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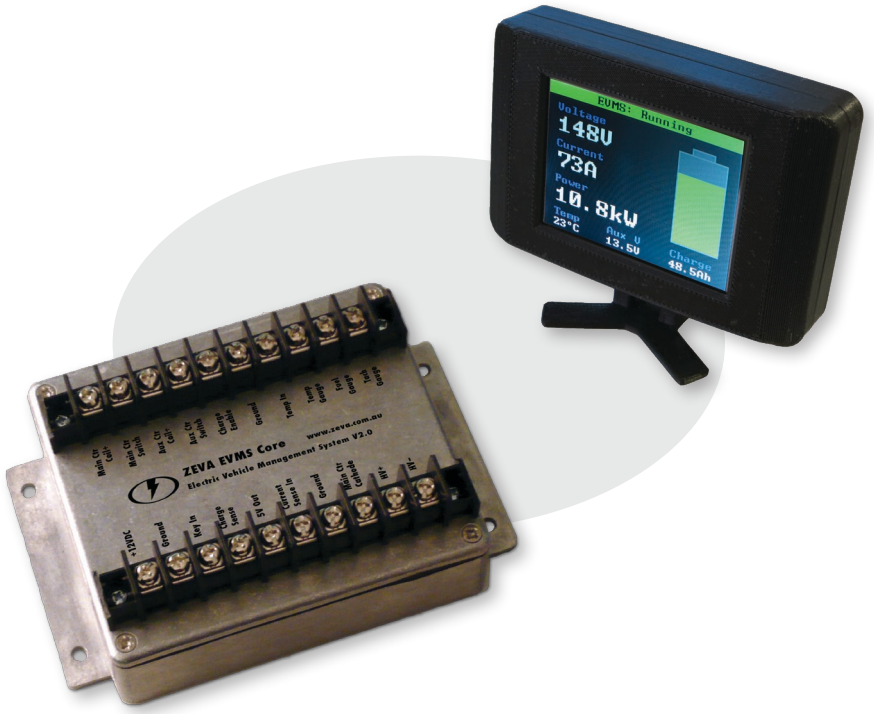


Electric Vehicle Management System

v2.0

The ultimate multifunctional, integrated control system for your EV

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 insulation integrity.
- Analog gauge outputs to re-use OEM fuel gauge, temp gauge and tachometer.
- Battery management including cell voltage and temperature monitoring with automatic response to under/over-charged batteries, and automatic pack balancing.
- 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 over 15 different operating errors/warnings.

A complete EVMS consists of a Core, usually installed in the vehicle's engine bay, communicating over industry-standard CAN bus with a Monitor module in the vehicle cabin, and battery management modules located within your battery boxes.

This manual describes the installation and operation of both the EVMS Core and EVMS Monitor devices. Please refer to documentation supplied with your BMS modules for information relating to those devices.

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 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. 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 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.

Specifications

- Power supply: 12V nominal (9-18V maximum)
- Traction pack voltage range: 12-320VDC nominal (±1% accuracy)
- Traction pack capacity: 10-1000Ah
- Current measurement: Up to ±1200A (±1% accuracy)
- Dimensions (EVMS Core): 150x100x50mm
- Casing: Fully enclosed die cast, weatherproof to IP65
- Fusing: Internal PTC type, 5A for power outputs, 200mA for logic I/O

