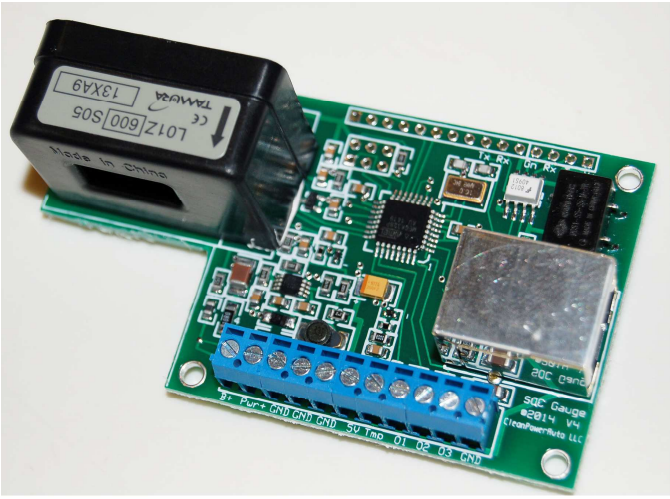
EV Display V4 User Guide



CleanPowerAuto LLC

Brief Description: EV Display a.k.a SOC Gauge 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-64V. Min-Max power voltage range 10-80V. Power ground is not isolated from pack voltage sensing circuit, so optional isolated DC/DC converter is required if you need galvanic isolation between main pack and 12V power ground.
- Power current 15mA without LCD backlight and 25mA 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. With optional current splitter the range can be doubled to 2000Amp.

- Monitored battery capacity from 1AH to 3000AH, in 1AH increments up to 50AH, then in 10AH increments. Configurable charge efficiency supports virtually any battery chemistry.

- Main Board and LCD 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 cause garbled data on LCD screen.

- 3 output circuits, CMOS type 0-5V, 5mA max current limited by 1k internal resistors. Binary outputs for "Full Charge" and "Low Fuel" conditions, and analog 0-5V output to drive mechanical fuel gauge, can be used to drive OEM fuel gauges in existing vehicles. This requires separate amplifier circuit to increase signal power.

- Pack voltage sensing ranges are 0V – 64V and 0V - 350V. In low range voltage display resolution is 0.1V; in high range resolution is 1.0V. You must select the range you need when purchasing EV Display.

- 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.

- Optional external temperature sensor can be used to more accurately display battery temperature, by sticking the sensor onto one of battery terminals. Without external sensor displayed temperature is of the ambient environment around main board.

- Serial port on the main board transmits battery data via serial stream. See the Appendix at the end of this manual for serial data format. Serial interface is at TTL levels (0-5V), galvanic isolated from the main pack. You need additional interface circuits to convert TTL signals to RS232, USB, etc. to interface with standard computer equipment. Such boards are available online.

- SOC data and configuration parameters are stored in EEPROM, so data is retained when power is turned off. When power is turned back on, SOC data is restored to last know level, with 0.1AH accuracy. However, if main battery has been charged/discharged while EV Display was turned off, then SOC data will be inaccurate and will require a full charge to sync with 100% SOC level.

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

Main board has a Hall Effect sensor and a 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 included 4” copper bar between any 2 connection points in your battery circuit and thread the copper bar thru Hall Effect sensor.

Connect 12V power to Pwr+ and Gnd terminals and main pack voltage to B+ and Gnd terminals, as shown on the wiring diagram. If you need galvanic isolation between pack negative and your 12V supply ground, then you must use optional isolated DC/DC converter as shown on the wiring diagram. DC converter input voltage must be between 10V and 15V. Any spike above 15V could damage DC converter.

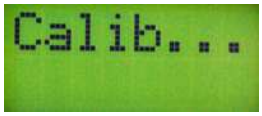
NOTE: Be extra careful when working with pack voltage. For safety reasons, make wire connections at the main board before connecting them to the battery pack. Make sure voltage sensing wires are safely routed and secured between the pack terminals and the main board, so there is no chance of shorting them. It’s a good idea to put an inline fuse at the pack terminals for extra safety. You can use any smallest fuse you can find, voltage sensing circuit takes less than 1mA.

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

NOTE: When powered directly, main board can take up to 80V power voltage, so if you are monitoring 12V-64V nominal batteries, then you can power main board directly from the main battery, by connecting B+ and Pwr+ terminals to the main battery.

