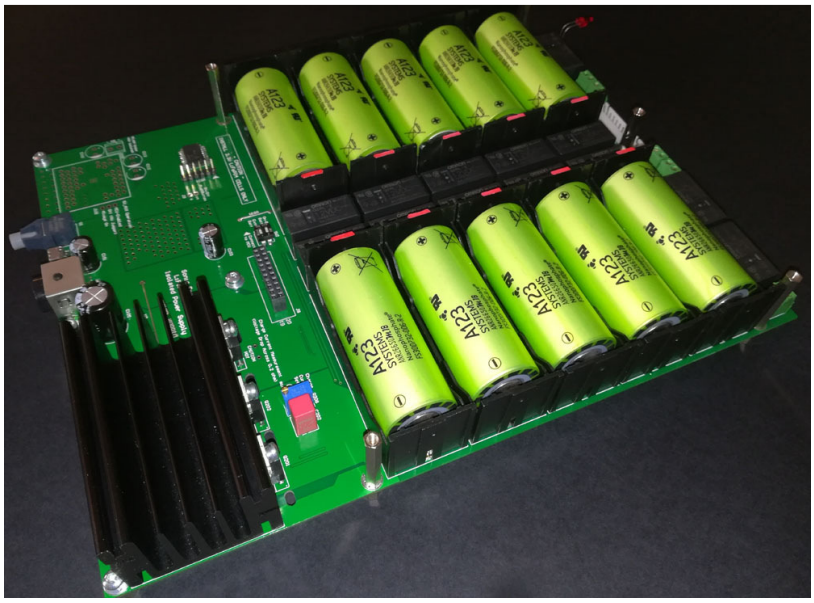
TWRPS-LBS-M LiFePo4 batteries power supply main board



This board is part of the new LiFePo4 batteries power supply system. This is the main board intended to supply oscillators, frequency doublers, FIFO buffer and so on. It provides the control for the whole system.

Features:

Input: PSU TWRPS-LBS-P

Output voltage:

- 3.3V to 16.5V, typically for oscillators

- 2x 3.3V to 6.6V, typically for DAC

- 3.3V, for LVCMOS digital devices (for example the clock section of the FIFO)

