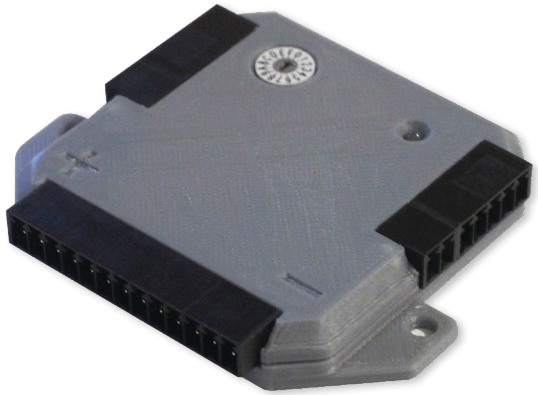


12-Cell Lithium BMS Module V3

Introduction

Lithium batteries have been a revolution in energy storage, for both electric vehicles and stationary / off-grid battery systems. However they can be easily damaged if their voltage goes out of safe operating range – either too high (from overcharging) or too low (over-discharging).

Battery packs are commonly built from a large number of individual cells in series to achieve higher voltages. Due to manufacturing tolerances, cells will always have some variation in capacity, so during use there will be some cells which reach full or go flat before others. In battery packs made of many cells in series, the overall voltage gives little indication of the voltage of individual cells in the chain, so it is important to have a system which monitors the voltages of each cell, and takes action if any cell goes out of range.

ZEVA's BMS12 modules offer a robust, automotive-grade solution for protecting your lithium batteries from damage, maintaining pack balance, and monitoring cell voltages remotely. A single module can manage from 3–12 lithium cells, and up to 16 modules may be used on the same CAN bus, allowing packs up to 192 cells or about 600VDC.

The BMS12 modules communicate over CAN bus with a BMS master control unit to form a complete Battery Management System for your vehicle. Voltage thresholds are fully configurable, allowing the module to be compatible with most lithium chemistries including LiFePO4, LiCo, LiPo and LiMn.

Battery Management Systems should be considered the last line of defence for your battery pack. During normal operation, the BMS should never have to intervene with vehicle operation, only taking action to protect the battery in exceptional circumstances. Although a BMS will protect your cells from damage from over-discharging, regularly discharging your cells to 0% SoC – i.e driving until the BMS stops the vehicle – will greatly shorten the cycle life of your batteries so is best avoided whenever possible.

Safety Warning

Lithium battery packs contain a lot of energy and can deliver a lot of power, with potentially lethal voltages and currents, so proper precautions and electrical safety procedures should always be observed. Voltages above 110VDC should be considered dangerous, and vehicles should never be worked on while power contactor(s) are engaged.

Please read this manual carefully to ensure correct installation and operation of your BMS12 modules. If you are unsure of anything, please contact us before proceeding.

We have endeavoured to make a safe and reliable product which performs as described, however since ZEVA has no control over the integration of its products into a vehicle, we can assume no responsibility for the safety or functionality of the completed vehicle.

It is the responsibility of the end user to determine the suitability of the products for the purpose employed, and the end user assumes all risks associated. Products should only be installed by suitably qualified and experienced persons, and should always be used in a safe and lawful manner.

Specifications

- Cells managed: 3–12 lithium cells per module
- Maximum total voltage: 60VDC
- Compatible with all lithium battery chemistries (LiFePO4, LiCo, LTO, NMC, etc)
- Cell measurement range: 0–5000mV
- Accuracy: Typically ±1mV
- Operating temperature range: -40˚C to 85˚C
- Pack balancing: 47Ω shunts, adjustable balance threshold
- Temperature sensing: Dual 100KΩ NTC thermistors (optional)
- Cell quiescent current draw: 1.5mA (idle) 2.2mA (when sampling)
- CAN power supply: 12V nominal (8-16V range), 20mA
- CAN bus specification: 250kbps 29-bit IDs (CAN 2.0B)
- Dimensions: 67 x 67 x 11mm (excluding connectors)
- Weight: 35g

