

HARDWARE INSTALLATION MANUAL



P/N 30-8401M & 30-8401S 18 CELL BMS MASTER MODULE 18 CELL BMS SATELLITE MODULE



STOP! - READ THIS BEFORE INSTALL OR USE!

WARNING:

IT IS THE RESPONSIBILITY OF THE INSTALLER TO ULTIMATELY CONFIRM THE CONFIGURATION USED FOR ANY PARTICULAR INSTALLATION IS SAFE FOR ITS INTENDED USE. AEM HOLDS NO RESPONSIBILITY FOR ANY DAMAGE THAT RESULTS FROM THE MISUSE OF THIS PRODUCT.

Working on Electric Vehicle tractive systems with high voltage battery packs requires special experience and training. Doing this safely is entirely the responsibility of the installer. AEM has done everything it can to ensure the VCU has appropriate fault detection and failsafe logic but that does not mean that your installation will be safe or that your VCU installation will not interfere with other systems on your vehicle and create a hazardous situation. It is the responsibility of the installer to understand the implications of each stage of tractive system installation and testing, and to know what might be unique about your application that presents an unintended hazard or potential safety issue – and to solve it.

Following is a brief list of recommended practices. This is not a comprehensive list; as noted below, if you are not well-versed in the appropriate installation and testing procedures, you should refer the installation and calibration to a reputable installation facility or contact AEM EV for a referral in your area.

- When access is required near the battery pack, the cell segments must be separated by using an appropriate maintenance disconnect plug.
- When working on the battery pack or tractive system, safety glasses with side shields and appropriate insulated tools must be used.
- Always wear Class 0 gloves rated at 1000V with leather protectors.
- Only use a CAT III rated digital multi-meter (DMM) and test leads.
- When working on the battery pack or tractive system, use the one hand rule: work with one hand keeping the other behind your back whenever possible.
- During initial system power up and testing, the vehicle must be raised off the ground and supported appropriately. Wheels/tires should be removed.
- During the VCU firmware upgrade process, battery cell segments must be separated by using an appropriate maintenance disconnect plug.
- Do not make calibration changes while the inverter PWM is enabled.

DANGER!

USE THIS PRODUCT WITH EXTREME CAUTION. MISUSE AND/OR IMPROPER INSTALLATION CAN CAUSE SIGNIFICANT DAMAGE TO YOUR VEHICLE AND PROPERTY BELONGING TO YOU OR OTHERS, AS WELL AS PERSONAL INJURY OR DEATH. IF YOU ARE NOT TRAINED IN ELECTRICAL ENGINEERING OR COMPLETELY FAMILIAR WITH THE SAFETY REQUIREMENTS OF HIGH VOLTAGE ELECTRIC VEHICLES, AND/OR ARE NOT WELL-VERSED IN CONFIGURING THE NECESSARY CONTROL CALIBRATIONS IN THE AEM VEHICLE CONTROL UNIT (VCU), DO NOT UNDER ANY CIRCUMSTANCES ATTEMPT TO INSTALL OR USE THIS PRODUCT. REFER THE INSTALLATION AND CALIBRATION TO A REPUTABLE INSTALLATION FACILITY, OR CONTACT AEM EV FOR A REFERRAL IN YOUR AREA. IT IS THE RESPONSIBILITY OF THE INSTALLER TO ULTIMATELY CONFIRM THAT THE INSTALLATION AND CALIBRATIONS ARE SAFE FOR ITS INTENDED USE.

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AEM'S Battery Management Systems ("BMS") for electric vehicles work with VERY high voltages, and improper use or installation can result in life-threatening injuries and extensive property damage. USE EXTREME CAUTION at every step of installation, and during use, of the BMS. Incorrect wiring on the high voltage taps may (a) destroy the BMS Module instantly upon connection, (b) destroy the battery if the connection is not broken immediately, and/or (c) start a chain reaction breakdown in the battery cell that can lead to a battery fire, which may destroy the battery, the vehicle and the storage structure the vehicle is housed. In all cases, confirm proper operation of the entire high voltage system, including charging, before leaving a fully-enabled vehicle unattended.