EVMS Core Installation

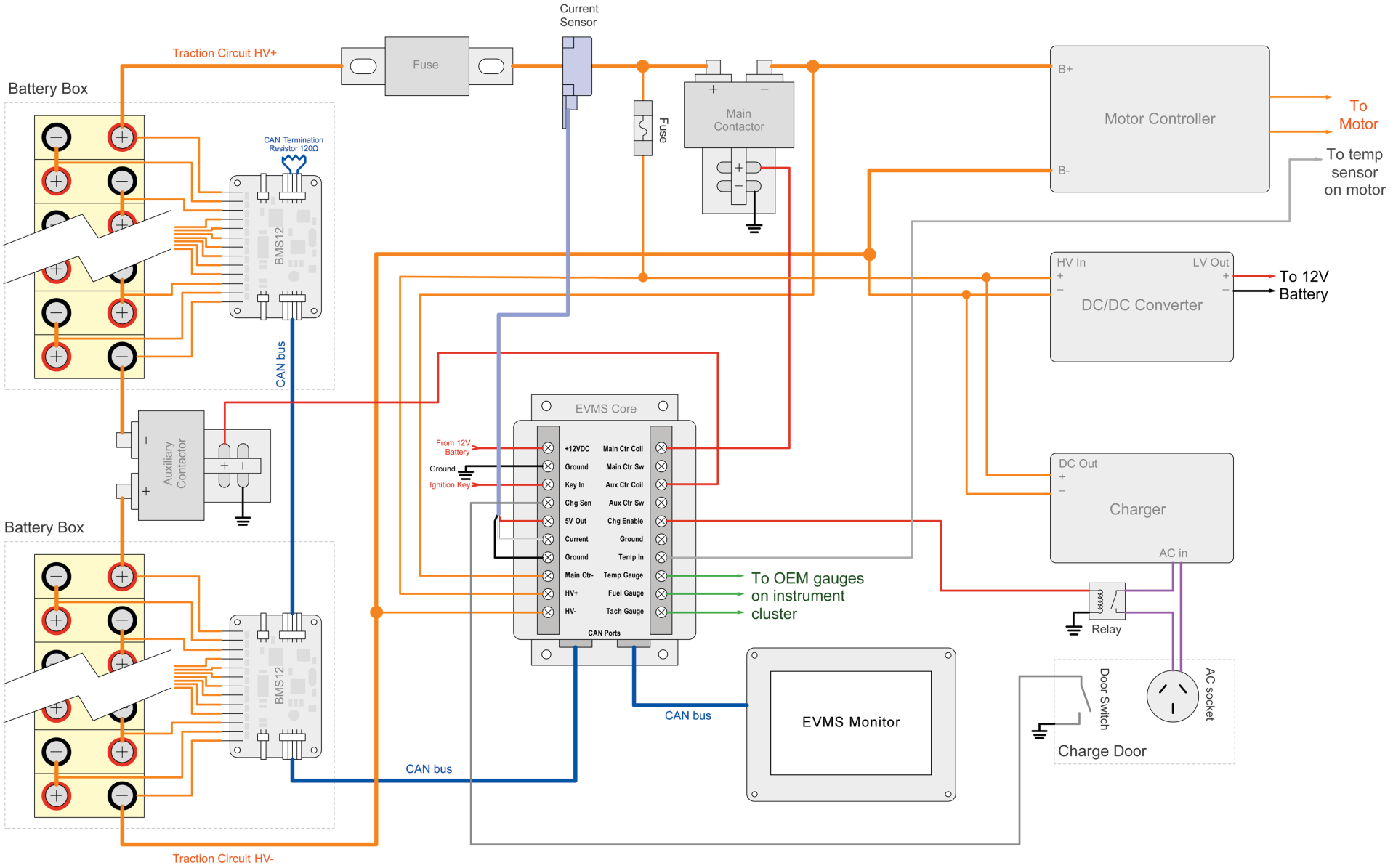
The EVMS Core should be mounted securely to the vehicle using screws through the four 5mm holes on the case flanges. The EVMS has 20 I/O screw terminal connections on the barrier blocks on top of the case, plus dual CAN ports on one side. Wire gauge for most connections should be around 18-20AWG to ensure reasonable mechanical strength. Any HV wiring should have appropriate insulation rating – 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.

Description of EVMS Core connections

Terminal name	I/O	Description
+12VDC	Input	To 12V battery positive (permanent supply, not key switched). Approx 9-18V 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 pull to ground when the switch is on (so attach other side of switch to chassis, near the switch is fine).
5V Out	Output	Independently fused 5V output, used for powering the current sensor
Current Sense In	Input	Return line from the current sensor, a 0-5V analog level
Ground		For connecting the ground wire on the current sensor cable.
Main Ctr Cathode	Input	Connect to the power terminal on the controller (output / cathode) side 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 (or negative terminal of motor controller)
Main Ctr Coil+	Output	To the positive wire of your main contactor coil. The contactor coil negative wire must be connected to ground/chassis.
Main Ctr Switch	Input	Attach to one of the wires of your contactor's auxiliary switch, if it has one. The other wire of the switch should be connected to ground/chassis.
Aux Ctr Coil+	Output	To the positive wire of your auxiliary/secondary contactor(s). The coil negative wire must be connected to ground/chassis.
Aux Ctr Switch	Input	Attach to one of the wires of your contactor's auxiliary switch, if it has one. The other wire of the switch 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 return for temperature sensor wiring.
Temp In	Input	Input Connect one of the temperature sensor wires to this pin. The other wire should go to ground/chassis.
Temp Gauge	Output	To the temperature sensor input connection on your vehicle's OEM instrument cluster.
Fuel Gauge	Output	To the fuel tank sensor input connection on your vehicle's OEM instrument cluster.
Tach Gauge	Output	To the tachometer input connection on your vehicle's OEM instrument cluster.

