

LiPo-Balancer

Version 6, April 2004

1. Benefits of using LiPo-Balancers for your packs

LiPo-Balancers eliminate the problem of cell imbalance, allowing your valuable LiPo packs to reach their maximum life span. Traditional LiPo protection circuits simply terminate the charge when one cell goes above 4.25 Volts. This gradually reduces pack capacity because the imbalance slowly increases with each cycle. LiPo Balancers allow the charging process to continue until ALL cells have reached 4.20V while still protecting each cell from overvoltage.

Warning: You will still need a suitable LiPo charger to charge your pack at higher rates than 200mA. While LiPo-Balancers make charging safer and more convenient, their primary function is cell balancing and overvoltage protection. See the safety tips at the end of this manual.

Packs equipped with LiPo-Balancers need no center taps. There is no need to charge cells individually. It is even possible to charge these packs at up to 200mA constant current using any low cost charger or other current limited power supply. You may use this feature to format your newly built LiPo pack similar to traditional NiCd or NiMH packs. Simply charge the pack at 200mA until all LiPo-Balancers are flashing.

2. How to add LiPo-Balancers to your pack

You need as many LiPo-Balancers as you have cells in series. Parallel cells always share one balancer. For example, you need 3 LiPo-Balancers for a 3s1p pack and also 3 LiPo-Balancers for a 3s4p pack. For a 10s4p pack, you need 10 LiPo-Balancers.

LiPo-Balancers are thin and robust. You may simply tape one LiPo-Balancer to each cell (or parallel group of cells) before you put the heat shrink on.

Each LiPo-Balancer has a red wire and a black wire. Connect the red wire to the positive terminal of a cell or group of parallel cells. Connect the black wire to the negative terminal of the same cell or group.

Please use clear heat shrink so that you can see the red lights through the heat shrink.

We do not recommend that the balancers are made up into unpluggable units. If you wish to use the balancers in this manner provision has to be made to allow them to be unplugged safely – please contact CSMs technical department for instructions.

3. How it works

Each LiPo-Balancer contains a precision voltage reference, a voltage comparator, seven discharge resistors, a power switch, and a pulse-width modulator. When the cell voltage rises above 4.20 Volts, the comparator activates the power switch, turning on the red light and allowing the cell to discharge in a controlled manner. Discharge current is pulse-width modulated. It will start with short pulses at 4.21V and reach "continuous on" at 4.24 Volts. The pulse width modulation is quite slow, so by watching the red lights you can see what each LiPo-Balancer is doing.

4. Meaning of the red light(s)

a) Permanently off:

This is the idle state. Cell voltage is below 4.21 Volts. The LiPo-Balancer is monitoring cell voltage, but not actively discharging. Current draw in this state is an order of magnitude lower than the self discharge current of the cells.

b) One or more lights are flashing:

Normally this will happen near the end of charge. It tells you that the flashing balancers are protecting "their" cells from being overcharged. The other cells in the pack continue to be charged until full. This is the time when the LiPo-Balancers automatically re-balance your pack.

A typical example would be a 3s1p pack where, after a few dozen cycles, the outer cells measure 3.6 Volts and the middle cell 3.4 Volts at the end of a discharge cycle. Charging the pack without LiPo-Balancers to 12.60 Volts will yield end-of charge voltages of approx. 4.25V, 4.10V, and 4.25 Volts. The pack is now severely out of balance, and useable capacity is already reduced to less than

90%. During the following discharge cycle, the middle cell will probably be deep-discharged, because it will be empty much sooner than the outer cells. This increases the amount of imbalance, and after a few more cycles, the pack will be unuseable.

The same pack with LiPo-Balancers will start flashing the outer LEDs and bypass the outer cell's charge current as soon as they reach 4.21Volts. The middle cell's LiPo-Balancer will not flash and this cell will continue to be charged until the pack reaches 12.6 Volts and the charger terminates. At this point, all cells are charged to 4.20Volts again, giving the pack its maximum capacity back.

c) One (or more) lights are permanently on:

The LiPo-Balancer cannot keep the cell voltage below the critical value, because the charge current is higher than the maximum discharge current of the LiPo-Balancers. **This is a potentially dangerous situation and the charging current must be reduced to 200 mA immediately.** Only then will the LiPo-Balancers be able to discharge the overcharged cells to a safe value before they are permanently damaged.

This may happen, when the pack is severely out of balance, or when you build a new pack from differently charged cells and charge it with high current. Such a pack should be charged one time at 200mA until all LiPo-Balancers are flashing.

d) All lights are flashing and the charger continues forever to charge at a low rate:

This means that your charger tries to charge the cells to more than 4.21 Volts per cell. The LiPo-Balancers won't allow this. This is nothing to worry about, but you wouldn't want to use this charger for packs that are not protected by LiPo-Balancers.

e) All lights are off during the complete charging process:

Congratulations! Your cells are fully balanced, and your charger terminates before the critical voltage is reached. The LiPo-Balancers have nothing to do.

5. Can I use a Zener diode and a LED as a cheap replacement for the LiPo-Balancers?

No. The idle current is way too high, the precision is orders of magnitude too low, and the "gray zone" between "off" and "on" would be much too wide.

Calibrating / Testing:

Each LiPo-Balancer is calibrated and tested before delivery. A band-gap reference and selected metal film resistors are used for precision and long-term stability. Re-calibration is not necessary, and, since it requires a low-noise voltage reference and SMD soldering skills, should not be attempted by the user.

A simple go / no-go test for LiPo-Balancers attached to a pack can be performed with only a charger and a digital voltmeter:

- a) Discharge the pack to approx. 4 Volts per cell. All red lights must be off.
- b) Charge the pack at 100 or 200mA and monitor all cell voltages.
- c) Each red light must begin to flash when the associated cell reaches 4.20 or 4.21 Volts.
- d) Stop the charge and wait until all red light stop flashing. At this point, all cells should be at 4.18 to 4.20 Volts.

If you can measure current draw, check that each LiPo-Balancer draws less than 10 Microamps when idle and more than 320 Milliamps when active.

Remember that most entry-level digital voltmeters are not very accurate. 1% accuracy means that 4.20 Volts may be displayed as anything between 4.16 and 4.24 Volts. Chances are, that the LiPo-Balancers are more accurate than your voltmeter.

Safety Tips:

Since any electronic device may fail silently without prior warning, it is recommended to follow the same safety measures for packs equipped with LiPo-Balancers that you would use for packs without these devices!

Use only chargers that have been specifically designed for LiPo packs.

Never charge any LiPo pack unattended!

Charge your packs in a fire resistant box and keep some sand (not water!) around to extinguish a burning cell or pack!

Each LiPo-Balancer must dissipate up to 1.5 Watts and may become quite hot while the red light is blinking near the end of charge. Please keep this in mind when mounting the LiPo-Balancers. Make sure that they do not touch any heat sensitive components. Also, do not touch the LiPo-Balancers while the red lights are blinking.

Specification (typ. values):

Discharge current: 335mA

100% duty cycle reached at: 4.23 Volts

Operating voltage range: 2.5V - 4.5V

Dimensions: 24.4mm x 14.5mm (950mil x 560mil)

Threshold voltage: 4.21 Volts +/- 10mV

Idle current: < 4 μ A @ room temp, < 10 Microamps at 85° C

Weight without wires and double sided tape: 1.0 grams (0.04 oz.)