DSSR20

SBMS0
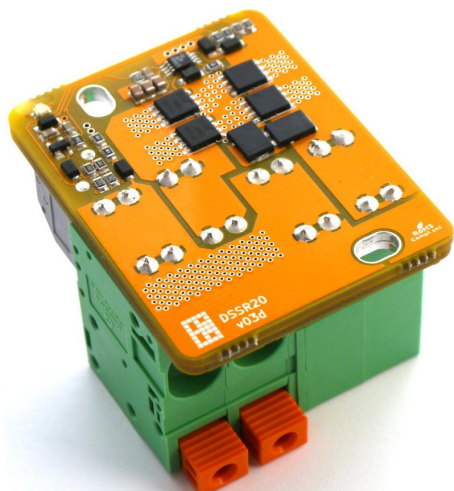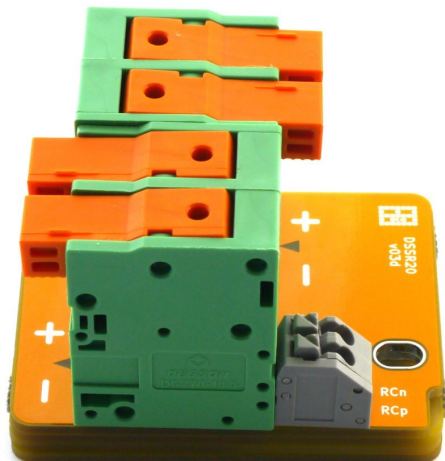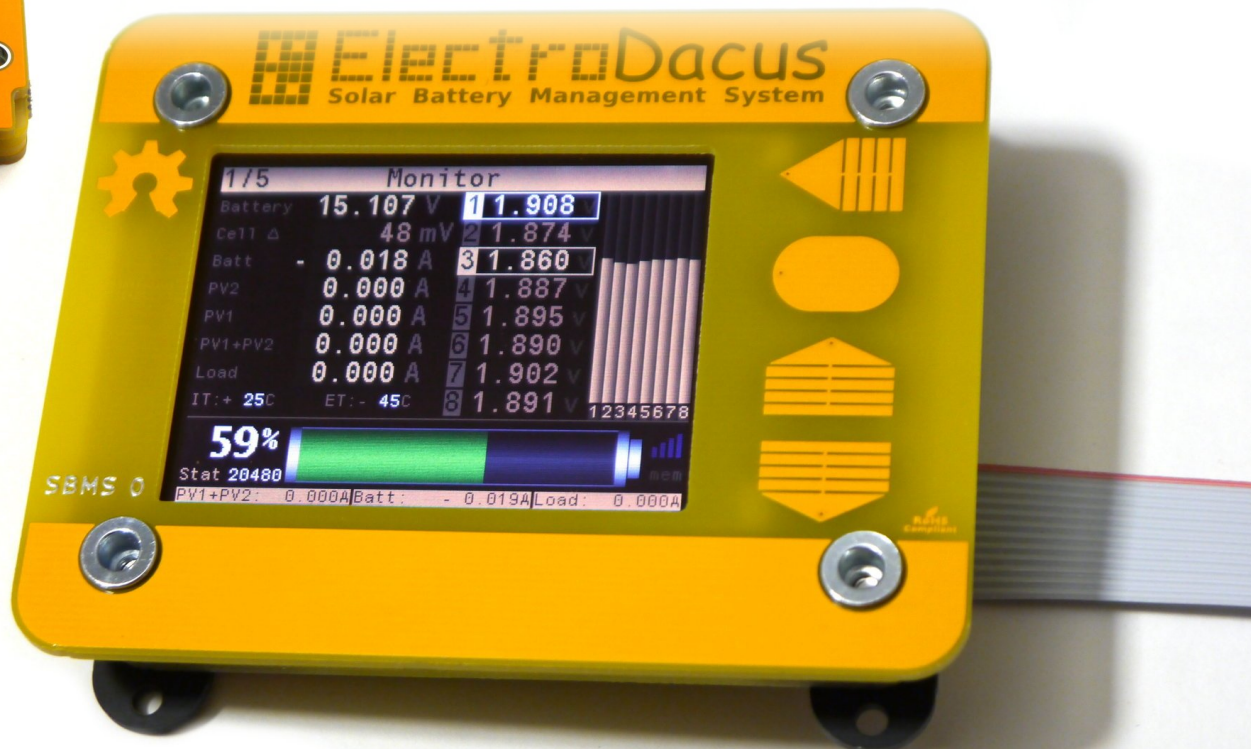
user manual *v0.1*

SBMS0

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SBMS40 / SBMS120   www.ElectroDacus.com

ADC1n / ADC1p

EXTIO3- / EXTIO3+

EXTIO4- / EXTIO4+

PVp / PVn

N   2   1

7   9   8   10&11&12   6   4   1&2   5   3

ADC1p   ADC1n   Pvn   PVp

Specification

Battery type	any type of Lithium cells and Supercapacitors
Number of cells	3 to 8 cells
Battery voltage limits (min/max)	8V to 32V
Battery/PV recommandation 12V	4 cell LiFePO4 / 32 or 36 cells PV panel
Battery/PV recommandation 24V	8 cell LiFePO4 / 60 cells PV panels
Max PV Open Circuit voltage for DSSR20	49V (mono or polycrystalline panels with up to 72 cells)
PV input	Using as many DSSR20 as you want up to 30 or Victron MPPT with remote
DSSR20 PV current	20A so up to two large 60 or 72 cell panels
External PV current shunt	10A up to 750A
External Batt current shunt	10A up to 750A this is required for SOC calculation so it needs to be installed
EXT IOx optoisolators	TLP187 max 300V 150mA
Cell balancing current	max 200mA
Power terminal max wire size DSSR20	AWG #10 (6mm2) should be great for two panels, connectors max AWG #6 (16mm2)
Battery temperature sensor	Thermistor (optional) 10KOhm B3900
16pin connector / (8pin + 2pin) side connector	Includes I2C, UART, Ext IO, 16bit ADC / ext current shunt for Battery and PV
Data logging to internal Flash memory	128Mbit (16Mbyte) 2 minute interval for one year of data
WiFi plus digital isolation and UART to USB	WiFi used for remote monitoring (SBMS acts as AP) USB for log data download
Display	SBMS0 2.4" (Color LCD 320x240)
Weight	SBMS0 ~150g / DSSR20 ~70g
Dimensions	90mm x 70mm x 26mm
Self consumption	300mW to 800mW (WiFi and Backlight ON)
Max TDP	SBMS0 (3W) / DSSR20 (1.4W)

SBMS0

1 Install Instructions

Step 1

Connect the included 12 wire cell monitoring/balancing cable to your battery pack. Number 12 wire is the one marked with red.

Any number of parallel cells are no different from a single higher capacity cell so if you have multiple small cells you will need to form first groups of parallel cells then connect those groups in series for needed voltage. LiFePO4 is the most cost effective battery at the end of 2019 and a 4s with that will make a 12V battery and a 8s will make a 24V battery.

All configurations from 3s to 8s are shown below. The corresponding wire number is marked with dark gray color (all wires are used).

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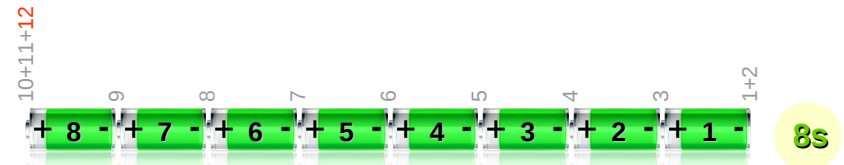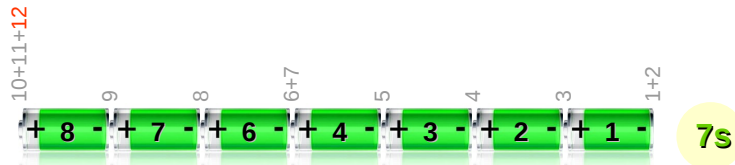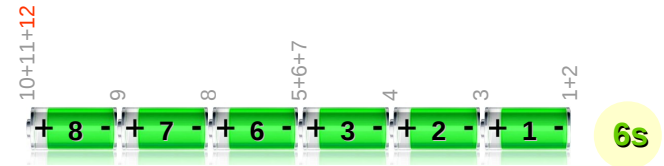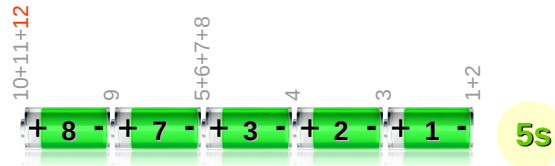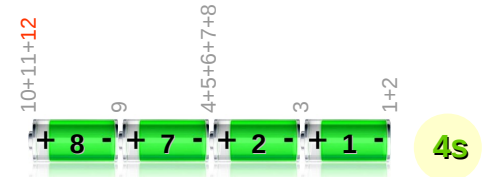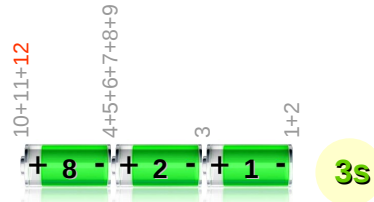
Step 2

Go to Parameter Settings menu and select the type of cell, number of cells and battery capacity then push Store Parameters button to save data to SBMS. **Then remove the 12pin connector and reconnect for the new stored parameters to be accepted.**
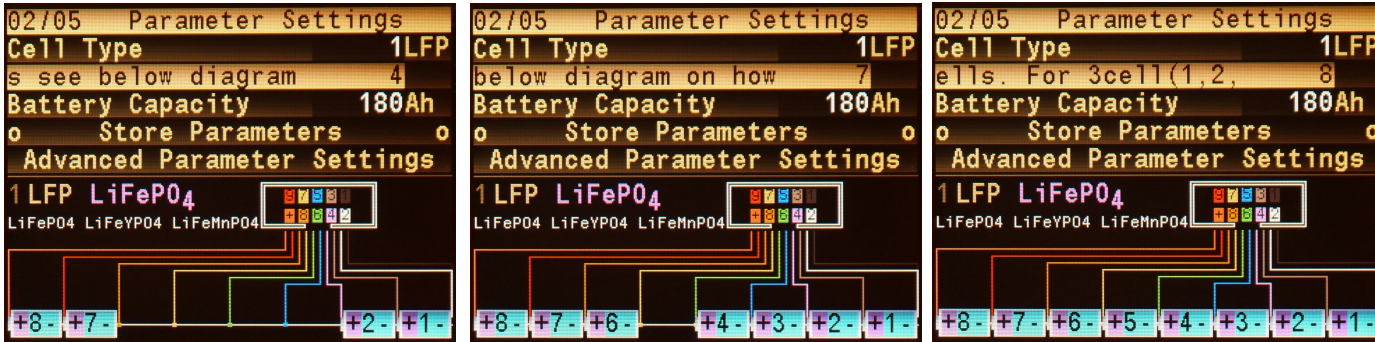
*Screenshots for SBMS40 the SBMS0 has a 12pin cell balancing connector so diagram will look different. Photo from SBMS0 will be updated in next revision of the user manual.

Step 3

You can now remove the 12pin connector and start working on the 8 + 2 pin side connector.

A CAT5 or CAT6 type cable is ideal there as you have 4 pairs of twisted wires and can use one for Battery current shunt (ADC1n/ADC1p) then second one for PV current shunt (Pvn/Pvp) the third one for EXT IO3 (EXTIO3+/EXTIO3-) and last one for EXT IO4 (EXTIO4+/EXTIO4-). See diagram on page 3 for details and you can even respect the color scheme that I used :) as usually the CAT cables have those colors Brown,Orange,Blue and Green.

The XT1+/XT1- is optional but if you want you can connect a battery temperature sensor that will be a 10KOhm Thermistor search for "10KOhm 3950 NTC" and you can find many options and also use a twisted wire pair for this.

All you need to do is strip 4 to 5 mm from the end of the wire and insert in the connector until the stop is reached. To remove the wires or insert stranded wire insert a needle in the corresponding rectangular hole above the wire as seen in the third drawing below. secure the cable to the SBMS0 or to the front panel the SBMS0 is mounted on.
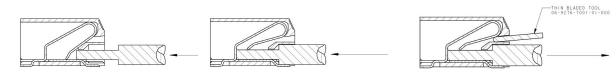
Step 4

Since the CAT5 or CAT6 cable is connected to the SBMS0 you can connect the current shunt's.

The Battery current shunt is mandatory as it is needed to calculate the battery SOC (State of Charge) and gets connected to Battery+ terminal on one side then on the other side to a fuse or circuit breaker and your Load and chargers.

