Lithium Polymer Battery Packs for RC Use FAQ's
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3/9/2012

Lithium Polymer or "Lipoly" batteries come in many varieties but two types are very popular for radio control use. The most popular is called "LiPo" but it's actually short for Lithium Polymer which all cells of this type of chemistry and style are classified under. The active ingredient in a LiPo is Cobalt but that is not apparent in the generic name of the cell. Another popular cell type is called LiFe. LiFe cells have been made popular by a brand called A123 and can be found in two forms; flat and round cells. The active ingredient in LiFe cells is Iron Phosphate. To date LiFe battery chemistry has evolved and is considered among the most stable forms of Lipoly battery chemistry.

Q: What is the difference and how do I use them for radio control applications?

The main difference between the two cell types is made apparent in their voltage. The LiPo cell nominal voltage is 3.7 Volts per cell (Vpc) while the LiFe cell is 3.3Vpc.
The difference in the peak voltage will make it very clear why a LiPo cell is preferred over a LiFe cell for performance applications.

LiPo **–** 3.7 V per cell Nominal Voltage / 4.2V per cell Peak Voltage
LiFe **–** 3.3 V per cell Nominal Voltage / 3.6V per cell Peak Voltage

Lipo cells have a higher performance capability and are ideal for powering vehicles that demand higher power levels as well as standard operational needs.
LiFe cells are perfect for applications such as transmitters and receiver packs due to their chemical stability and lower voltage. LiPo batteries can be used for the same application but caution should be taken because the voltage is higher and can require the use of a voltage regulator depending on the RC equipment used. Some newer equipment is designed to handle direct LiPo power.
LiPo cells are slightly more delicate than LiFe cells for one basic reason, chemistry. The LiFe cell is more stable in the long run and will retain more of its performance in comparison to LiPo cell chemistry. LiPo chemistry is the second most powerful battery power and as such it has a shorter service life due to its active ingredients.
LiFe cells can be used as the main power source for a vehicle but their lower voltage means the application will require more cells to reach a desired peak voltage. The added weight of the extra cells will offset or begin to offset the potential performance gains commonly found with LiPo use in radio control applications.

Q: How do LiPo cells compare to NiMh?

LiPo cells are much lighter than NiMh round cells by as much as ~33%.
LiPo cells maintain a much higher voltage under operational load which means greater performance for the model.
LiPo's usually have lower operational temperatures under normal operating conditions.

All things being equal the single most significant performance gain an electric model can receive is more voltage. A LiPo pack will not only provide more voltage under load it will be lighter than a NiMh pack of the same capacity. If you add back the ~33% weight reduction in extra capacity you gain more runtime for the same weight and more performance due to the increase in pack capacity and power delivery. This is especially significant in RC car applications which typically use NiMh battery packs.

<u>More power, more runtime and less weight??? Inconceivable! Nope it's true!!</u>

Q: What is Continuous Discharge and how do I apply that?

Continuous Discharge is simply the packs ability to deliver its rated current from start to finish for its full capacity. Its expressed as a C Rate specified for the battery pack.
How it is applied can vary from just the knowledge that if you call on it the pack could deliver that power rating to needing to know the peak RPM of your motor.
Knowing this figure will help you balance your models power system needs and help prevent you from asking too much of any one component i.e. Battery, ESC or Motor.

Q: What is C Rating?

The C Rating of a cell/pack is the manufacturers' performance value of the cell/pack.
The value suggests or implies the battery packs continuous discharge capability. This number will help you determine the applications of the battery pack and if it is a good match for your application.
There is a simple formula to figure out what the battery pack is capable of which is expressed in Amps.

Pack capacity Divided by 1000 then Multiplied by the C Rating.
For example; 20C 2500mah battery pack

2500/1000 = 2.5
2.5 X 20C = 50
50A Continuous Discharge

The best way to understand C rates today is to use the number as a way to gage the packs ability to maintain its voltage under load and resist voltage sag. Typical discharge graphs for NiMH cells will show an immediate decline in voltage as the load is applied. This will continue typically until the end of the discharge cycle. This means that your operating voltage is always in a state of decline.
With LiPo's the graph will maintain a more level discharge graph as the pack is loaded and then there will be a noticeable drop off at the end of the discharge cycle. The area in-between is where the LiPo truly shines and out performs any other battery as you will notice consistent power delivery nearly to the end of the charge.

Q: What is Burst Current?