Initial setup procedure: When EV Display is powered on, it will enter normal data mode using previously set default parameters. To enter setup mode to change those parameters press and hold both buttons for 5 seconds. This will trigger zero point calibration and then first setup value will show on the screen. You must get to the 2nd parameter within 20 seconds to prevent timeout of setup mode. Left button scrolls thru possible values; right button saves the value and switches to the next parameter. 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. Below is the listing of all setup values and their descriptions.

NOTE: If no buttons are pressed within 20 seconds after calibration then setup mode will time out and switch to data mode automatically, using previously stored values. Once you move to the 2nd value, timeout is cancelled, so you can take your time setting all remaining values.



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 calibration is done 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.

Following setup parameters are available:

- **V Range** – Voltage Range. Set this to match configuration of the main board. There are 2 available settings, "to 64V" and "to 350V". This is typically set at the factory and should not change.
- **PackSize** - Battery pack capacity. Settings are from 1AH to 3000AH. Up to 50AH increments are 1AH, after 50AH increments are 10AH.
- **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 350V, 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 analog 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.

- **SensType –** Allows selection between standard 1000A sensor and specially designed optional current divider, allowing 2000A sensing range. Current divider will be offered as a separate upgrade option, at additional cost.

- **CurScale –** Allows fine tuning of current reading, to match with trusted precision tools. You can leave it at default value of 0 since it already provides very good precision. If current reading does not match your other measurements and you trust those measurements more, then use this value to match EV Display reading with your own measurements.

- **Idle Load –** Since EV Display cannot register very small loads you can preset such known loads, so if your battery is sitting idle for long periods, SOC value will be adjusted based on preset idle load value. You need to measure or estimate actual idle load in your system and set the value accordingly. Allowed range is 0mA – 200mA. If you are not sure about your idle loads, leave this value at zero.

- **Calib –** Since Hall Effect sensor is a bidirectional device, it's 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 was done at the factory; however, another zero point calibration may be needed after you install your EV Display. Make sure to only use this option when your battery is idle, i.e. no charging or discharging at the time of calibration. Press left button to select Yes and then press right button to initiate calibration.

Using EV Display:

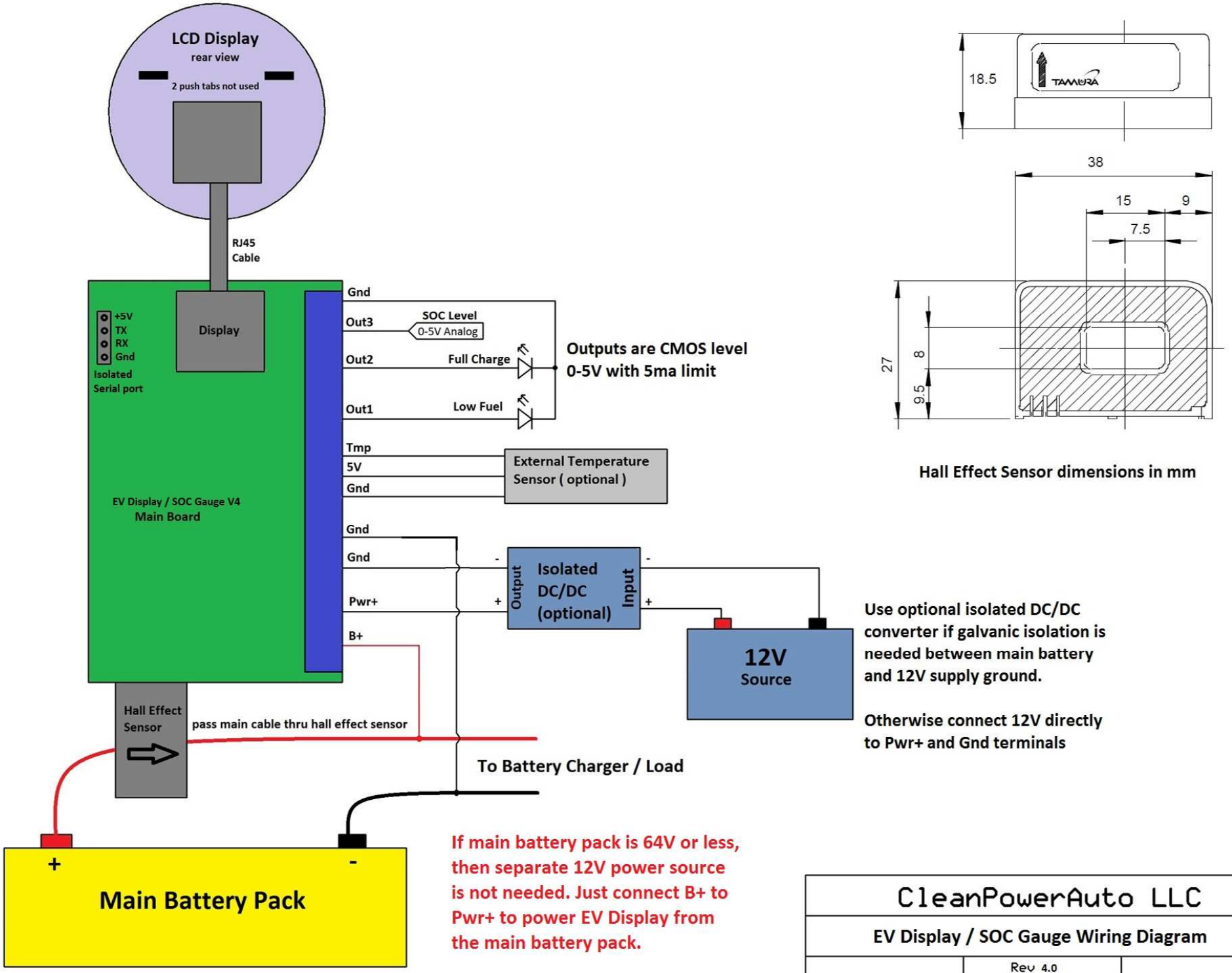
EV Display has the 2 line LCD screen, capable of showing 2 pieces of data independently. Press Left button to scroll thru available data on upper line, press Right button to scroll thru available data on the lower line. Any combination of data is possible on 2 lines. Following list explains all available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