The PV current shunt will be great to have as it will provide way more info as with just the battery current shunt mentioned above all you see is battery current and you have no idea of how much the load uses or how much the PV array is producing.

Example: Say you have a 50A load and 30A coming from your PV array then the battery current shunt will see 20A getting out of the battery and that is only useful to calculate how much energy gets out of the battery and calculate the SOC but you know nothing else.

By adding the PV current shunt now you measure those 30A and so if you add that to 20A getting out of the battery you can calculate the Load and get the 50A load uses thus you know with two current shunts know all the data and SBMS0 can display that for user and calculate the total energy coming from PV, the energy used by the Load and how much the battery was involved in all this so unless you want to save a few $ I highly recommend having both current shunt's installed.

Current shunts are nothing more than a power resistor and they may be spec as a max current they can handle and the voltage drop at that current like say 100A 75mV or as a resistance value and a power rating for the resistor so 0.075V/100A = 0.00075Ohm or 0.7500mOhm (this will be the number you set in the SBMS0) and a power rating 100A x 0.075V = 7.5W

The ADC1n/ADC1p input can read in the -90mV to +90mV range so can read current in both directions while the PVp/PVn current shunt can read current in a single direction 0V to +90mV thus to best take advantage of this range a 75mV current shunt can be used but 50mV current shunts and 100mV current shunts will also work.

You will want to select a current shunt so that your max continues current is no more than 66% of the shunt rating. As an example if you expect a 2000W max continues load from your 24V battery then 2000W/24V = 83.33A and thus a 100A current shunt will get to hot and you will want a 150A or 200A current shunt. You will also not want to jump to a 500A or 1000A current shunt in this example as then your resolution when you measure small current will not be that great.

SBMS0
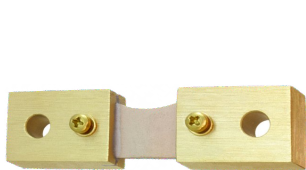
Step 5

Connect the EXT IO3 set as type 2 to your inverter, large DC/DC converter or for multiple small DC loads to Victron Battery Protect or similar device. Most of you will use an inverter and the inverter will need to support remote ON/OFF and while a lot of them do not all can support that. Simple rule will be that any inverter with a mechanical single pole single trow ON/OFF switch will be able to support remote ON/OFF compatible with SBMS0 but you may need to solder two wires in parallel with that ON/OFF switch if there is no remote port available on the unit.
Inverters that have a momentary type ON/OFF switch most likely will not support compatible remote ON/OFF but there are a few exceptions.
To test set the EXT IO3 as type 0 and inverter should turn OFF then you can set back on type 2
Bellow is just a short list of inverters compatible with SBMS0 but way more than this presented here will work.

I think all Victron inverts are compatible.
Pheonix, Multiplus, Quatro
Pheonix 12/500   (~$180)
Pheonix 24/1200   (~$400)
Multiplus 24/3000/70   (~$1300)
BP65 for small DC loads (~$40)
The Victron multiplus inverter/charge may be the only one with separate remote for inverter and charge.

Most Cotek inverts are compatible.
COTEK SP1000   (~$350)
COTEK SP2000   (~$640)
COTEK SP3000   (~$960)
COTEK SP4000   (~$1280)

Some other inverts that are compatible not sure if spec are real.
Ronegy 3000W   (~$370)
PIP2424HSE - 220V   (~$250)
PIP2424HSE can be used as inverter only not charger and it is 220V only, the 120V version is much more expensive.

Step 6

Connect the EXT IO4 set as type 1 to your charger and that can be the DSSR20 (multiple of them up to 20 no problem and up to 30 if using two EXT IOx ports) an MPPT solar charger that has remote ON/OFF support as some Victron Smart solar or Blue Solar with the adittion of a $20 remote ON/OFF cable or a grid charger that has remote ON/OFF like the RSP-750-15 for 12V battery or RSP-750-27 for 24V battery.
A few battery to battery charger also have remote ON/OFF and can be used but charging from vehicle alternator is 50x more expensive than form PV so it should be avoided if cost is important to you.
To test set EXT IO4 as type 0 and charging should stop then you can set back as type 1
Bellow is just a short list of chargers compatible with SBMS0 but way more than this presented here will work.

Electrodacus DSSR20.
This is sure the most cost effective option for PV solar charging and allows PV arrays from 100W up to 18kW
PV needs to match battery voltage so 32 or 36 cells for 12V battery and 60 or 72 cell PV for 24V battery.
DSSR20   (~$27)
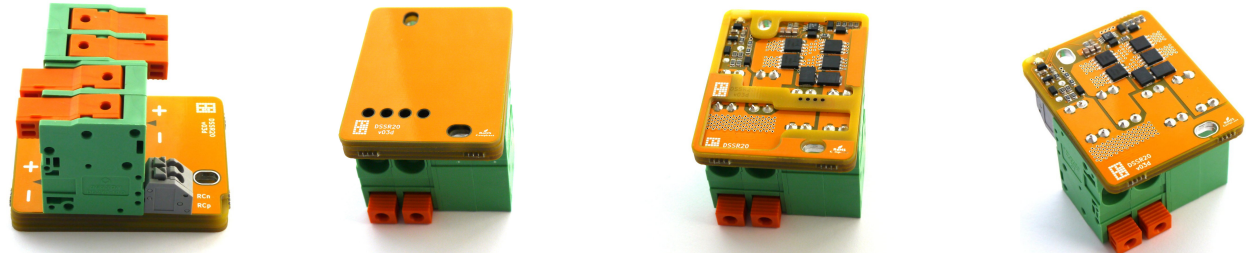
Victron MPPT Solar chargers with remote.
BlueSolar 100/20 + remote (~$160 + $20)
SmartSolar 150/85-TR   (~$680)

Or

+
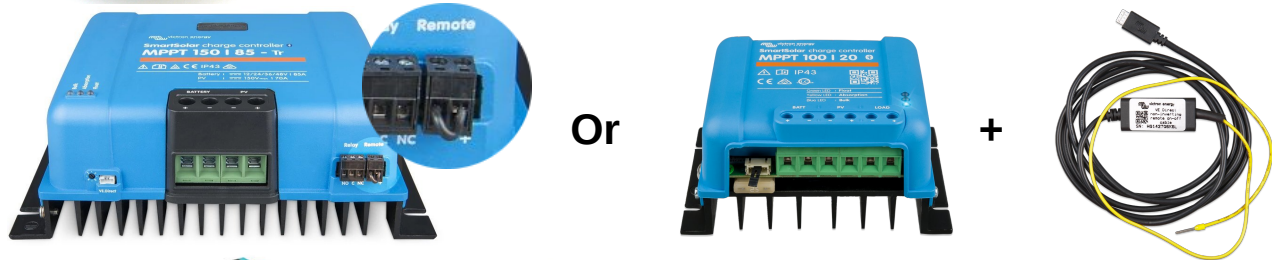
Other type of chargers.
Ronegy 40A battery to battery (~$200)
(alternator >$1/kWh not recommended).

RSP-750-15 grid charger   (~$180)
(grid ~$0.2/kWh)
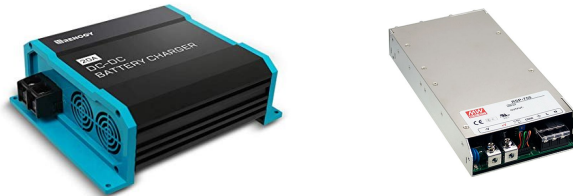
2 Thermal Management

The SBMS0 and DSSR20 are passively cooled and do not require any heat-sink or active cooling.

DSSR20 has a total of 3.5mΩ internal resistance
So at 20A TDP = 20A x 20A x 0,0035Ω = 1.4W
With 60 cell panels 27V x 20A = 540W and with 1.4W loss it will be a 99.7% transfer efficiency.

3.1 Cable Selection

For DSSR20 ideal and most cost effective is 6mm2 (AWG #10) PV cable for groups of two parallel panels. The two panels can be 60 cell panels for 24V battery so 250 to 320W depending on panel efficiency and if panels are very far like more than 20m (60ft) then you may consider going with 72 cell panels as then you can accept higher voltage drop and can sue this same cable up to 60m (200ft).
With 32 cell panels for 12V batter keep the distance below 20m (60ft) with same 6mm2 (AWG #10) for two parallel panels if made with 156mmx156mm (6x6") cells usually rated 160 to 180W depending on cell efficiency or you can use up to 3 panels in parallel if panels are made with 32 or 36 cells in series that are 125mmx125mm (5x5").

With SBMS0 a 1.8m (6ft) ribbon cable is provided and is best to keep it to this max limit or you can cut the cable shorter. For the 10pin side connector ideal is a CAT5 or CAT6 type cable as that will have 4 pairs of twisted wires and you can use one for each of say ext current shunt, ext PV current shunt, EXT IO3 and EXT IO4. If you also want to measure the battery temperature (will likely just be the same as ambient as in this applications battery is charged with at most 0.2C and discharged at 0.5C in average and that is nothing especially for LiFePO4 that I strongly recommend as they are still the best most cost effective option for offgrid energy storage) then just use a pair of twisted wires maybe get that from another CAT5 or CAT6 cable.

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3.2 Mechanical installation.

SBMS0 is designed for front panel mount see photos below for an example. Yes I used a piece of cardboard from the last mouser shipping but you will of course not use that :) and this is just to show how it should be installed.
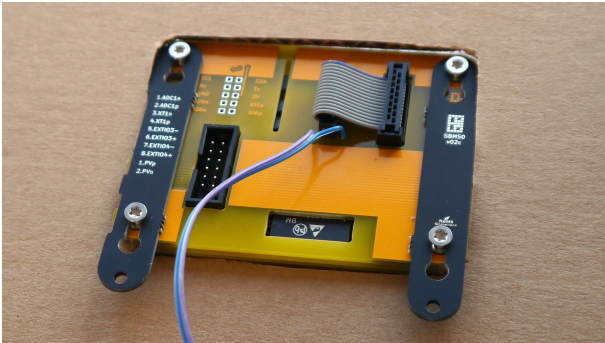
Unscrew the 4 screws (T10) just enough to be able to slide the two black PCB's and this will allow you to slide the SBMS in the front panel cutout.
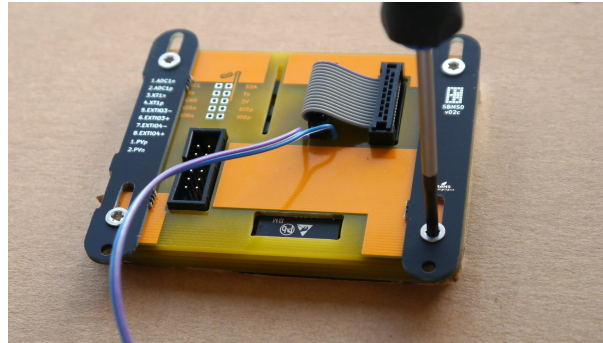
*Slide the PCB's back in to position and tighten them.
The blue a purple wires are soldered to ADC2 & ADC3 that can read 0 to 60VDC and was for testing not much use at this time.
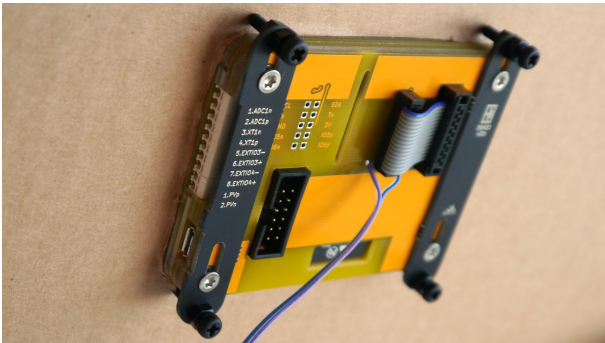
Get the 4 nylon bolts and 8 nylon nuts included and install them in the 4 corners as illustrated.

Nothing to say here other than front panel needs to be less than 3mm thick and that it looks great even on cardboard :).
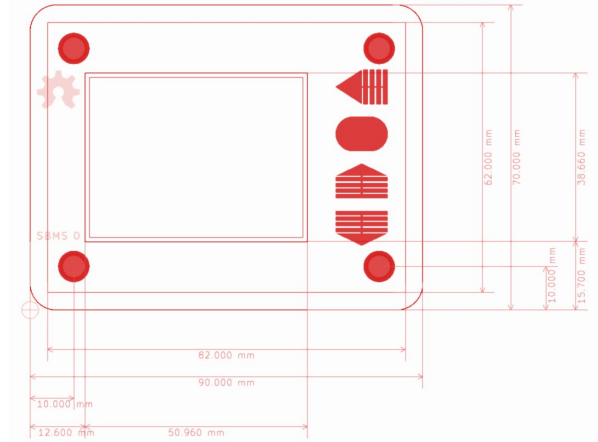
5 Battery Temperature

It is possible to add external temperature sensor but in most cases not needed and so is optional.