Burst Current is the battery packs ability to provide more power than the standard C rating and it is expressed as an additional C rating.
For example; 20C/30C Burst
Use the standard C formula to determine the Burst Current of the pack.
Typically the Burst Current is a value that is only meant to be interpreted as an instantaneous release of power and not the continuous discharge rating. Never plan your models power system around the Burst Current value of a battery pack. The Burst Current value is only meant to be good for a few seconds of "overdrive". The duration is not always disclosed by the manufacturer so it's safe to assume it's less than 10 seconds.
The Burst Current of a pack will only be useful to know if you have an onboard data logger or telemetry so you can observe the requirements of the model under load. The typical application in a model when this figure could be of importance is in racing cars, 3D helicopters and 3D aerobatics. These models typically require fast throttle inputs and surges of power. A graphical read out of the power consumed will show amp spikes where the load

was very high for an instant. These peak values will reveal a packs Burst Current capability and your models actual requirements in use.

Q: What is the operating temperature of a LiPo pack?

Opinions vary on this but here are some solid truths about how LiPo's like to be used in RC vehicles from our extensive testing in all weather conditions locally.

1. Max safe operating temp under load in a vehicle – 120F
2. Max temp– 140F
3. Min temperature – 60F
4. Best starting operational temp – 95F (cold day use, preheat the pack before use)

Q: What is Heat Soak?

Heat soaking is a phenomenon that occurs with all things that achieve an excited heat state and then are allowed to cool and relax. The chemistry in a LiPo cell will become very excited during use and an Operational Temperature will be reached. There will be an exchange of heat or cooling off on the surface and the pack and it will reach a state of relative temperature stability in use. Once the battery pack is allowed to rest the molecules within the cells will remain at an excited state for a period of time. This period is called a heat soak period and will last for about 5 minutes.
The significance of this is knowing at what point your packs operational temperature peaked and when the heat soak period began. You can expect the battery pack to increase in temperature as much as 15 to 20 degrees extra over the operational peak temperature.
So in other words <u>*how hot was the pack when you turned the power off from the battery pack to the ESC?*</u>

This takes us back to the previous subject, operational temperature and safety. A LiPo pack's chemistry becomes unstable at temperatures above 140F. If you operate a pack up to 140F and then it heat soaks there is a very real risk of a thermal run away reaction within the pack or an individual cell. At this point one or more cells will "balloon" and the pack will be very hot, 150F and above. The best thing to do is to remove the pack from the model and immediate area. Place it on a cement slab or on sand/dirt or any nonflammable cool surface. Observe the pack for 15 minutes. More on this in another section covering pack disposal.

There are no performance gains to be had by operating a LiPo pack above 120F.

Q: What is Low Voltage Cut Off (LVCO) and how do I apply this?

LVCO is very important to operating your vehicle especially if it flies. This is the minimum operating voltage of the cell or pack. It is usually expressed in voltage per cell.
Typical LVCO of a single LiPo cell – 3.0Vpc
Min voltage before damaging the cell – 2.8Vpc

This is equivalent to your fuel tank gauge and lets you know how much power you have in the battery pack. Most ESC's (electronic speed controls) today have preset and or selectable LVCO's to choose from. The settings can range from 2.6V to 3.2Vpc. How this setting is used is very important because it is also tied into the operating temperature of the battery pack. The lower a LiPo cell is allowed to drop in voltage under load the more it will stress to deliver power. More stress = more heat. A good base set up is 3Vpc. A high power application requiring quick throttle changes will stress a battery pack with instantaneous high amp peaks. During this spike the voltage will drop. Later in the pack the average voltage will be lower and the demands may be the same. In this condition the packs average voltage will reach the LVCO preset by the ESC. Once the LVCO is reached and sustained for short period of time the ESC will alert you by reducing the throttle setting and slowing the model or interrupting power momentarily.

In a high power model example if you have adequate cooling for the pack and know your equipment very well you can lower the LVCO to 2.8Vpc. At this point you are taking full advantage of the Burst C rating of the battery pack because your letting the pack become fully stressed and then recover. This is a very advanced set up and is not recommended for average applications or anyone without proper experience or guidance.
The LVCO can be used to help you tune the temperature of your set up, maintain a safe operating temperature, reach maximum power, runtime and help you extend the life of your investment in batteries.

Note: In general, for LiPo's, sustained conditions are more dangerous than momentary ones during operation. Pay close attention to operational temperatures and adjust your set up accordingly.

Q: What is cell balancing and do I have to do this all the time?