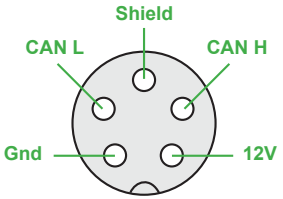
Wiring Diagram

The diagram below shows typical wiring for a complete EVMS installation. It may look a little intimidating at first but should become clear as you start to wire up your own EV. Note that the diagram does not show an inertia switch (crash sensor), which should be installed between the 12V battery and the EVMS Core's 12V supply. You will also usually need to use the key signal to switch a relay for powering auxiliary devices such as brake vacuum pump, power steering pump, water cooling pump, cabin heater, etc. Make sure all wiring has appropriate current and insulation ratings, and that fuses have appropriate DC voltage and current ratings.

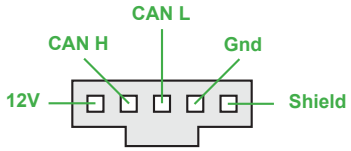


CAN Bus Wiring

The EVMS Core has two CAN bus ports (5-pin aviation plugs) on one side of the case. These are wired identically, and can be connected in either order in any location along the CAN bus. The EVMS Monitor and BMS12 modules use 5-pin Molex C-Grid SL series plugs for CAN bus connections. Wiring is shown in the diagrams below:



CAN pin assignments as viewed on EVMS Core



CAN pin assignments as viewed on EVMS Monitor

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 ports 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 beside the plug to disable the internal termination resistor.

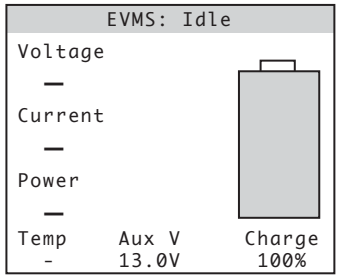
For the sake of noise immunity, CAN buses typically use twisted pair cable. Since electric vehicles can involve high electromagnetic interference (EMI) from the traction circuit, we recommend using shielded twisted pair wire for maximum noise immunity. Very short connections are usually OK with untwisted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

CAN buses draw a significant amount of power (the full EVMS and BMS will be using in the order of a few hundred milliamps) so in order to reduce quiescent drain on the auxiliary battery, the EVMS Core will power down the CAN bus after 1 minute in Idle state (neither driving, charging, or in Setup). Setup mode can only be entered from Idle state, so this one minute window will give plenty of time to enter. The Core will also provide 1 minute of CAN power after powering up.

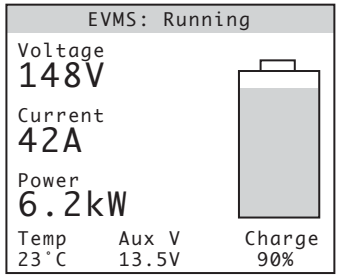
If the outputs are disabled due to a BMS error (such as an over-voltage or under-voltage cell), the CAN bus will remain powered up for 1 hour. This is to allow a window for the BMS modules to continue pack balancing after the charger has been shut down, before the CAN bus is powered down to avoid flattening the auxiliary battery.

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.

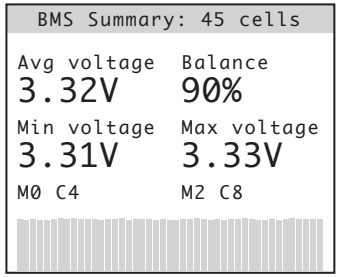


The default display when the vehicle is idle (neither driving nor charging). Battery state of charge and auxiliary battery voltage are visible, but other parameters are only available while driving or charging.



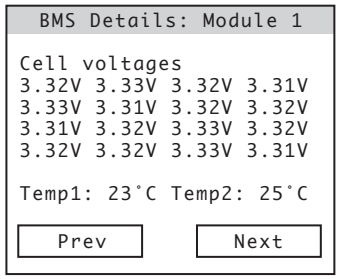
The standard display when Precharging, Running or Charging, showing instantaneous voltage, current, power, temperature, auxiliary battery voltage and traction battery State of Charge.

