

Energy Management System Operation and Installation Manual



Elite Power Solutions 21411 N. 11th Ave, Suite 3 Phoenix, AZ 85027 www.elitepowersolutions.com

Table of Contents

1 Introduction	1
2. Packing List	
3. Specifications	4
4. Installation	6
Heartbeat LED	7
Isolated Battery & Shunt Connections	7
12v Car Battery	8
Page Select Switch Input	8
Sense Board Wiring	9
Making your own cables	12
Video Output	13
5. Programming	14
6. Usage	15
Video Display	16
Home Page	16
Detail Page	19
Alarms and Warnings	20
Controlling Other Devices with Alarm Outputs	21
Battery Balancing	22
7. Capacity Algorithm	23
8. CAN Interface	24

EMSOPERATION AND INSTALLATION MANUAL

9. Trouble Shooting	26
Appendix A. Enclosure Mounting	28



Warning! Read ALL of the instructions before attempting installation. All connections should be made when the system is OFF. No connections of energized wires should be made.



Revised 3/3/11

1 Introduction



NOTE: It is important that you read this manual before installing or operating any of these components.

Thank you for purchasing Elite Power Solutions Energy Management System (EMS). This manual covers operating and installation information for the Elite Power Solutions Energy Management System.

The EMS system has everything needed to display the condition and maintain the health of your lithium batteries. It consists of two major components, the computer and the cell sense boards. The computer will tell you many things about the condition of your batteries. It will tell you overview information like the battery state-of-charge, battery current, battery voltage as well as the voltage and temperature of individual cells.. The cell sense boards mount on each individual cell to read voltage and temperature. They also have a battery balancing circuit to equalize the charge of all the cells in a battery pack. There are programmable outputs from the computer for battery over voltage and battery under voltage interlocks. These can be used to control other systems in the vehicle such as battery chargers and motor controllers. In addition, there are warnings to let you know that error conditions are approaching.

One of the important safety features of the EMS is ground fault detection. When an inadvertent connection is made between the battery pack and the vehicle chassis, it is detected and a warning is shown on the screen.

The EMS is designed so that the battery monitoring is completely isolated from the regular vehicle 12V system. The EMS is powered by a powerful, 8 core 32-bit

microprocessor that is capable of outputting composite video. A CAN interface option is available to display the EMS information on a CAN display. Many options in the EMS are programmable and can be customized for your car.



2. Packing List

- 1x EMS Computer
- 1x Composite video cable
- 1 per cell Battery Sense Boards
- Wiring Harness(es)
- 1x- Current Shunt
- 1x Installation Guide & User's Manual

Note: The number of battery sense boards and the wiring harness vary based on the number of cells in your system.



3. Specifications

Items Displayed	Voltage, Current, Battery Capacity (Main Screen)	
	Cell number, cell voltage, cell temperature (Detail Screen)	
Computer Power	8 - 20V, 20mA or 8 - 85V as an option	
Battery Voltage	36-500V	
Shunt Input	500A = 50mV	
Voltage Resolution	0.01V	
Current Resolution	1A	
Temperature Measurement Range -99°F to +199°F or -146°C to +92°C		
Battery Types Supported	Lithium Iron Manganese Phosphate	
Video Output	Composite Video, Color, NTSC	
	RS-170	
Programming Port	Asynchronous Serial, TTL levels,	
	115200, n, 8, 1	
Measurement accuracy	Better than 1%	

EMS OPERATION AND INSTALLATION MANUAL

Measurement speed Voltage and current 3 times per second main screen Voltage and Temperature 1 time per second detail screens

Number of cells supported128

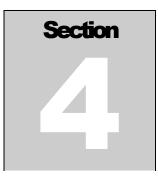
Cell Voltage.....2.5 to 4.5

Balancing Current0.5A

Digital Output Current......200mA

Optional Display Interface.....CAN

Connection Fault Detection2mA (5000 Ohm/Volt)



4. Installation



ALWAYS USE HIGH CAUTION WHEN WORKING ON AN ELECTRIC VEHICLE. ALWAYS DISABLE THE CIRCUIT BREAKER WHEN THE ENGINE BAY IS OPEN (THIS WILL HELP MINIMIZE RISK OF SHOCK). ALWAYS TAKE NOTE WHERE THE HIGH VOLTAGE LINES ARE.



he Elite Power Solutions EMS is designed to make installation easy. All of the connections to it are made with convenient pluggable ¼" quick disconnect terminals. The EMS computer should be installed as close to the shunt as possible. The shunt sense wires should be less than 1' long and twisted around each other. Mounting holes for the computer box are shown in **Appendix A**. After the installation is complete, you must completely charge the car before the capacity will read correctly (see **Section 7**. **Capacity Algorithm** for more details).