In a battery pack of 2 cells or more it is important that the pack begins service in a "balanced condition". What this means is that the voltage of each cell is nearly identical to within about 0.01-0.001 Volts. During operation the pack will see high temperatures and the individual cells will begin to vary in voltage. Over time the pack will be considered to be out of balance. The significance of this becomes clear when you consider the LVCO of and ESC. The LVCO reads the average voltage of the pack and not the individual cells, typically. So for example Mr. X never balanced a LiPo pack and one day it comes out of the plane with one cell ballooned…so what happened? Let's say it was a 3 cell pack.

Cell 1 = 3.0V
Cell 2 = 3.15V
Cell 3 = 2.6V
Average 3.0V

Cell 3 with some heat and a low voltage will probably balloon and ruin this battery pack or at least make it a 2 cell pack now if it's safe to disassemble.

Your best bet is to make a habit of balancing the battery pack once every 3-5 cycles depending on service style. If your application is a high stress and high power set up then balance your packs more frequently for best results. If you're set up is more conservative then balancing the pack every 5 cycles is just fine.
During a cell balance charge cycle the battery pack will take longer to charge, this is normal. There is a very accurate charge cycle going on and unlike NiMh cells there is no "overflow" during a charge. Try filling 5 tea cups at the same time from 3 feet away without spilling a drop!

Q: How do I charge a LiPo and can I speed it up?

Charging a LiPo battery requires the use of a charger specifically designed for this chemistry and the individual chemistry of the Lithium Polymer battery type. A LiFe pack cannot be charged on a LiPo charger/profile. So *LiFe with LiFe* and *LiPo with LiPo* and so on. Select the correct cell type before charging a pack.
LiPo cells should always be charged following a 1C rule unless otherwise specified by the manufacturer.
1C means the C rating of the cell or battery pack X 1
For example; 5000mah / 1000 X 1 = 5A charge rate

You should only charge a LiPo pack at a higher C Rate when the manufacturer specifies it is ok. Some packs today can be charged at as high as 10C however this requires a very powerful charging system.

Insider Note; even if a pack is specified to be capable of a 10C charge rate it is not advisable because it will harm the pack and reduce the service life. If you must speed charge a pack do not exceed 3C. The charger and power supply should also be capable of high charge rates.

Most LiPo packs will take about 50-70min to fully charge in normal charge mode.

There is no appreciable temperature change during a charge cycle under normal conditions. If the pack is getting hotter than ambient temperature there is a problem. Stop the charge and review your settings and connections.

One simple method to achieve faster battery charge cycles is to never fully discharge your battery pack. When possible use only 70-80% of the capacity of the pack. This will also have the side benefit of extending the life of the battery pack.

Q: What are the battery pack designations and what do they mean?

LiPo battery packs can be constructed in a couple of ways. The goal is to create more voltage or capacity by assembling the cells in parallel or series circuitry, or both parallel and series circuits to make a larger power source with more than one battery pack.
For example a 3S2P designation tells me there are 6 cells total and the voltage is 11.1V.

Series (S) = multiple cells in series increases the voltage of a pack
Parallel (P) = multiple assemblies of cells in parallel increase the capacity of a pack

So 10S4P = 40 cells total, 37V (nominal voltage not peak)
But 5S8P = 40 cells total, 18.5V
Same cell count but different voltage and total capacity

How does this apply to capacity?

3S2P 5000mah pack = 6 cells total, 11.1V
3 X 2500mah cells X 2 sets of cells

3S1P 5000mah is simply 3 X 5000mah cells in Series

Double that and you get 6S1P 5000mah = more voltage

Or place them in parallel = 3S2P = 10000mah = more capacity

There are many ways to combine packs and cells to create the power required by any application.

NOTE: Remember the C Rating is always constant regardless of the pack configuration. With increased capacity comes an increase in Amp performance from the larger assembly of packs.

Common problems with larger pack configurations;

1. High cell count in Parallel = increases the chance of excess heat and cell failure
2. Long charging times due to excessive cell count
3. Difficulty in balancing packs
4. Higher likelihood of cell imbalance due to heat and excess circuitry
5. Less reliable capacity accuracy with higher P cell count

The best course to take with larger pack configurations is to use more single cells in series and fewer cells in parallel. The benefits are;

1. lower operating temperatures
2. easier to balance the packs
3. fewer points of failure
4. more reliable capacity accuracy
5. more robust system

CAUTION: These assemblies must use the same cells of the same capacity and C rating. Do not mix and match different cells.