Do not open the BMS Modules as high voltage may be present. If you suspect a Module may be damaged, immediately disconnect the unit and do not use it until it has been inspected by AEM. NEVER ATTEMPT TO USE A UNIT THAT YOU SUSPECT MAY HAVE BEEN DAMAGED. AEM is not liable for continued use of a damaged BMS unit.

All battery packs must have a suitable current limiting fuse. Failure to use a suitable fuse may result in catastrophic failure of the BMS or battery pack.

The Vehicle Control Unit ("VCU") must be in full control of the power connections to the battery and must have the ability to interrupt all connections to the battery in case of an emergency. This includes the Inverter, Charger, DC/DC converter and any other connection to the high voltage battery.

For the VCU to properly determine the maximum safe current flow, the BMS must be connected to all of the battery cells and the current sensor must measure the entire current. The person installing the BMS is responsible for ensuring this is done correctly.

Overview



The AEM Battery Management System (BMS-18) hardware expansion for the AEM VCU is a modular BMS add-on designed for multicell lithium battery packs. The BMS allows the VCU to monitor all relevant Battery functions and adds the ability for the VCU to interface directly with a J1772 charging plug and allow the VCU to directly control a supported On-Board Charger (OBC).

The BMS expansion cannot operate as a stand-alone system and requires a VCU200 or VCU300 to function. All BMS configuration and communication is performed via the VCUs normal calibration process and the user does not communicate directly with the BMS Modules.

Specifications

| Parameter | Value |
|----------------------|--|
| 18 Cells | 0-5v per cell |
| 3 Temperature inputs | Thermistor |
| Maximum Units | VCU-200 = 1 Master + 5 Satellites VCU-300 = 1 Master + 11 Satellites. If you are running more than 1 pack in parallel, then multiple masters must be used. Contact AEM for assistance. |
| Cell Balancing | Passive, up to 165mA per cell |
| Status LED | Tri-colour status indication |
| Casing | Sealed Billet Aluminium |
| Size | 3" x 4.7" x 1" |
| Weight | 196 grams (6.9 oz) each |

The BMS is implemented as two different Module types: the BMS Master and the BMS Satellite. Each Module is capable of measuring up to 18 cells and 3 temperatures (thermistors) but the Master also contains the CAN communication interface and J1772 charging specific connections needed for each battery pack. The VCU talks to the BMS via the Master Module and all battery packs need at least one Master unit. The Satellites expand the capability of the Master by an additional 18 cells and 3 thermistors per additional Satellite connected. The Satellite Modules are connected to their Master via a high-speed serial interface (isoSPI) that allows additional units to be daisy chained together, adding as many Satellites as necessary for the battery pack configuration.

When the VCU-200 is used, up to five additional Satellites may be connected to the Master, resulting in up to

108 cells and 18 temperatures.

When the VCU-300 is used, up to eleven additional Satellites may be connected to the Master, resulting in up to 216 cells and 36 temperatures. Another option available with the VCU-300 based systems is the ability to support 2 Masters, each with up to 5 satellites and have these monitoring parallel battery packs. Contact AEM before using multiple masters in this way.

In addition to battery voltage measurement, the BMS allows the VCU to support for passive cell balancing, calculate the state of charge (SoC), pack health, charge and discharge current limits and more. Refer to the VCU instructions for all the BMS related configurations and settings.

BMS Architecture

All modules have connections for 18 cell taps, 3 thermistors and the isoSPI channels. The Master module has additional connections for Power, CAN, and the J1772 charger connections. The Master receives its direction from the VCU over the CAN bus and it forwards them on to the Satellite units over a robust two-wire isoSPI datalink. The master only has an isoSPI output channel since it is the originator while the Satellites have both an input and an output channel.

