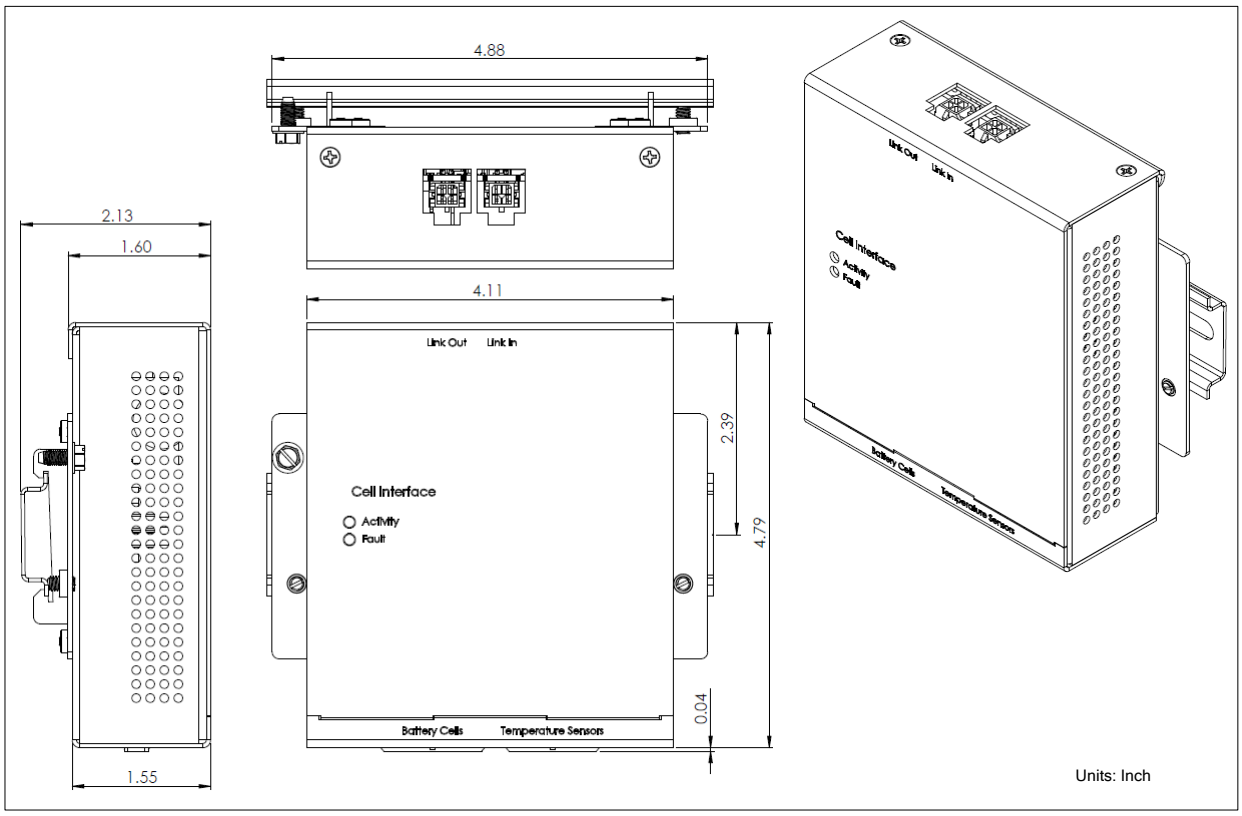

Figure 29: Cell Interface Mechanical Drawing

Cell Interface with Bulkhead Enclosure

This enclosure has five metal walls, leaving the bottom of the unit fully exposed. It must be mounted to a metal bulkhead panel so that the panel will become the missing side. The module will produce up to 24W (32W if it is the CI-16 model) during cell balancing. A portion of this heat will be transferred to the bulkhead.