On models equipped with Connection Fault Detection, it is important that the screw with the chassis wire be attached to the metal chassis of the car. This will enable the Connection Fault Detection to work properly.

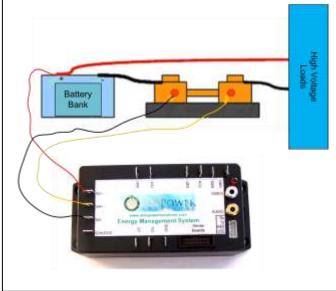
Heartbeat LED

When the EMS is correctly connected to 12V, the heartbeat indicator will blink about once per second.



Isolated Battery & Shunt Connections

The Terminals on the left side of the computer are used for making the High-Voltage and shunt connections. Refer to the figure below for these connections. The connections between the battery bank, shunt and high voltage loads are usually large wire like 2/0. The connections to the EMS from the battery and the shunt can be smaller gauge like 18 or 20.



High Voltage Connections

12v Vehicle Battery

The 12V supply to the computer is connected on terminals on the top and left of the computer as shown below. This connection should be made through a fused circuit to an always-on point in the 12V system. If the computer looses 12V power then the capacity will reset to 99% (see **Section 7. Capacity Algorithm** for further details). When 12V power is applied, the red "Heartbeat" LED will blink.



12V Connections

Page Select Switch Input

In order to display the voltage and temperature of the individual batteries, a switch to select the appropriate display page is needed. This can be any normally open momentary switch. The switch is connected to the mode (MDE) and ground (GND) pins as shown below. There is no polarity on the switch. You may use small wire (18 or 20 gauge) for the switch connections.



Page Select Pins

Sense Board Wiring

The sense boards are connected to the computer via a 14 conductor ribbon cable. There are 2 types of ribbon cables: a cable with a 6 foot end for connecting the computer to the first 8 batteries and an "extension" cable for connecting subsequent groups of 8. The ribbon cable plugs into the computer as shown below:



The ribbon cable connector has a key to prevent it from being plugged in the wrong way. When correctly inserted, the cable will go towards the edge of the box.

The summary screen will show how many sense boards are connected. You can connect the sense boards one at a time while the system is powered up to verify that they are working. The sense board that is plugged into the connector closest to the computer is number 1, as they go down the line to the end away from the computer, they increment. As an aid to trouble shooting, it may be useful in a system with many cells to write the ID number on each battery cell. Should the summary screen show less than the full number of cells, you can locate the problem by going to the last cell registering on the screen or the next higher number up.

EMS OPERATION AND INSTALLATION MANUAL

Before installing the first sense board, plug in the ribbon cable and then bring the cable under the board, then attach it to the cell. You can have cell number 1 be either the most positive or the most negative cell. Be sure to note pin 1 on the board, it needs to be plugged into pin 1 on the ribbon cable (denoted with the stripe). The first board will look like this when it is plugged in and attached to the first cell:



It will not harm the board to connect it backwards, however it will not work. When the board is installed correctly, the green light will light up. There is also a red LED which indicates that the board is balancing. Normally, this LED will not light. It will come on when the voltage is above 3.6V.

The sense boards, like the cells they attach to, alternate + and – for the series connection. The ribbon cable is set up to go underneath the boards and alternately have the stripe of the ribbon cable on the side of pin 1 and pin 14.