Cell Wiring and Cell Groups

Each Module can monitor from 4 and 18 cells wired in series. The cells that are monitored by one Module is called a Cell Group.

The first module in the system is always a Master and referred to as Group 1. The next module in the system is called Group 2 and would be the first Satellite immediately downstream from the Master. The next Satellite would be Group 3 and so on. The Group number assignment of a module is defined by the order in which they are attached to the Master while remembering that the Master is always Group 1.

Pack & Cell Numbering

Modules are numbered from 1 to 6 on the VCU200 and each Module manages a Cell Group from 4 to 18 cells. A cell may be identified by specifying the Module (Group 1 to 6) and the Cell Number (from 1 to 18) managed by the Module (e.g., Group 2, cell 4).

A basic 18 cell battery connected to a single BMS module requires 19 wires to connect the 18 cells in a Cell Group since you need to connect the ground of the first cell as well. The wires are numbered c0 to c18 with c0 being the ground of the first cell. All cells in a Cell Group must be wired consecutively with the positive terminal of one cell connected to the negative terminal of the next cell.

If fewer than 18 cells are to be monitored, the unused cell inputs should be at the top and all connected together to c18.

A Cell Group **MUST NOT** “span” a circuit protection device (such as a Contactor, Fuse, Service Disconnect or a Circuit Breaker). Wherever a device exists that could ever potentially result in a continuity break you **MUST** locate this between individual BMS modules. The reason for this guideline is that if the fuse blows (or contactor opens, or circuit breaker trips), then the Module may be destroyed because the Module will span the newly open circuit and could be damaged by full pack voltage.

Status LED

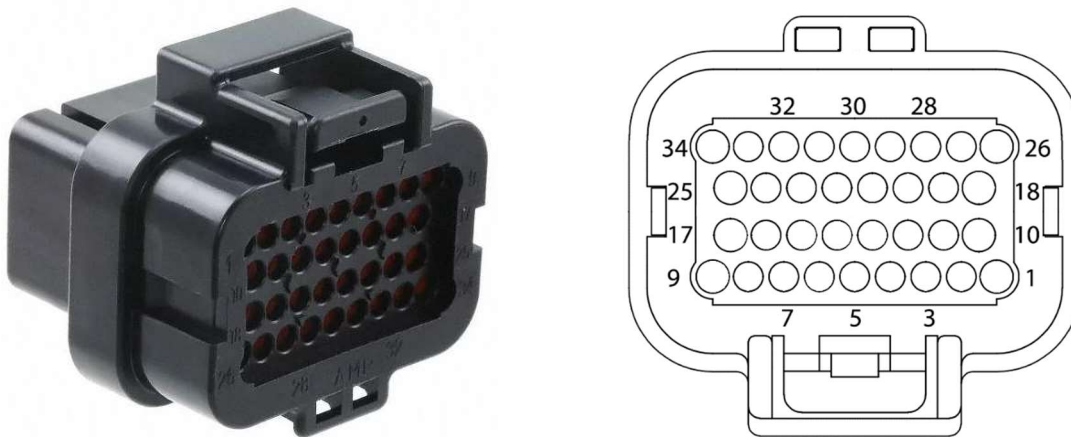
The Master has a Status LED which will inform the user of the current operating state of the BMS. The following blink patterns are supported:

| LED | Status |
|---------------------------------|--|
| Green | All OK |
| Green Blink | All OK, Balancing |
| Off | Powered Down |
| Yellow | VCU Keepalive Timeout |
| Yellow 200ms blink every 8 secs | Dozing (BMSM powered up / VCU keepalive timeout) |
| Red / Yellow | Thermal Shutdown |
| Red | LTC Diagnostic Failure |
| Red 200ms Blink | IsoSPI error detected (PEC error or “no reply”) |

Connector

| | |
|--------------------------|----------------|
| Harness/Mating Connector | TE 4-1437290-0 |
| Terminal | TE 3-1447221-4 |
| Blanking Plug | TE 4-1437284-3 |

A mating connector kit is available separately from AEM (P/N 30-3712, BMS-18 Plug & Pin Kit). It contains 1x mating connector, 34x terminals, and 10x blanking seals.