All Lithium batteries require temperature above freezing (> +5°C) during charging otherwise they will be damaged.

Best way when possible is to have the battery inside the living space were temperature is ideal for battery operation.

The SBMS is designed to accept a thermistor as temperature sensor connected between pin 3 (XT1-) and 4 (XT1+) of the 8 pin connector.

The SBMS is calibrated for a particular 10kΩ thermistor made by Murata NCP21XV103J03RA (this same thermistor type is used internally to measure the power board temperature) but a common 10kΩ NTC with B25/50 = 3900 to 3950 will work great.

The low and high temperature limits for this external temperature sensor can be set from the Advanced Parameter Setting submenu parameter 29 and 30.

Value is a 12bit binary number and if you use the recommended thermistor the 0°C=3144b,+5°C=3000b, +50°C=1338b,+55°C=1182b, +60°C=1040b.

You can see the actual temperature in Monitoring menu and the raw binary value in Diagnostic menu.

SBMS0

6 The 16pin connector

There is a 16pin connector on the left side of the LCD on SBMS and it is used for different functionality described below.

USART TX	01 02	USART RX
SDA / EXT IO1	03 04	EXT IO2 / SCL
BOOT 0	05 06	EXT IO5 / SWK
ESP RST	07 08	EXT IO6 / SWD
GND	09 10	GND
3.3V (2.7V)	11 12	3.3V (2.7V)
EXT ADC2	13 14	EXT ADC3
GND	15 16	GND

01 & 02 UART TX and RX pins are used for the WiFi module so if you want to use the USART for something else then WiFi will be disabled (voltage levels 0 to 3.3V).

03 & 04 This two pins are reserved as I2C port for communicating with Digital MPPT heat controller. Firmware version 3.0g or higher has support for DMPPT450 but only for monitoring and settings with SBMS0 not charging.

05 Boot 0 connected to pin *12* will put the STM32F373 microcontroller in programming mode.

06 & 08 This pins have dual function as programmable EXT IO5 and IO6 (0 to 3.3V 20mA max) and as SWK and SWD programming interface for the STM32F373.

07 ESP Flash connected to GND will put the ESP32 WiFi module in programming mode.

12 This is a 3.3V (3.15V typical) supply from the main board after it will go trough a schottky diode will supply the WiFi module drooping to around 2.7V or if WiFi is OFF 2.8V that will supply the digital isolator.

13 & 14 Ext ADC inputs 2 and 3 with analog input range of 0 to 1.8V that will be logged in the internal SBMS memory at 2 minute intervals but not used in any automation with the latest firmware version. This are good if you want to log some other analog signals.

09, 10, 15 & 16 GND (same common ground plane for all 3 pins).

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8 WiFi

Both SBMS120 and SBMS40 include a WiFi module that can be used for remote monitoring. The SBMS acts as an AP (Access Point) and will deliver data to a WiFi enabled computing device that supports a HTML5 capable web browser (a smart phone, tablet or laptop/desktop computer). All you need to do is download and decompress this html file http://electrodacus.com/SBMS120/SW/SBMS.zip and copy to your device then connect to SBMS-120 or SBMS-40 named AP and open that file with your preferred web browser.

Notice cell balancing on cell number 5. I had not captured cell balancing in the other photos since cells are well balanced. The "<" symbol after cell voltage indicated cell balancing is performed on that cell.

*Photo shows the older SBMS100 but it works the same in this regards.

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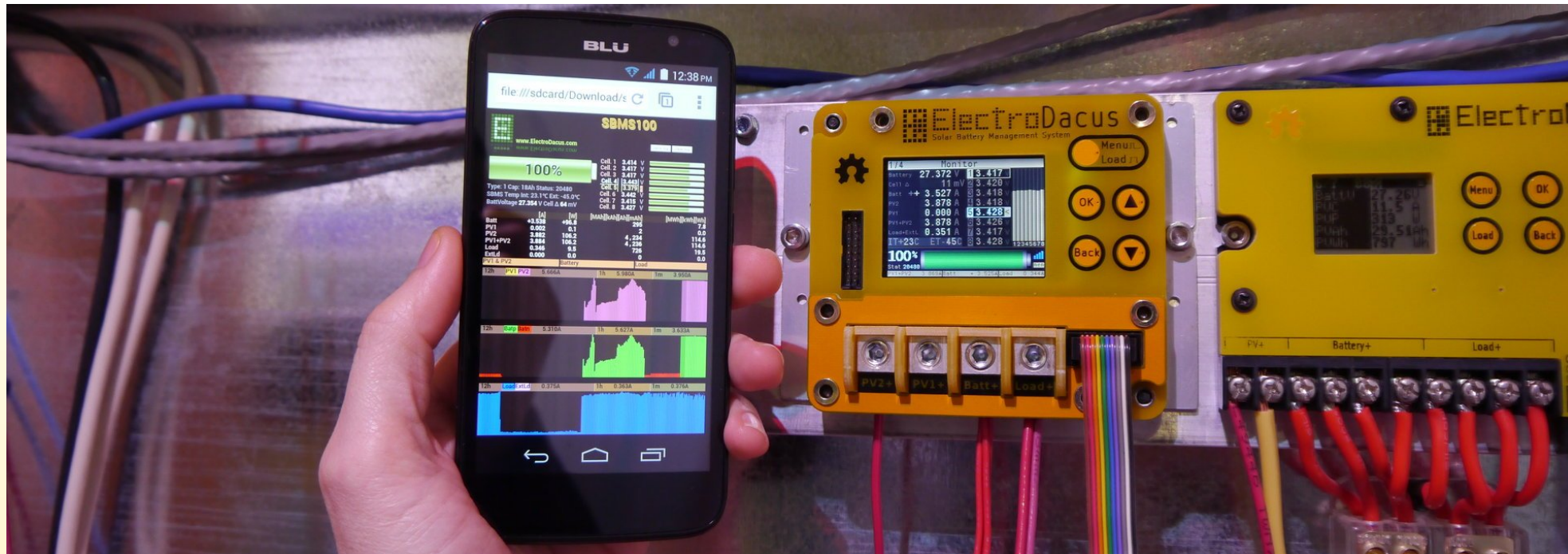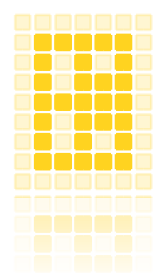
The raw data over WiFi are transmitted in a compressed format and if you want to see the raw data you can just write in your web browser address window the following IP address while connected to SBMS 192.168.4.1 then you will see something similar as below.

var PV1="##";
var PV2="###A_ky]vnM#L$##@*###===#D###L$###I2#-;}xtqp6#################MnoqpoligU###########:VUUTSSRQP||||||||||||{|||||{|||{|{||||||||||||{|||{{{{|||{{{{{{|{{|||{";
var Btp="###?X\\iy}vml#G###9####6###?###H####<$##4}vqoo'##################0Y[\\\\ZWTR<############<<GJIHHFFx}vuvwvvwww{|{|vu{tu|uvwwvvvuv{zvutyzttuvw{uuttt{uwvvvvwvu";
var Btn="###,#*,,#,,,#,,,#,,,#*,,,##3(######666666676677677777778:#########GGGGGGGGGGHH*####################################";
var Ld ="%$$$$$$$%$%$$$$$%%%%%%%$$$$%$%$%$%$%%%$$$$$$$$$%$%&&&&%%&%&&&%%&&&%%&&&%&%%&'(''&%%&%&>QRSSRRQQTSUTUSTUUSTTTRTTTPRSTW|z}|UOOPNMQRQQRRRRSRSSSRSTTTSTTUZ}{z{{zzyxxzzz{{{{|{{{||zzz^TSSQSRvIy{yxxzwwwxnnomxzn|zmzzvwyzyzypryz}rp|zywuo{z{zznywwxvwwxxz";
var ELd="##";
var sbms="3';2LD$,I)|*l+l+H}l%l+l**h##+#)P####->###############%N(";
var xsbms="#&lL6>N$##5";
var gsbms="#Kc#7?#-L#H&#3p#*+#)r#)|#&|";
var eA="####.(##########K2empty-####K2####3i######";
var eW="####&%##########-xempty-####-x####'X######";
var s1=['Ah','A','SBMS100'];
var s2=[0,0,0,0,0,0,0,0,3,5,1,1];

The small print above is an example of what you will get if you look at the raw data. The data is compressed using my proprietary base 91 encoding using the ascii characters from 35 "#" to 125 "}" this was a simple and efficient way for me to compress data.

The first 6 variables in that raw data are the data for displaying the 6 graphs (3 graphs windows each containing 2 graphs or in the case of battery a separate graphs for charging and discharging)

It will be simple to deduce each of those variables and what they contain by looking at the java script code inside the html file mentioned above.

Since this are just raw data representing measurements made by the SBMS you can modify the html page so that you can get a better / nicer user interface or more tailored to your needs.

The sbms variable is the one containing the most important data and I will go in to more details about that one in the next chapter related to SBMS internal data logging.

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9 Internal data logging

The SBMS has an internal 128Mbit (16Mbyte) SPI Flash memory that can log data at a fixed 2 minute interval.
The memory is capable of storing a full year (12months) of data in a circular type buffer so you always have the last 12 months worth of data in that internal Flash memory.
In order for the data logging to start you will need to set the Date and Time and you will notice the small "mem" symbol in the lower right side of the SBMS LCD being highlighted.
The data is also stored compressed in the memory same base 91 compression mentioned in the WiFi chapter and contains the data sent also over WiFi in the sbms variable.
Here is an explanation of what is contained there and what it is logged in the internal memory.

var sbms="YMDHMS%%C1C2C3C4C5C6C7C8ITET+BATPV1PV2EXTAD2AD3AD4ht1ht2ERR"

Y-year last two digit (limited to 2090); (sorry if you read this in 2091 I will not expect a software update :)).
M-month
D-day
H-hour
M-minute
S-seconds
%% - SOC 0 to 100%
C1 to C8 - cell voltage in mV
IT and ET - internal and external temperature in hundreds of a degree 0 is -45C and 1449 is 99.9C so you need to subtract 450 from the result and divide by 10 (example 689 as result of the decompression will be (689-450)/10=23.9C)
+ - sign for battery charging (+) and discharging (-) used as it is no compression.
BAT - Battery current in mA from -750000mA to +150000mA
PV1 - PV1 input current in mA
PV2 - PV2 input current in mA

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EXT - Ext Load current (the use of 10A up to 500A 75mV external current shunt is possible on both SBMS40 and SBMS120 see)

AD2 and AD3 - user available ADC inputs the value is the digital output of the ADC.

ht1, ht2 - reserved for power output of the DMPPT450

ERR - this is error code it will contain the information referring to the error flags on the SBMS.

There are 15 Flags (see monitoring page3 on SBMS) not all flags represent an error some are representing normal operation and if you consider this a 15bit binary number each bit representing one flag with "1" highlighted and "0" not highlighted and you start from the top left with OV flag and continue to right and then down to the last flag DFET and consider the OV as the least significant bit and DFET most significant bit then you get this binary number and convert to decimal that will be the value contained in this ERR Status and you can also see this number on the SBMS LCD just under the battery SOC value and also displayed as Status: in the html page.

Uncompressed data and formatted in .csv as it was on SBMS4080 will look like this

Y ,M ,D ,H ,M ,S ,SOC,cel1 ,cel2 ,cel3 ,cel4 ,cel5 ,cel6 ,cel7 ,cel8 ,IT ,ET ,-Batt   , PV1 , PV2   ,ExtLoad, ADC2, ADC3, ADC4, heat1 , heat2 , ERR
00,01,31,22,53,47,100,3414,3416,3444,3433,3426,3419,3420,3380,000,000,-002000,000000,000000,000000,000000,000000,000000,000000,000000,000000

This is the javascript function for decompression (you will find this inside the SBMS webpage) function dcmp(p,s,d){xx=0; for (z=0;z<s;z++){xx = xx + ((d.charCodeAt((p+s-1)-z)-35)*Math.pow(91,z));}return xx;}

Were

p - location of the data in the string.

