ELECTRICKERY

…by Richard Neve

Welcome to the second in a series of articles where I will attempt to pass on some of the things I have learned about flying electrically powered aircraft over the past couple of years.

Last time we covered basic electrical theory and how it applies to typical model aircraft power systems. This time, I want to look in more detail at batteries, charging and balancers.

Batteries

This is a good place to start! There's a lot of tosh talked about batteries and the pros and cons of Nickel Cadmium (NiCd) vs Nickel Metal Hydride (NiMH) vs Lithium Polymer (LiPo) but if we exclude specialist applications such as F5D or pylon racers which use currents high enough to weld steel with, the only batteries you should use for general sport flying are **LiPo**s. Why? Well, first off, the energy density of a LiPo chemistry battery is nearly twice that of a NiCd so you can either have the same capacity at half the battery weight or twice the capacity at the same weight. Second, prices have dropped considerably in the last six to nine months and good quality batteries in useful sizes start at £25.

NiMH Battery

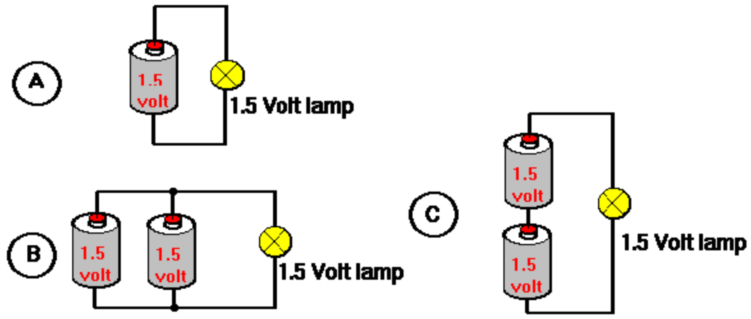
LiPo Battery

Let's talk a bit now about capacities and the much misunderstood "C" rating. Battery capacity is measured in milliamp hours (mAh) so a 2500mAh battery will deliver 2,500 milliamps for one hour. Since there are 1,000 milliamps in 1 amp, another way of expressing this is 2.5 amps for one hour and this 'one hour' rating expressed in amps is also called **1C**. So, a 2500 battery rated at 15C discharge would be capable of delivering a maximum current of 2.5 x 15 = 37.5 amps.

This rating is important when considering the motor / prop combination the battery is going to drive. If, for example, we connect a low capacity battery to a big motor driving a big prop, it's very likely that the current needed to drive the motor will exceed the capability of the battery and one thing LiPos *do not like* is being discharged too hard – in extreme cases, they can catch fire so beware. In general, you should have about 30% spare in current capacity for long cell life so a 15C 2500 battery should really only be discharged at a maximum of 37.5 x 70% = 26 amps.

One more thing about the C rating and current. One thing you can do to increase current capacity is to up the battery capacity. If you think about it, a 15C 4300 battery can deliver 4.3 x 15 = 64.5 amps. Same C rating as the 2500 battery but getting on for twice the discharge current. This is the reason earlier LiPo battery packs were doubled up and wired in parallel; same voltage but twice the capacity.

This brings me on to the other "codes" used to describe LiPo packs and which gives their configuration; nS and nP. Batteries can either be connected in series or in parallel. NiCd and NiMH batteries always rated as 1.2v per cell (this is controlled by the chemistry of the cell) and are always connected in series which is why a 7 cell pack is 8.4v. LiPo cells are always rated as 3.7v, again this is a product of the cell chemistry, but they are sometimes made up into a "series/parallel" pack because this gives greater capacity.



Ⓐ The lamp is in parallel (across) the battery and will be normal brightness.
Ⓑ The batteries are in parallel and will give 1.5 volts. The lamp will be normal brightness but the batteries will last twice as long as Ⓐ
Ⓒ The batteries are in series and give 3 volts. The lamp will be very bright but will 'blow' very quickly!

As you can see from the diagram, if you connect cells in series you increase the voltage but if you connect them in parallel, you increase the capacity.

But, what happens when you want to do both? That's when a connection method called series/parallel is used which is basically two or three sticks of series connected cells which are then connected in parallel.

