Using the Orion BMS with Tesla Battery Modules

IMPORTANT SAFETY NOTE: Reclaimed cells always carry risk. Cells may have been involved in an accident or been exposed to other physical stress which may have caused internal damage. This can lead to premature failure or risk of internal shorts within the modules. **Appropriate precautions must be taken to account for these risks.**

The Orion 2 BMS and Orion Jr BMS products are compatible with the widely popular Tesla battery modules found in the Model S / X electric vehicles. These modules use a proprietary chemistry developed by Tesla in conjunction with Panasonic that delivers a unique combination of high power output while still retaining an industry leading energy density. They are a popular choice for aftermarket projects.

Depending on which vehicle the Tesla module came from, the actual build-up of the module may be slightly different. At the time this document was written, the Model S and Model X battery modules remain the most commonly used, though the recently released Tesla Model 3 battery packs are likely to grow in popularity quickly.

Ewert Energy Systems, Inc
161 E. St Charles Rd. Carol Stream, IL 60188
Phone: (630) 868-3173

For the Model S variant of the battery module (which this document will focus on), the battery is comprised of 6 total cells in series (for a nominal voltage of 22.2v) with a variable number of 18650 style cells connected in parallel ranging from ~40 cells up to ~80 cells depending on which model vehicle the pack originated from. This means each module could have nearly 500 discrete battery cells inside it. Because the BMS itself is only concerned with the number of cells in series, however, the exact number of cells in parallel does not impact how the modules are wired to the Orion BMS.

Below is a picture of a 22.2v Tesla Model S / X battery module:

SAFETY WARNING: The 18650 style battery cells found in Tesla modules can be very dangerous to work with without proper training and equipment. **It is not recommended that the Tesla battery modules be disassembled or modified in any way.**

From the factory, each Tesla battery module includes a small circuitboard that originally provided the individual cell voltage measurement data back to the main battery controller. **By itself, the existing Tesla circuitboard does NOT protect the battery pack or do anything meaningful as it merely acts as a remote sensor for the main battery controller which was located elsewhere in the original vehicle.** When using Tesla modules with the Orion BMS, this onboard circuitboard is no longer necessary as the Orion BMS will now perform the main monitoring/protection functions (and many others). Because of this, the existing Tesla battery monitor circuitboard must be removed, however, the wiring harnesses connecting to this circuitboard will be reused and should not be cut or removed.

Ewert Energy Systems, Inc
161 E. St Charles Rd. Carol Stream, IL 60188
Phone: (630) 868-3173

NOTE: The existing Tesla battery monitor circuitboard must be removed in order to use the module with the Orion BMS. Keeping the Tesla battery monitor circuitboard connected while also using the Orion BMS to monitor the same cells may result in one BMS interfering with the other and influencing results.

Tesla provides a single reference cell tap wire for each of the 6 cells in series within the Model S module. Originally these taps were used by their onboard battery management circuit, however, these can now be repurposed for use with the Orion BMS.

Depending on which revision of the battery module is being used, there should be between 2 and 4 connectors that had previously been connected to the Tesla circuitry. These connectors contain the cell voltage reference taps (needed by the Orion BMS to measure the individual cell voltages) as well as access to 2 embedded thermistors within the module.

In order to connect the Orion BMS to a Tesla module, each of the 6 cells within the module is treated as an individual cell in series.

As noted above, the Tesla modules technically contain dozens of cells in parallel and then 6 of those blocks of paralleled cells in series (eg: 6s76p), however, the Orion BMS treats blocks of cells which are paralleled directly together as a single cell. Because of this, the Orion BMS will see a single Tesla module as 6 cells in series. The Orion BMS can easily be used with these by simply utilizing the cell voltage reference wires provided by Tesla for monitoring the individual cells.

Depending on what revision of module is being used, the pin-out on the battery module side may be slightly different. Please see below for a list of the common configurations. **Alternatively, the pinout for the connectors may be printed on the Tesla battery monitor circuitboard itself.**

Wiring Adapter Circuitboards

NOTE: Due to the popularity of used Tesla modules, a number of aftermarket cell tap voltage adapter boards are now available that allow for easier integration between the Orion BMS and the existing Tesla battery voltage tap leads. Please inquire with the companies listed below for more information.