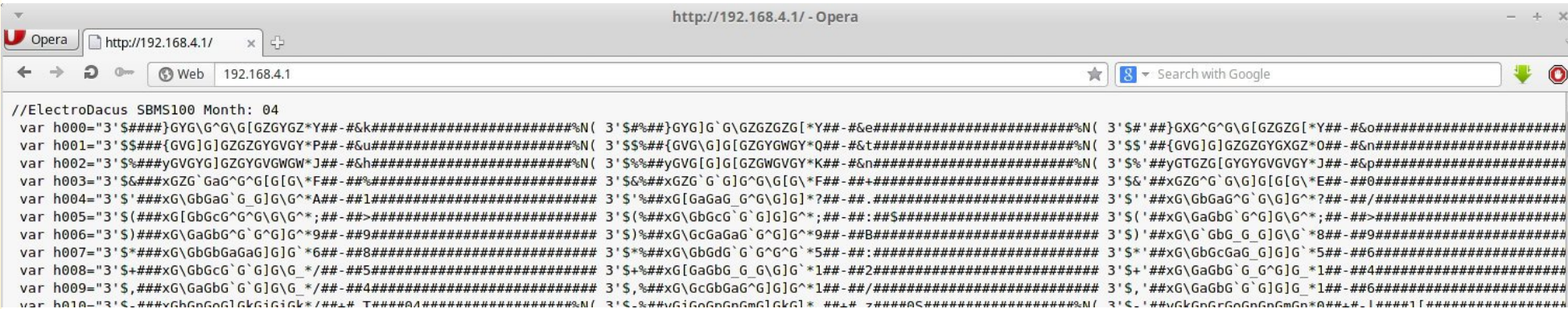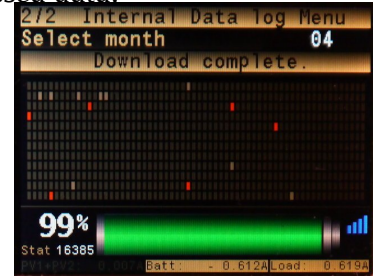s - size of the data (example year is 1 cell voltage is 2 and PV1 current is 3)

d - the name of the variable in this case sbms.

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Not implemented in the new SBMS40 and SBMS120 as of now because the new ESP32 will not support the old transfer function. You can download the compress raw data available in the internal memory over WiFi by going to Device Settings menu and Internal-datalog submenu were you can select the month you want to download. It work over UART on firmware version higher than 3.0g

After you selected the month and you are in this menu connect your device to the SBMS if you are not already connected then open a web browser and write 192.168.4.1 in the address bar push enter and the browser is ready to receive data then go to SBMS and push OK while you selected the Start data download button.

Depending on the device and browser used you should see data filling the browser window and a complete month will take around 40 to 50 seconds after this is done just save the file on your disk (there is no application at the moment to decompress and display this data but there will be one soon).

Below you see an example of one hour of compressed data made of 30 sets of data since it will log each 2 minutes and there are 744 hours in a full month and you can get why I can not list all in the manual. When saved as a text file it will be about 1.4MB of compressed data.

var h019="3'$6##$+H+H0H1H/H/H.H+H1*\##-#'%####%f##############%N(3'$6%#$+H)H-H.H,H+H*H(H-*[##-#'F####%L###############%N(3'$6#$+H%H*H*H*H(H'H%H)*K##-#'W####%4############%N(3'$6)#$+G}H'H(HHH#G|H'*[##-#'o####$z###############%N(3'$6+#$+GxH#H#G}G{G{GxG}*Z##-#(####$i################%N(3'$6-#$+GvG{G}G{GzGwGwG{*Y##-#(2####$[###############%N(3'$6/#$+GtGwGyGxGvGtGsGw*]##-#(K####$J###############%N(3'$61#$*GrGwGxGvGvGtGqGv*Y##-#(J####$C##############%N(3'$63#$*GpGuGvGtGrGqGpGt*X##-#(T####$7################%N(3'$65#$*GnGrGtGqGpGpGnGq*Y##-#(c####$-###############%N(3'$67#$*GmGqGsGpGoGnGkGo*X##-#(j####$z###############%N(3'$69#$*GjGpGqGnGnGmGiGn*W##-#(w######o###############%N(3'$6;#$*GhGmGnGlGlGiGhGm*W##-#))#####e#############%N(3'$6=#$*GfGlGmGjGiGiGgGj*W##-#)/####$Y###############%N(3'$6?#$*GfGkGlGiGiGgGgGi*S##-#)?#####M##############%N(3'$6A#$*GcGiGjGhGhGfGdGh*W##-#)K##################%N(3'$6C#$*GcGiGjGgGgGeGcGg*U##-#)N####<################%N(3'$6E#$)GbGhGiGfGeGdGbGf*U##-#)b#####1###############%N(3'$6G#$)GbGgGhGfGfGbGbGf*W##-#)b#####(################%N(3'$6I#$)GaGgGhGdGeGcGaGd*U##-#)r############%N(3'$6K#$)G`GeGeGcGcG`G_Gc*V##-#)r###############%N(3'$6M#$)G`GfGgGcGbGaG`Gb*V##-#){####################%N(3'$6O#$)GaGfGhGdGcGbGbGc*V##-#&f##############%N(3'$6Q#$)G_GfGgGfGcGaGaGc*X##-#&a##############%N(3'$6S#$)G_GfGgGdGcGbGaGb*W##-#&e###############%N(3'$6U#$)G`GfGfGdGcGbGaGb*U##-#&f##############%N( 3'$6W#$)G`GeGfGdGcGaGaGb*X##-#&p##############%N(3'$6Y#$)G^GfGfGcGbGaG_Gc*U##-#&p##############%N(3'$6[#$)G_GeGfGcGbGaG`Ga*W##-#&r##############%N( 3'$6]#$(G^GfGgGcGbGaG`Gb*Y##-#&j##############%N(";

//ElectroDacus SBMS100 Month: 04
var h000="3'$###}GYG\G^G\G[GZGYGZ*Y##-#&k###############%N(3'$#'##}GYG]G`G\GZGZGZG[*Y##-#&e####################%N(3'$#'##}GXG^G^G\G[GZGZG[*Y##-#&o###################%N(3'$
var h001="3'$$###{GVG]G]GZGZGYGVGY*P##-#&u###############%N(3'$$%##{GVG\G]G[GZGYGWGY*Q##-#&t################%N(3'$$'##{GVG]G]G[GZGZGYGXGZ*O##-#&n#################%N(3'$
var h002="3'$%###yGVGY]GZGYGVGWGW*J##-#&h###############%N(3'$%%#yGVG[G]G[GZGWGVGY*K##-#&n#################%N(3'$%'#yGTGZG[GYGYGVGVGY*J##-#&p#################%N(3'$
var h003="3'$&###xGZG`GaG^G^G[G[G\*F##-##$###############%N( 3'$&%##xGZG`G`G]G^G\G[G\*F##-##+###############N( 3'$&'##xGZG`G`G]G[G*E##-##0###############
var h004="3'$'###xG`GbGaG`G_G`G^A*##-##1#############%N( 3'$'%##xG[GaGaG_G^G`G]G]*?##-##.###############N(3'$''##xG`GbGaG`G^G`G^*?##-##/##############
var h005="3'$(###xG[GbGcG^G^G\G`G^*;##-##>##############N( 3'$(%##xG[GbGcG`G`G]G]G^*;##-##:##S############N( 3'$('##xG\GaGbG`G^G`G^*;##-##>#############
var h006="3'$)###xG[GaGbG^G^G_G`G^*9##-##9####%N( 3'$)%##xG\GcGaGaG^G`G_*9##-##B#########%N(3'$)'##xG`G`GbG_G]G_G^*8##-##9##########
var h007="3'$*###xG[GbGaGbGaG]G]G]*6##-##8#############%N(3'$*%##xG\GbG[G`G^G^G^*5##-##:###########N(3'$*'##xG\GbGaGaG]G]G]*5##-##6###########
var h008="3'$+###xG[GbGaG`G`G]G_*/##-##5##############N(3'$+%##xG[GaGbG_G_G]G]G]*1##-##2#############N(3'$+'##xG[GbGaG`G^G]G_*1##-##4#############
var h009="3'$,###xG[GaGbG`G`G]G_*/##-##4##############N(3'$,%##xG[G^GaGbG]G]G]G]*1##-##/#############N(3'$,'##xG[GaGbG`G^G]G_*1##-##6############
var h010="3'$-###xGbGpGoGlGkGiGiGk*/##+# T####04##########%N(3'$-%##yGiGoGpGnGmG]GkG]* ##+# z####0S#########N(3'$-'##yGkGnGrGoGnGpGmGn*0##+-L####[#########

10 User interface

10.1 Main menu

At power on the SBMS will be on main menu and this can also be access later from any other sub-menu by pressing the menu button on top.
The same Menu button has a dual function and if you keep that button pressed (is a touch button so touched) for about 5 seconds you can power ON or OFF the Load and Charge FET's.
You will also be able tho see the most important information on the bottom part of the screen (that part is present in most menus).
The bottom part contain SOC level in numeric and graphic form the SBMS status represented by a number, the WiFi and internal data log "mem" symbols. The lowest part will indicate if charge and discharge FET's are active by highlighting or not the PV and Load and you also have the current for PV, Battery and Load.
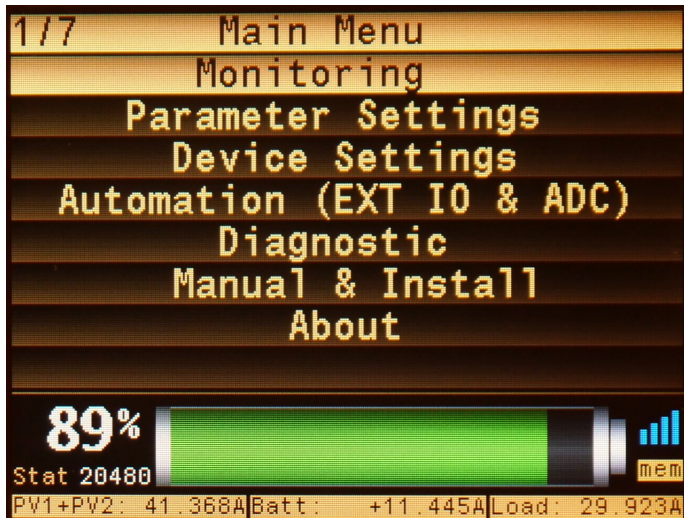
* SOC (State Of Charge) indication will be set automatically to 50% (49%) when you connect the SBMS to battery for the first time since SBMS can not guess the state of charge based only on cell voltage.
After the first full charge (on battery type 1 when highest cell gets to 3.53V and EOC flag will be set the battery SOC will jump to 100%) from that point SOC indication will represent the real value.

10.2 Monitoring

The monitoring menu is were you see all the information about the current state of the battery, PV and load.

All is hopefully obvious. The IT (+32°C in the example below) is the internal temperature of the power board and if that gets above +60°C then both the Charge and Discharge will be disabled and will only be enabled after temperature drops below +50°C

ET is external temperature optional since a LiFePO4 will not have any temperature increase working within the 0.3C charge rate and 0.6 to 0.8C discharge rate recommended for Off Grid solar type applications.

The first direction sign for the battery with a darker color represents the ISL94203 current direction detection not as sensitive as the dedicated current shunt and if there is no minimum load or charge in order for the ISL94203 to detect the IC will try to enter in sleep mode after 4.5h of inactivity so you may notice a short one second or less power OFF if you have a really small load and charge not detected by ISL94203 IC.

The green DMPPT symbol in the top right corner shows that there is successful communication over I2C with the external DMPPT450.
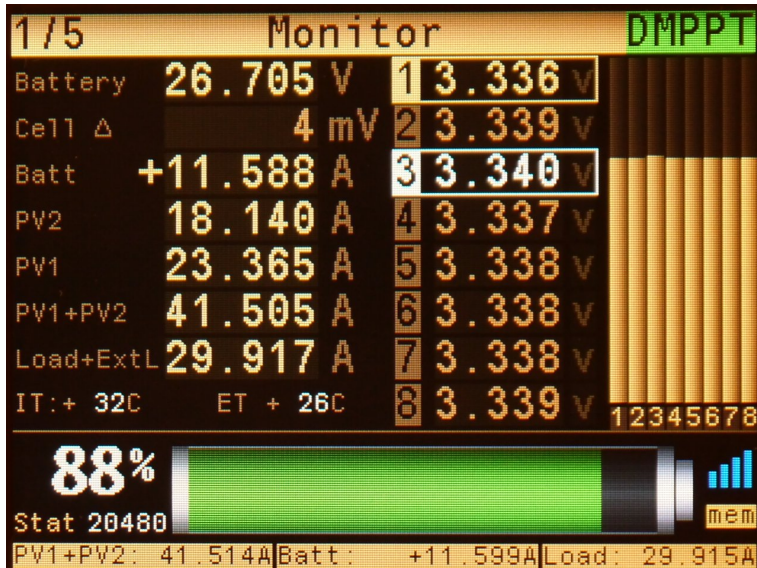
By pressing the OK button while in this menu you will be presented with a small submenu allowing you to change the display from current measured with 1mA resolution to power measured with a 0.1W resolution and also allowing you to change the temperature units from Celsius to Fahrenheit
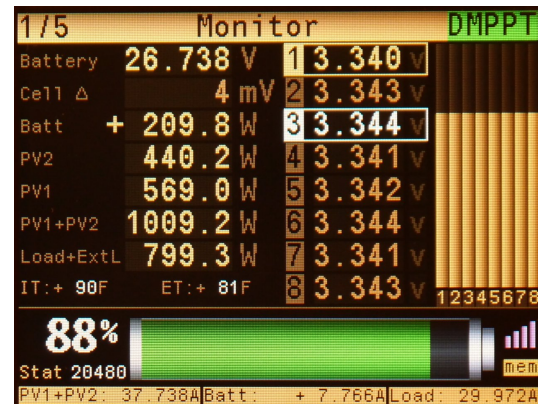
The monitoring menu has a total of 4 pages (5 pages for firmware above version 3.0g as support for DMPPT450 was added) and the second page of the monitoring accessed by pushing the up key contains the energy counters as you see in the below screen shoot.

