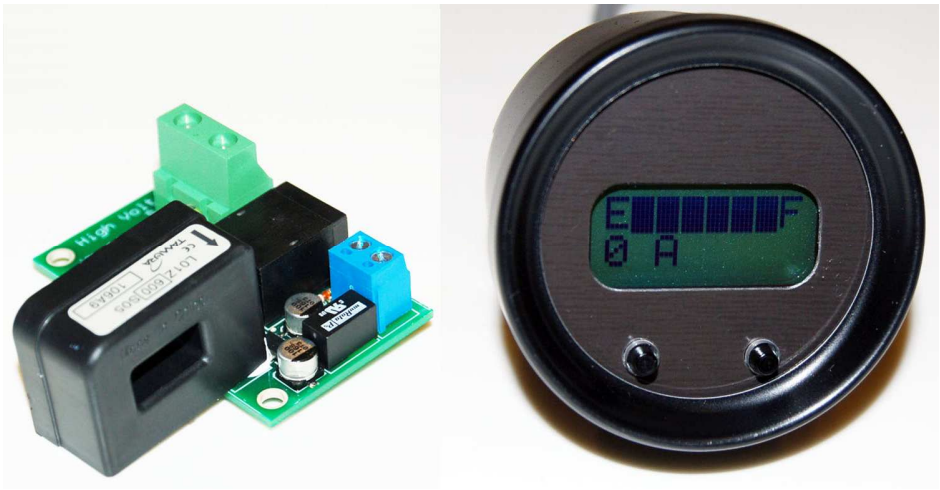
EV Display User Guide



CleanPowerAuto LLC

Brief Description: EV Display is designed to track battery state of charge and other related data in battery powered Electric Vehicle. EV Display is primarily designed for LiFePo4 battery, but can be used with any other battery if properly calibrated. Tracking state of charge requires a reference point when battery is considered full since EV Display can only assume what actual SOC is, based on initial setup parameters. SOC data will only be correct if current reading is correct and reference point is reached on the regular basis. Reference point can be full pack voltage or the fact that amount of full charge taken by the battery is always a little more than amount of discharge, to compensate of battery inefficiency. Display will be more accurate if the battery is fully charged on a regular basis. If battery is always partially charged then EV Display reading may drift long term and will become less reliable. Its recommended to do a full charge at least weekly.

Specifications:

- Nominal power voltage 12V. Min-Max voltage range 10-15V. Power circuit is isolated from pack voltage sensing circuit via internal DC-DC converter; allowing easy and safe installation in EVs with isolated high and low voltage systems.
- Power current 30mA without LCD backlight and 60mA with LCD backlight. LCD backlight comes on when any button is pressed or current reading is non-zero and stays on for 60 minutes.
- Hall Effect current sensor with max range of +/-1000Amp. Best accuracy is guaranteed in the range +/- 600Amp. Sensor can be installed anywhere in the battery current circuit, which passes both charge and discharge currents. Current reading resolution is 0.1A.

- Monitored battery capacity from 10AH to 2000AH, in 10AH increments. Configurable charge efficiency supports virtually any battery chemistry.
- Sender unit and the Display are connected with standard CAT5e or CAT6 Ethernet cable. 7ft shielded cable is supplied. If you need longer cable, replace with high quality shielded Ethernet cable of appropriate length. Poor cable quality may have negative effect on Display's accuracy.
- 3 opto-isolated output circuits, open collector type, 50mA max current and 70V max voltage. Binary outputs for "Full" and "Low Fuel" conditions, and PWM output for mechanical fuel gauge, can be used to drive OEM fuel gauges in existing vehicles.
- Pack voltage sensing range 0 - 512V. Entire range is broken into 4 segments for best accuracy. Selection is made by jumpers on the sender board and corresponding software setting. Ranges are 0 – 64V – 192V – 384V – 512V.
- 2 lines LCD display shows any combination of 2 data points. Available data points are: Voltage, Amperage, AmpHours, SOC, Fuel Gauge, Temperature, Wattage, WattHours.
- Display unit comes in a standard automotive 2" round gauge case, or square open board for custom mounting inside dash boards.