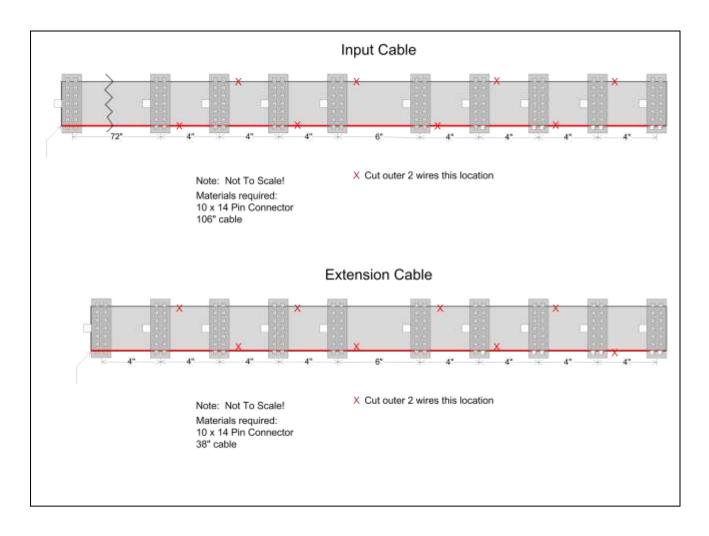
The extension cable should be connected like this:

Making your own cables

Should the need arise to make your own cables, you can do so easily. You will need to procure 14 Pin Ribbon Cable, 14 pin connectors, and 14 pin headers (for the extension cables). You can buy them from us or most good electronics distributors.

You cut the cable to the desired length, locate the connectors where you want them, and crimp the connectors with a small bench vise or a crimping tool for that purpose. If you are making your own cables, you can make 1 cable to run the entire length of your project, you need not use extension cables.

There is a signal that goes in and out of the sense boards. It is important to cut these wires on every other connector to prevent the signals from interfering with each other. Here is what the input and extension cables look like:



Video Output

The composite video output of the computer is accessed through the connector shown below, labeled "Video". This can be fed to any composite video display including many indash DVD players. With many models you can even feed the composite video to the backup camera input. You can then add a switch to tell the receiver whether to display the computer (receiver thinks it's the back-up camera) or just the normal receiver display. If you need to reconnect the video coax cable to J3 then the outer shield wire is connected to the 12V Ground and the center wire is connected to VIDEO.

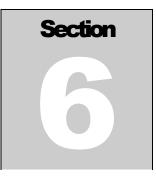




5. Programming

Many parameters in the system can be programmed. Please use this form to tell us how to program your EMS computer.

Contact Name	Phone
Email	Date
Over Voltage Alarm	Under Voltage Alarm
Over Current Alarm	Over Temp Alarm
Battery Capacity (AH)	Centigrade/Fahrenheit
Main Screen Title	
Other Parameters	
Comments	



6. Usage

When properly installed, the EMS shows the status (Voltage, Current, and Battery Capacity) of your Electric Vehicle. Here is an example of what you see on the display.

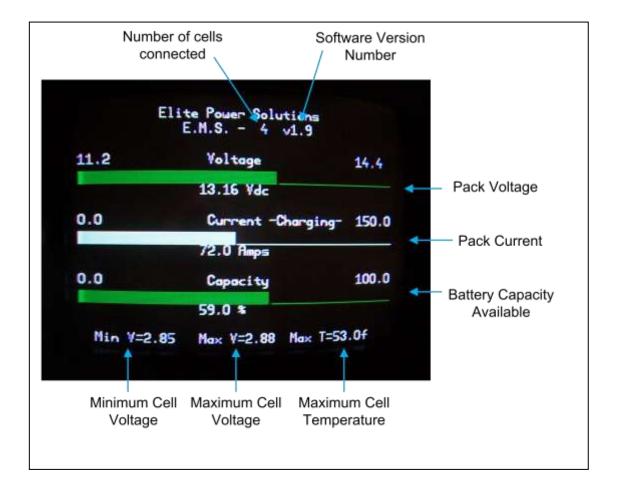


Main Screen

Video Display

The EMS has at least two pages of information it can display. The first is a summary page which has information for the entire system and then one or more detail pages. The detail page shows voltage and temperature for each cell. The number of detail pages is determined by the number of cells. Twenty cells are displayed per page.

Home Page



Battery Voltage is the total voltage of the battery system. This value is updated in real time. When something happens that changes the battery voltage, like accelerating the car, this value changes immediately. The voltage is displayed as a bar graph from 2.8V x the number of cells to 3.6V x the number of cells. The voltage is also displayed as a number which gives a precise reading. The graph is green when the voltage is above 3.0V per of maximum, and it changes to red when it is below. If the voltage goes outside the range of the graph, a warning (off scale high or off scale low) will show instead of a bar.

