Charging and caring for lipo and NiMH batteries

Lithium-polymer (lipo) batteries

Lithium-polymer batteries are impressive. Unless you are planning to boil a kettle, shorting them when changing connectors is a bad idea as I discovered. Luckily a window was nearby. That, and avoiding a full discharge, are the only vices. Otherwise they pack a decent amount of energy into a compact package.

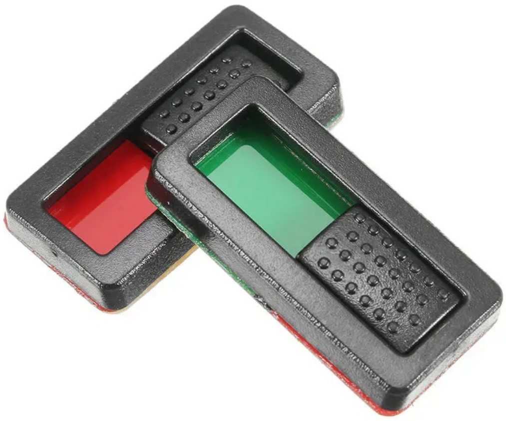
I am careful not to discharge lipos too low so I set telemetry to tell me when I have used a certain amount of mAh or energy. For example with a 2200 mAh it tells me when I have used 1500 mAh.

It is a bad idea to store lipos fully charged or below about 20% charged, as it reduces their lives. Ideally they should be discharged to a middle ‘storage voltage’. More of that later. I left a battery in a glider with the receiver switched on. When I realised it, the battery was down to 0%. I was tempted just to throw it away but it was an expensive graphene and I decided immediately to try a recharge. To my surprise it charged without complaint and appears to be back to normal performance. On the other hand I have just had to recycle a 6S 4.5 Ah that I left connected overnight to an ESC that I had been testing. That was gone beyond recovery so it might be that graphene handles full discharge better.

The energy cost is low - about 0.8 pence (1 cent) to charge a 3S 2.2 Ah at 50% efficiency, but there is one major drawback with electric flying. With IC flying you use the same fuel in all of your models. Apart from the 2.2 Ah 3S size which is used for many small and medium sized models, you have to buy a whole range of different sizes of battery. It gets expensive. On a long flying day you will need to recharge at the field. I am lucky to have mains electricity at my club but I take a 12 V 120 Ah leisure battery to the field anyway.

It pays to buy well-known brands of lipo. When they were out of stock everywhere in 2021 I bought some that were unknown to me but from a well-known model shop. I always check and record the internal resistances (article 2) of the cells in new batteries. I was horrified to see after three charge/discharge cycles that these were all around 30 milliohms rather than the 1 to 5 that you should expect. They went back for a refund.

I use the self-adhesive indicators shown in picture 1 on my batteries. As I remove a battery after a flight I slide it to red. When fully charged I move it to green. When discharged to storage voltage I move it half-way. Hobby King sells them but I prefer the EV-PEAK ones in the picture. I got mine from Tomtop at $US3.67 for ten. They are much more robust and the backing paper comes off more easily. You also get sheets to stick on your batteries to record when each charge was done. No, I don’t bother with those.



Picture 1

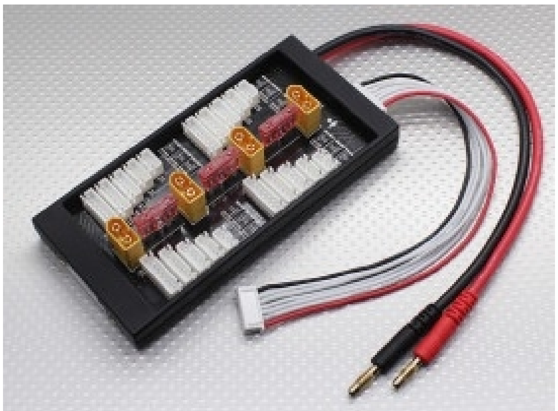
Lipo storage voltages

Being an optimistic cove I always assume that the next flying session will not be too long coming so I usually don't discharge my often-used batteries to storage voltage. However I expect that reduces the battery's life. Your charger will have a storage setting, but just in case you want to check without hooking up here are rough storage voltages. A bit either way won't matter.

