



Electric Vehicle Management System V3

Multifunctional, integrated control system for your EV

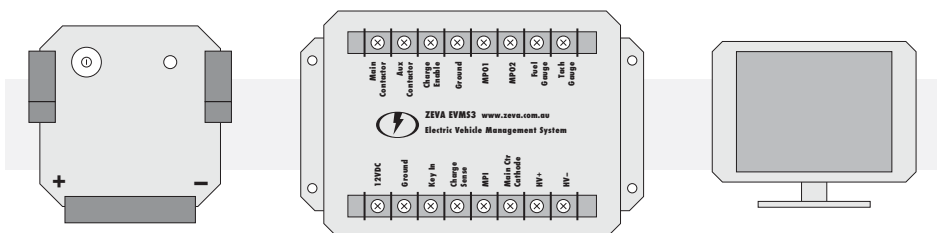


Table of Contents

Introduction	2	Charger Integration Options	10
About Lithium Battery Management	2	Auxiliary Contactors	11
Safety Warning	3	EVMS Monitor	12
EVMS3 Specifications	3	List of Settings	14
BMS12 Specifications	3	Multi Purpose Inputs and Outputs	18
EVMS3 Installation	4	Error Detection	19
BMS12 Installation	5	Voltage Thresholds	21
Example Wiring Diagram	6	Stationary Applications	22
Description of EVMS Connections	7	Use With Batteries Over 360VDC	23
CAN Bus Wiring	8	Isolation Fault Detection	23
12-Cell BMS Modules	9	Technical Support and Warranty	23
Current Sensor	9		

Introduction

Thank you for purchasing ZEVA's Electric Vehicle Management System. The EVMS was developed to address the need for safer, more reliable and better integrated EV conversions. It combines many common functions and a range of fault detection, providing warnings of operating errors and automatically responding to serious faults.

- Instrumentation including voltage, current, power, battery charge, temperature, and isolation integrity.
- Battery management via 12-cell BMS modules (aka "BMS12"), including cell voltage and temperature monitoring with automatic response to under/over-charged batteries, and automatic pack balancing.
- Analog gauge outputs to re-use OEM fuel gauge, temp gauge and tachometer.
- Contactor control for management of auxiliary contactors, allowing battery pack break-up and isolation for safety when vehicle is not in use.
- Optional 2-stage precharger with fault detection for soft-starting motor controllers
- Detection of many different operating errors/warnings.

A complete installation consists of an EVMS, usually installed in the vehicle's engine bay, communicating over CAN bus with a Monitor module in the vehicle cabin, and a current sensor and battery management modules located within your battery boxes. The CAN bus may also include up to three TC Chargers and a ZEVA motor controller.

This manual describes the installation and operation of the EVMS3, BMS modules and Monitor devices. Please refer to documentation supplied with your motor controller and charger for further information relating to those devices.

About Lithium Battery Management

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 (overcharging) or too low (over-discharging).

Due to manufacturing tolerances, cells in a battery pack will always have some variation in capacity, so during use there will be some cells which reach full or go flat before others. Due to this variations, in battery packs made of many cells in series the overall voltage gives little indication of the individual cell voltages, 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.

There will also be differences between rates of self-discharge in cells, which causes pack imbalances to develop over time, so it is valuable for a lithium BMS to include a system for balancing cells - most commonly, by draining a small amount of power from any cells above average voltage.

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

Electric vehicles are high powered machines which involve potentially lethal voltages and currents. Proper precautions and electrical safety procedures should always be observed, voltages above 100VDC 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. 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 or battery system, we can assume no responsibility for the final safety or functionality of the completed vehicle. It is up to 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.

EVMS3 Specifications

- Power supply: 12V nominal (8-16V maximum)
- Power consumption: Approx 35mA when active (EVMS only), 3mA when sleeping
- Fusing: Internal PTC type, 5A for power outputs, 200mA for logic I/O
- Traction pack voltage range: 12-360VDC nominal (405V absolute max)
- Traction pack capacity: 5-1250Ah (5Ah steps)
- Current measurement: Via CAN bus current sensor, up to $\pm 1200A$
- CAN bus format: 250kbps 29-bit (CAN 2.0B). Other formats by request.
- Dimensions: EVMS 120x100x40mm, Monitor 96x62x17mm + mounting foot
- Housing: ABS plastic, approx IP44 rating (weather resistant, not waterproof)

BMS12 Specifications

- Cells managed: 4–12 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 $\pm 1mV$
- Operating temperature range: -40°C to 85°C
- Pack balancing: 47 Ω shunts, adjustable balance threshold
- Temperature sensing: Dual 100K Ω 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

EVMS Installation

The EVMS should be mounted securely using screws through the four 4mm holes on the case flanges, in a location protected from direct water. *Please note that although the housings provide some weather protection, they are not fully waterproof, so should not be exposed to rain or submerged in water.*

The EVMS has 16 screw terminal connections on top of the case, plus dual CAN ports and a temperature sensor input on one side. Wire gauge for most connections should be around 16-20AWG for suitable current rating and mechanical strength. Ensure all wiring has appropriate voltage (insulation) ratings – beware that most automotive insulated wire is not rated for the higher voltage of EV traction circuits. The supplied fork crimp lugs are recommended for the most reliable connections to the screw terminals.