Weight: 450g

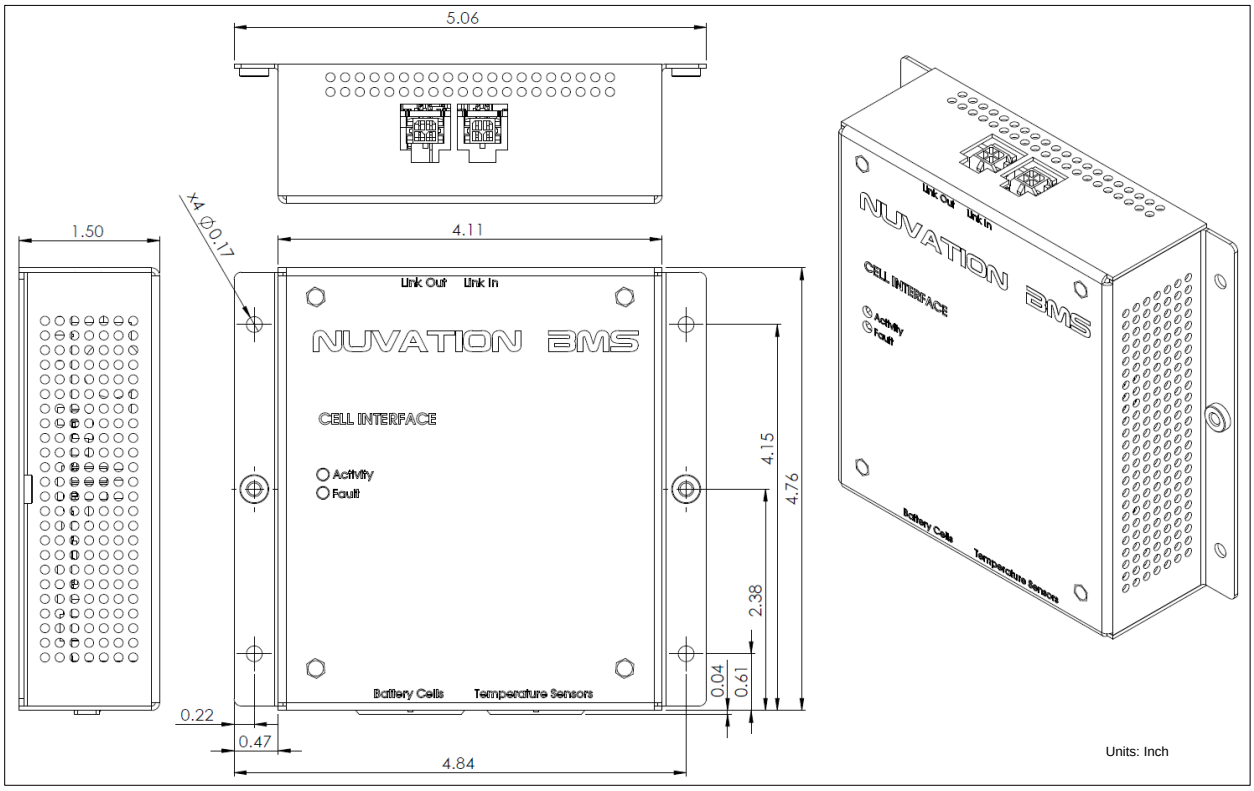

Figure 30: Cell Interface with Bulkhead Enclosure Mechanical Drawing

Cell Interface without Enclosure

The Cell Interface can contain signals at high voltages relative to chassis/earth ground. Each CI can be 60V away from its neighbouring CIs, up to a maximum of 1200Vdc separated 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 1200Vdc as an example, the metal walls must be at least 4.2mm from the nearest exposed conductor, and must not touch the PCB or any component on the PCB, including the connector housings.