Battery Current is the total current being drawn from or put into the battery system. It is updated in real time, just like the battery voltage. The voltage is displayed as a bar graph from 0 to the maximum expected value and a number which gives a precise reading. The graph is green when the current is below 40% of maximum, and it changes to red when it is above. When the battery is being charged, the graph changes to white and the notation "(charging)" appears. When charging, the scale also changes.

Battery Capacity is the state of charge of the battery (0 to 100%). It works by counting the amount of energy drawn from and put into the battery. It also uses voltage as a "sanity" check. If the battery is being charged, and the voltage goes above 3.7V x the number of cells, the display will automatically show 100%. Similarly, if the battery voltage falls to 2.5V x the number of cells then the display will show 0%. When the system is powered up for the first time it will show 100%. The graph bar is green when there is more than 50% of battery capacity available, and red when it is below 50%.

Number of Cells is the number of sense boards the computer finds. It is updated once every few seconds. This is useful for when connecting the sense boards during installation. As the sense boards are connected, the number will increase.

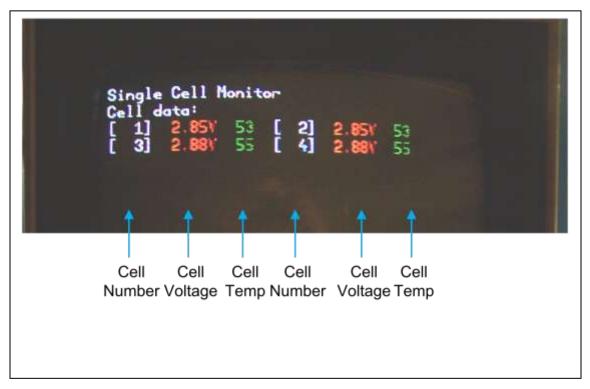
Minimum Cell Voltage is the minimum of the readings of the individual cell voltages. This value is updated after each scan of the individual cells, every 1-2 seconds. Maximum Cell Voltage is the maximum of the readings of the individual cell voltages. This value is updated after each scan of the individual cells, every 1-2 seconds.

Maximum Cell Temperature is the maximum of the readings of the individual cell temperatures. This value is updated after each scan of the individual cells, every 1-2 seconds. The Letter F or C indicates whether the temperature is in Fahrenheit or centigrade.

Version Number is the software release number. This number is changed whenever there is a change in the software release.

Alarms and Warnings are displayed below the cell voltages and temperature when an alarm or warning condition occurs. There are 5 alarms and warnings: over voltage, under voltage, over current, over temperature and connection ground fault. They are described in more detail below.

Detail Page



The data for up to 20 cells is displayed on each page as two columns of up to 10.

- **Cell number** is the ID number of the cell. The ID numbers start with the cell connected closest to the computer.
- **Cell Voltage** is the actual voltage on each cell. This value is updated every 1-2 seconds. The number is shown in green if it is above 2.5V and below 3.7V. If it is outside this range, it changes to red.
- **Cell Temperature** is the actual temperature of each cell. If it is less than a set point value, it is shown in green otherwise it is shown in red. The temperatures are normally shown in Fahrenheit, but it may be set to Centigrade. The temperatures are in the same units as on the summary page. The set point for the numbers to change from green to red is normally 150F.

EMS OPERATION AND INSTALLATION MANUAL

Alarms and Warnings

To protect the battery pack, there are a number of alarms and warnings. These are based on Voltage, Current, Temperature and connection ground fault. As one or more of these parameters go out of spec, a warning will first appear on the screen. If the parameter goes more out of spec, an alarm indication will appear on the screen and an output will be activated.

The set points can be programmed at the factory. The defaults for those set points are as follows:

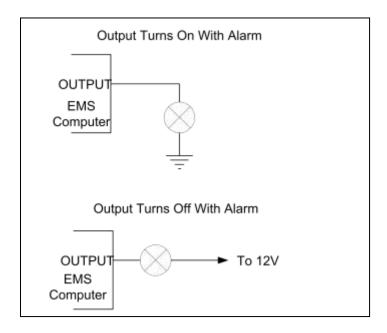
OC Over Current 800A

- OT Over Temperature 150F
- OV Over Voltage 3.7V
- UV Under Voltage 2.5V

The connection ground fault alarm is activated when a connection between the battery pack and the chassis is detected.