Let's take an example from the ThunderPower LiPo battery range. It's not easy to see under the shrink wrap but this battery actually has twelve individual 2100mAh cells and these are connected in two sticks of six. At 3.7v per cell that gives 22.2v per stick but as they are in series, the mAh capacity of each stick is still 2100mAh. Each stick is then connected in parallel so the final capacity of the battery is 4200mAh. This is known as a 6S2P configuration, i.e. 6 series, 2 parallel.

As LiPo capacities have increased, there is less need for this parallel doubling up and in fact it's now possible to buy single cells with 5000mAh capacity. This pretty much eliminates the need to wire cells in parallel and now you'll usually only see "S" labels such as 2S or 3S.

Care and Feeding of LiPos

LiPo batteries are rather unusual compared with other types of battery in that the internal electrodes and electrolyte are held in a plastic (polymer) bag rather than the more familiar metal casing. That, coupled with the much higher energy density than NiCd or NiMH, means that the cells are more delicate and can react strongly if mistreated so we need to follow a couple of simple rules.

The first is pretty obvious and is to make sure you don't puncture the polymer bag either through rough handling or by something on the airframe in the event of a crash, for example a bit of undercarriage piano wire.

The main thing to beware of though is voltage. LiPos are very sensitive to both high and low voltages and only work properly when they're kept in the range 3.0v to 4.1v (each cell is nominally 3.7v). This is why you see warnings about using a charger with a dedicated LiPo program that doesn't allow over-voltage and also about not discharging the cells too far as both are excellent ways of killing the cell. Overcharging, which will happen if you use a NiCd / NiMH charger, is the worst case and is the source of the horror stories we've all seen about LiPo fires. Use a proper charger and don't leave them unattended while charging and all will be well.

Balancing

Manufacturing tolerances being what they are, there are always going to be slight variations in the cells as they come off the line. The suppliers take account of this when making up packs containing several cells and match them as closely as possible. Over time however, the cell voltages can drift and you end with a pack that's out of balance and because LiPos are so sensitive to voltage, charging or discharging a pack that has one cell weaker than the others can cause it to fail. Most of the time, the low voltage cut-off in the speed controller will protect against this situation but let's say we have a typical 3S (3 cell) pack and the controller is set to a 9v cut-off (3.0v per cell). That's fine if the cells are 3.0v / 3.0v / 3.0v but if they are closer to 3.3v / 3.3v / 2.4v, you can see how the weaker cell can be overdischarged without anyone being aware of it. This is an extreme example by the way and normally the voltages stay much closer.

The way to avoid this situation developing is to use some sort of balancing device. All packs have a little multi-wire tail these days and this provides individual connections to each cell in the pack. The balancer, which is really a sensitive voltmeter plugs in to this and if the readings are more than 0.1v different, it will discharge the higher voltage cells to match the lowest one. This balancing action can be done with just the pack on its own, when charging, or when discharging (i.e. flying).

There are *many* different balancers on the market now, mostly separate units but increasingly they're being built in to chargers as manufacturers become more aware of the benefits of balancing. Here are some examples of an in-flight unit, a "through balancer" (goes between the charger and the battery) and a stand-alone unit. All are around £30 or less.

Leton in flight voltage monitor

FlightPower V-Balancer

Astro Blinky

Next time…

Next time, we'll go in to more depth on the complete powertrain from battery to propeller but if there's anything you'd like me to cover in more detail, please don't hesitate to get in touch.

Future

Speed controllers
Rotation direction
Propellors – loading, current draw

These are the formulae you will need:

Watts = Volts x Amps
Volts = Watts ÷ Amps
Amps = Watts ÷ Volts

Power and Aeroplanes

Watts are important to the electric flyer because they give a good indication of how well an aircraft is likely to fly. As a rough rule of thumb, 50 watts per pound of aircraft weight will make the plane fly but the performance will be so-so. 70 watts per pound will give good, trainer-like performance and 100 watts will ensure excellent aerobatic performance.

Watts/Pound	Aircraft Performance
30	Barely get off the ground
40-50	"Sunday" flyer, sport gliders and old-timers
60-70	Mildly Aerobatic
80-100	Aggressively Aerobatic
100 plus	Ducted Fans, Competition gliders and E-3D models