The following diagram shows a typical schematic for a complete EVMS installation in an electric vehicle, other than gauge outputs and Multi Purpose terminals. It may look a little intimidating at first but should become clear as you start to wire up your own vehicle. Note that the diagram does not show an inertia switch (crash sensor), which should be installed between the 12V battery and the EVMS's 12V supply. You will also usually need to use the key signal to switch a relay for powering auxiliary 12V devices such as brake vacuum pump, power steering pump, water cooling pump, cabin heater, etc.

Make sure all power wiring has appropriate current and voltage (insulation) ratings, and that fuses have appropriate DC voltage and current ratings. The EVMS has an internal self-resetting fuse which limits the total combined current of all outputs to 5A continuous, but up to 10A is fine intermittently (e.g. when contactors are energising).

With motor controllers which manage the main contactor themselves, the Main Contactor output from the EVMS can be wired to the controller's Key Switch Input (KSI) so that the EVMS is able to turn the motor controller off in the case of a low cell detected, for example.

BMS12 Installation

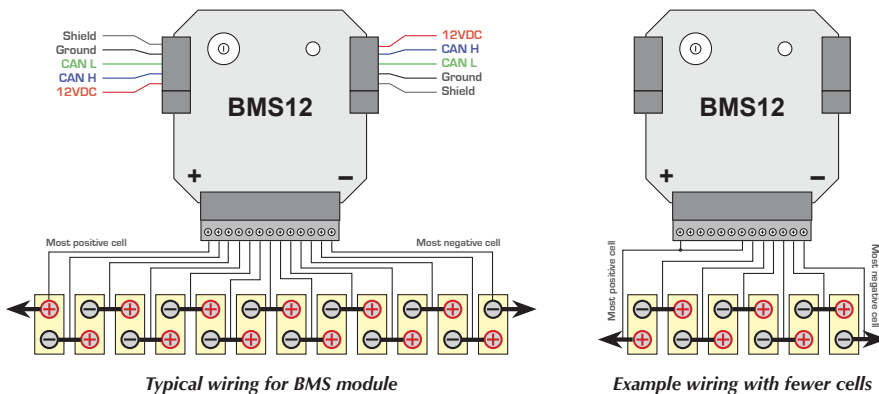
The module has two 4mm mounting holes 72mm apart which should be used to mount the module securely. Alternatively, double-sided foam tape may be used to attach the module to a surface. Although the plastic housing provides some weather resistance, *they are not waterproof!* Modules should be installed 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 under 1m recommended. *Longer wiring can act as an antenna for EMI noise which in extreme cases can damage the module!* 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.

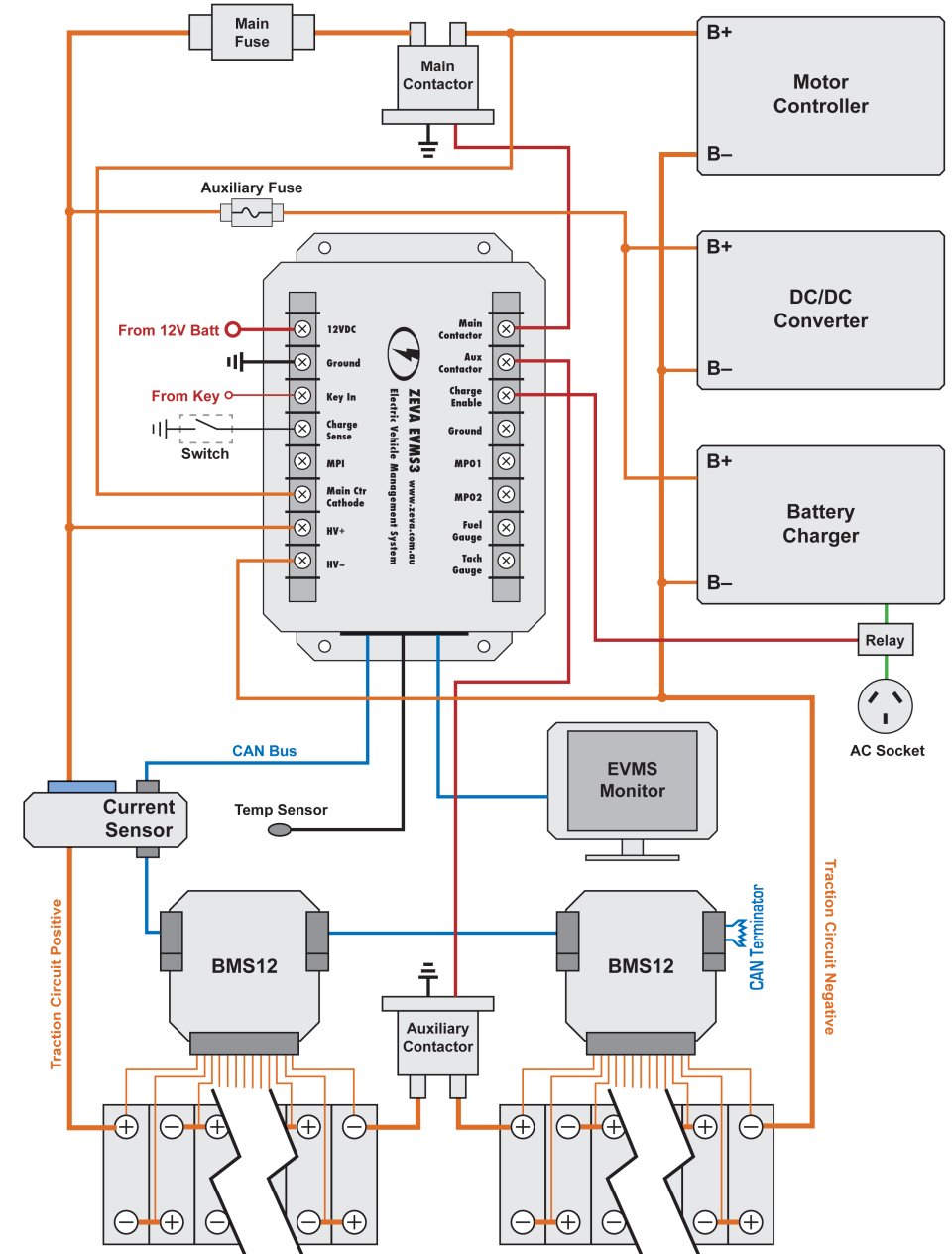
Connect flywires between the 13-pin plug and the cells as per the diagram below. It is best to leave the plug disconnected from the module while wiring up, and verify all voltages / cell orders before connecting to the module, to avoid wiring mistakes which could damage the BMS module.

