Dawnmist Lithimon 234
Instruction Manual

Lithium Battery Monitor and Power Smoothing Circuit for Electric Models

Issue 1.0e: October 2008

Introduction

Lithium batteries are a useful addition to the world of electric models, but they have two main limitations: the Peak Pulse Effect and the risk of over-discharge.

The Peak Pulse Effect is a result of the pulsating load presented to the battery by Electronic Speed Controllers (ESCs). This load pulses regularly up to full current, no matter what speed the motor is set to, and these sharp peaks can easily overload a lithium battery. The symptoms are just the same as any overload: the battery appears to go flat, but if rested for a minute or two will recover and deliver several more minutes' power. Typical LiIon batteries are rated for 3.5–4C, therefore a 1.4 Ah battery (for example) can deliver up to 4.9–5.6 Amps. But because of the Peak Pulse Effect, a motor that draws 5 Amps at 'half-stick' actually draws peaks of about 10 A, which would demand either a battery with a 7C discharge capability, or a larger capacity of 2.8 Ah at 4C. Lithimon's energy-smoothing circuit solves the problem by assisting the battery during the peaks, while recharging itself between peaks, thus presenting the battery with a steady load of 5 A (in this example) rather than pulses of 10 A. A steady 5 A is within the capabilities of the 1.4 Ah, 4C battery. Thus the Lithimon can enable a lithium battery to perform at its full specified discharge rate, unimpaired by the Peak Pulse Effect.

Over-discharge prevention is also less simple than it seems: the basic principle, that the battery must not be discharged below a certain voltage (usually 3.0 Volts per cell), is straightforward, but this refers to off-load voltage and neglects the effect of heavy loads on the battery which cause a temporary voltage drop due to the internal resistance of the battery. Thus the precise cutoff point, and also the point at which a pre-cutoff warning is given, needs to be lowered under heavy load conditions. As a guide, under heavy load conditions a cutoff point of 2.7V per cell is appropriate, and under extreme conditions this may be further reduced to 2.4V per cell. To further complicate matters, the measurement must be based upon a short-term running average of the battery voltage in order to prevent either false alarms or over-discharge as a result of the load spikes and interference produced by the ESC and motor(s). Thus, a simple voltmeter is not suitable and will give misleading results. Something more sophisticated is required.

To solve these problems and make the Lithium battery useful, Dawnmist Studio has developed the Lithimon 234. This compact, lightweight unit is simply connected in parallel with the speed controller, and has two functions. Firstly it uses a pair of energy-storage capacitors to 'smooth out' the peaks of the ESC's energy demand — thus presenting an average, rather than peaked, load to the battery (these are purpose-designed capacitors, since regular 'over-the-counter' types cannot meet the demands of Lithium batteries). Lithimon supplies an extra burst of current to the ESC during the peaks to assist the battery, while recharging in between the peaks. This happens automatically, thousands of times per second. As well as curing the Peak Pulse Effect and allowing the battery to work right up to its full rated current without going flat prematurely, Lithimon also greatly extends the service life of the battery by avoiding overload conditions during every peak, and furthermore, reduces the heat generated in the battery (wasted power).

Without the Lithimon's energy-smoothing function, the only way to deal with the Peak Pulse Effect would be to use a much bigger battery, negating the principal advantage of Lithium technology — its light weight.

The second function of the Lithimon 234 is a sophisticated battery monitor which helps prevent over-discharging of the battery and consequent battery damage. Three ultra-bright LEDs, visible at a distance even in daylight, show the battery status, and an 85 decibel audible 'Land Now!' alarm activates when the battery reaches its limit. The battery monitor can be configured for 2, 3 or 4 cells (7.2, 10.8 or 14.4 Volts) and has three selectable discharge responses corresponding to a final cutoff of 3.0, 2.7 or 2.4 Volts per cell. An on-board microprocessor makes accurate measurements despite the spikes and variations in the model's electrical system by using advanced Digital Signal Processing (DSP) techniques. For higher-voltage applications, Dawnmist Studio also manufactures a Lithimon 5678, for 5, 6, 7 or 8 series cells and a Lithimon 9012 for 9, 10, 11 or 12 series cells.