EV Display wiring diagram:

Complete wiring diagram is shown on the next page.


LCD Display
rear view
2 push tabs not used
RJ45
Cable
Display
+5V
TX
RX
Gnd
Isolated
Serial port
EV Display / SOC Gauge V4
Main Board
Gnd
Out3
SOC Level
0-5V Analog
Out2
Full Charge
Out1
Low Fuel
Outputs are CMOS level
0-5V with 5ma limit
Tmp
5V
Gnd
External Temperature
Sensor (optional)
Gnd
Gnd
Pwr+
B+
Output
Isolated
DC/DC
(optional)
Input
12V
Source
Use optional isolated DC/DC
converter if galvanic isolation is
needed between main battery
and 12V supply ground.
Otherwise connect 12V directly
to Pwr+ and Gnd terminals
Hall Effect
Sensor
pass main cable thru hall effect sensor
To Battery Charger / Load
Main Battery Pack
If main battery pack is 64V or less,
then separate 12V power source
is not needed. Just connect B+ to
Pwr+ to power EV Display from
the main battery pack.
18.5
TAMURA
38
15
9
7.5
27
8
9.5
Hall Effect Sensor dimensions in mm
CleanPowerAuto LLC
EV Display / SOC Gauge Wiring Diagram
Rev 4.0
07/30/2014

Serial Data protocol for SOC Gauge (a.k.a EV Display)

There will be continuous stream of data packets with 1 second time interval between packets. Each data packet is an ASCII string of 45 characters, containing 10 data fields. Each field starts with label character and follows by decimal numeric data of constant length, padded by leading zeroes. Each string is terminated by return and new line characters, bytes 0x0D and 0x0A.

Example of Data packet:

B1H00000V000F000S000D0A00000W000000T000R00000

Data packet fields:

B – Battery address, typically 1, in multi-battery systems this will represent battery order – 1 digit long
H - AmpHours remaining, in 0.1Ah resolution, i.e. 123 = 12.3Ah – 5 digits long
V – Volts, in 1V resolution for HV systems or 0.1V for LV systems, i.e. 123 = 12.3V – 3 digits long
F - Fuel Gauge, in percent, i.e. 100 = 100% – 3 digits long
S - SoC percent, in percent, i.e. 100 = 100% – 3 digits long
D – Current direction, 1 – charging, 0 – discharging – 1 digit long
A - Amps instant, in 0.1A resolution, i.e. 123 = 12.3Amp – 5 digits long
W - Watts instant, in 1W resolution, i.e. 20000 = 20000W – 6 digits long
T – Temperature, in degrees, units depends on setup parameter – 3 digits long
R – Reserved for future use – 5 digits long

Serial Port parameters:

Baud Rate – 9600
Data bits – 8
Stop bits -1
Parity - none