Weight: 85g

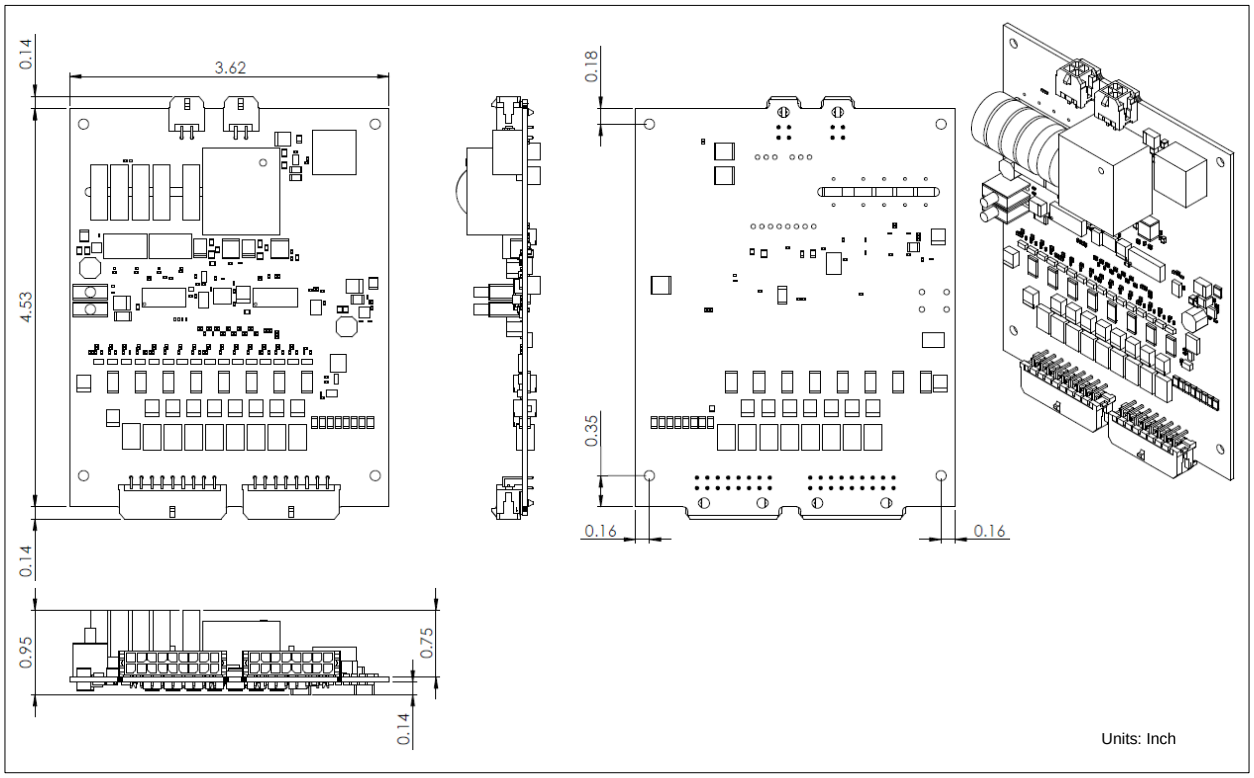

Figure 31: Cell Interface PCB Mechanical Drawing

Power Interface Model A/B

Power Interface Model A/B with Enclosure

Weight: 790g

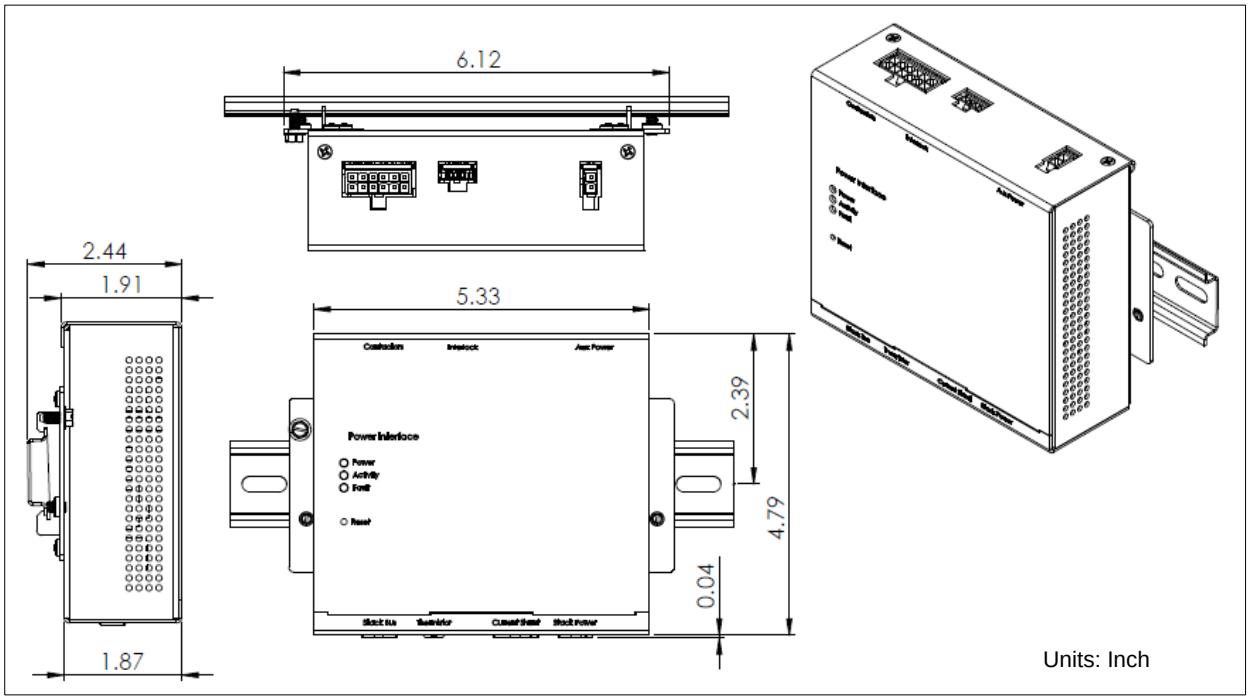

Figure 32: Power Interface Model A/B Mechanical Drawing

Power Interface A/B without Enclosure

The Power Interface A/B can contain high-voltage signals. It is possible to have signals 280Vdc away from chassis/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 280Vdc as an example, the metal walls must be at least 1.4mm from the nearest exposed conductor, and must not touch the PCB or any component on the PCB, including the connector housings.