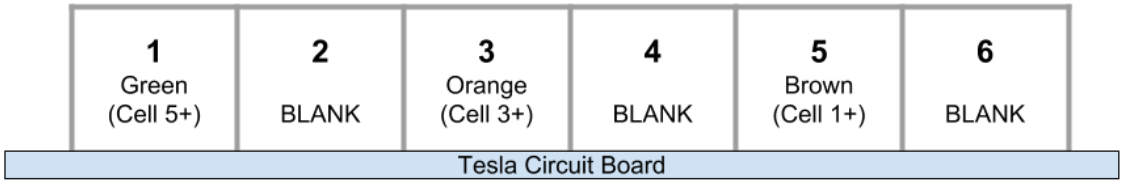
Ewert Energy Systems is not directly affiliated with any of these suppliers.

- Stealth EV (http://www.stealthev.com, USA, California)
- Zero EV (http://www.zero-ev.co.uk, United Kingdom)
- EV Europe (http://eveurope.eu, Netherlands)

Ewert Energy Systems, Inc
161 E. St Charles Rd. Carol Stream, IL 60188
Phone: (630) 868-3173

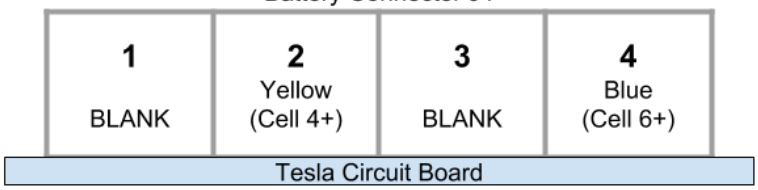
Revision A Tesla Module Pinout

Battery Connector J3



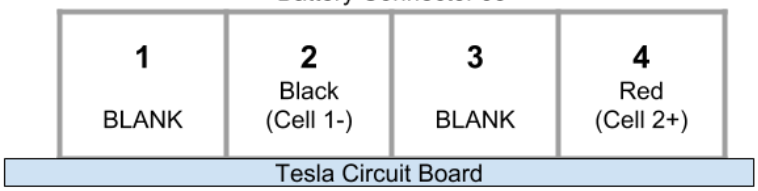
Viewed from the back side of the J3 connector

Battery Connector J4



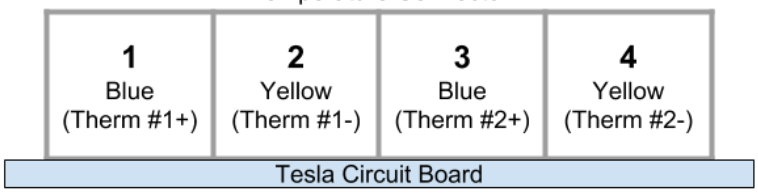
Viewed from the back side of the J4 connector

Battery Connector J5



Viewed from the back side of the J5 connector

Temperature Connector

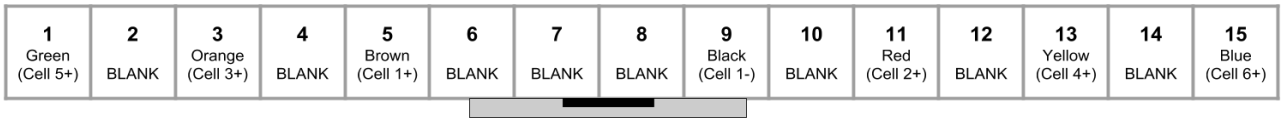


Viewed from the front side of the temperature connector

Ewert Energy Systems, Inc
161 E. St Charles Rd. Carol Stream, IL 60188
Phone: (630) 868-3173