Both the Master and the Satellite units use the same TE Superseal 34 pin connector and share the majority of their pin assignments. All of the battery cell connections are the same between the units.

Pin Out

| BMS Master | | | BMS Satellite | | |
|------------|---------------|-----------------------|---------------|-----------|-----------------------|
| Pin | Desc | Notes | Pin | Desc | Notes |
| 1 | Cell 3 + | Group Cell 3 voltage | 1 | Cell 3 + | Group Cell 3 voltage |
| 2 | Cell 5 + | Group Cell 5 voltage | 2 | Cell 5 + | Group Cell 5 voltage |
| 3 | Cell 7 + | Group Cell 7 voltage | 3 | Cell 7 + | Group Cell 7 voltage |
| 4 | Cell 9 + | Group Cell 9 voltage | 4 | Cell 9 + | Group Cell 9 voltage |
| 5 | Cell 11 + | Group Cell 11 voltage | 5 | Cell 11 + | Group Cell 11 voltage |
| 6 | Cell 13 + | Group Cell 13 voltage | 6 | Cell 13 + | Group Cell 13 voltage |
| 7 | Cell 15 + | Group Cell 15 voltage | 7 | Cell 15 + | Group Cell 15 voltage |
| 8 | Cell 17 + | Group Cell 17 voltage | 8 | Cell 17 + | Group Cell 17 voltage |
| 9 | Cell 18 + | Group Cell 18 voltage | 9 | Cell 18 + | Group Cell 18 voltage |
| 10 | Cell 2 + | Group Cell 2 voltage | 10 | Cell 2 + | Group Cell 2 voltage |
| 11 | Cell 4 + | Group Cell 4 voltage | 11 | Cell 4 + | Group Cell 4 voltage |
| 12 | Cell 6 + | Group Cell 6 voltage | 12 | Cell 6 + | Group Cell 6 voltage |
| 13 | Cell 8 + | Group Cell 8 voltage | 13 | Cell 8 + | Group Cell 8 voltage |
| 14 | Cell 10 + | Group Cell 10 voltage | 14 | Cell 10 + | Group Cell 10 voltage |
| 15 | Cell 12 + | Group Cell 12 voltage | 15 | Cell 12 + | Group Cell 12 voltage |
| 16 | Cell 14 + | Group Cell 14 voltage | 16 | Cell 14 + | Group Cell 14 voltage |
| 17 | Cell 16 + | Group Cell 16 voltage | 17 | Cell 16 + | Group Cell 16 voltage |
| 18 | Cell 1 + | Group Cell 1 voltage | 18 | Cell 1 + | Group Cell 1 voltage |
| 19 | T1- | Temp sensor 1 ground | 19 | T1- | Temp sensor 1 ground |
| 20 | T2- | Temp sensor 2 ground | 20 | T2- | Temp sensor 2 ground |
| 21 | T3- | Temp sensor 3 ground | 21 | T3- | Temp sensor 3 ground |
| 22 | VCU Wake | VCU/BMS Wake in/out | 22 | --- | --- |
| 23 | J1772 CP | CP pin on J1772 Conn | 23 | --- | --- |
| 24 | J1772 Prox | PP pin on J1772 Conn | 24 | --- | --- |
| 25 | Perm 12 volts | Permanent +12V | 25 | --- | --- |
| 26 | Cell 0 | Group Cell ground | 26 | Cell 0 | Group Cell ground |
| 27 | T1+ | Temp sensor 1 | 27 | T1+ | Temp sensor 1 |
| 28 | T2+ | Temp sensor 2 | 28 | T2+ | Temp sensor 2 |
| 29 | T3+ | Temp sensor 3 | 29 | T3+ | Temp sensor 3 |
| 30 | IPO | IsoSPI Plus Out | 30 | IPO | IsoSPI Plus Out |
| 31 | IMO | IsoSPI Minus Out | 31 | IMO | IsoSPI Minus Out |
| 32 | CANH | CAN High | 32 | IPI | IsoSPI Plus In |
| 33 | CANL | CAN Low | 33 | IMI | IsoSPI Minus In |
| 34 | Ground | 12v Ground | 34 | --- | --- |