The Ah and Wh counters for PV, Battery and Load can be reset by pressing the OK button that will present you with a Reset submenu as you see in the second image allowing reset of each individual counter or resting all counters at the same time by using the last option.

You can get out of this submenu without resetting any counter by selecting by using the Back touch key.

You can reset this counters every day if you want since there is also a total counter you will be able to find in the About menu and you can read more about that one later in this manual.

2/5	Monitor	DMPPT
PV2	252.59Ah	6789.8Wh
PV1	275.70Ah	7412.9Wh
PV1+PV2	528.30Ah	14.202kWh
Battery	292.93Ah	7776.8Wh
Load	153.17Ah	4086.7Wh
ExtLoad	346.49Ah	9225.0Wh
DMPPT	380.41Ah	12.418kWh

89%
Stat 20480

PV1+PV2: 38.263A Batt: + 8.406A Load: 29.857A
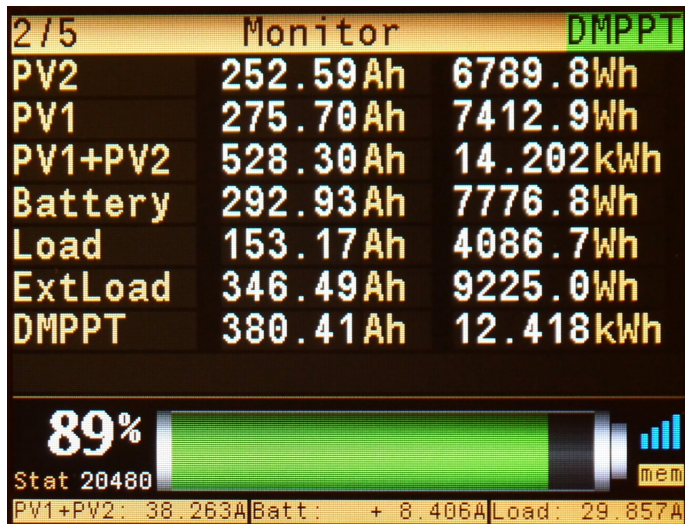
The third monitoring page will display the 15 "error" flags. While I call them error flags they are not all errors and represent normal operation of the SBMS.

CFET and DFET show if Charge and Discharge FET's are ON or OFF (if highlighted they are ON). Then when highest cell gets to 3.55V (in case of default battery type 1 settings) the CFET will be turned OFF terminating the charging and the OV (Over Voltage) flag will be highlighted but this is normal operation and not an error. Same will be true if battery is getting discharged and the lowest cell gets below 2.8V for more than one second then DFET will be turned OFF and the UV (Under Voltage) flag will be highlighted (again normal operation even if you probably do not want to have an empty battery while off grid).

EOC (End Of Charge) is also a normal operation flag and it will be set when the highest cell gets to 3.53V with battery type 1 default settings.

UVLK or OVLK is an error since those limits are set lower and higher than UV and OV and it means that the respective mosfet has failed as a short circuit and can not disconnect the PV or Load or you played with advanced parameter settings and used wrong values in there.

COC, DOC and DSC are also errors for over-current or short circuit and they can be caused by multiple conditions.

OPEN (open cell wire) is also an error indicating that you have a bad connection to one of the cell monitoring wires while CELF (cell fail) means that one of the cells has a voltage below what is acceptable and may be do to a bad cell to cell power connection or a defective cell with high internal resistance.

LVC is also an error and means that one of the cells has a voltage so low that normal charging is not allowed (you can manually charge that cell with a small current and see if it can be recovered).

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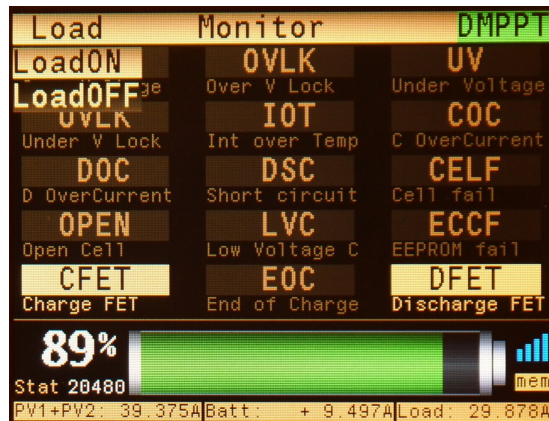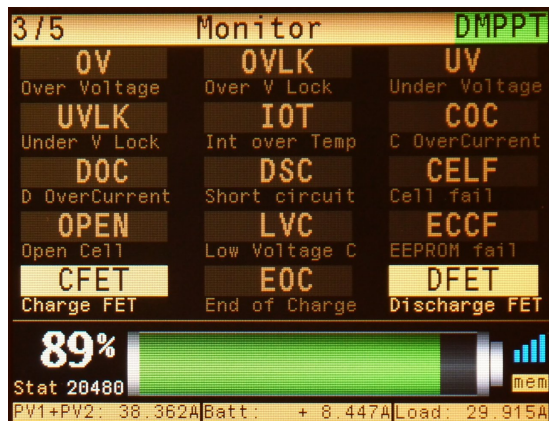
The monitoring page (page 4) will give you a graphical representation for current or power energy graphs.
To select between the current and power energy graphs you push the OK button that will bring a submenu with the first to options being current or power.
There are 9 mini graphs from top to bottom you have PV, Battery and Load graph and from left to right you have last 12h, last 1h and last one minute energy graphs.
All this graphs can be zoomed in by using the OK button and selecting one of the 3 options PV, Battery and Load.
The mini graphs are auto scaling and the peak in each graph is represented by a number displayed on the top right corner of the graph.

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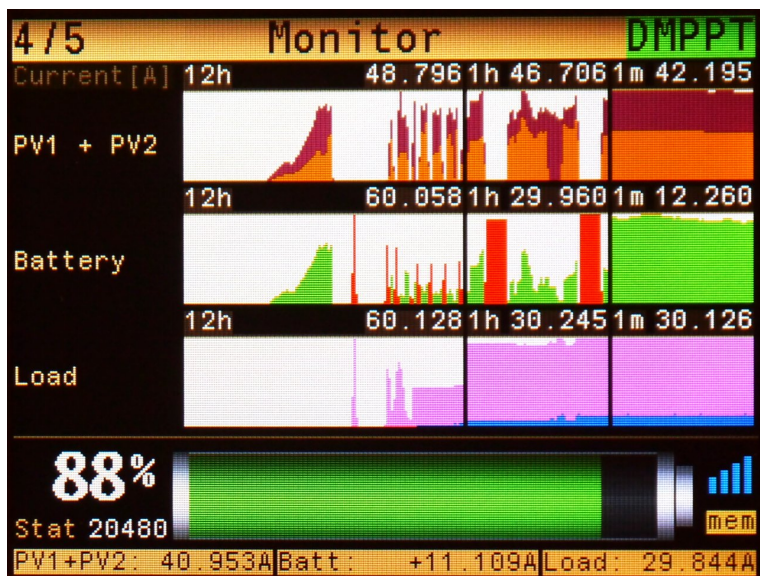
Here you can see some of the zoomed graphs they will show a larger time range than the mini graphs so you see the last 24h the last 4h and the last 4 minutes and you can select that again by pressing the OK button and being presented with a submenu.
In this zoomed graphs you also have the possibility to use a cursor to make measurements on the graph and the cursor can be moved with the up and down keys.

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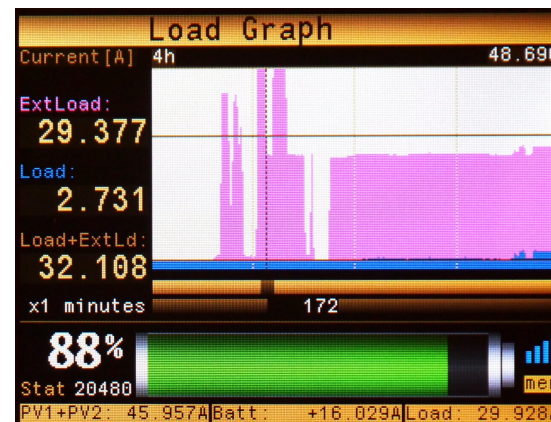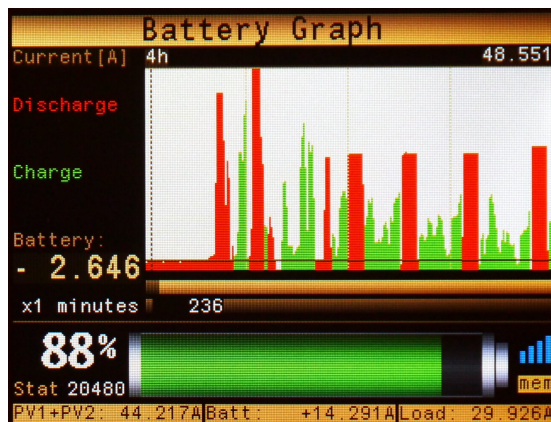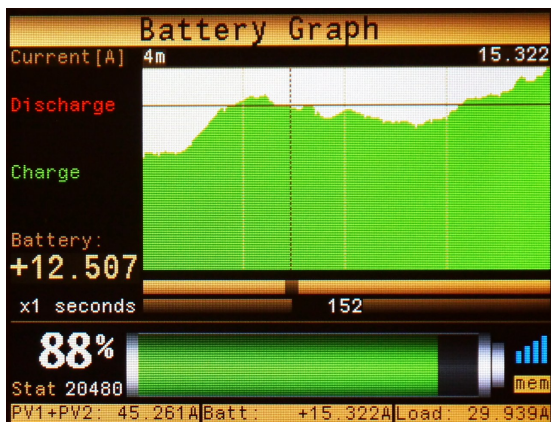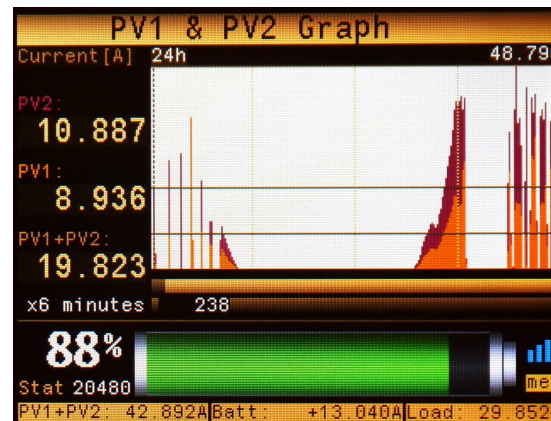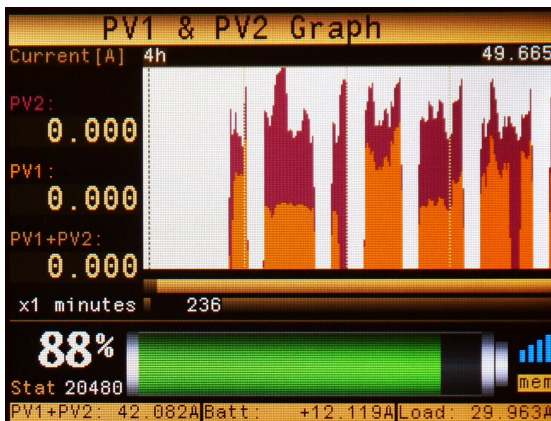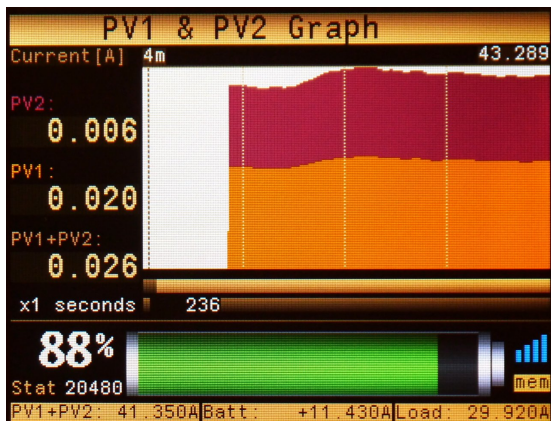
Monitoring page 5 will be populated with data if the SBMS is connected to DMPPT450 that in turn is powered by the PV array.