Weight: 210g

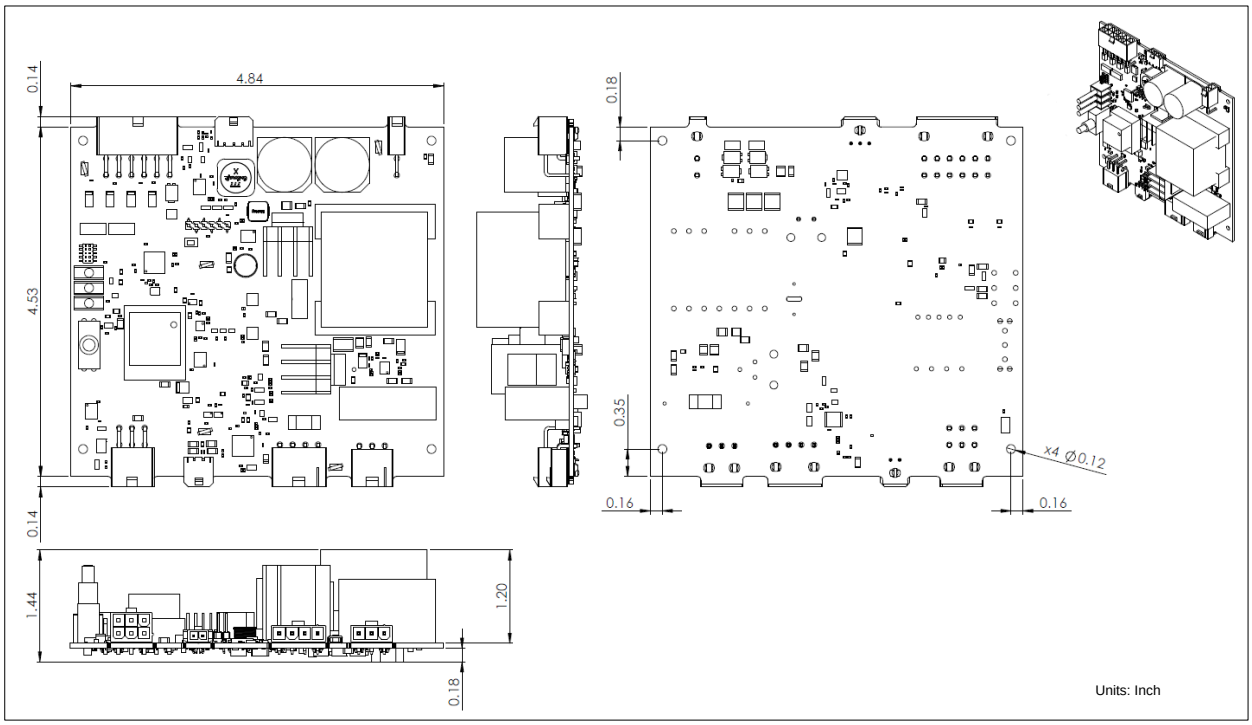

Figure 33: Power Interface A/B PCB Mechanical Drawing

Power Interface Model C/D

Power Interface Model C/D with Enclosure

Weight: 915g

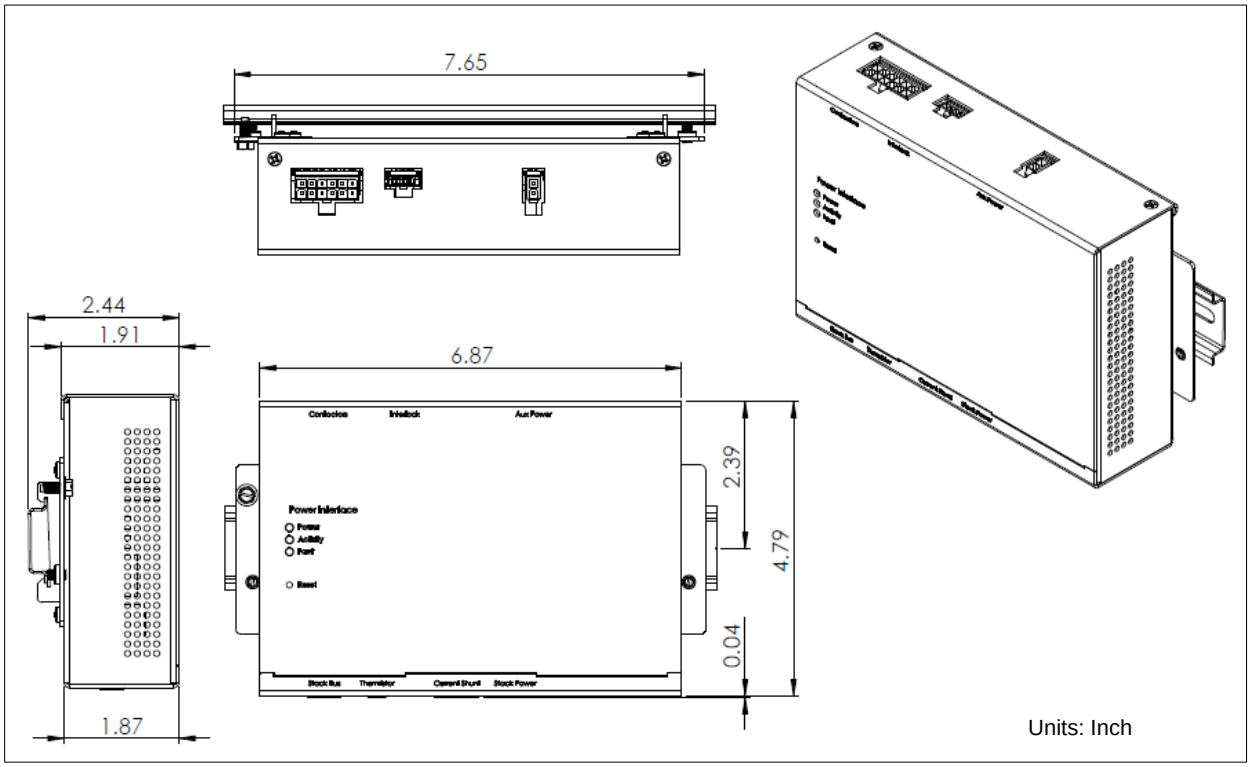

Figure 34: Power Interface Model C/D Mechanical Drawing

Power Interface Model C/D without Enclosure

The Power Interface Model C/D can contain high-voltage signals. It is possible to have signals 1200Vdc 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 1200Vdc as an example, the metal walls must be at least 4.2mm from the nearest exposed conductor, and must not touch the PCB or any component on the PCB, including the connector housings.