- 5V 500mA linear regulator to supply other devices like USB to I2S, and so on

Board size: 260mm x 195mm

Board options: finished and semi-finished

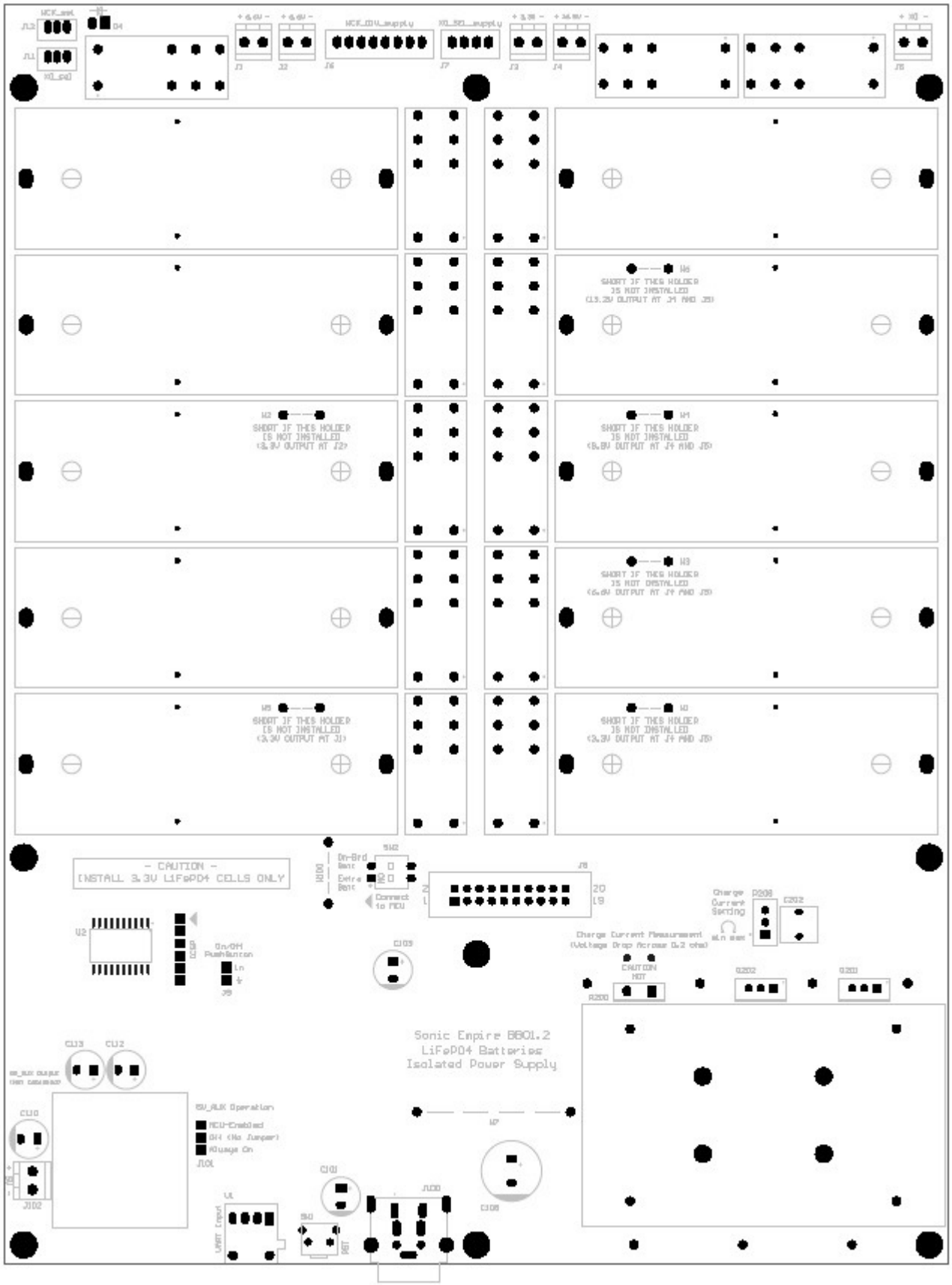
Note: supplied without batteries and battery holders