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



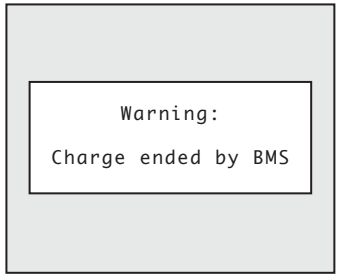
BMS summary page, showing the total number of cells being monitored, the voltage and location of both the lowest and highest cells, the average voltage per cell, and a metric for pack balance.

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

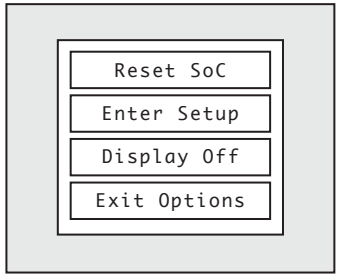


Detailed information for a single BMS module, showing voltage of each cell (to 2 decimal places) and two temperatures if available. Orange bars beneath the voltages indicate if cell shunts are currently on.

Touch within the Prev and Next buttons to change which BMS module is being viewed, or anywhere else in the display to change Monitor pages.



If the EVMS Core detects an error, this warning page will be displayed. In most cases, the error can be acknowledged/reset by pressing Select. For a full list of errors you might see, refer to section *Error Detection*.



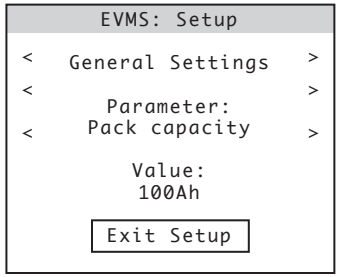
You can bring up this options menu by holding your finger down for 1 second. From here you can do a manual reset of the State of Charge (back to 100%), enter the Setup mode, or switch the display off.

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.

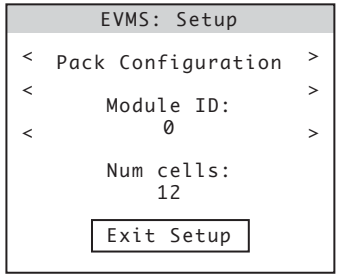
Setup mode can only be entered from Idle state, i.e when the vehicle is not charging or being driven.

Configuring Settings

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



The Setup mode has three rows. The top row toggles between the General Settings and the Pack Configuration sections. Tap the arrows either side to nagivate 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 network then return to normal operation.



The page for configuring your battery pack (so the BMS knows how many cells to monitor) looks like this.

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

List of settings - EVMS Core

The following table describes the parameters available in the General Settings page.

Name	Range	Description
Pack capacity	10-1000Ah	The rated capacity of your traction battery pack, in Amp Hours. For lead acids, use the C20 rate (see also section on Peukert's Effect).
SoC warning	0-99%	The EVMS can raise a warning when the traction battery's SoC reaches a predetermined level. Use 0% to disable.
Full voltage	1-400V	The EVMS uses a "full voltage" threshold combined with charge current dropping to under 2 amps to detect charge completion, and automatically reset the SoC to 100%.
Warn current	0-1200A	The EVMS will provide a warning if the current in the traction circuit exceeds this threshold.
Trip current	0-1200A	The EVMS will provide a warning and automatically shut down the traction circuit if current exceeds this threshold.
Temp warning	0-150C	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 investivate as soon as possible.
Min aux voltage	10-14V	If the vehicle's 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.
Max leakage	0-100%	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 *Leakage / ground fault detection*.
Tacho PPR	1-6	The EVMS Core 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 have different scaling, these four parameters allow the EVMS Core 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 first.)
Fuel gauge empty	0-100%	
Temp gauge hot	0-100%	
Temp gauge cold	0-100%	
Peukert's Exp	1.0 - 1.3	Allows adjustment of Peukert's Exponent so the EVMS can compensate for discharge characteristics of different battery types. See also section *Peukert's Effect*.
Enable precharge	YES/NO	The EVMS Core's internal precharge can be disabled, but make sure your controller does not require it or contactor damage may result!
Enable aux swch	YES/NO	If your contactors have auxiliary switches, turn this setting on for monitoring the switch status.
BMS: Min voltage	0 - 5.00V	Adjusts the low voltage warning threshold for each cell in your traction pack.
BMS: Max voltage	0 - 5.00V	Adjusts the high voltage warning threshold for each cell in your traction pack.
BMS: Shunt voltage	3.00 - 5.00V	Adjusts the voltage at which shunt balancers turn on for each cell in the tracion pack.
BMS: Low temp warn	0-100˚C	The EVMS can provide a warning if any BMS modules report a temperature below or above these respective thresholds.
BMS: Overtemp warn	0-100˚C	
Stationary Mode	YES/NO	Switches the EVMS into Stationary Mode, for battery backup and off-grid power type applications. Please refer to the "Stationary Applications" section for more information.
Current sensor	300A, 600A, 1200A	Selection of the current sensor size (as shipped with your EVMS Core)
Display brightness	0-100%	Adjusts the brightness of the LCD display's backlight.
Buzzer On	YES/NO	Selects whether the Monitor should sound the buzzer for alerts. (Safest to leave this on.)
Use Fahrenheit	YES/NO	Changes display of temperature units to Fahrenheit instead of Celcius.