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 6-cell example diagram (below, right).



Each BMS module needs to be assigned a unique ID using the rotary selector on top, and the EVMS gets configured for how many cells it should expect at which BMS IDs.

Example Wiring Diagram



Description of EVMS Connections

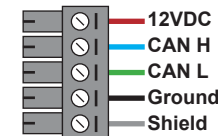
Terminal name	I/O	Description
+12VDC	Input	To 12V battery positive (permanent supply, not key switched). 8-16V maximum range.
Ground	Input	To vehicle chassis or 12V battery negative
Key In	Input	To key signal, should be +12V when key is turned on
Charge Sense	Input	Connect to your charge detection switch, such as a fuel door switch or 240V detect relay/circuit. Should connect to ground/chassis when the switch is on.
MPI	Input	Multi-Purpose Input, assignable to a range of additional functions.
Main Ctr Cathode	Input	Connect to the power terminal on the motor controller side (i.e output / cathode) of your main contactor
HV+	Input	Connect to the most positive potential of your battery, or the input / anode of your main contactor.
HV-	Input	Connect to the most negative potential of your battery.
Main Ctr	Output	Connect to the positive wire of your main contactor coil. The contactor coil negative wire should be connected to ground/chassis.
Aux Ctr	Output	Connect to the positive wire of your auxiliary/secondary contactor(s). The coil negative wire should be connected to ground/chassis.
Charge Enable	Output	Connect to the +12 terminal of a relay which can enable your charger (usually turning the AC supply on, or charge enable input pins supported by some chargers). The other side of the relay should be connected to ground/chassis.
Ground		A spare ground connection point, often used as a ground for contactor wiring.
MPO1	Output	Multi-Purpose Outputs 1 and 2, assignable to a range of additional functions. Please refer to section <i>Multi-Purpose Input and Outputs</i> for more information.
MPO2	Output	
Fuel Gauge	Output	To the fuel gauge input connection on your vehicle's OEM instrument cluster (or aftermarket fuel gauge).
Tach Gauge	Output	To the tachometer input connection on your vehicle's OEM instrument cluster (or aftermarket tachometer).

CAN Bus Wiring

The EVMS uses CAN bus to communicate with other devices in the vehicle such as BMS modules, EVMS Monitor, CAN current sensor, TC Chargers and ZEVA motor controllers.

Note that every manufacturer tends to implement their own protocol on CAN bus so the EVMS will not be able to communicate with CAN-enabled devices from other manufacturers (other than TC Chargers). Normally it is best for ZEVA devices to use their own dedicated CAN bus rather than share an existing CAN bus with other devices, to avoid the possibility of bandwidth limitations and ID conflicts.

The EVMS itself has two CAN bus connectors, joined to the same bus internally, which can be connected in either order in any location along the CAN bus. The EVMS3 and most associated devices use Molex Eurostyle pluggable screw terminals for the CAN bus. Connector wiring is shown in the diagram below:



Note that while connectors into most devices go screw side up, due to the orientation of the internal circuit board in the EVMS3, its CAN plugs are inserted with screw side down.

CAN buses work best when wired as a single daisy chain of devices, with 120ohm termination resistors at each end to prevent signal reflection. Most ZEVA CAN-enabled devices have dual CAN plugs for easy daisy-chaining. The order of devices is unimportant - usually the shortest path between devices is best. The EVMS Monitor is most commonly installed at one end of the CAN bus so only has a single CAN port, and a built-in internal termination resistor. The monitor may be installed in the middle of a CAN bus by creating a short Y-branch off the bus to the Monitor's CAN plug, and removing the small pin jumper on the right of the CAN plug to disable the internal termination resistor.

For the sake of noise immunity, CAN buses typically use twisted pair cable. Since electric vehicles can involve high electromagnetic interference (EMI) from the traction circuit, we recommend using shielded twisted pair wire for maximum noise immunity. Very short spans are usually OK with untwisted and/or unshielded cable.

CAN buses and the attached devices do consume some power (an EVMS with a few BMS modules and an EVMS Monitor will use in the order of 200mA), so in order to reduce quiescent drain on the auxiliary battery, the EVMS will normally switch off the CAN bus after a configurable number of minutes in Idle state (i.e neither driving, charging, or in setup) to save power. Setup mode can only be entered from Idle state, so needs to be done during the time window before the CAN bus powers down. The sleep delay is configurable in settings, and sleep can be disabled altogether.

12-Cell BMS Modules

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, so must communicate with an appropriate master controller such as the EVMS, which is able to respond to any reported error conditions.