Per cell	3.8 V
3S	11.4 V
4S	15.2 V
6S	22.8 V

Parallel charging and balance boards

These made no sense to me at all. How can several batteries be charged and balanced off one lead? Surely each must be charged and balanced to its own voltages? But people assured me that a board like this from Hobby King actually works (Picture 2). So I decided to see if I could figure it out.



Picture 2

Charging

Let's say we have four 3S batteries. When connected each will have different overall voltages, say 11.00, 11.32, 11.20 and 12.01. Plug them all in and what happens? Two effects. First the charger will start to pump charge into all of them. Secondly the higher voltage batteries will discharge into the lower voltage ones. That makes sense. Eventually all will settle to the same voltage.

Balancing

Is the same thing going on at balance level? Can we extend the above argument to the four sets of three cells. I suppose the higher voltage cells will discharge into the lower until they are the same.

How long does it take?

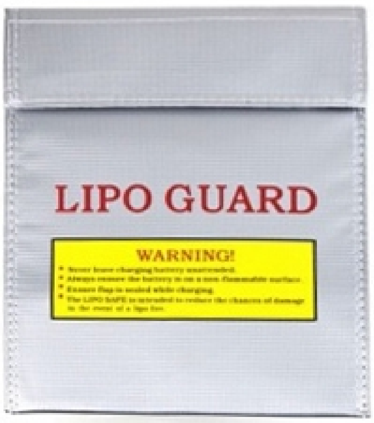
So I can now see how it can happen. However logic tells me that this is all going to take a long time as the balancing currents produced by small voltage differences will be small. Is there an optimum number of cells? Maybe with two batteries it would be quicker to charge them separately. Maybe not for three. Does anyone know? I'm not asking for a scientific study but practical experience.

Charging lipos safely

We are always advised not to go away from lipos when charging or to use a fire-resistant bag or box (Picture 3). I recently found out the wisdom of that.

I was testing out the motor of a new electric glider using a nearly new lipo. The voltage on the telemetry was fine, but dropped rapidly under high throttle. The ESC shut down, which should have made me suspicious even though the battery was new. I just assumed the battery needed charging.

I started charging it and put it in a fire resistant bag. As I was working nearby I heard a loud hiss coming from the bag. I unplugged the lipo and chucked it out of the window still in the bag. It didn't catch fire but swelled to double the size and it might have gone up if I hadn't disconnected it.



Picture 3

Fire resistant bag

Stay out of the sun

No, not you, your lipos. I charged a battery at the field not realising that the sun would hit it after a while. It was intense that day and I found that the battery had swollen badly. Tests proved that it was not worth risking it so another one bit the dust.

What lessons did I learn? If a lipo behaves strangely check its cell voltages and internal resistances. The latter is covered in an earlier article. If in doubt discharge it and recycle it. It is cheaper than redecorating, quicker than a house rebuild and less painful than skin grafts. Oh and only charge in the shade.

Comparing energy stored in different lipo batteries

It is energy that mostly decides powered flight times. However no battery label shows us how much energy it holds when fully charged, only amp-hours and the number of cells. Comparing the energies in different batteries can be troublesome.

Though they are improving, lipo batteries still fall a bit short of what we would like. What I will do here is give two simple ways to compare the energy stored in different combinations of number of cells and capacity.

The formula is energy = voltage x current x time (volts x amps x seconds)
A fully charged lipo has about 4.2 V per cell.
Current x time is shown on the battery as capacity.
However it is shown as amp-hours (or milliamp-hours which we divide by 1000).
In the formula we need amp-seconds so we multiply the result by 3600.

If **N** is the number of cells in series e.g. 3S gives N = 3
And **C** is the capacity in Ah (mAh divided by 1000),
The final formula is:

Energy = N x 4.2 x C x 3600

For example a common 3S 2.2 Ah battery has:
3 x 4.2 x 2.2 x 3600 which is about 100,000 joules of energy
A 6S 5Ah has 6 x 4.2 x 5 x 3600 which is about 450,000 J

By the way a kWh 'unit' of mains electricity is 3,600,000 J

Of course batteries waste energy internally due to their resistance, which is why they get warm. And they lose capacity as they age, but using the above method will give you the chance to compare. As shown in a previous article, using more cells, giving higher voltage, reduces current which reduces heating and wasted energy, so will use the energy more efficiently.