Weight: 250g

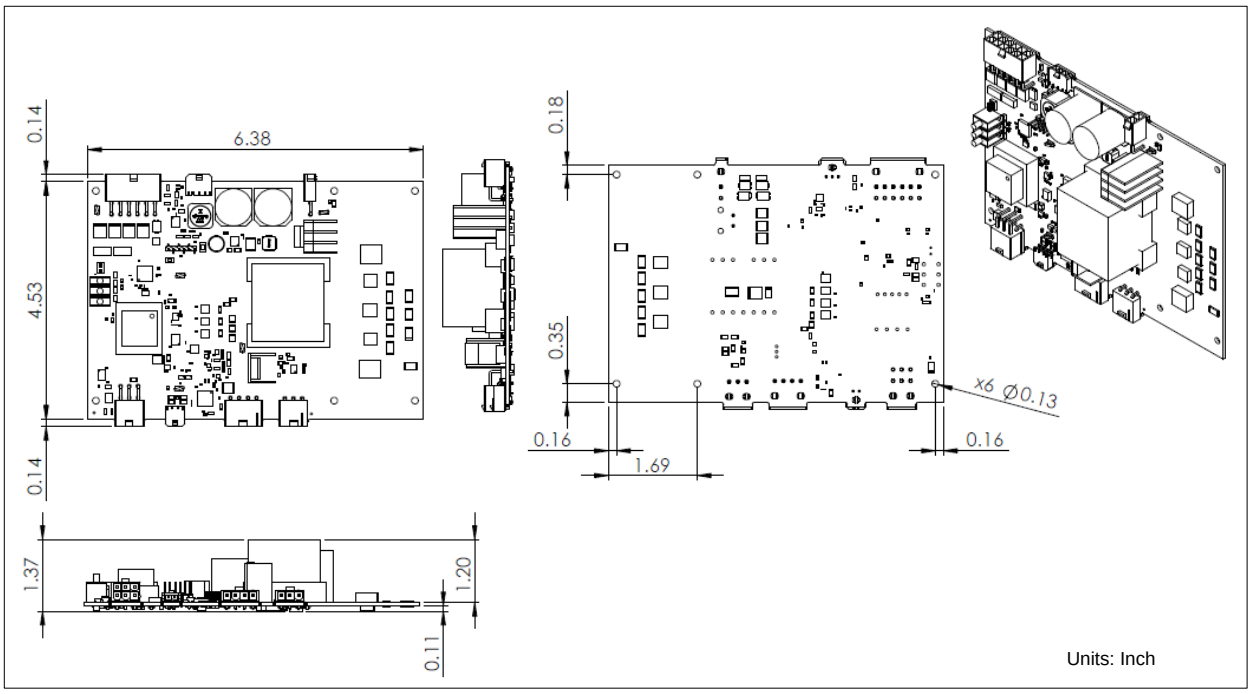

Figure 35: Power Interface Model C/D PCB Mechanical Drawing

Grid Battery Controller

Grid Battery Controller with Enclosure

Weight: 2.5kg