Remote power On-Off

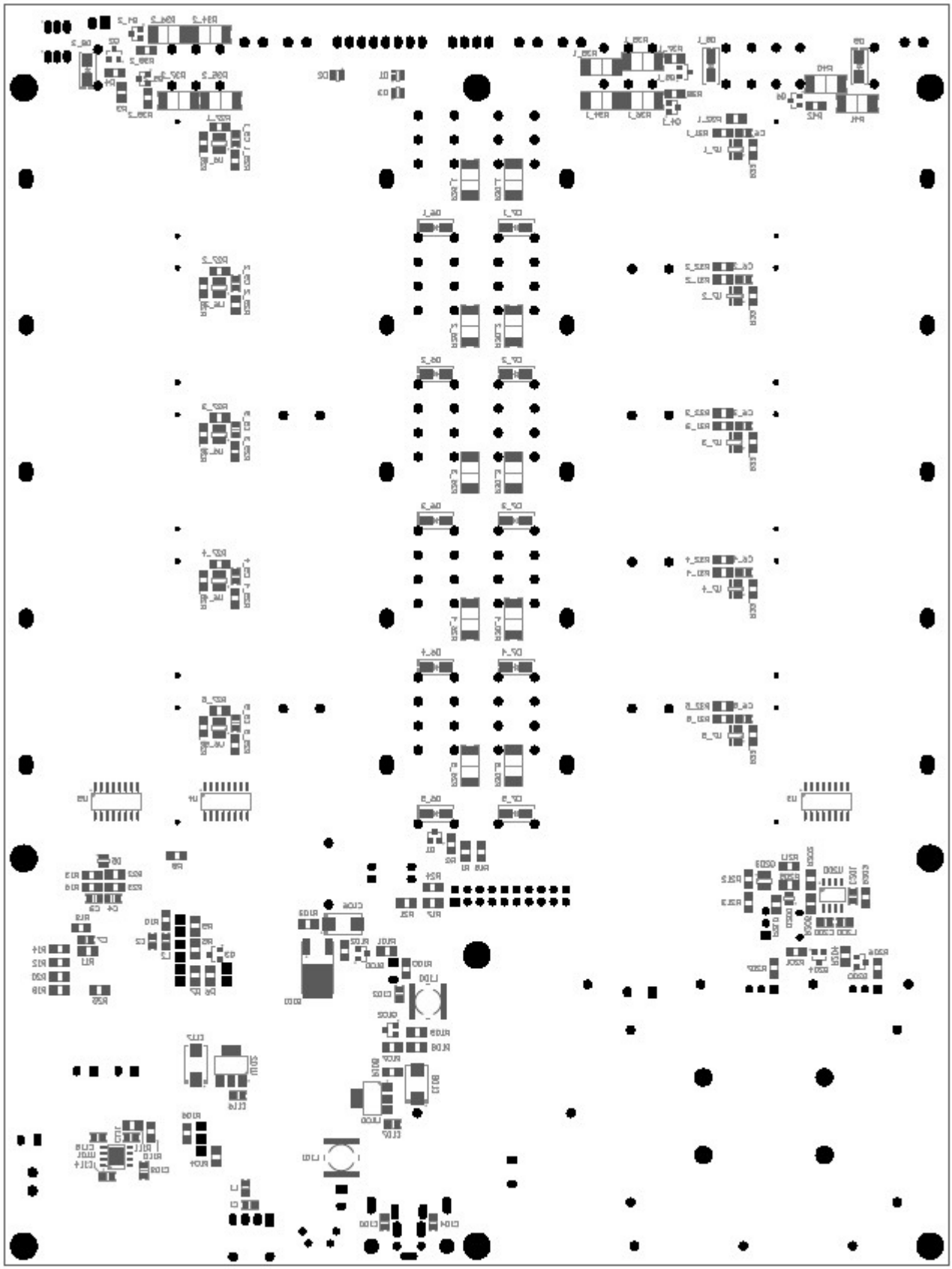
No switching devices or active oscillators during listening

No RF emissions at all (no multiplexed display, microcontroller sleeps in stand-by mode during listening)

PCB layout (Top view)



PCB layout (Bottom view)



Connectors and switches

J1: 3V3 or 6V6 output rail (depending on the installed batteries).

J2: 3V3 or 6V6 output rail (depending on the installed batteries).

J3: 3V3 output rail. It can be used to power the clock section of the TWSAFB-LT FIFO Lite.

J4: 3V3, 6V6, 9V9, 13V2 or 16V5 output rail (depending on the installed batteries). It can be used to power the oscillators and the frequency doublers.

J5: same output rail as J4 with 13-13.5V backup from linear regulator to power the oscillators during batteries recharge. It can be used instead of J4 to the oscillators always on.

J6: Reserved for future use.

J7: Reserved for future use.

J8: 20 pin header to fit the TWRPS-LBS-D daughter board. Install only if the daughter board is in use. Suitable connector is Samtec SSW-110-01-F-D (Mouser part# 200-SSW11001FD). It is provided separately with finished board option.

J9: On-Off function. A push-button or a switch have to be used in order to switch on and off the output rails. It's a good practice to switch off the output rails when the power supply system is not in use to avoid batteries discharging. When the board move to recharging state, the output rails are disconnected. Once the system has completed the recharge, the push-button connected to J9 has to be pressed again to reconnect the output rails.

J10: Reserved (ICSP).

J11: Reserved for future use.

J12: Reserved for future use.

J100: Input power supply for batteries charging and oscillators supply backup. Use a 4 wires cable to connect the output connector installed on the TWRPS-LBS-PSU. The 7V conductors have to be large enough to carry the high current from the PSU (3-4 A).