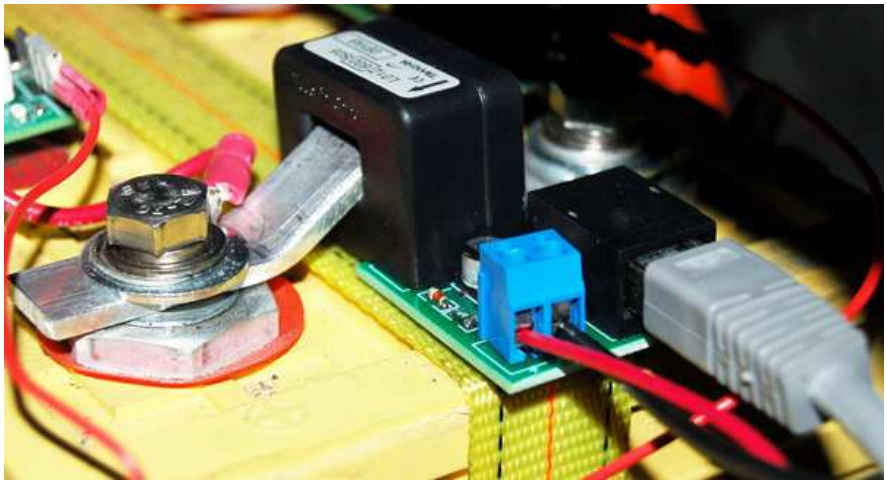
Installation procedure:

Display unit and sender unit are connected via shielded Ethernet cable. 7ft cable was supplied with your display, if you need longer cable you can buy it from any computer store. Make sure you get CAT5 or CAT6 high quality shielded cable to avoid high noise levels in EV.

Display installs in a standard 2" gauge pod or appropriate size hole in the dash panel. You can also buy EV Display without the case, for custom install behind existing dash panels.

NOTE: 2 push-on tabs at the back of the display case are not used for anything, leave them disconnected.

Sender unit has a Hall Effect sensor and temperature sensor and must be mounted as close as possible to the battery pack to better reflect battery temperature. If you have insulated battery boxes, you should mount sender unit inside the battery box. Battery current must pass thru the hole of the Hall Effect sensor, so you must find a way to fit a bus bar thru the sensor's hole. It's possible to fabricate a custom bus bar to replace the standard bus bar which connects any 2 adjacent cells in your pack. Or you can use a piece of straight copper or aluminum stock between any 2 connection points in your battery loop and thread the hall effect sensor thru that stock. Here is an example of sender unit installed on a custom bus bar between 2 cells.



Once the sender unit is installed, connect 12V nominal power to the blue terminal on the sender unit. Watch for correct polarity. 12V power circuit must be always on, regardless of key switch position, since EV Display requires constant power source to keep track of battery SOC. You can power the unit from 12V aux battery or via DC-DC converter from the main pack, as long as DC-DC output is less than 15V and more than 10V.

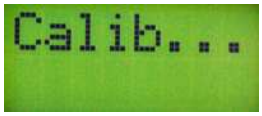
Connect pack voltage sensing wires to green terminal on the sender board. There is less than 1mA current going thru voltage sensing circuit, so you can use any size wires.

NOTE: Be extra careful when working with pack voltage. For safety reasons, make wire connections at the sender board before connecting them to the battery pack. Make sure voltage sensing wires are safely routed and secured between the pack terminals and the sender board, so there is no chance of shorting them. Voltage sensing circuit is fused on the sender board, but you can also fuse it at the pack terminals for extra safety.

Make sure bottom of the sender board is not touching any conducting surfaces; insulate the sender board if needed, to prevent any potential contacts between exposed areas of the sender board and nearby conducting surfaces or terminals.

NOTE: If you are using EV Display to monitor 12V battery pack, such as marine or RV house bank, solar bank, etc. , then you can connect power terminals and voltage sensing terminals in parallel, using single pair of wires going to the battery.

Initial setup procedure: When EV Display is first powered on it will present all configurable parameters, so you can set appropriate values for your EV. Once setup is completed those values are stored in EEPROM so you don't have to reconfigure all values every time EV Display is power cycled. Press Left button to scroll thru the range of values, press Right button to lock the value and move to the next screen. Below is the listing of all setup screens and their descriptions.



This is initial calibration screen, it takes a few seconds to determine zero current levels, so current sensor can properly distinguish current direction and value. Its critical that EV Display is powered on when there is no current flowing thru the battery pack, its best to completely turn off ignition and make sure the charger is turned off or disconnected from EV. There is no input on this screen, just wait until it's done and it will move to the next screen on its own. Following setup parameters are available:

- **V Range** – Voltage Range. Set this to match jumper configuration on the sender board. There are 4 available settings, "to 64V", "to 192V", "to 384V", "to 512V". For best voltage sensing accuracy use lowest range which covers the maximum voltage of your battery. For example, if your battery reaches max voltage of 156V at the end of charge, then use "to 192V" range setting. Sender board has a trimpot which is used for fine calibration of the voltage reading.