The green DMPPT symbol on the top right corner indicates successful I2C connection to the DMPPT450.

In this current image you can see that TPV1,TPV3,TPV4 and TPV5 are all redirected to battery charging (showed by highlighted units "A") while the remaining TPV2 and TPV6 are used to power the TLD2 with about 14.6A (a 500W DC heating element in this example).

DMPPT450 (Digital Max Power Point Thermal controller 450A) has dual functionality.

One is to take the energy from a large PV array (up to max 14kW possible split in to 6 subarray's) and redirect as much as needed to battery charging this way a smaller battery capacity can be used to handle a large energy consumption.

Second is to use all the energy not needed for battery charging and store that in to thermal mass (example of thermal mass can be water, concrete, sand …) . The DMPPT450 will have 6 outputs connected to different size heating elements that will be embedded in your preferred thermal mass for house heating applications or domestic hot water.

The very low cost solar PV energy together with even lower cost thermal storage makes this the ideal solution for house heating application competing in therms of cost amortization with natural gas. For details see DMPPT450 user manual.
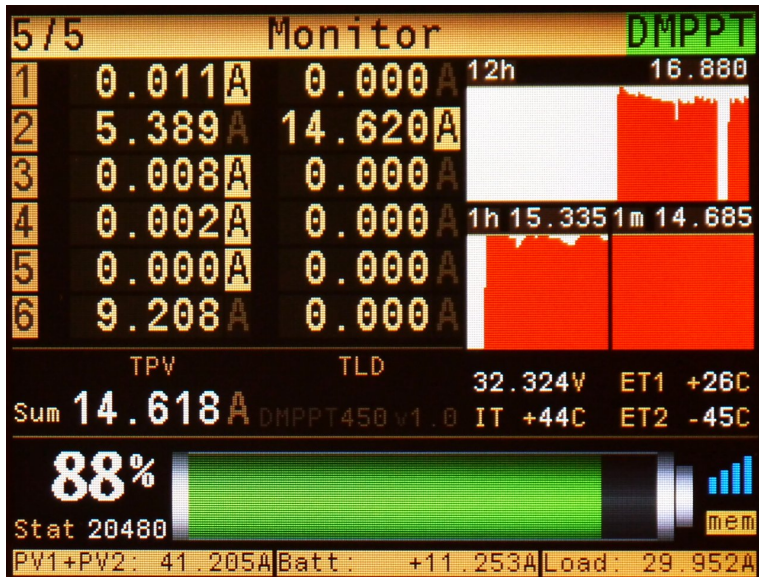
10.3 Parameter settings

The parameter settings menu is important and the first you will use when you instal the SBMS since you need to select your battery type.
Fortunately the settings are simple since all you need to do is select battery type probably type 1 "LiFePO4" since that is the most cost effective
battery for stationary energy storage do to is long cycle life compared to other type of lithium batteries and also one of the safest batteries.
Then next thing you select is the number of cells probably 8 cells or in some case 4 cells if just a 12v equivalent system is needed and the circuit
diagram on the bottom will auto update to show you how to make the connections for different number of cell configurations starting with a
minimum of 3 cells and up to max 8 cells.
The third and last setting is the battery capacity in Ah and this is needed so that SBMS can know to calculate the real SOC (State Of Charge) for
your battery pack.
In the example below is my small 20Ah A123 system battery but the settings is set at 18Ah because that is the real capacity I measured and using
that will give me a more accurate SOC calculation.
Then just push the Store Parameters button and a green progress bar will show up briefly (about 2 seconds) indicating that data is written to the
ISL94203 EEPROM and for this to take effect a power cycle will be needed as explained in install instructions.
*the parameters can not be set while SBMS is powered by USB you need to be connected to a battery to use Store Parameter button.
**notice the diagram for cells setup based on 4,7 or 8s where all cell monitoring wires are used exactly as in the diagram so for 7s green and yellow are connected together.
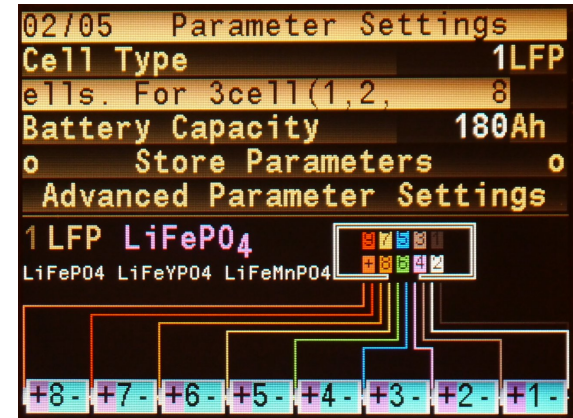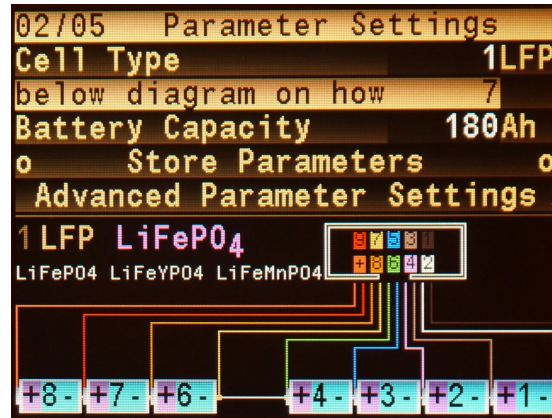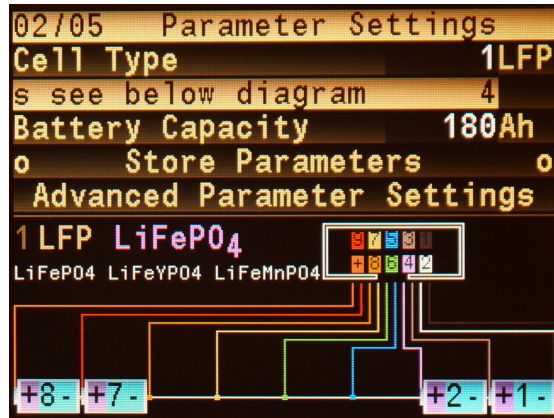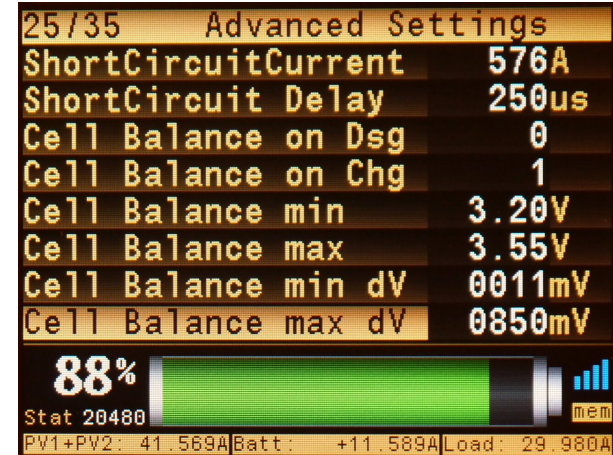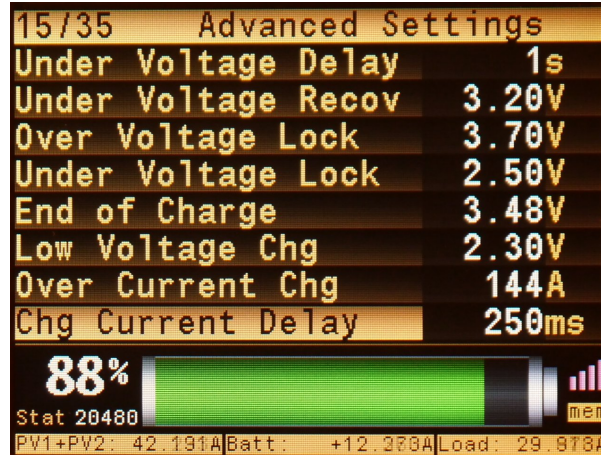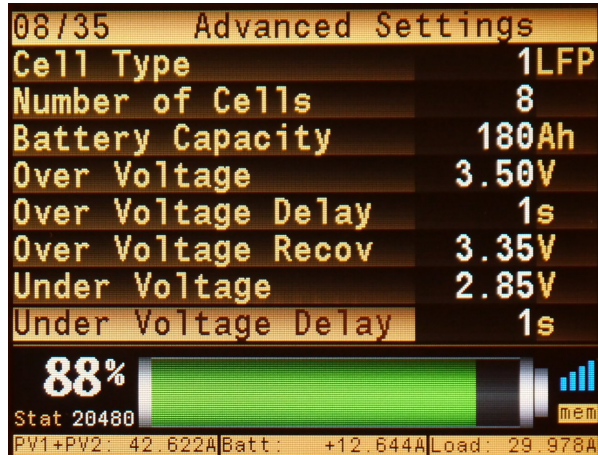
10.3.1 Advanced parameter settings

The advanced parameter settings contains over 30 parameters related to battery charging and discharging and for most users this is not something they will want to mess with :) . If you think you have strong knowledge about how the Lithium cells should be charged then just read the build in scrolling help explaining each parameter.
The default parameters that I carefully selected for long battery life are good for most cases. Unless you want something specific and you understand the implications of changing this settings is better not to change settings in this menu.
If you do change one parameter look also at the rest of them since there are probably related parameters that need to be changed also in order for the charge and discharge to work correctly.
When entering from the main menu in the Parameter setting the parameters displayed in both simple and advanced are the one currently set in the ISL94203 when you select a Cell Type all the values will be set to default.
*the parameters can not be set while SBMS is powered by USB you need to be connected to a battery to use Store Parameter button.

```
08/35     Advanced Settings
Cell Type                  1LFP
Number of Cells               8
Battery Capacity          180Ah
Over Voltage              3.50V
Over Voltage Delay           1s
Over Voltage Recov        3.35V
Under Voltage             2.85V
Under Voltage Delay          1s
88%  ████████████████████
Stat 20480
PV1+PV2: 42.622A Batt:  +12.644A Load: 29.978A
```

```
15/35     Advanced Settings
Under Voltage Delay          1s
Under Voltage Recov       3.20V
Over Voltage Lock         3.70V
Under Voltage Lock        2.50V
End of Charge             3.48V
Low Voltage Chg           2.30V
Over Current Chg           144A
Chg Current Delay        250ms
88%  ████████████████████
Stat 20480
PV1+PV2: 42.191A Batt:  +12.270A Load: 29.973A
```

```
25/35     Advanced Settings
ShortCircuitCurrent        576A
ShortCircuit Delay       250us
Cell Balance on Dsg          0
Cell Balance on Chg          1
Cell Balance min          3.20V
Cell Balance max          3.55V
Cell Balance min dV     0011mV
Cell Balance max dV     0850mV
88%  ████████████████████
Stat 20480
PV1+PV2: 41.569A Batt:  +11.589A Load: 29.980A
```

10.4 Device settings

10.4.1 Time & Date

To enable internal data log you need to set the time and date. While in the time and date menu the data logging is disabled but once you get out of that menu after you set the date and time the internal data log is enabled and you will see the "mem" symbol under WiFi symbol highlighted. New option since 3.0g version was added allowing automatic reset of energy counters every 24h at midnight.