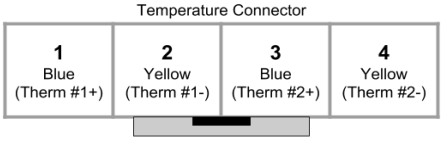
Revision B Tesla Module Pinout

Battery Connector



Viewed from front side of battery connector

Temperature Connector

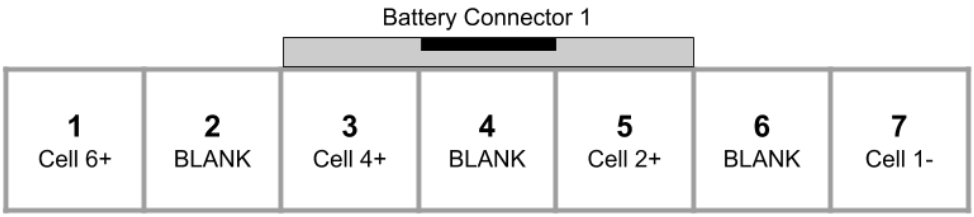


Viewed from front side of temperature connector

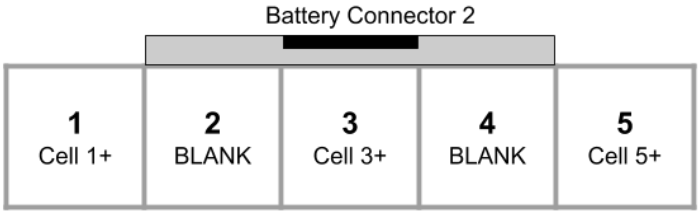
Document Revision: 1.3
Last Updated: 03/04/2019

Ewert Energy Systems, Inc
161 E. St Charles Rd. Carol Stream, IL 60188
Phone: (630) 868-3173

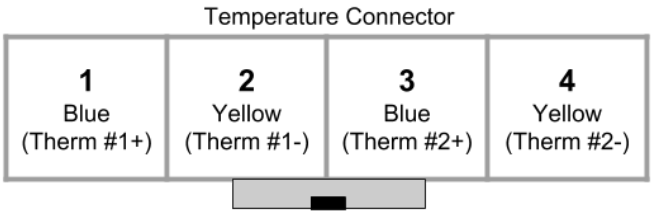
Revision C Tesla Module Pinout



Viewed from the front side of 7 pin connector



Viewed from the front side of 5 pin connector



Viewed from the front side of temperature connector

Cell tap 1- (the negative) is connected to the cell 1 negative reference for the module, then tap 1 is connected to the cell 1 positive reference, tap 2 is connected to the cell 2 positive reference and so on.

NOTE: When multiple modules are connected together in series, the cell 1 negative reference may not be used on the second module (it would only be needed for referencing the first cell in a group of 12 on the Orion BMS connectors).

IMPORTANT NOTE: It is very important that 6 cell tap inputs are used per Tesla module as shown in the diagram above (one tap going to the first cell in series and the second tap going to the second cell in series, etc). **DO NOT CONNECT THE ENTIRE 22.2v MODULE TO A SINGLE CELL TAP INPUT ON THE BMS.** This will result in over 5v being applied to a single cell tap input and cause damage to the BMS which is not covered under warranty.

Ewert Energy Systems, Inc
161 E. St Charles Rd. Carol Stream, IL 60188
Phone: (630) 868-3173

Other Considerations

IMPORTANT NOTE: Due to the way the cells are designed and packaged, they can generate considerable amounts of heat during extended use. While Ewert Energy Systems cannot make a formal recommendation on how the modules should be installed in the application, **it is very strongly recommended that supplemental cooling such as active airflow or liquid cooling be installed** in order to maintain a suitable operating temperature for the pack.

Paralleling Multiple Tesla Modules

CRITICAL NOTE: Because Tesla modules contain multiple cells in series, **they CANNOT be directly connected together in parallel without taking sufficient precautions and design strategies**.

Even though Tesla modules have a fairly large capacity, often times an application will demand an even larger capacity than a single module itself can provide. The only way to achieve this with Tesla modules without increasing the pack voltage (by placing modules in series instead of parallel) is to introduce parallel strings (that is, the parallel connection of series strings together to form multiple discrete high voltage battery packs).

This is not a trivial task and requires the use of a separate (discrete) BMS per string being used, along with other support equipment and supplemental engineering work.

Because of the extra costs and additional engineering work required, the use of parallel strings is not recommended if there are any other viable alternatives. In many cases, it may be lower cost and easier to use a different cell type where cells can be directly paralleled together to achieve the necessary capacity (with those blocks then placed in series to form a single string). **Alternatively, if a higher system voltage is acceptable, it may be possible to place multiple Tesla modules in series rather than parallel to achieve higher energy capacity, but at a higher voltage.**

Ewert Energy Systems has published an independent document regarding Parallel Strings and the challenges faced when using them for additional details on this (there is far too much information to include in this application note). **Please review this supplemental document (which is available on the Application Notes section of the Orion BMS website) carefully before attempting parallel strings. Due to the risks of parallel strings, our BMS products may only be used with parallel strings when the integration work is performed by an electrical engineer familiar with the safety concerns of parallel strings.**

Ewert Energy Systems, Inc
161 E. St Charles Rd. Carol Stream, IL 60188
Phone: (630) 868-3173