Your complete system should be “failsafe”, so if any BMS12 modules are not detected by the EVMS, 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 that it is failsafe by temporarily unplugging the cell connector or unplug the CAN bus, and verify that this causes the EVMS to stop the charger or shut down the drive system.

The BMS modules also handle pack balancing, to correct differences in self-discharge between cells over time and optimise available capacity. The default balancing scheme used by the EVMS + BMS12 modules is to apply (shunt) balancing to any cells more than 0.01V above average voltage at any time during charging. The system can also be configured to use a fixed balance threshold, best set to be the average per-cell peak charge voltage. Balancing can also be disabled altogether.

In order to avoid excessive heat build-up, the shunt balancers are quite small and will take a long time to correct any large imbalances – but will get the pack incrementally closer whenever you charge, and can easily maintain balance once achieved. If there appears to be any major imbalances between cells prior to assembly, we recommend manually balancing cells (e.g by connecting in parallel).

Current Sensor

The EVMS3 communicates with a current sensor on the CAN bus to receive instantaneous current, and uses this to calculate battery State of Charge through integration over time. Two types of current sensor are available, Hall Effect or Shunt.

- Hall Effect current sensors are available for 300A, 600A or 1200A maximum, and are installed simply by slipping the battery cable through the blue torus of the hall sensor. Smaller rated sensors offer proportionally higher measurement accuracy so are more appropriate for lower current systems. Hall sensors are normally easier to

install and generate no heat, but are a little more expensive and have slightly less accurate zero point.

- The Shunt Interface measures current flow through a shunt installed on the battery cable and outputs it to the CAN bus. The Shunt Interface can work with 50A, 100A, 200A or 500A shunts, either 75mV or 50mV. Smaller shunts offer proportionately higher measurement resolution. *Note that the current ratings for the shunts are maximum continuous ratings, but the shunt interface can measure up to twice the shunt's nominal rating intermittently - limited by heat buildup in the shunt.* A shunt interface plus shunt works out a little cheaper than the Hall Effect sensor and has a slightly more accurate zero point (better accuracy with very low currents), but can be a little more effort to install, and generates some heat.

As a general guide, hall effect sensors are more suitable for high power systems, and shunts are more suitable for lower power systems.

In both cases the current sensor or shunt may be installed on either the positive or negative battery wire. The Hall Sensor should be oriented such that discharge current flows from the back (black) side to the front (blue) side. Ensure that there are no devices installed between the battery and the current sensor or shunt, or the EVMS will not be able to calculate state of charge correctly, since the current flow to/from those devices would not be measured by the current sensor. *Note: If the status light is blinking when no current is flowing, hold down the button until it stops blinking to recalibrate the sensor's zero point.*

Charger Integration Options

To enable charging, the EVMS needs to switch into charging mode by connecting the Charge Sense input to ground / chassis. This will wake it from sleep if needed, power up the CAN bus to communicate with BMS modules, and start the charger. It will also prevent the vehicle from being accidentally driven off while plugged in to charge. There are several ways to implement charge detection:

- A magnetic reed switch (or similar) can be wired between Charge Sense and ground/chassis, and set up to close its contacts when the door/cover to the charging port is opened.
- An AC relay with its coil wired in parallel with the charger's AC input, so that whenever the charger has power, the relay will also close to enable EVMS charge mode.
- Some chargers (e.g newer TC Chargers) have an output 12V supply which can be used to switch a small signal relay to join Charge Sense to ground / chassis.

It is also essential that the EVMS is able to switch off the charger if any cells exceed safe voltage, to prevent damage from over-charging. There are several ways to implement this:

- If using CAN integration with a TC Charger, the EVMS is able to disable the charger over CAN bus so no additional control relays are required, and the Charge Enable

output can be left unused. To connect a TC Charger to a ZEVA CAN bus, **join only the CANGND, CANL and CANH pins.** (The charger also has a 12V pin but this should not be joined to the ZEVA CAN bus, since it is a 12V *output*, and only the EVMS should manage 12V power to the CAN bus.)

- Many chargers have a pair of control pins that get joined to enable the charger. To use this mechanism, use a small 12V relay switched by the Charge Enable output of the EVMS, with the normally open contacts wired to the enable pins.
- The Auxiliary Contactor output is disabled as well as the Charge Enable output if any cells go over-voltage, so if your traction circuit has any auxiliary contactors (and your charger is tolerant of having its DC side interrupted mid-charging), there is no need to add further relays/contactors to stop the charger, as the opening of the auxiliary contactor will necessarily interrupt charge current.
- The final option, which can be safely used with any charger, is to use a power relay switched by the Charge Enable terminal from the EVMS, with the relay's Normally Open outputs wired to interrupt the AC input to the charger (as shown on the example wiring diagram on the previous page).

Auxiliary Contactors

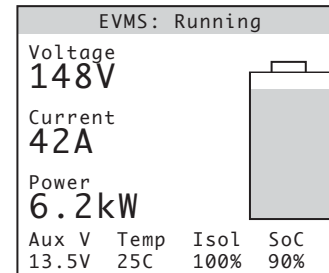
Auxiliary contactors (as shown on the example circuit diagram) are optional but can serve several functions in an EV.

- Split up high voltage battery packs into smaller groups of non-lethal voltage, or to isolate separate groups of cells distributed around the vehicle, for safety.
- Switch on/off other HV loads that are before the main contactor, either directly (using a relay switching power to the device itself) or indirectly (by breaking the main traction circuit). The most common example is the DC/DC converter, so that it is not permanently in-circuit.
- Effectively functioning as an automatic maintenance switch. (If you don't have an auxiliary contactor breaking the traction circuit when the key is off, it is advisable to have a manual maintenance switch to do the same job whenever working on the vehicle.)