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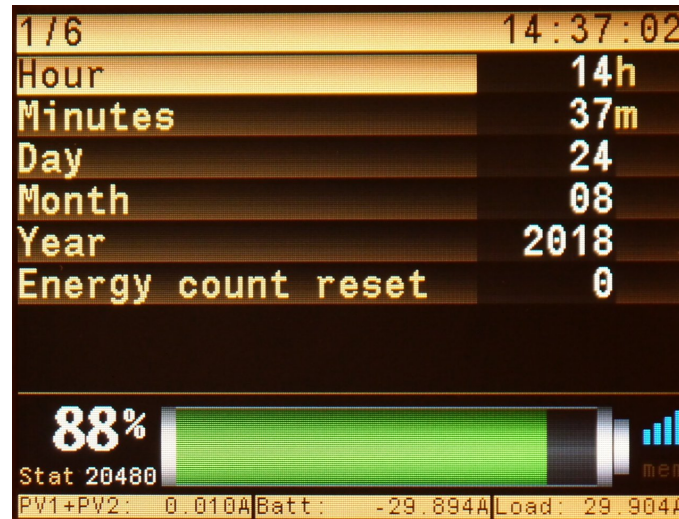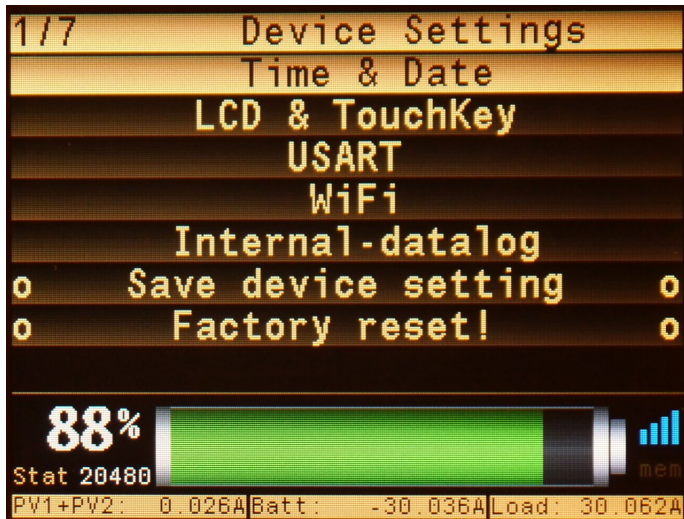
10.4.2 LCD & TouchKey

The LCD & TouchKey menu has 4 settings.
Back light level *has a value from 1 to 32 and will affect the brightens of the LCD's LED back light with 1 the lowest setting and 32 the highest. The LED current limiting is an analog constant current level no PWM dimming is used so there will be no flicker.*
Menu color *allows you to change the color scheme from 0 to 9 with number 2 set as default. A large percentage of people especially men are color blind with most of them not being able to see red, green or both and in that case the default yellow/orange color is quite bad (is not so high contrast even for people that see all colors) and you should probably select the light blue number 9 for more visibility or try the other colors to see what looks best for you.*
Back light time out *is the amount of time in minutes until the back light level will enter a low power mode were level will be set to 5 if no keys are touched in this interval of time. Sting a lower level or even turning off the LED will not save any significant amount of power so I decided to have level 5 as low power mode. If set to zero it will never enter low power mode.*
Key lock time out *is the amount of time in minutes until the capacitive touch keys will be locked and to unlock you will need to push 3 keys in the flowing order OK,UP,DOWN (there will be on screen instructions about this). If set to zero keys will never get locked.*
Invert Color *(option added since firmware 2.0) allows to reverse colors so you have a white background instead of default black.*

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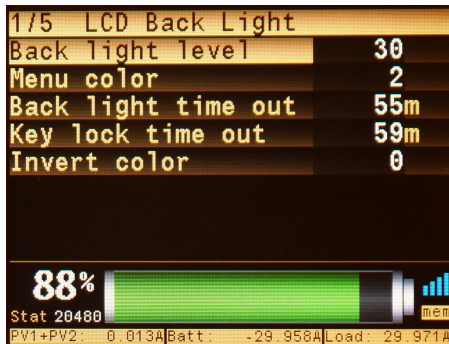
10.4.3 USART

The USART RX and TX pins are available on the 20 pin connector for the user but they are also used by the WiFi module so if you want to use the serial port the WiFi can not be used.

When you set the USART data log on 1 the WiFi will automatically be deactivated. You may also want to set the bit rate lower since that default 921.6kbps is used by the WiFi module.

The log interval represents the interval at witch the compressed log data will be sent over automatically (no request is necessary). You just need a device reading and storing the data.

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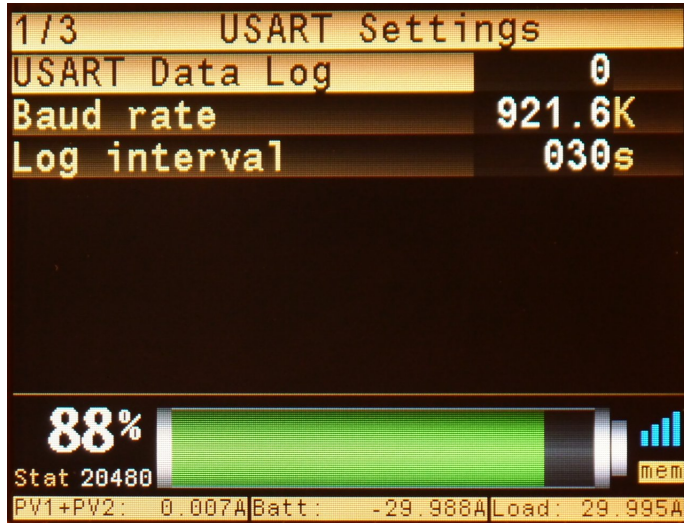
10.4.4 WiFi settings

The SBMS has an internal WiFi module based on the popular ESP32.
The WiFi is set as an AP (access point) and you can select the channel, the AP name (useful is you have more than one SBMS) and you can also set a password if you want there is none by default. The lower part is the raw response of the module to CWSAP command if WiFi module is ON.
Disabling the WiFi will power down the module and that is the best way to save power (not that is needed with the huge battery capacity used in offgrid).
Check page 19 for more details on the WiFi

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10.4.5 Internal data log menu

You can download one month at a time worth of data from the internal 128Mbit (16Mbyte) internal SPI Flash memory that can store the last 12 months worth of data.

The progress that normally takes around 40 to 50 seconds is shown as a matrix of small rectangle each representing one of the 744 hours in a full month. The ones with a different color represent a transmission error but that will be "corrected" so there will be no missing data but there may be some data sent twice still not a problem since no data is missing.

For more details on how to use this to download data over WiFi check

Not implemented since the new ESP32 has no support for bulk data transfer as the old ESP8266. Will need to find an work around in the next firmware release.

The work around since firmware version 3.0g is to allow download over UART (serial port) of the internal log data.

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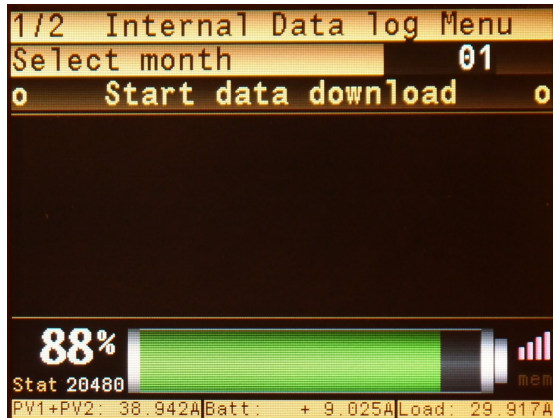
10.4.6 Save device settings & Factory reset

There are two buttons one that will save all the settings made in the Device Settings menu except for the time and date settings and all the settings in the Automation menu. After the power to SBMS is removed this data will be in the internal Flash memory so they will be loaded at power up.
The Save device settings will just give you a confirmation that data were saved but the Factory reset (that actually just deletes this saved settings so that default are loaded initially) needs also a confirmation.
So for Factory reset you need to push OK once then it will ask to confirm by pushing the OK button again.

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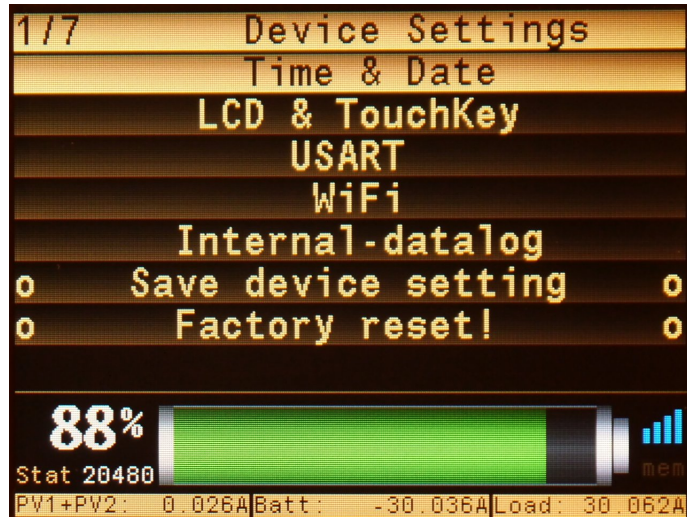
10.5 Automation (EXT IO & ADC)

In this menu you can see the 16pin connector pinout and you can set the 4 EXT IO pins as one of the 5 types including the possibility to change state when battery SOC is above or below a user defined SOC.
In the ADC settings you can set ON/OFF and external load see *page 13* for more details and you can also manually calibrate the internal current readings by fine adjusting the internal current shunt value. The default should be close enough in most cases.
The current sense amplifiers used for PV and ExtLoad can have a positive or negative offset. In case the offset is positive the auto-calibration done when SBMS powers ON can be done correctly. Since ADC inputs (with the exception of battery ADC) are single ended and can only see a positive voltage as reference to ground it will not be able to see a current sense amplifier negative offset (offset has to do with manufacturing tolerances) and a manual correction may be necessary. The offset is usually very small and will translate in just a few mA worst case 300mA.
You will notice that at a small current there will be no reading and after current is above the offset level the reading will exist but it will have the subtracted offset value. If you add that offset in here the reading will be more accurate since it will include that negative offset.

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DMPPT Settings

This is only useful when you have a DMPPT450 paired with the SBMS.

Max PVOUT Current: *refers to the amount of current DMPPT450 will provide to SBMS as DMPPT450 will typically have a large PV array up to 450A STC and the current will need to be limited to the battery capabilities and battery long life. (You see 50A limit set for my particular 180Ah LiFePO4 battery as that is about the ideal max charge current for long life around 0.2 to no more than 0.3C)*

Max SOC: *at the beginning of each new day the battery will be fully charged 100% SOC but after first full charge each subsequent charge can be caped to the value set here in this example 90% and so DMPPT450 will not send any charge current until the SOC drops below so 89% and it will stop when it gets above so 91% to maintain this state of charge for the remaining of the day.*

TLD235 & TLD146 1Heat 2Cool: *there are 6 thermal Load outputs on the DMPPT450 and they are split in to two groups. The first group is made of output's 2,3 and 5 and are limited to 50A while the second group is made of remaining outputs 1,4 and 6 limited to 100A.*

Setting this to 0 will disable the respective group, setting to 1 for heating applications and setting to 2 for cooling applications (cooling with peltier elements).

TLD235 & TLD146 Temperature: *the temperature limit can be set individually for for each of the two groups but if you only want a single large group you just set them at the same temperature.*

for details please check the DMPPT450 user manual.

only use the provided communication cable between SBMS and DMPPT as that has the build in protection needed.

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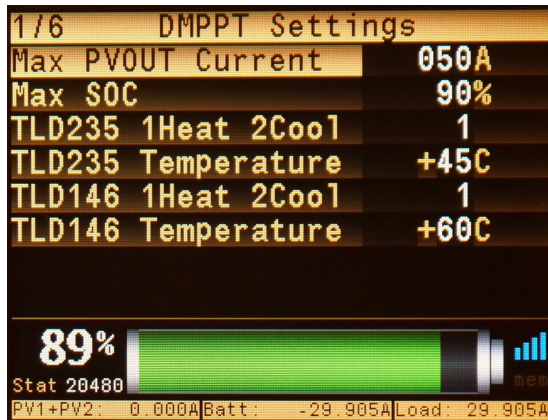
10.6 Diagnostic

This is just useful for development there are some raw ADC readings and the content of the ISL94203 memory again as raw data. Since I used this during development I decided to leave in the final release but is not useful for most people.
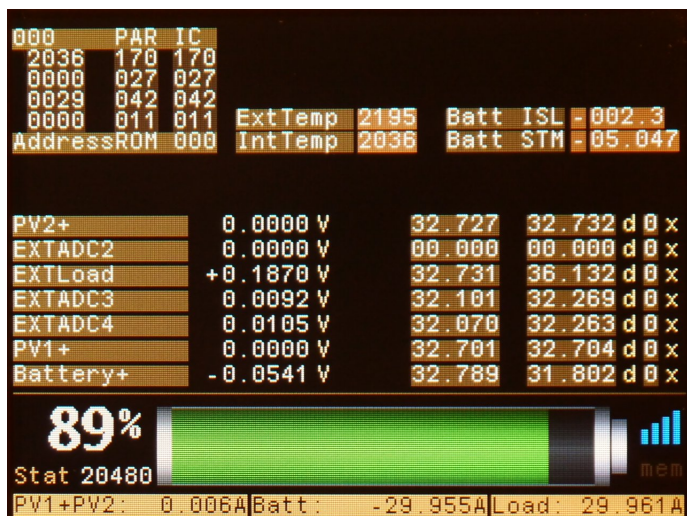
10.7 Manual & Install menu