Installation

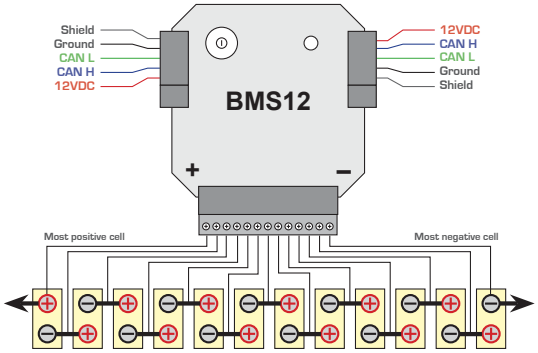
The module has two 4mm mounting holes 72mm apart which should be used to mount the module securely. Alternatively, double-sided foam tape may be used to attach the module to a surface. Although the plastic housing provides some weather resistance, *they are not waterproof!* Modules should be installed in a location protected from water and debris. Inside sealed battery enclosures is ideal.

It is best to mount the module close to the cells it is monitoring, with flylead lengths of 50cm or less recommended to minimise induced EMI noise and the chance of wiring/insulation faults. If cells are distributed in physically separate groups, it is best to keep cell modules near the cells and run longer CAN bus to the master controller, rather than have cell modules close together with longer wires to the cells.

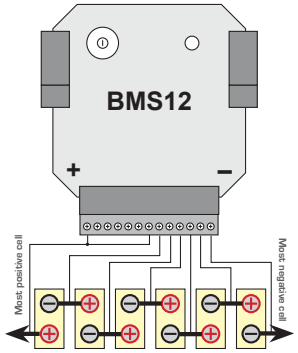
Note: *Be careful not to have cell inputs span any mid-pack contactors or emergency stop buttons, as this can subject the module to damaging high voltages when opened, since the BMS module becomes a conduction path across the break! For similar reasons, be sure to unplug all BMS modules before doing any battery pack maintenance.*

Connect flywires between the 13-pin plug and the cells as per the diagram below. It is best to leave the plug disconnected from the module while wiring up, and verify all voltages / cell orders before connecting to the module, in case of wiring mistakes which could damage the BMS module.

If fewer than 12 cells are to be connected, some cell inputs at the positive end will be unused. The voltage sampling chip powers itself from the most positive screw terminal, so the most positive cell wire connected must be bridged to the most positive screw terminal on the BMS module, as shown in the diagram below (right).

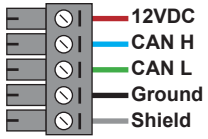


Typical wiring for BMS module



Example wiring with fewer cells

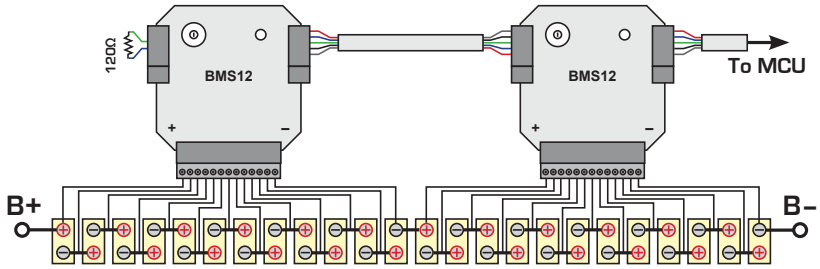
The CAN plugs are Molex Eurostyle screw terminals. Wire gauge around 20-24AWG is recommended for appropriate current rating and mechanical strength. The connectors require some force to plug in, so make sure the plug is fully inserted for a reliable connection. Ensure all wiring is secured with strain relief so it will not become damaged from vibration or abrasion. Wiring for the Eurostyle connectors is as follows:



Shielded twisted pair cable is recommended for CAN bus wiring, with two conductor pairs – one pair for CAN signals, and one pair for bus power. (During operation, the traction circuit in electric vehicles can emit fairly high levels of electromagnetic interference, which can induce noise on signal wiring.) We use and recommend Belden 8723 or equivalent.