Remember not to have any BMS module's wiring harness span any auxiliary contactor (or maintenance switch), or the BMS module becomes the only conduction path for the traction circuit when the contactor opens, which exposes the module to damaging voltages!

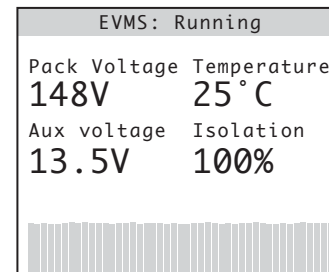
EVMS Monitor

The EVMS Monitor is used to remotely interact with other devices on the CAN bus, both for viewing operating data and to edit settings. The Monitor has various different pages of information as described below.

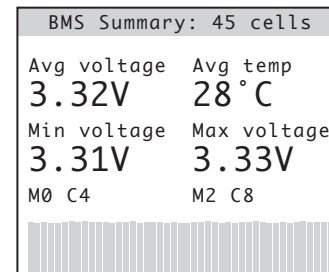


The main display, showing EVMS status at the top, instantaneous voltage, current, power, auxiliary battery voltage, temperature, isolation, and State of Charge (SoC).

Touching the left or right half of the display will swap to the previous or next display page respectively.

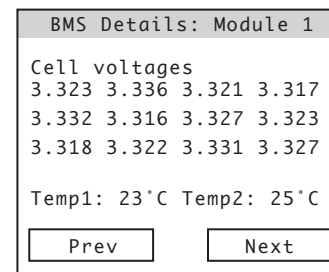


If no current sensor is present on the CAN bus, the EVMS is unable to show current or calculate power or state of charge, so a different page is shown with only pack voltage, temperature, aux voltage, isolation, and a bar graph of all individual cell voltages.



BMS summary page, showing the total number of cells being monitored, the average voltage per cell, the average of any BMS temperature sensors, and the voltage and location of both the lowest and highest cells. *M* is Module ID, *C* is the cell number.

Along the bottom is a graph of all cell voltages. Green bars indicate cells within range. Bars will change to blue for undervoltage cells, orange for cells being balanced, and red for overvoltage cells.



Detailed information for a single BMS module, showing voltage of each cell (to 3 decimal places) and two temperatures if available. Orange bars beneath the voltages indicate if cell shunts are currently on.

Tap the Prev or Next buttons to change which BMS module is being viewed, or anywhere else in the display to change Monitor pages as usual.

TC Charger Status	
Output Volts	Output Amps
149V	19.4A
Target Volts	Target Amps
154V	20.0A
Charger Status: OK	

If a TC Charger is present on the CAN bus, it will be autodetected and a new page of data made available on the Monitor showing charger's output voltage and current, the target voltage and current being requested by the EVMS, and the charger status at the bottom.

MC600C Status	
Batt Volts	Batt Amps
149V	150A
Motor Volts	Motor Amps
75V	300A
Temp	Throttle
42°C	60%
Status OK	

If a ZEVA motor controller is present on the CAN bus, it will be autodetected and a new page of data made available on the Monitor showing battery voltage, battery current (into the motor controller only), motor voltage, motor current, the controller's internal temperature, the current throttle position, and the status at the bottom.

Warning:
Charge ended by BMS

If the EVMS detects an error, a warning page will be displayed. In most cases, the error can be acknowledged/reset by pressing Select. Some critical errors can not be dismissed until the error condition is corrected.

For a full list of errors you might see, please refer to section *Error Detection*.

Reset SoC
Enter Setup
Display Off
Exit Options

You can bring up this options menu by holding your finger down on the screen for 1 second. From here you can do a manual reset of the State of Charge (back to 100%), enter the Setup mode, or switch the display off.

When the display is off, touch and hold anywhere for 1 second to turn it back on. Display will automatically wake if there is a new warning to display.

Setup mode can only be entered from Idle state, i.e. when the vehicle is not charging or being driven.

Configuring Settings

The EVMS Monitor can be used to configure settings for all ZEVA devices on the CAN bus.

EVMS: Setup	
< General Settings >	>
< Parameter: Pack capacity >	>
< Value: 100Ah >	>
Exit Setup	

The Setup mode has three rows. The top row toggles between the General Settings and the BMS Configuration sections. Tap the arrows either side to navigate between these. In the General Settings page, the second row selects the parameter to be modified, and the third row modifies the parameter itself. The Exit Setup button will distribute new settings to all devices on the CAN bus then return to normal operation.

EVMS: Setup	
< BMS Configuration >	>
< Module ID: 0 >	>
< Num cells: 12 >	>
Exit Setup	

This page is for configuring your battery pack (so the BMS knows how many cells to monitor).

Tap the arrows either side of the Module ID row to select the module in question, and the arrows either side of Num cells are used to modify how many cells that BMS module should expect at that ID.

List of Settings

The following table describes the parameters available in the General Settings page. The number of settings can be a bit overwhelming at first, but most of them can be left at their default value unless you need to adjust a specific function to suit your installation.

If you wish to lock the settings after the system has been commissioned, simply remove the small jumper on the left-hand side of the Monitor's CAN port. (The right-hand jumper is for disconnecting the Monitor's internal CAN termination resistor, in cases where the monitor is not at one end of the CAN bus.)