J101: 5VDC auxiliary regulated power supply control (if the ADM7151 regulator is installed). Use a jumper to select the desired operation: Off (No Jumper) means regulated output disabled, MCU-Enabled means the regulated output is activated by the MCU when the board is operating, Always On means the 5V regulated output is always active.

J102: 5VDC low noise regulated power rail output (if the ADM7151 regulator is installed).

Charge current measurement test point (close to R200): Use this test point to measure the voltage drop across R200 (0.2 Ohm) in order to calculate the charge current. The current is calculated by the Ohm's law I=V/R where V is the measured voltage and R is 0.2 Ohm. For example: measuring 0.5V the charge current is 2.5A (0.5V/0.2R=2.5A).

SW1: MCU reset. Use this button to reset the system.

SW2: Use the dip-switch to force batteries disconnection from the circuit. Use this function to prevent batteries discharging when the board is not used for long time. The upper switch disconnect the batteries of the TWRPS-LBS-M main board, while the lower switch disconnect the batteries of the TWRPS-LBS-D daughter board. When the switches are in the ON position the batteries are connected to the circuit.

Settings

The only necessary setting is the charge current. The max charge current is around 2.5A.

Turn the trimmer R208 to set the charge current at the desired value using the Charge current measurement test point.

The charge current might be set to the maximum value without any damage for the batteries. The charge current should be decreased if not all the batteries are installed. As a rule of thumb, 250mA for each battery can be used as reference to set the charge current.

Getting started

Both finished and semi-finished boards are supplied without batteries and battery holders.

A good source for the LiFePo4 batteries is NKON: https://eu.nkon.nl/a123-systems-anr26650m1b-a-grade-3-3v-a-grade.html

CAUTION: INSTALL 3.3V LiFePO4 CELLS ONLY.

Battery holders can be sourced from Aliexpress or eBay.

Suitable battery holders.

The battery holders should be installed only if the cell has to be installed. Don't install the battery holders on unused rails.

Use zip ties to keep the batteries securely in place.

The rails from series batteries, like both 6V6 and 16V5 rails, can be adjusted to get lower output voltage than the nominal one: install the required battery holders to get the desired output voltage, for example to get 3V3 from one 6V6 rail only one batter holder has to be installed. Then, in place of the other battery holder, install a jumper as indicated on the PCB overlay.

CAUTION: DO NOT INSTALL BOTH BATTERY HOLDER AND JUMPER IN THE SAME BATTERY REGION TO AVOID SHORT CIRCUIT.

CAUTION: don't install new battery when the other cells are already charged and the board is switched on to avoid overvoltage of the batteries that are already charged. Firstly switch off the board, then install the new battery and wait at least 2-3 hours. This way the higher level cells yield energy to the low ones, balancing the charge of all the installed cells.

There are 2 available options for this board:

- finished boards (fully assembled and programmed)

- semi-finished boards (users have to solder some parts, mostly TH)

The BOM for semi-finished board is available at post #164 on the diyaudio.com thread: The Well Regulated Power Supply.

Notes on semi-finished board

The semi-finished board option needs some parts to be soldered (mostly through hole parts), both on the top and the bottom layer.