- **PackSize** - Battery pack capacity. Settings are from 10AH to 2000AH in 10AH increments.

- **Full Vlt –** Full Voltage. Set this to the maximum voltage your battery reaches at the end of charge. This will be used to sync the display's 100% SoC reading when the battery reaches this preset level. If for any reason you are not connecting voltage sensing circuit to your battery, set this value to zero. If for any reason your display is not reporting correct voltage levels (wrong jumper settings, wrong V Range setting, etc) you must set this value to some high level, up to maximum of 512V, so it will not interfere with display's SOC reading.

- **Min SOC** – Minimal State Of Charge. This percentage value sets "Empty Fuel Tank" level, so the driver can go by Fuel Gauge reading and not completely deplete the battery, to preserve its lifecycles. For example, if this value is set to 20%, then Fuel Gauge will report 0% when SoC is still at 20%. If you desire to use your battery to its full capacity and/or want Fuel Gauge to reflect true SoC, then set this value to zero.

- **CurrDir** – Current Direction. Hall Effect sensor reports direction of DC current passing thru the sensor. Its important for correct EV Display functionality that current is sensed in correct direction for charge/discharge. If you installed the sender board and then realized that its reporting wrong direction of the current, then flip this value to avoid having to reinstall the sender board. Current should be reporting with "+" sign during charge and without any signs during discharge.

- **TempComp** – Temperature Compensation. At low temperatures batteries cannot supply their entire capacity due to slowdown of electrochemical processes. This percentage value reduces Fuel Gauge reading based on temperature drop, linearly from 25C to 0C and below, such that Fuel Gauge reduction is equal this value at 0C (freezing point). For example, if you set this to 10% (recommended value for LiFePO4 cells), then Fuel Gauge will report 10% less

capacity at 0C, linearly changing across wide temp range. This value only effects Fuel Gauge reading, SOC reading still remains true to battery capacity regardless of the temperature.

NOTE: For this feature to work properly, mount the sender board as close to your cells as possible. If your cells are insulated, mount the sender board inside the battery box, so temp sensor at the sender board closely reflects cell's temperature.

- **Low Fuel** – Low Fuel level. This percentage value determines the minimal Fuel Gauge level at which "Low Fuel" circuit is triggered. This is used for external signaling, such as OEM dash boards, etc.

- **TempUnit** – Temperature Units. Set this to Fahrenheit (F) or Celsius (C).

- **ChargeEff** – Charge Efficiency. This percentage value slows down rate of SoC climb during the charge, to compensate for battery losses during discharge. Recommended setting for LiFePO4 cells is 98%. This would be much less for Lead Acid batteries, depending on their Peukert value and battery application. For example, in EVs with high C rates, Peukert effect is more pronounced, so this value must be set lower to more accurately report SoC and Fuel Gauge values during partial charges. This setting must be tuned experimentally for best accuracy. Ideal setting will cause SOC to reach 100% at approximately the same time as charger is finishing up the full charge.

  NOTE: This feature assumes that Pack Size is set to actual useful capacity of the battery at high C rates, which is almost true for LiFePO4 cells, but not for Lead Acid batteries. Lead Acid battery will have smaller useful capacity than its rated capacity, so Pack Size should be set to useful capacity, so EV Display can reflect meaningful Fuel Gauge.

- **DeadZone** – Dead Zone. In some cases when temperature fluctuations are wide and fast, EV Display might show non-zero current reading when not expected. This is due to imperfect temperature stability of Hall Effect sensors. EV Display software compensates for this, but in some extreme situations it might not work 100%, resulting in small current reading when not expected. Dead Zone allows ignoring small current readings when they are likely false (when small reading starts after zero reading). During charge, when current is dropping during CV phase, EV Display will count it even in the Dead Zone. If small reading persists for over 60 minutes, it will be considered as false reading and will be ignored. You can turn off this feature by setting this value to zero. Default 0.3A is recommended for best zero reading stability.

- **TestMode** – Test Mode is designed for verification of external circuits. If you connect external mechanical fuel gauge, driven by EV Display's PWM output, you can use test mode to make sure external gauge correctly follows EV Display's Fuel Gauge values. You can also test "Full" and "Low Fuel" circuits using test mode. In test mode, SOC and Fuel Gauge values will automatically

swing back and forth from 0 to 100% with 1% increments every second. Once you tested external circuits, repeat the setup routine and set this mode to Off.