Controlling Other Devices with Alarm Outputs

There are 2 outputs available on the EMS for controlling other devices. These outputs will supply up to 200 mA to drive a relay. In this way, these outputs can signal an alarm when there is an error condition or have the voltage go away when there is an error condition. When power is removed from the EMS computer, the outputs will not supply power.



These outputs can directly drive relays without a suppression diode.

There are two error outputs: Over Voltage and Under Voltage. These outputs have a time delay so that the condition causing the error must be present for 30 seconds for the output to activate, and absent for 30 seconds for the output to de-activate.

Over Voltage is active when the pack voltage is too high. It is typically used to turn off a charger when the battery is charged.

Under voltage is active when the pack voltage is too low. It is typically used to turn off a motor controller when the battery is discharged.

The other error conditions of Over Current and Over Temperature will cause both the Over Voltage and Under Voltage outputs to become active after the 30 second delay.



The alarm outputs are located as shown below:

Battery Balancing

When the cell voltage rises above a predetermined threshold (see specifications for this value), a small current is drawn from it. This will bring all the batteries in the pack to the same level of charge. When the balancing function is active, the red light will come on.



7. Capacity Algorithm

The EMS keeps track of the capacity of the battery bank by tracking the current in and out of the battery (integrating the current over time). However, there are corrections to the calculation to allow for a more accurate reading over time. Because the EMS is keeping track of all current in or out of the battery, it must powered at all times. When the EMS first powers up, it sets the capacity to 50% so it will not read correctly until after the first complete charge. Subsequent charges must reach a voltage of 3.7V per Cell volts in order to reset the EMS Display to full charge. If the battery voltage falls below 2.5V per cell, the capacity reads as zero. These values can be changed by EPS (see chapter 5 Programming).



The cell capacity (Amp Hours) must be programmed to the right value for the capacity algorithm to work properly.



8. CAN Interface

A CAN BUS interface is available as an option for the EMS computer. The CAN BUS Interface transmits all the summary information on the main page, alarm status, and the information on the detail page about the sense boards continuously over the BUS, so that a display device can present the data in graphical form. The video output is also operational, so that the data can be verified. Elite Power Solutions also offers a version of the computer with the data acquisition section removed to be used as a remote display.

The CAN BUS is electrically isolated from 12V to reduce interference in the data transfer from chargers and motor controllers.

You can identify whether this option is installed by the presence of the CAN BUS connector on the side of the computer:



The green terminal block can be unplugged for easy wiring. Simply insert wires into the terminal block and tighten the screws.

The signals available on the interface are as follows:

12V the 12V input

CAN H the normally high CAN signal in the differential pair

CAN L the normally low CAN signal in the differential pair

GND isolated ground

NC make no connection to this pin

The typical connection to another CAN device, or to the CAN bus will be only CAN H, CAN L and GND. This connection is best made with a shielded 2 conductor cable. The shield is connected to GND. This cable is typically 22ga.

There are two status indicators to indicate traffic on the BUS, RX (received data), on the right and TX (transmitted data), on the left. The blinking lights indicate that data traffic is present. If they are always on or always off, there is a fault on the bus.

The CAN interface uses a subset of the "Open CAN" protocol. Full details of the data transfer are available on request from us. Other protocols are also supported; please contact us for more information.



9. Trouble Shooting

When the system does not work we suggest that you check the items below:

The red light does not blink	Check 12V connection
No Video	Check that the video output is present with another monitor
	Check video cable is fully plugged in
Sense Boards not detected	Check wiring Check first board and verify green light on, if not, check board is oriented on battery correctly or board is defective
Incorrect number of boards detected	Check wiring Check first not working board and verify green light on, if not, check board oriented on battery correctly or board is defective
board showing -225 degrees	Temperature sensor on bottom of board broken
Not reading pack voltage	Check battery + and – wiring Check Bat+ is fully plugged in

EMS OPERATION AND INSTALLATION MANUAL

Not reading pack current	Check battery + and – wiring Check wiring to shunt, may be reversed Check shunt + is fully plugged in
Current display wrong polarity	Shunt wires reversed
"Snow" on video display	Check grounding on monitor

Appendix A. Enclosure Mounting