Wiring Up

Wiring the Lithimon 234 into your model is simple: just connect the black and red wires in parallel with the main battery feed to the ESC (red is positive). See Figure 1 below. The Lithimon may be secured in any convenient position using servo mounting tape or double-sided adhesive pads. It is preferable to keep the connecting leads between the Lithimon and the ESC as short as possible, both to maximize electrical performance and also to save weight by cutting the leads to length. Do not be tempted to replace the leads supplied with thinner wire: high pulse currents have to flow to cancel out the Peak Pulse Effect, and the leads supplied are the correct gauge for this.

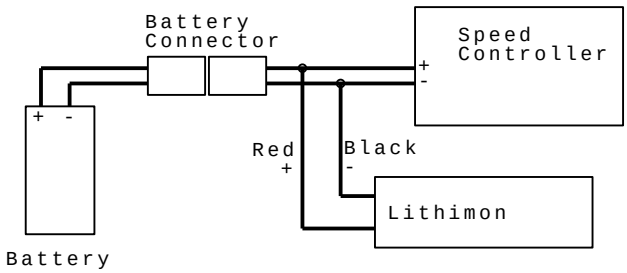

Fig. 1: Connecting Up

Setting Up

At the other end of the unit from the LEDs, you will see two jumper links. Each of these has three pins and a shorting link which connects the centre pin to one or other of the outer pins. These are just like the jumper links used in PCs, but smaller — use of tweezers is advised when moving the links. Their positions are shown in Figure 2 below. These links are used to set the number of cells in the battery, i.e. its voltage (J1), and the discharge profile, i.e. the cutoff voltage per cell (J2). By changing these links, the Lithimon may be reconfigured at any time — but please ensure that the battery is unplugged before moving the jumpers. Each jumper selects one of three options, depending on whether the link is at one end or the other, or no link is present at all.

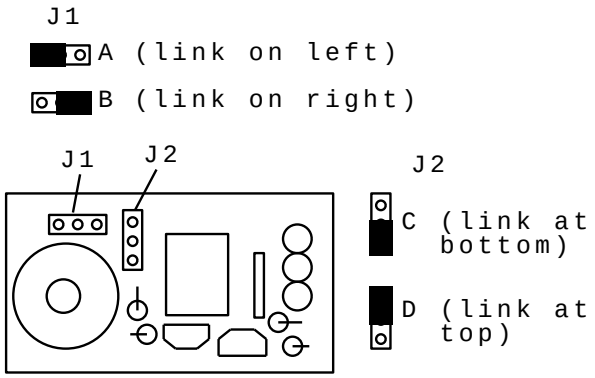

Fig. 2: Options Links

The links are set according to the following tables:

Number of Cells	*Nominal Voltage*	*Set J1 link to*
2	7.2V	Position A
3	10.8V	Position B
4	14.4V	No Link

Discharge Profile	*Set J2 link to*
Medium	Position C
Heavy	Position D
Extreme	No Link

Each discharge profile configures the warning and alarm voltages accordingly, based on the number of cells selected. The exact voltage trip points and hysteresis values have been determined as a result of extensive studies in the practical use as well as the theoretical physics of lithium batteries — but as a guide, *Medium* profile alarms at 3.0 volts per cell, *Heavy* at 2.7V, and *Extreme* at 2.4V. The exception is when using a two-cell (7.2V) battery in *Extreme* mode, when the cutoff point is set to 5.0V because most electronic systems require this voltage to operate, and allowing the battery to discharge below this would risk a loss of control.