Name	Range, (Default)	Description
Pack Capacity	5-1250Ah (100Ah)	The rated capacity of your traction battery pack, in Amp Hours.
SoC Warning	0-99% (20%)	The EVMS can raise a warning when the traction battery's SoC reaches a predetermined level. Use 0% to disable.

Full Voltage	1-400V (160V)	The EVMS uses a “full voltage” threshold to detect charge approaching completion. One hour after reaching this voltage, the EVMS will reset the SoC to 100% and power down.
Warn Current	0-1200A (Off)	The EVMS will provide a warning if the current in the traction circuit exceeds this threshold. Set above 1200A to disable.
Trip Current	0-1200A (Off)	The EVMS will provide a warning and automatically shut down the traction circuit if current exceeds this threshold.
EVMS Temp Warning	0-150C / Off (Off)	The EVMS will provide a warning if its temperature sensor exceeds this threshold. It will not shut the vehicle down, but it is recommended that you stop to investigate as soon as possible. Note that this is independent from BMS temperature sensors and warnings.
Min Aux Voltage	0-14V (10V)	If the 12V supply drops below this threshold for more than 5 seconds, a warning will be provided. It may indicate a weak 12V battery and/or faulty DC/DC converter.
Min Isolation	0-100% (50%)	A warning will be raised if isolation integrity from traction circuit to chassis drops below this threshold, indicating compromised insulation or an unexpected conduction path. See also section on <i>Isolation fault detection</i> .
Tacho PPR	1-6 (2)	The EVMS can drive your vehicle’s OEM tachometer as an ammeter, displaying hundreds of amps instead of thousands of RPM. Tachometers typically expect a number of Pulses Per Revolution, being half the number of cylinders that the original engine had.

Fuel Gauge Full	0 - 100%	Because every vehicle’s OEM gauges use different scaling, these four parameters allow the EVMS to tune it’s outputs to suit your gauges. When these parameters are selected for editing, the EVMS will drive the appropriate gauge for the current parameter, allowing you to tune the gauge visually. (Note that you may need the key in the On position to power the instrument cluster – but enter Setup mode first.)
Fuel Gauge Empty	0 - 100%	
Temp Gauge Hot	0 - 100%	
Temp Gauge Cold	0 - 100%	
BMS: Min Voltage	1.50 - 4.00V (2.50V)	Adjusts the low voltage warning threshold for each cell in your traction pack.
BMS: Max Voltage	2.00 - 4.50V (3.80V)	Adjusts the high voltage warning threshold for each cell in your traction pack.
Balance Threshold	2.00 - 4.50V, Dynamic or Off (Dynamic)	Adjusts the voltage threshold at which BMS modules will be instructed to balance high cells. Either a fixed Voltage (usually equal to average maximum charge voltage) for “top of charge” balancing, <i>Dynamic</i> to set balance threshold to be equal to the average cell voltage at any time, or <i>Off</i> to disable balancing.
BMS: Hysteresis	0 - 0.50V (0.20V)	Only applicable in Stationary Mode, to prevent rapid oscillation of self-resetting outputs by adding a hysteresis band. Please refer to section <i>Stationary Mode</i> for more information.
BMS: Min Temp	Off or -39- 100°C (Off)	A temperature exceeding these values will automatically shut down the system. In Running mode, there will be 10 seconds of warning before an automatic shutdown. Shutdown can be suppressed by acknowledging the warning within 10 seconds.
BMS: Max Temp	-40-100°C or Off (Off)	

Max Charge Voltage	0-500V (100V)	Only applicable when using a TC Charger with CAN integration to the EVMS, these set the target voltage and current that are sent to the charger (for its CCCV charging algorithm). The "Alt" settings are only used if the MPI function is set to "Alt charge", and the MPI terminal is connected to ground/chassis.
Max Charge Current	0-120A (10A)	
Alt Charge Voltage	0-500V (100V)	
Alt Charge Current	0-120A (20A)	
Sleep Delay	1-5min / Off (5min)	Sets the time delay before the EVMS will go to sleep when in Idle mode. Can be disabled by setting to Off, but note that the CAN bus and other peripherals will remain powered up which results in higher quiescent power consumption, which can flatten batteries more quickly.
MPI Function	Various	Sets the function of the Multi-Purpose Input terminal and the two Multi-Purpose Output terminals. Please refer to section <i>Multi-Purpose Inputs and Outputs</i> below for further details.
MPO1 Function		
MPO2 Function		
Parallel Strings	1-20 (1)	The EVMS normally uses the sum of cell voltages to calculate the overall battery voltage. In installations with multiple strings of cells and BMS modules in parallel, this setting can be used to correct the voltage calculation.
Enable precharge	Yes/No	The EVMS's internal precharger (if present) can be disabled – but make sure your motor controller does not require it, or contactor damage may result!
Stationary Mode	Yes/No (No)	Switches the EVMS into Stationary Mode, for battery backup and off-grid power type applications. Please refer to the <i>Stationary Applications</i> section for more information.
Rev Current Disp.	Yes/No (No)	Reverse Current Display. By default, current is displayed with discharge amps positive. In some applications it is preferable or more intuitive to display charge amps positive instead.

Night Brightness	0-100% (20%)	Adjusts the brightness of the LCD display in low light mode, to reduce screen glare at night. Toggle between full brightness and night brightness by either swiping a finger up/down, or using the MPI pin as a headlight sense.
Buzzer On	Yes/No (Yes)	Selects whether the Monitor should sound the buzzer for alerts. (Safest to leave this on.)
Use Fahrenheit	Yes/No (No)	Changes display of temperature units to Fahrenheit instead of Celcius.
SoC Display	Percent or Amp-Hours (Percent)	The battery State of Charge value displayed on the Monitor can either be shown as a percentage of full charge, or as the number of amp-hours remaining.