Power Wiring

The Master is powered from the 12v Perm Power (Pin 25) and is awakened with +12v on the VCU wake pin (pin 22). The individual modules are powered from their HV pack connections. When “on”, the Master consumes approximately 20mA of 12V. The Perm Power connection must remain powered with +12v at all times, regardless of the vehicle operating state otherwise the J1772 charging will not function properly.

Wake Function

The VCU/BMS Wake (pin 22) is a bidirectional input/output that both wakes up the BMS and also allows the BMS to wake up the VCU. This is needed since there are times when the VCU is asleep and the cockpit wake switch is off but the J1772 charging needs to wake up the VCU and initiate charging. This input should be

connected to the VCU Wake pin as well as the cockpit +12v wake switch. **It is CRITICAL that no other devices are connected to this wake switch and it should not be treated like an “ignition switch” that supplies power to other devices. The BMS communicates with the VCU over this pin when charging and any external load will prevent proper operation.**

CAN Wiring

CAN is provided at the CANH and CANL connections. The BMS Master uses a CAN data rate of 500Kbs and does not have an internal termination resistor. CAN wiring should be kept short and the conductors should be twisted. Wiring should be placed away from the motor and controller and parallel runs next to the traction cabling should be avoided.

The possible CAN connections to the different VCUs is as follows:

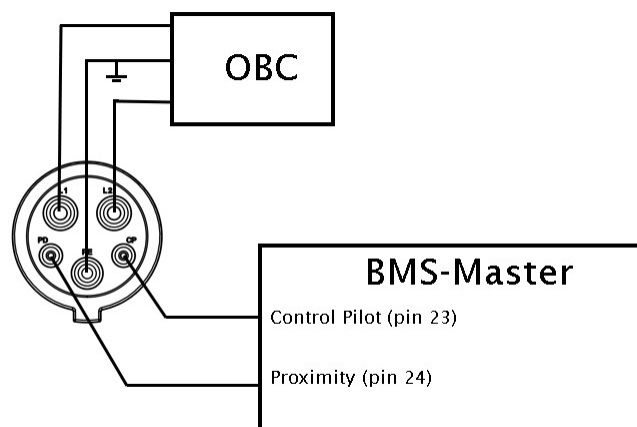
| BMS-18 Master | VCU-200 | VCU-275 | VCU-300 |
|---------------|------------------|-----------------|----------------|
| CANH Pin 32 | CAN 4+ Pin J2-F1 | CAN 3+ Pin A-92 | CAN 3+ Pin K77 |
| CANL Pin 33 | CAN 4- Pin J2-E1 | CAN 3- Pin A-93 | CAN 3- Pin K78 |

isoSPI Satellite System Wiring

The isoSPI datalink wiring **must be twisted pair** and connects to the IPO and IMO (IPout and IMout) signals (IPO pin 30, IMO pin 31). These signals are connected to the corresponding IPI and IMI (IPin and IMin) signals (IPI pin 32, IMI pin 33) on the next module downstream. The instructions flow **out** of the Master and **in** to the Satellites. If there are no more devices in the chain you simply leave the last IPO and IMO disconnected, there is no termination required.