- **PWM Mode** – Allows you to select from 4 different PWM frequencies and pick appropriate signal phase. Some mechanical fuel gauges work better at low PWM frequencies and some may work better at higher frequencies. You can pick from 4000Hz, 500Hz, 125Hz, 31Hz. You can also select "P" for positive or "N" for negative PWM phase. This can be useful if you need to amplify PWM signal using a transistor, which inverts the signal. See optional wiring diagram at the end of this guide. This setting only applies to PWM fuel gauge output. If you are not using such output, you can leave this setting at any value, as it has no bearing on display functions. NOTE: Some mechanical gauges may "sing" at the PWM frequency, i.e. produce audible sound. You can try different frequencies or add some RC filtering to your gauge driver circuit to reduce "singing".

Using EV Display. EV Display has the 2 line LCD screen, capable of showing 2 pieces of data independently. Press Left button to scroll thru available data on upper line, press Right button to scroll thru available data on the lower line. Any combination of data is possible on 2 lines. Following list explains all available data counters:

- **160.0 Ah** – remaining AmpHour capacity of the battery. When EV Display is initially powered, it will show full capacity, 100% SoC and 100 Fuel Gauge. To sync the battery with EV Display, make sure the battery is fully charged after display is powered up. AmpHour capacity will not go over its preset max value even if the battery is still charging, which allows for top sync procedure.
- **10000 Wh** – remaining WattHour capacity of the battery. WattHour value is derived by multiplying AmpHour value and the Pack Voltage, so this value will be changing dynamically as voltage fluctuates with load.
- **E[redacted]F –** Graphical representation of the Fuel Gauge. Each of 6 bars corresponds to approximately 17% of capacity.
- **100% Fuel** – Digital Fuel gauge.
- **100% SoC** – State Of Charge.
- **123.4 A** – Instant current reading. "+" sign in front of the value indicates charge current. No sign indicates discharge current.
- **20000 W** – Instant Wattage reading. This power value is derived by multiplying instant current and voltage. This is useful to estimate how much instant power is passing thru the battery

circuit. In EVs, this value at certain preset driving conditions can be used to determine EV's efficiency compared to other EVs at the same driving conditions.

- **123 V Pk** – Instant voltage reading.
- **25C Tmp** – Instant temperature reading at the sender board location.

Zero Point calibration:

Since Hall Effect sensor is a bidirectional device, its critical for correct EV Display functionality to maintain correct zero point, such that EV Display is showing zero amp reading when there is no current in the battery circuit. Initial calibration is done when EV Display is initially powered up. However, if initial calibration was wrong (current was flowing in the battery circuit during calibration), then it might be required to do another zero point calibration. Once you make sure there is no current in the battery circuit, press and hold both buttons on the EV Display for 5 seconds to begin calibration.

Pack voltage calibration:

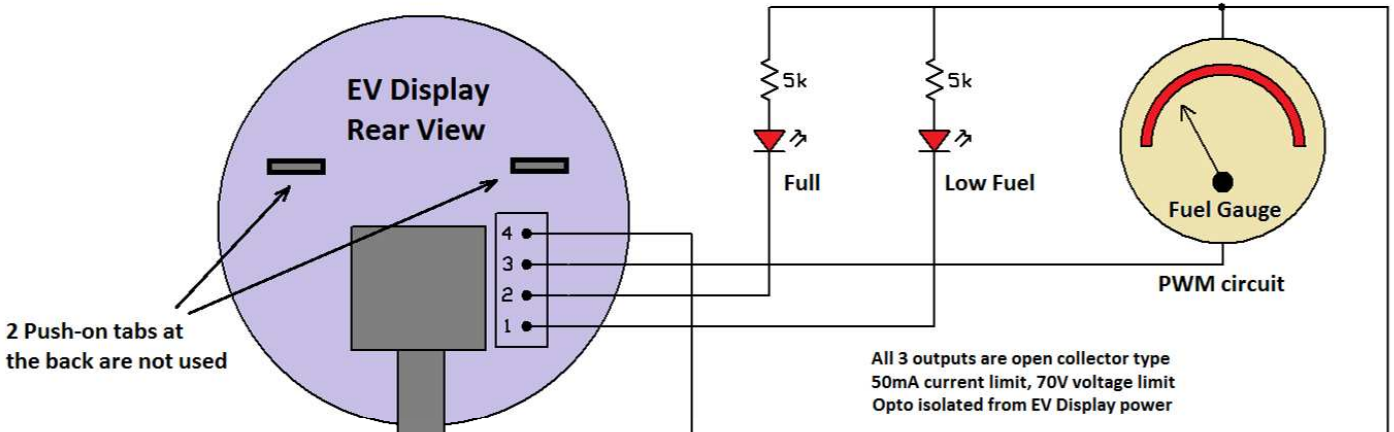
EV Display is pre-calibrated to show correct voltage. However, if you made changes to jumper configuration on the sender board, or if EV Display shows slightly incorrect voltage compared to your trusted multimeter, you can adjust voltage reading using multi-turn trimpot located at the sender board. Slowly turn the trimpot with fine tip flat screwdriver and observe changes in the voltage reading on the EV Display until it matches with expected value.