Multi-Purpose Input and Outputs

The EVMS has one Multi-Purpose Input (MPI) terminal and two Multi-Purpose Output (MPO) terminals, which can be assigned to a range of additional functionality.

The MPI terminal has a high input impedance so will never draw more than a fraction of a milliamp. The MPO terminals are limited to about 0.5A continuous current (either in or out of the terminal), but can handle several amps short term so are compatible with driving full size contactors, so long as they include a coil economizer to reduce holding current below 0.5A.

MPI Function	Description
Wake up	Join terminal to ground/chassis momentarily to wake the EVMS from sleep mode (without entering Running or Charging mode). Note: Other MPI functions will still perform an EVMS wake up too.
Alt charge	Join terminal to ground/chassis to switch TC Charger to second ("Alt") set of voltage and current settings. Useful if you sometimes use two different sized chargers, or if you sometimes need to restrict a large charger from overloading a small AC socket.
Hdlight In	Headlight Input. Connect MPI terminal to the headlight signal in your car (+12V when headlights are on) to have the EVMS automatically dim the Monitor brightness at night, based on the <i>Night Brightness</i> setting.

Ctr Aux Sw	Contactors Auxiliary Switch. Wire the MPI terminal to the auxiliary switch of your main contactor (with the other side of the switch connected to ground) to have the EVMS monitor the state of the aux switch. This allows the EVMS to provide a warning if the contactor is not working correctly (not closing when it should close, or not opening when it should open).
------------	---

MPO Function	Description
Ground	Default state for the output, can be used as a spare ground terminal.
Temp gauge	Can be connected to the temperature sensor input of many OEM instrument clusters, to view the EVMS temperature input on the original temp gauge (calibrated to the gauge in the settings and scaled between 0°C and the “overtemp” setting).
Low SoC Signal	Will output 12V if the battery’s state of charge percentage is below the “SoC Warning” setting. Can be used for a warning system, or to turn on additional charging systems (such as a genset).
Overtemp signal	Will output 12V if any BMS temperature sensors exceed the “BMS Overtemp” setting. Can be used as an additional warning or to turn on battery cooling systems.
Undertemp Signal	Will output 12V if any BMS temperature sensors are below the “BMS Undertemp” setting. Can be used to enable battery heating systems in cold climates.
Error Buzzer	Will output 12V if any error is pending in the EVMS, to drive additional warning buzzers. May be used to supplement the EVMS Monitor’s internal buzzer, or if no Monitor is present.
Status Light	Can be used to drive an external light to show EVMS status. Off when the system is idle or sleeping, on (12V) when running or charging, and flashing if any error is pending.

Error Detection

The EVMS monitors a wide range of operating parameters for your electric vehicle and can notify you if any exceed their safe range or any faults are detected. In most cases, errors can be acknowledged/dismissed by tapping on the screen. Critical errors are responded to automatically (such as by shutting down the traction circuit due to an undervoltage cell), while others are at the driver’s discretion to respond to (such as over-temperature warnings). The following table describes the errors you may encounter.

Error	Description
Overcurrent Warning	If battery current exceeds the programmed threshold for more than 1 second, this warning will appear.
Overcurrent Shutdown	As above, except the EVMS will also automatically shut down the traction circuit if this threshold is exceeded. <i>Note that for safety reasons this system cannot replace a physical fuse, though it can be used to prevent blowing the fuse first.</i>
BMS - Low Cell	A BMS module has reported a cell voltage below the minimum threshold. This error will likely first start appearing under heavy acceleration, then with increasing frequency. It is recommended that you pull the vehicle over as soon as safe to avoid a forced shutdown.
Shutdown by BMS	A low cell condition has been present for more than 10 seconds, so the EVMS has shut down the traction circuit to protect the batteries.
BMS - High Cell	A BMS module has reported a cell voltage above the maximum threshold.
Charge Ended by BMS	A high cell condition has been present for more than 1 second, so the EVMS has shut down the charger to protect the batteries.
BMS - Overtemp	A BMS module has reported a temperature above the programmed threshold, and the system will be shut down for protection.
BMS - Undertemp	A BMS module has reported a temperature below the programmed threshold, and the system will be shut down for protection.
Low Battery Charge	The battery’s State of Charge has reached the programmed warning threshold.
Over-Temperature	The EVMS’s temperature sensor has reported a temperature above the programmed warning level.
Isolation Fault	A chassis leakage above the programmed threshold has been detected. (May indicate an insulation fault with traction circuit wiring or even water ingress into the motor or other device.)
Low 12V Battery	The voltage of the 12V auxiliary battery (power supply for the EVMS) has dropped below the programmed threshold. May indicate a weak battery or faulty DC/DC converter.

Precharge Failed	Displayed if an error is detected during the precharge sequence, either failing to start (usually a wiring fault) or taking too long to finish (usually an unexpected load “downstream” from the main contactor). The startup sequence is cancelled automatically.
Contactor fault	If using contactors with auxiliary switches and a discrepancy is detected (contactor closed when it should be open, or vice versa), this error will be displayed.
BMS - Comms error	If the EVMS hasn't received data from a BMS module for a while (about 1 second), this error will appear and the traction circuit will be shut down for safety.
No comms to EVMS	If the Monitor hasn't received data from the EVMS for more than 1 second, this error will appear. Most commonly this is due to a wiring fault on the CAN bus.
Corrupt Settings	Occurs if memory corruption has been detected in the EVMS or Monitor's saved settings. They will automatically be reset to defaults. Contact us if you see this one.