J1772 Charging

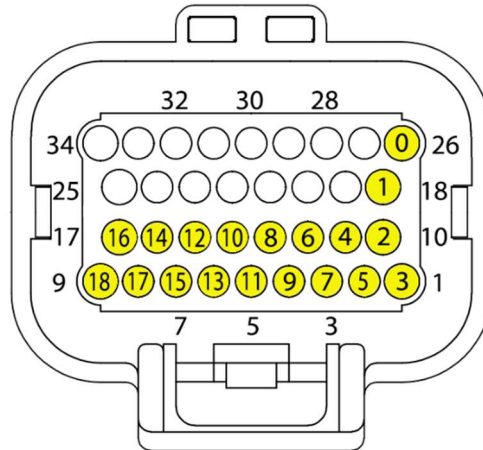
The BMS/VCU combo can control the J1772 Charge Port. Connect J1772 CP (Pin 23) to the CP terminal on the J1772 connector. Connect J1772 Prox (Pin 24) to the PP terminal on the J1772 connector. Connect L2, L2 and PE to the On-board Charger and you must also tee-off the PE connection to the vehicle ground as well or the Proximity signal will not read correctly.



J1772 Charging Connections

Master and Satellite Cell Wiring

Cell wiring is identical for the Master and Satellite.



Cell Harness Connections as viewed from the wire entry side of the Connector

When wiring the cell harness connector, remember that Cell 0 is the ground of Cell 1 and that all cells within a group must be connected in series with voltage increasing. Each cell group has 19 connections to connect to the 18 cells in the group. If fewer than 18 cells are to be monitored, then the unused cell inputs should be at the top, all connected together with the highest actual cell to the Cell 18 input.

Once the cell group is wired, use a voltmeter to verify that cells are connected with the proper polarity, and that they are in series. Verify that voltage difference between adjacent cells is correct. Also verify that if fewer than 18 cells are used in the group that the top cells all have identical voltage readings.

NOTE: The terminals are connected directly to pack voltage and so there can be up to 90V connected on the harness. Be Careful!

Once the cell harness is verified, it is safe to plug into the Master or Satellite. Cell Harness connectors may be plugged in or unplugged in any order. It is not necessary to remove 12V power from the BMS in order to plug or unplug Cell Harness connectors.

Temperature Sensors

Each BMS module supports 3 external thermistors and these should be mounted to measure battery cell temperatures. It is important that these are used since the VCU adjusts the max allowable current (both discharge and charge) based on the cell temperatures as well as alerts the user of a critical over-temp event is occurring. The thermistors supplied with each BMS module is the Vishay NTCLE413E2103F102L 10k sensor. You can substitute your own sensors as long as you know the temperature versus resistance calibration values and understand that the maximum resistance readable by the BMS is 131kOhms and enter the values in the calibration table in the VCU software. All thermistors used in the BMS must have the same calibration.

The thermistors are wired to pins 19 & 27 for thermistor 1, pins 20 & 28 for thermistor 2 and pins 21 & 29 for thermistor 3. Polarity is unimportant.