So how do you choose the correct discharge profile for your application? As a rule, choose *Medium* if the maximum load is less than about 2C (e.g. 2.8 Amps for a 1.4 Ah battery), or *Heavy* if it is greater. In practice, this means that any model which runs its battery down within half an hour (and hence almost all electric flight applications) requires the *Heavy* profile. *Extreme* may be selected if the battery manufacturer approves a fully-loaded terminal voltage of 2.4V (this varies between manufacturers, though most lithium batteries will in fact accept such rough treatment). If you select a 'gentler' profile to that required, the unit will exhibit false alarms, showing a premature warning and/or alarm when the battery still has plenty of charge (an off-load voltage exceeding 3.0 V per cell) and the current demand is maximal, i.e. under 'full stick' conditions. This is a result of the battery voltage 'sagging' under heavy load conditions, and a 'heavier' discharge profile should be selected to compensate. Some battery manufacturers specifically rate their batteries for a heavy-load voltage as low as 2.4V, and for these batteries, *Extreme* should always be selected to ensure that every last drop of charge is used. Check the instructions that came with your battery — improper use of *Extreme* mode could possibly over-discharge some types of battery.

You will find additional information about discharge profiles in the Lithimon FAQ on our web site (`http://www.dawnmist.org/rcmfaq.htm`); if you are still not sure which profile best suits your model, please check out the FAQ.

Operation

The Lithimon 234 is very simple to use. Upon power-up, the unit checks the jumper links and flashes out a confirmation of the settings in the first five seconds of operation. The settings are shown thus: firstly, the green LED flashes once, twice or three times to indicate *Medium*, *Heavy* or *Extreme* profile, respectively. Then the yellow LED flashes two, three or four times to indicate the number of cells chosen. The unit then enters its measurement mode (normal operation).

In the measurement mode, the unit continuously monitors the battery according to a specially-designed Digital Signal Processing algorithm which eliminates the effects of electrical noise and peaks from the ESC and motor(s). The condition of the battery is indicated on the LEDs: green for **OK**, yellow for **Warning**, and flashing blue, accompanied by a loud audible alarm, for **Alarm**. Additionally, if the battery voltage is impossibly high for the number of cells selected, the green LED will flash to indicate a setup error — if this should occur, indicating that the battery actually has more cells than the number selected, re-check the setting of J1.

The indications could be interpreted as follows in an electric flight application:

- **Green** — Keep Flying.
- **Yellow** — Start looking for a suitable landing spot and prepare to land.
- **Blue** — Land immediately to avoid battery damage.

Technical Specifications

Product Title:	Dawnmist Lithimon 234
Dimensions:	$35 \times 20 \times 22$ mm
Weight:	12 gm approx. (exc. connecting leads)
Battery:	2, 3 or 4 (series) cells LiIon/LiPo (7.2–14.4V nom)
	Any number of parallel cells
Peak Output Current:	25 Amps per volt dropped (typical)
Audible Warning:	85 decibels (10 cm) at 2.3 kHz
Pulse Impedance:	less than 0.04 Ohm
Energy Storage Capability:	0.25 Joule (max)
Quantization:	10 bits
Oversampling:	$64\times$
Signal Processing:	Dawnmist Proprietary Algorithm
Voltage Reference:	Temperature compensated bandgap circuit
Approvals:	Meets relevant CE specifications

Warranty and Support

The Lithimon 234 comes with a limited warranty against defects in parts and workmanship for a period of one year after purchase. This does not cover damage caused by overload, misuse, impact or unauthorised modification, and is limited to the repair or replacement of the defective unit. Consequential losses of any sort are not covered, and it is stressed that it is the purchaser's responsibility to ensure that this product is used safely and properly. This does not affect your statutory rights.

Dawnmist products are engineered to a high standard, and we want you to get the best out of them. If you have any difficulties, please email `tech@dawnmist.org`.

Please note that there is a comprehensive Lithimon FAQ (Frequently Asked Questions) page on our web site (`http://www.dawnmist.org/rcmfaq.htm`); if you have any problems or queries, we recommend that you check this FAQ before contacting our Helpline, as it may very well contain the answer that you need.