Voltage Thresholds

By default the EVMS will come with BMS voltage thresholds configured to suit LiFePO4 cells, but the thresholds can be changed to suit any lithium chemistry. The following table lists recommended voltage thresholds for Lithium Iron Phosphate (LiFePO4), Lithium Cobalt (LiCo) and Lithium Titanate (LTO) cells. Most other lithium chemistries (LiPo, NMC, etc) are variations of Lithium Cobalt and share the same voltage range, but if in doubt please refer to the datasheet for your batteries to confirm.

Chemistry	Nom Voltage	Min Voltage	Max Voltage	Charge To	Temp Range
LiFePO4	3.2V	2.5V	3.8V	3.65V	-20°C – 60°C
LiCo	3.7V	3.0V	4.2V	4.1 – 4.2V	-20°C – 60°C
LTO	2.4V	1.6V	2.8V	2.7V	-30°C – 60°C

Quick tip: LiCo chemistry cells may be charged to 4.2V, but will achieve almost double the cycle life if slightly undercharged to 4.1V instead – though at the loss of about 10% available capacity. It also leaves some margin between peak charge voltage and maximum allowable voltage, for tolerance of pack imbalance.

State of Charge Synchronisation

The EVMS receives current data over CAN bus from either a hall effect sensor or a shunt interface. By integrating current flow over time, it is able to calculate battery SoC. But because this calculation is an integration over time, it is possible for small measurement errors to accumulate, resulting in possible inaccuracy in the state of charge value.

To mitigate this, the EVMS includes a mechanism to automatically resynchronise the SoC at the end of any full charge cycle, using the configurable *Full voltage* setting to tell the EVMS what voltage the pack is when fully charged. Ideally, set this to a volt or two below the peak charge voltage of your charger for a small tolerance. When this voltage is reached during a charge cycle, a one hour timer is started to allow the Constant Voltage phase of charging to complete. After one hour, the the SoC will be synchronised back to 100%, the charger will be turned off, then after the programmed *Sleep Delay* time the system will go to sleep to save power.

The SoC can also be manually reset to 100% via the Options menu of the EVMS Monitor.

Stationary Applications

The EVMS configuration includes a setting for Stationary Mode, intended for use in battery backup and off-grid power applications. In this mode, the Key input enables both Main Contactor and Charge Enable outputs concurrently. An under-voltage cell will disable the Main Contactor output (to remove any loads on the battery) and an over-voltage cell will disable the Charge Enable output (to disable any charging sources).

Outputs will automatically be re-enabled once the cell voltage has recovered by a configurable amount, known as hysteresis. For example, if *BMS Hysteresis* is set to 0.20V, the Main Ctr output will turn off if any cell goes below the *Min Voltage* threshold, and will reset once the cell is 0.20V above the *Min Voltage* threshold. *Note: Systems supplied prior to May 2019 also had the hysteresis amount added to the trip threshold, not just subtracted from the reset threshold. Be sure to test your trip thresholds to confirm safe behaviour.*

Common settings for LiFePO4 cells are a *Min Voltage* setting of 2.50V, *Max Voltage* of 3.80V, and *Hysteresis* of 0.40V, giving a 2.5V-2.9V band for the Main Ctr output and 3.4V-3.8V band for the Charge Enable output. LiCo cells have a more linear charge curve so typically need a smaller hysteresis band around 0.10V, with a *Min Voltage* setting of 3.00V and a *Max Voltage* setting of 4.2V.

In Stationary Mode, the Charge Sense input is no longer used, and precharging is not supported. The Aux Ctr output will be on permanently whenever the system is in Running mode.

Use With Batteries Over 360VDC

The EVMS's internal voltage measurement and isolation monitoring circuit has an absolute maximum voltage rating of 400VDC, making it suitable for nominal battery pack voltages up to about 360VDC. The EVMS may be used with higher voltages, but the *HV+*, *HV-* and *Main Ctr-* connections must be omitted. Precharging and isolation monitoring are no longer supported, and system voltage can only be calculated from the sum of all cells connected to BMS modules.

Isolation Fault Detection

The EVMS has an internal high resistance connection (200Kohm) between the traction circuit and the vehicle chassis. By monitoring microamps of current flowing across this resistor, the EVMS can detect if the isolation between traction circuit and the vehicle chassis is compromised, such as from damaged wiring insulation, excessive carbon buildup in DC motors, or even a human touching a HV terminal.

This is quantified as a 0-100% range, where 0% represents a very low resistance path between the traction circuit and the chassis, and 100% represents no detectable leakage. The default warning threshold for leakage is 50%, which is usually sensitive enough to detect if a human touches any of the HV terminals. Ideally, you should see at least 90% at all times.

Technical Support and Warranty Information

All ZEVA products 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: excessive voltage or reversed polarity on terminals, short circuits on outputs, opening of housings and/or modification of internal electronics, severe impact damage (e.g due to vehicle crashes), submersion in water.

We have taken great care to design a safe and reliable product, but faults can happen. If you believe your product has a fault, please contact us via our website to discuss. If it is determined that a hardware fault is the likely cause, we will provide RMA information and a return address to proceed with repairs.

If you have any questions not covered by this manual, please contact us via our website:

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