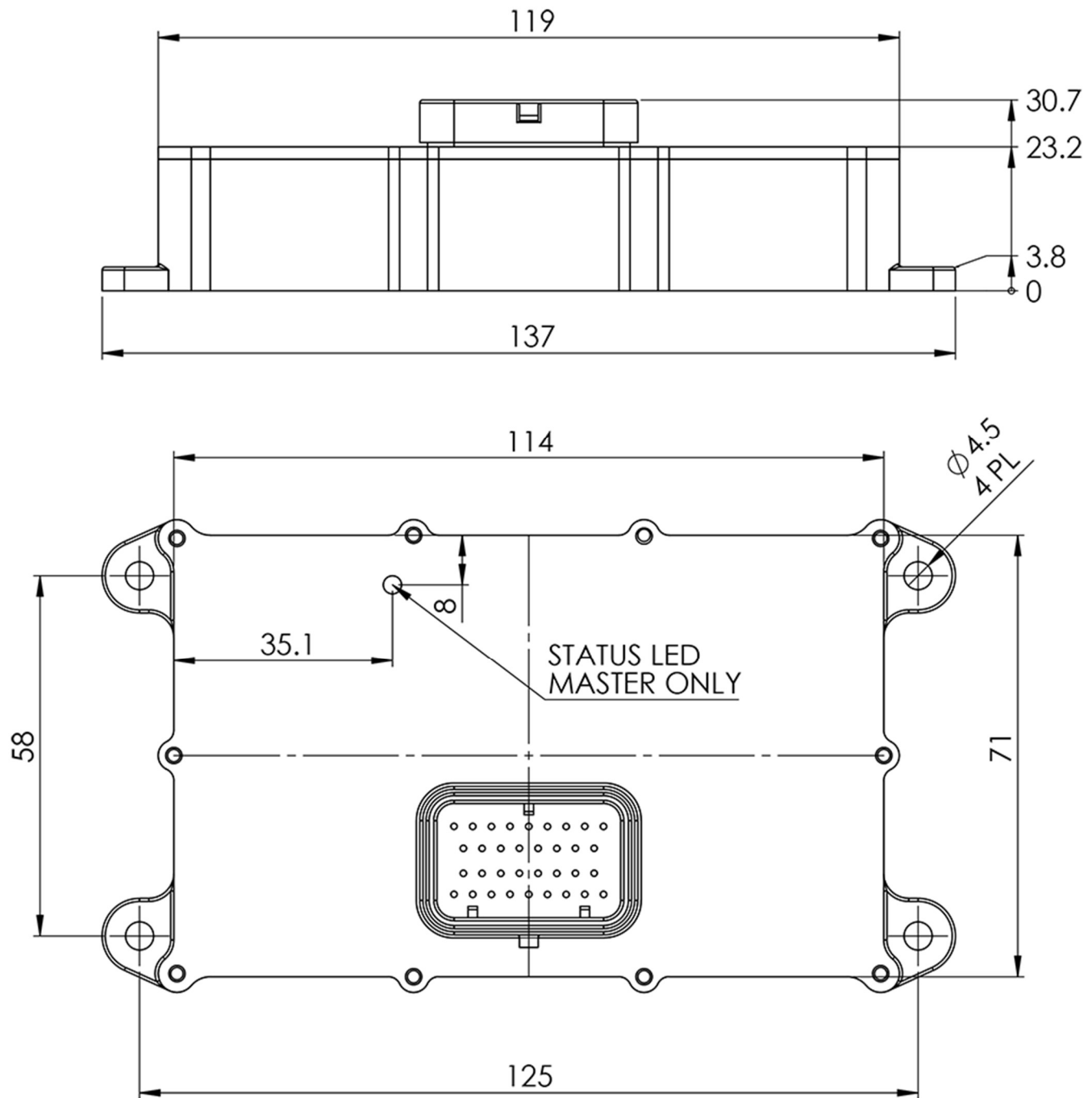
Environmental Sealing

The BMS modules are sealed to IP64 levels as long as wire cavity blanking plugs are used in place of all unused connections. (P/N TE 4-1437284-3).

Dimensions

Both the Master and Satellite are housed in sealed billet aluminum enclosures measuring 114mm x 71mm x 24mm not including the connector or mounting tabs.

3D models of the BMS modules are available by request from AEM.



Battery Pack Service Note

Warning! When servicing battery modules, disconnect the connectors to all the Satellite and Master BMS modules before servicing. After servicing or modifying battery modules, verify the wiring before re connecting the Satellite and Master BMS Modules.

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PROCEDURES FOR ISSUANCE OF A RETURN MERCHANDISE AUTHORIZATION (RMA) NUMBER-

Please note that before AEM Electronics can issue an RMA for any product, it is first necessary for the installer or end-user to contact our technical support team to discuss the problem. Most issues can be resolved over the phone. Under no circumstances should a system be returned, or an RMA requested before our support team is contacted. This will ensure that if an RMA is needed that our team is able to track your product through the warranty process.

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