Note that the cell sampling electronics is galvanically isolated from the CAN bus electronics in order to maintain isolation between your traction circuit and vehicle chassis. There should also be no external electrical connections between HV wiring and CAN bus wiring.

For optimum performance, CAN buses should be wired as a single daisy chain of devices (without branching), and terminated at both ends of the bus with a 120Ω resistor across the CAN H and CAN L lines. Modules and the Master Control Unit (such as a ZEVA EVMS3) may be in any order on the CAN bus, and the MCU does not have to be an endpoint (it could be in the middle of the bus). Usually the CAN bus route requiring the shortest cable lengths is best. The diagram below shows an typical topology for an example 24-cell battery pack.



Example wiring for a 24-cell battery pack

Each BMS module needs to be assigned a unique ID on the CAN bus. This is done by adjusting the 16-position rotary switch near the top left of the board. Switch markings are in hexadecimal, so “A” means ID 10, “B” means ID 11, etc. Your MCU / EVMS will need to be programmed accordingly with information about module IDs and numbers of cells to expect.

Powering up

The BMS12 modules run most of their circuitry from CAN bus power. When the module powers up, the onboard LED should light up green. The LED may display a variety of codes as follows:

Green	BMS active, no errors
Blinking green	No CAN bus communications detected
Blinking red	No cells detected
Flashing green/orange	One or more shunt balancers active

The BMS12 modules themselves are unable to take action if a monitored cell is out of safe voltage range (in fact the BMS module stores no information about acceptable voltage ranges, only reports information and balances when instructed), so must communicate with an appropriate BMS master control unit which is able to respond to any reported error conditions, such as our EVMS. Please refer to the user manual for your BMS master control unit for advice on integration with BMS12 modules.

Your complete BMS should be “failsafe”, so if any BMS12 modules are not detected by the MCU on startup, or if any cells are out of safe voltage range, the vehicle or battery system should not be able to run. It is a good idea to verify the failsafe by temporarily unplugging the cell connector or unplug the CAN bus, and verify that this causes the MCU to stop the charger or shut down the drive system.

Automatic Pack balancing

In battery packs built from many cells, optimum performance is attained when all cells are at the same State of Charge – also known as pack balance.

The BMS12 modules use a system known as “shunt balancing” to maintain balance, which switches on small resistors across any cells which are above a shunt threshold. The shunt threshold is sent dynamically over CAN bus from the BMS master controller, typically set to the average cell voltage or the average peak charge voltage so that any cells above average voltage receive balancing.

To avoid excessive heat buildup, the shunt balancers are quite small and can take a long time to correct large imbalances. If possible it is recommended to manually balance your cells prior to initial pack assembly (e.g by charging each cell individually, or wiring them all together in parallel to equalise with each other). However the shunts will get an unbalanced pack incrementally closer to balanced each charge, and once balanced are able to maintain balance with minimal effort.

CAN Protocol Details

For those wishing to integrate BMS12 modules with their own master control unit, we have prepared an application note detailing the required CAN format and packet IDs/structures. Please download a copy from the BMS12 product page at **http://www.zeva.com.au**.

Tech support and warranty information

BMS12 modules are covered by a 12 month warranty against manufacturing faults or failures under normal operating conditions. The warranty does not cover misuse of the product, including but not limited to physical damage or modification to the module, and reverse or excessive voltages to inputs.

We have taken great care to design a safe and reliable product, but faults can happen. If you believe your BMS12 module has a fault, please contact us via our website for RMA information. Or if you have any questions not covered by this manual, please contact us via our website:

http://www.zeva.com.au/Contact