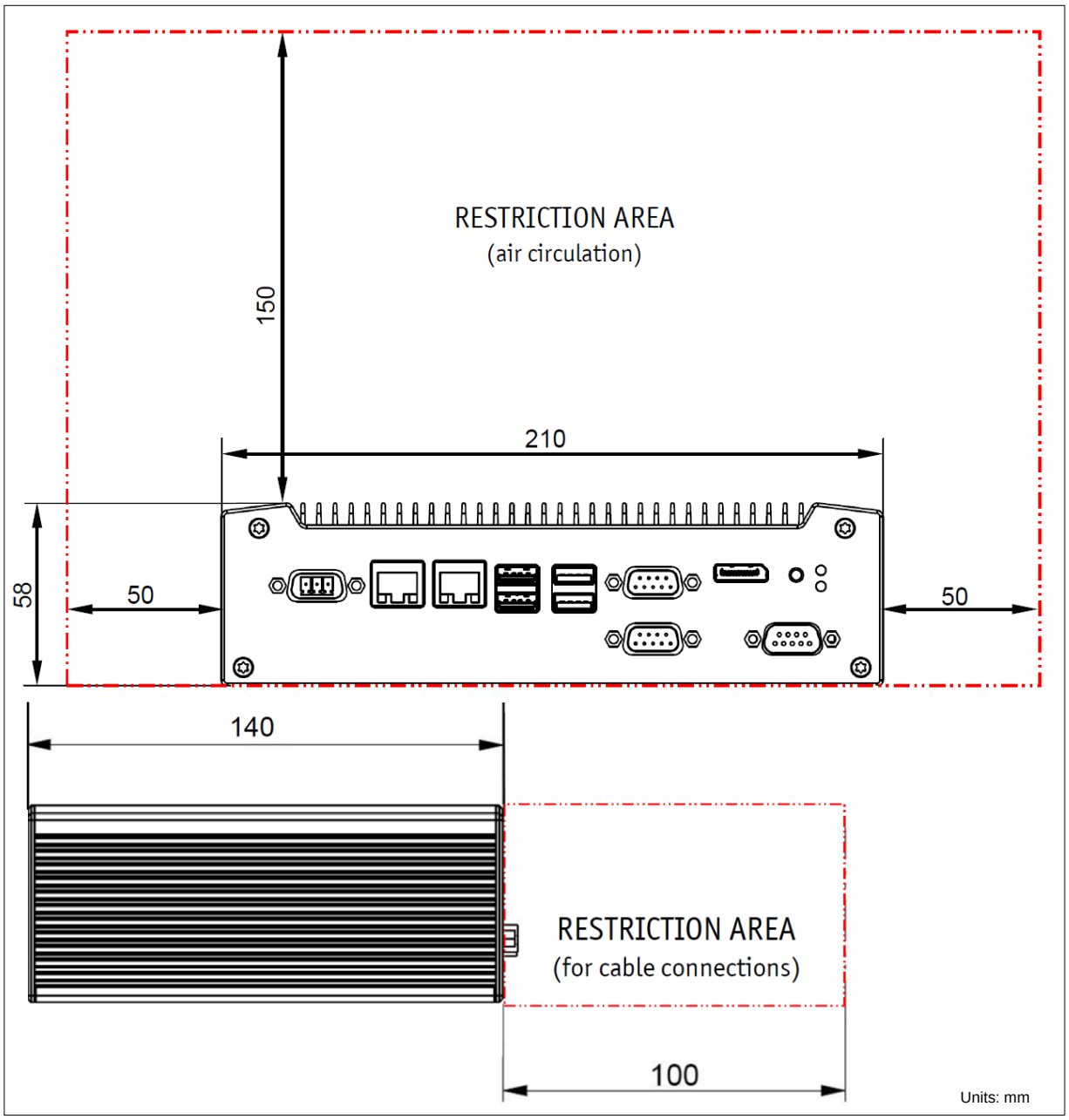

Figure 36: Gird Battery Controller Mechanical Drawing

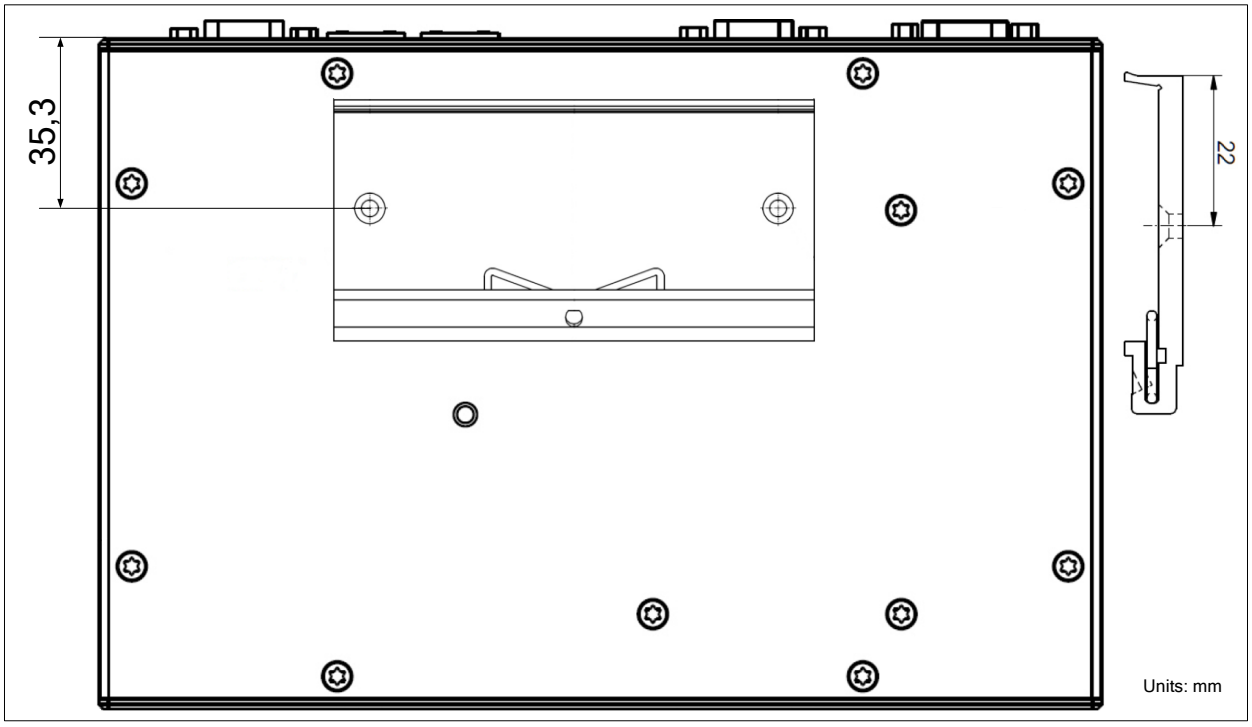

Figure 37: GBC DIN Clip Location

Notes:

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