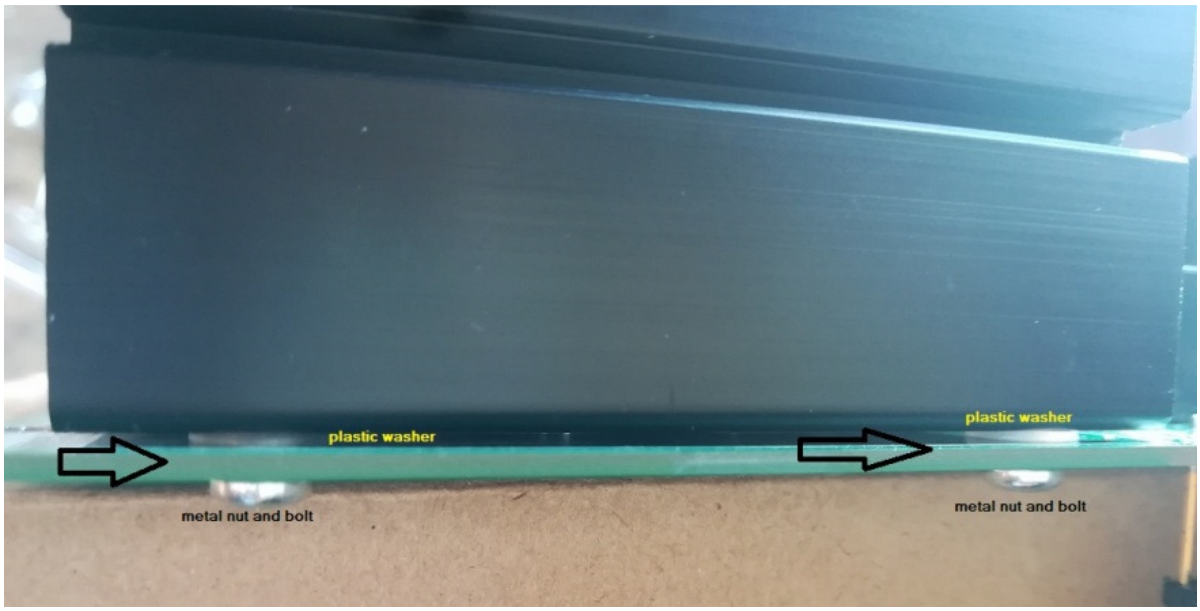
There are a few things to pay the maximum attention:

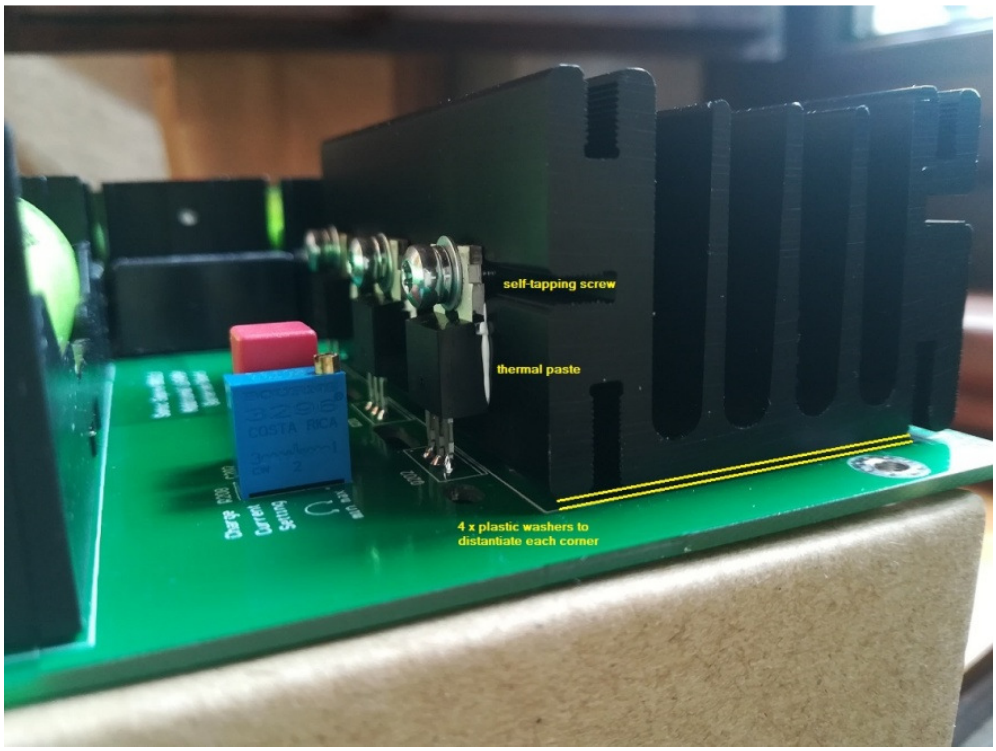
- be careful installing connectors and polarized parts with the right orientation, the component orientation is clearly visible on the PCB overlay

- pay particular attention to the comparators to be soldered on the bottom layer (part MCP65R41T-1202E/CHY) because the laser marked pin 1 is not well identifiable. If the orientation of the component is not respected the cell undervoltage protection will not work and some batteries could be damaged.