The SBMS has build in install instructions and a basic manual so if you do not have this pdf manual but have access to SBMS and an micro-usb cable you can read the install instructions from the SBMS LCD.

this pdf manual is more up to date and detailed so use this one.
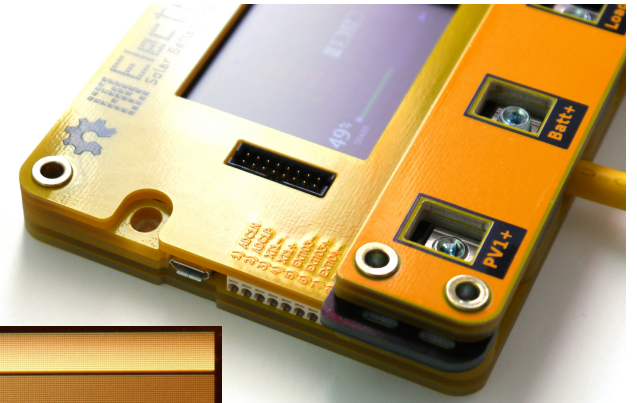

```
1/8          Install steps
 Step 1
Connect the Batt+ power connector to battery
positive terminal with a max 2m (6ft) of
16mm2 (#6AWG) flexible copper wire with 200C
silicone insulation (check manual for more
details about the recommended cable).
Make sure this is the first connected and
last to be removed.


 89%  [███████████████████      ] .ııl
Stat 20480                            mem
PV1+PV2:   0.008A Batt:   -29.968A Load: 29.976A
```

```
01/19            Manual
 Table of Contents
Specifications.....................02
Thermal management.................05
Cable selection....................10
External Load......................13
External Temperature...............17




 89%  [███████████████████      ] .ııl
Stat 20480                            mem
PV1+PV2:   0.003A Batt:   -29.984A Load: 29.987A
```

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10.8 About menu

The about menu offers some important information. On top of the expected model number, hardware and software version you also have an energy counter for PV1, PV2 and Battery that are separate from the resettable counters on the monitoring menu.

This counter has no option to be reset and the counter value will be saved once every 24h in the internal flash memory so the value will be there even after a power cycle.
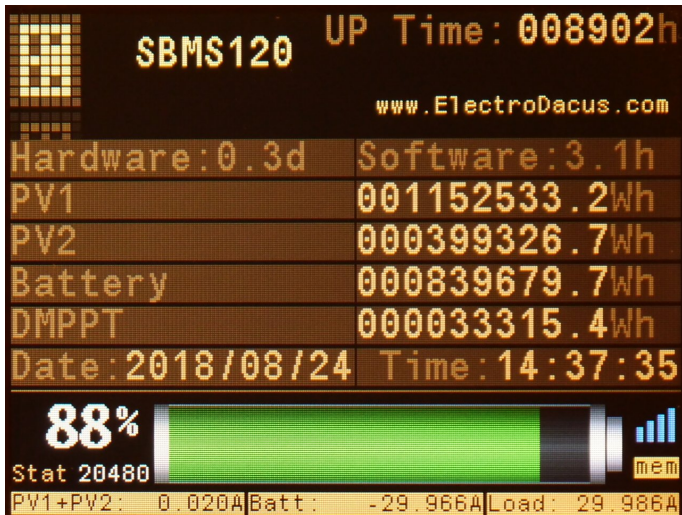
There is also an UP Time counter that will count the number of hours the SBMS was powered.
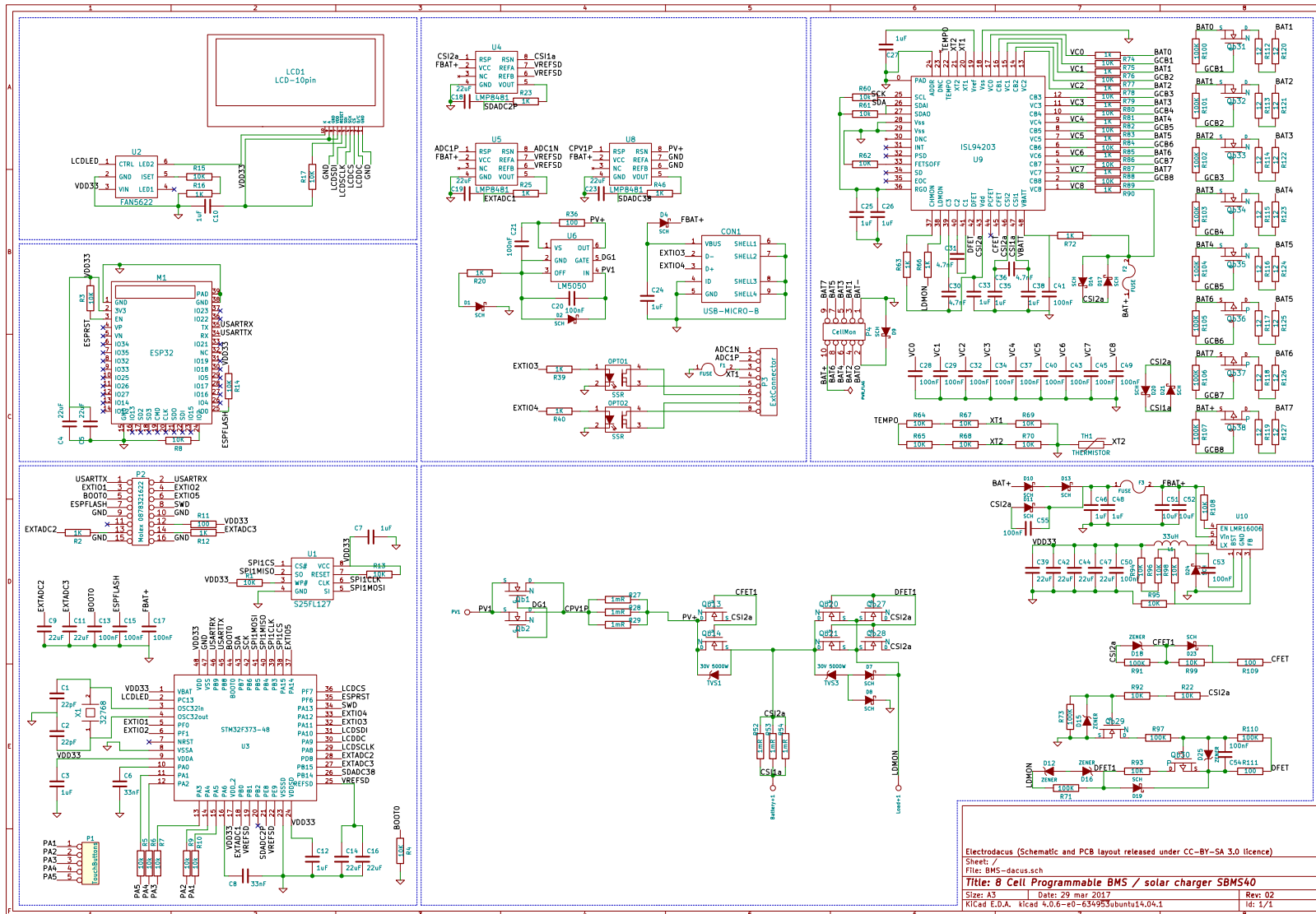
This screen capture below is from the SBMS120 installed on my house A123 180Ah 24V battery connected for a bit more than a year 371 days (8902h).

Total energy used was 1551.8kWh with a part of it was used directly by load but also a significant part 839.7kWh was used from the battery.

An average of about 4kWh/day was used typical for my house needs around 120kWh/month.

The DMPPT450 was just installed so there is not much just around 33.3kWh used for some tests on the last few days and this represents energy used by the heating elements and this will be by far the largest energy usage as it will be used to fully heat my house.
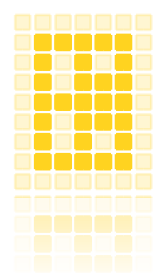
8 Cell Programmable BMS / solar charger SBMS40

Sheet: /
File: BMS-dacus.sch

Title: 8 Cell Programmable BMS / solar charger SBMS40

Size: A3   Date: 29 mar 2017   Rev: 02
KiCad E.D.A.   kicad 4.0.6-e0-634953ubuntu14.04.1   Id: 1/1
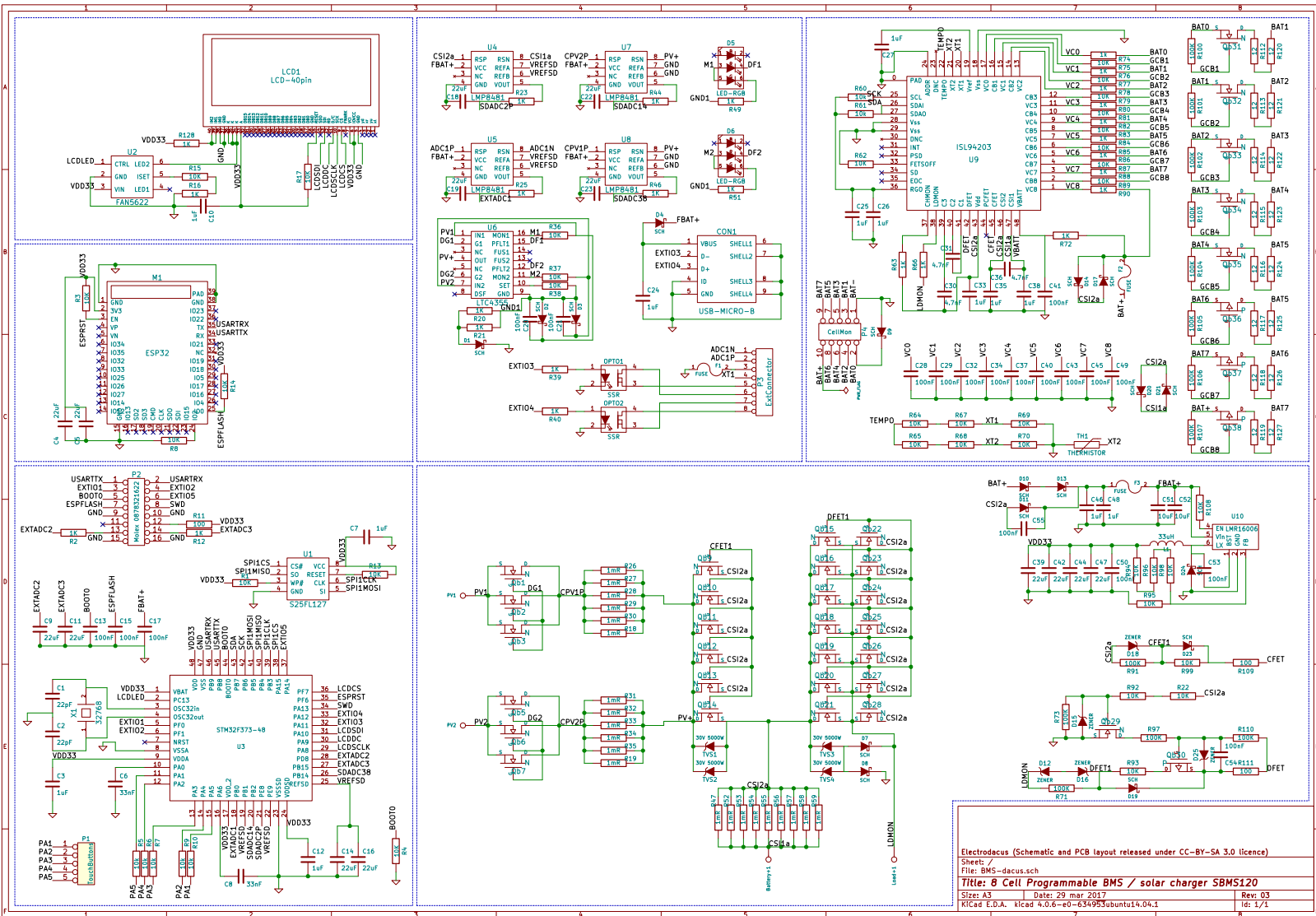
Electrodacus (Schematic and PCB layout released under CC-BY-SA 3.0 licence)
Sheet: /
File: BMS-dacus.schem
Title: 8 Cell Programmable BMS / solar charger SBMS120
Size: A3 | Date: 29 mar 2017 | Rev: 03
KiCad E.D.A. kicad 4.0.6-e0-634953ubuntu14.04.1 | Id: 1/1

SW and HW files for SBMS40 and SBMS120

HW : http://electrodacus.com/SBMS120/HW/SBMS_HW.zip
SW : http://electrodacus.com/SBMS120/SW/SBMS_v3.2h.zip
Firmware binary : http://electrodacus.com/SBMS120/SW/SBMS_v3.2h_bin.zip

SBMS40 / SBMS120

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