An even easier way

This method won't give you the energy in joules but it will allow you to compare energy content and so powered flight times.

Simply multiply the number of cells by the capacity.

For example which has the highest energy, a 3S 6 Ah, a 4S 4 Ah or an 8S series combo with 2.5 Ah?

3S 6Ah	3 x 6	= 18
4S 4 Ah	4 x 4	= 16
8S 2.5 Ah	8 x 2.5	= 20

So the 8S wins and could well be even better as the lower current will waste much less energy. I feel entitled to give a name to the measure. Let’s call it ‘esscap’. S x C.

Nickel metal hydride batteries (NiMH)

Charging NiMHs

NiMHs are probably the most tricky batteries to look after. Charging is complicated and slow and they lose charge when not being used, at up to about 4% a day. Why do we use them then? The four and five cell receiver packs give 4.8 and 6 volts which is exactly right for many receivers, retracts and servos. They are compact for their capacity and do not risk high voltages ruining equipment as can be the case with a 2S lipo with voltage at up to 8.4 V.

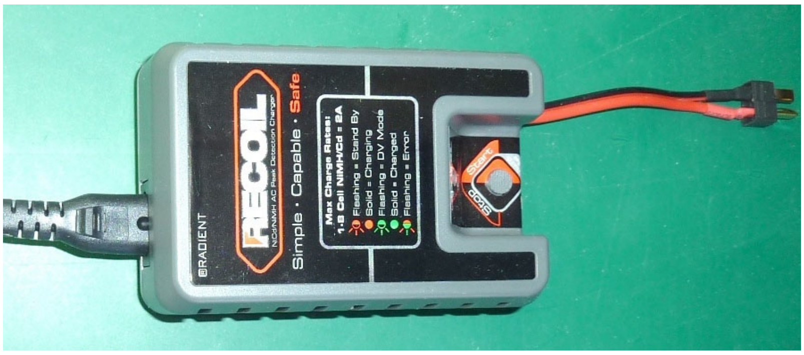
Why are they tricky?
I had just bought some eneloop 4.8 V packs. The label says to charge at 200 mA for 16 hours. How long? As I wanted two in the model because of the powerful coreless servos this meant using two chargers or charging for up to 32 hours. And this has to be done just before a flying session to avoid charge losses. I thought I would find out more.

NiMHs must be charged carefully. It turns out that there are two safe modes of charging, at C/10 and 1C where C is the capacity in Ah. That is ‘safe’ in the sense of getting long life out of the batteries. They don’t catch fire like lipos. Alternatively if you are really organised you could do it all manually by fully discharging then doing a timed charge at a certain current.

Mode 1: Low current
This can be done, with care, using a general-purpose charger in NiMH setting. You charge at C/10. For my 2 Ah this gives the 200 mA on the label. There is a potential problem. If you do not disconnect the battery at full charge, oxygen is generated in the cells. There is a catalyst in the cell that destroys this but it generates heat. So you have to be around to disconnect when the battery gets warm. For up to sixteen hours?

Mode 2: minus deltaV
When a NiMH cell gets near to full charge its voltage drops by about 10 mV, called ‘minus DeltaV’ (-deltaV). It is safe to charge at much higher rates if the charger is designed for NiMHs and its specification includes words like ‘peak’, ‘delta’, ΔV or ‘-deltaV’. This means that its software can detect the voltage drop and switch to a low current to do the remaining charging. It then switches off.

I bought a mains-powered Radient Recoil charger shown in Picture 4 for the surprisingly low price of £13 ($16). This charges at 2 A, which for my batteries is 1C. This current means that it is probably not suitable for NiHMs with a capacity lower than 1 Ah. There is an LED indicator to show the various charge stages: Stand by, Charging, DV mode, Charged, Error. DV is the -deltaV final charging stage. As you see it has, for no obvious reason, a Deans connector so I had to make an adaptor for the JR connectors on the batteries.



Picture 4

It is likely that your general-purpose charger also has DV detection in its NiMH settings, but you will need to check in the manual or on the menu. At least you now know what to look for. My iSDT, GT Power and other chargers have the option when you select NiMHs.

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