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/reset by pressing the Select button. Critical errors are responded to automatically (such as by shutting down the traction circuit due to a critically low 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
Corrupt Settings	Occurs if memory corruption has been detected in the EVMS Core's saved settings (they will automatically be reset to defaults). Contact us if you see this one.
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. *Note that for safety reasons this system cannot replace a real fuse, though it can usually avoid blowing the real fuse.*
BMS - low cell	A BMS module has reported a cell voltage below the minimum threshold.
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 minimum 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.
Low battery charge	The battery's State of Charge has reached the programmed warning threshold.
Over-temperature	The EVMS Core's temperature sensor has reported a temperature above the programmed warning level.

Insulation fault	A chassis leakage above the programmed threshold has been detected. (May indicate an insulation fault, or even water inside a DC motor.)
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 seized	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 Core 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.
Comms error to Core	If the EVMS Monitor hasn't received data from the Core for more than 1 second, this error will appear. Most commonly this is due to a wiring fault on the CAN bus.

Peukert's Effect

All batteries exhibit a reduction in available capacity depending on how fast they are discharged, known as Peukert's Effect. For most lithium batteries in EVs the effect is negligible, but for lead acid batteries it can be quite significant. The EVMS can automatically compensate for Peukert's Effect for different battery types. The Peukert's Exponent is modified in the EVMS Core settings to suit your battery type as follows:

Peukert's Exponent	Chemistry and type	Capacity at 1C
1.0	Lithium: LiCo, LiMn, LiFePO4	100% of C20
1.1	Lead acid: AGM	75% of C20
1.2	Lead acid: Gel cell	55% of C20
1.3	Lead acid: Flooded	40% of C20

Lead acid batteries have a capacity rated at C20 – that is, how many amp-hours the battery can supply if discharged over a 20 hour period. When configuring the pack capacity in the EVMS, use the C20 rate. Lithium batteries are typically rated at 1C, but they exhibit minimal Peukert's Effect so it is close enough to their C20 rate.

State of Charge drift and synchronisation

The EVMS uses a hall effect sensor for current measurement and, by integrating current over time, calculating battery state of charge. While offering easy installation, safe isolation and good linearity, hall effect current sensors can exhibit a small amount of zero-point drift and inaccuracy at low currents, which can accumulate over time causing the reported SoC to differ from the actual SoC. To mitigate this, the EVMS includes a system to automatically resynchronise the SoC at the end of any full charge cycle, via programmable "Full voltage" setting. Ideally, set this to a volt or two below the peak charge voltage of your charger. This way at the end of each full charge, the SoC will be synchronised back to 100%.

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 undervoltage cell will disable the Main Contactor output (to remove any loads on the battery) and an overvoltage cell will disable the Charge Enable output (to disable any charging sources). In both cases the outputs are re-enabled once the voltage has recovered by 0.4V (i.e there is ±0.2V hysteresis around the configured thresholds).

In Stationary Mode, the Charge Sense input is no longer used, typically the Aux Ctr output will not be used, and precharging is not supported.

For LiFePO4, we recommend an undervoltage threshold of 2.8V (which results in 2.6V cutout and 3.0V re-enabling for any loads on the battery), and an overvoltage threshold of 3.6V (for 3.8V charger cutout and 3.4V re-enabling). These thresholds give about 1% hysteresis on the battery state of charge to avoid rapid cycling of the charger or outputs.

Use with system voltages above 320VDC nominal

The EVMS Core'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 320VDC. The Core may be used with higher voltages, but the *HV+*, *HV-* and *Main Ctr-* connections must be omitted. Precharging and isolation monitoring no longer supported, and system voltage is instead calculated from the sum of all cells connected to BMS modules.

Leakage / insulation fault detection

The EVMS Core 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 Core 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 over 90% at all times.

Tech 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 an RMA number and 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