- do not install the ADM7151 if the 5 VDC regulated output will not be used

- be careful assembling the heat-sinks and the components attached to them; the heat-sink has to be spaced from the PCB using 4 plastic washers (one for each corner), then they have to be blocked with M3 screws (10mm length). To align to the heat-sink slot, TO220 parts should be soldered after the heat-sink has been installed and their tabs have been fixed with M3 screws (6mm length) - caution: aluminum is not so hard, be careful when tightening; use thermal paste to improve thermal transfer to the heat-sink;





Operation

For the LiFePo4 cells, the following threshold voltage levels are used to determine the state of charge:

- 2.5V cells under voltage

- 3.28V low cells default voltage

- 3.32V cells minimum operating voltage (allows power-on during recharge)

- 3.52V end-of-charge voltage

- 3.8V cells overvoltage (abnormal)

During fault condition or recharge, power-on command is not allowed so it is ignored.

Overload of maintaining regulator is always checked during power-off. Overload at batteries outputs is checked only when relays are activated: if currents are within limits, the sensing resistors are bypassed and control is no longer possible; if an overload condition is detected the batteries are straightaway disconnected and the maintaining regulator is shutdown. The proper error condition is forced.

Low batteries detection forces off state of the device, so the output rails are disconnected and recharge starts. Following switch-on requests from the pushbutton are evaluated, if the voltage of the cells is equal or greater than 3.32V, early exit from recharge is allowed, otherwise it is ignored.

If the batteries are deeply low, pulsed conditioning charge is tried. If the batteries are normally low they are recharged. Output rails are always disconnected during recharge.

When the batteries are full, the fast charge is stopped and the output rails are ready to be activated by the On/Off push button.

If recharge time is excessive or batteries are in overvoltage condition the proper fault state is forced. This means that at least one cell is defective and has to be replaced.

At the end of charge, or at an early exit from it, settling time is calculated based on cells' voltage: min. 10 seconds, max. 4 minutes. During this period, On/Off button pressures are retained, they take effect when settling time has expired. If no power-on command is detected the system enters a suspend state.

In case of an early exit from the recharge process (power on during recharge) the recharge state is resumed at power off.

Power on sequence:

- output rails with series sense resistors are connected

- output current is checked

- fault condition is evaluated

- if all the controls are passed the sense resistors are bypassed

- low batteries detection is activated

Power off sequence:

- maintaining regulator is enabled

- output rails are disconnected

- batteries level is measured, if they are low, recharge starts.

Status indicator (LED D4)

The LED D4 should remain visible because it's used to indicate the operation and the failure messages of the board.

It indicates the actual function of the board and the error in case of failure as in the following list:

off: outputs rails are disconnected, oscillators are powered from the maintaining regulator;

on: power is supplied from the batteries;

fast blinks: push button or switch detection phase (can be bi-stable or mono-stable), occurs only once after a reset or when the board is connected to the power supply, switch must be operated congruently not to mislead the processor;

2 blinks and a pause: drained cells pre-charge operation;

3 blinks and a pause: battery fault (output rails are disconnected, On/Off detection is disabled);

4 blinks and a pause: overload fault (output rails are disconnected, On/Off detection is disabled);

normal speed dimmer (1 dimming cycle and a pause): cells fast charge operation;

double speed dimmer (2 fast dimming cycles and a pause): power-on allowed (early exit from recharge);

continuous dimmer: batteries settling period, wait until it finishes.