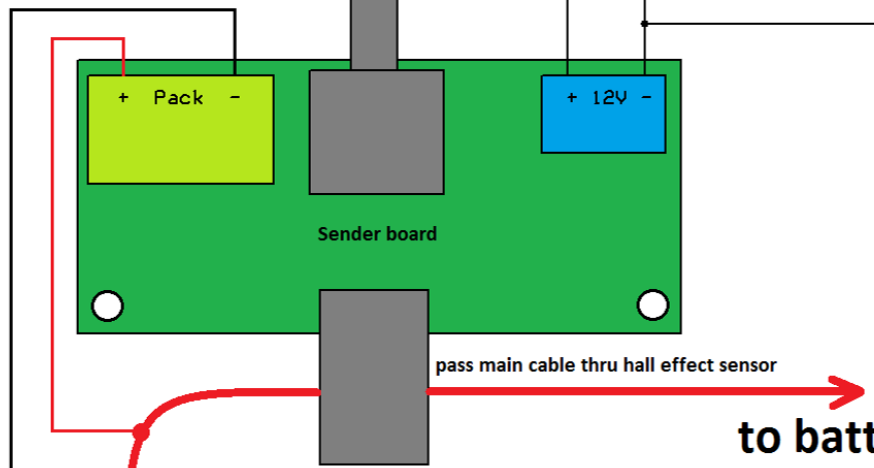
NOTE: Voltage calibration has very limited range. If your voltage reading is significantly different from actual battery voltage, then you likely have a mismatch between jumper settings and "V Range" software settings. Check your jumper settings and match "V Range" setting as follows:

- Low, Med & High jumpers set – V Range up to 64V
- Med & High jumpers set – V Range up to 192V
- High jumper set – V Range up to 384V
- No jumpers set – V Range up to 512V

EV Display wiring diagram:

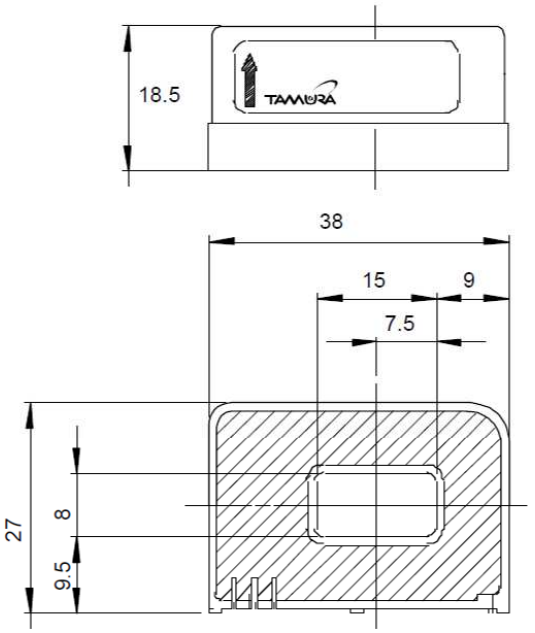
Complete wiring diagram is shown on the next page. External connections are shown as simple examples to illustrate the functionality of output circuits. You can use external outputs in any way you want, as long as you stay within current/voltage specs, stated on the diagram (70V max and 50mA max, open collector output with negative common). PWM circuit may require additional RC filtering to properly interface with your electromechanical fuel gauge. PWM frequency can be selected in the setup menu. Use the test mode to calibrate and test external outputs. Optional wiring diagram using MOSFET transistor is provided for fuel gauges which need more than 50mA operating current.





12v source

AUX battery or DC-DC from main pack



Hall Effect Sensor dimensions in mm

For best voltage sensing accuracy, following jumpers are set on the sender board:

1. **Up to 64V - set Low & Med & High jumpers**
2. **Up to 192V - set Med & High jumpers**
3. **Up to 384V - set High jumper**
4. **Up to 512V - no jumpers are set**

CleanPowerAuto LLC		
EV Display Wiring Diagram		
	Rev 2.0 2/28/2011	

Optional wiring diagram for fuel gauge drivers over 50 mA

All parts can be purchased at Radio Shack or any online retailer