Battery Basics

Courtesy of Chris True

Lithium (lipo) cells have a voltage range within which they should be operated. Step outside these ranges and damage may occur, either immediate, or a long term shortening of the packs useable lifetime. The maximum resting voltage of a lipo cell should not exceed 4.2 volts and the minimum resting voltage should not dip below 3.7. Under charge the upper voltage limit can be slightly higher, a Thunder Power 1010C will typically show a value of 4.209 on the highest cell during charge. No charger should show more than 4.235 volts per cell under charge. After charge termination, all these values will decline and should show a resting value of 4.2V per cell or less. Under a heavy discharge load the volt per cell values will be lower, modern lipo capable ESC's have a voltage cutoff value. For today's high performance packs set this value to 3.0 volts per cell. See the "Tips" section for more on flight timers, after flight voltage readings, and the amount you should be putting back in to your packs when recharging.

Lithium technology has rapidly evolved over the past 3 years; new series of higher performance cells are released at least once per year. What changes? Each new generation has a lower internal resistance, higher voltage under load, greater discharge capability (measured in "C-rate") and a higher voltage cutoff point. "C-rate" is electro geek speak for the discharge rate in amps compared to the capacity of the pack being used in amp hours (AH). So if your power system draws 100 amps and your packs have a 5.0 AH capacity, the "C-rate" is 20C (100 / 5). Battery capacity can also be converted from amp hours to amp minutes – 5.0 AH 60 = 300 Amp Minutes. This is great for telling what your average current draw is. If you land and it takes 4.0 AH to recharge the pack you have used 4.0 60 or 240 amp minutes, if your flight time was 5 minutes your average amp draw is 240 / 5 = 48 amps.

I'll discuss some basics and things like choosing a good charger then launch in to the how to's of charging your new lipo pack. The end of the document contains lots of information about fire danger, trouble shooting and other advice – please read it!

Charge process

The charge profile used to fill a lipo pack is known as CC / CV or **C**onstant **C**urrent / **C**onstant **V**oltage You set the charger to the charge current desired, on some chargers you set the cell count, on others the charger chooses that for you. After an initial condition check, sometimes called Initial Charging, the charger ramps up current to the value you have set and holds this constant until the pack voltage reaches 4.2 volts per cell. Then the charger switches to constant voltage mode and slowly ramps the current down as needed to maintain that 4.2 volt per cell value. When the current reaches zero or close to it, the charge terminates.

Which Charger?

BVM uses the FMA CellPro 10S charger. It is a stock item at BVM.

Flying in low temps – Lipo's really want to be at around an 80F starting temp for best performance. That doesn't mean you can't fly in the winter but you will notice a fall off in initial performance until they warm up in flight. A starting pack temp in the 60 – 65F

range will still fly OK although you'll notice less "punch" initially. If the temps are below 60F you really want to do something to keep you packs warmer than ambient. Store the battery box in the warm house overnight so they are at room temperature then insulate them on the way to the field or keep them in the warm passenger compartment until ready to fly. Often the cars dashboard sitting in the sun on a cool day is a nice warm place, set your packs there between flights. Just don't do that in the Spring or Summer when the dash temp can be way over 100F!

Summer time – DO NOT leave your battery box in the car all day with the windows rolled up, temps inside a closed car in the summer can get up to very high levels, heat soaking @ 140 – 160F is not good for your batteries, not to mention a possible fire hazard.

Breaking in packs – Yes, your lipo's need a bit of a break-in. You will notice performance improve over the first 5 flights or so. Ideally the first 5 flights would be a gentle 5C average discharge. If you have a prop plane that will fly on a 5S or 10S pack use that for the first 5 discharges before using them in your jet. If not, don't worry about it too much, by all means use full throttle on takeoff! But, once you are in the air and have flown a circuit or two to get up to speed and trimmed out, fly around at ½ throttle for the rest of the flight. Repeat for the next 3 or 4 flights and your packs will perform better long term. <u>For the first 5 charge cycles use a charge rate of no more than 1C.</u>

Fire Danger

Perhaps you have heard horror stories about lipo packs igniting either under charge or after a crash – how can this happen?

<u>Under charge</u> – There is a voltage that if reached under charge will cause a cell to ignite; it is something above 4.6 volts per cell depending on the brand and specific construction of the cell. There are two prime causes of this - #1 would be an imbalanced pack. If we have a 5 cell pack the charger
will expect to reach 4.2*5 or 21 volts. If all the cells are equally matched in voltage and capacity this works great. What if you have a weak cell in the pack? Say 1 cell has 20% less capacity than the other.

Over time the weak cell will always discharge to a lower value and the stronger cells will charge higher
Than 4.2V per cell since the charger is looking for 21 volts to switch to Constant Voltage mode. After each cycle the imbalance grows to the point that you have a problem, that problem could include spontaneous ignition of the pack. When a lipo burns it BURNS, it is a very impressive, very hot and very smoky fire. Fire mode #2 – you set the incorrect cell count on the charger and it is not smart enough to realize the error – eventual fire as the charger drives all cells to a higher than desired voltage.

<u>Crash and or Handling Damage</u> – These cells are soft side cells encased in a plastic / foil envelope. There have been cases of protruding screws and bolts inside airframes or projecting from hatches, the battery is installed and pressed down on these protrusions, puncturing the cell and causing a fire. You run off the runway and your aircraft comes to an abrupt stop – the pack is not securely bolted via a frame or velcroed in place. The pack continues forward and impales itself on one of those protrusions. You crash you airplane

at high speed, the pack is severely deformed and damaged internally. If this happens to you, get to the crash scene as soon as possible and remove the battery from the remains if it is still among the pile of wreckage. Generally any fire doesn't happen immediately but takes some time to develop. Set the pack off to the side and observe it for 20 – 30 minutes. If it is going to ignite that is when it will happen. There have been cases of helicopters crashing, the pilot picks up the wreckage and throws it in the back of the car, leaving for home. ½ way home the rear of the car is engulfed in smoke and flames. Observe crash damaged packs for a ½ hour!

Damaged packs should be submerged in a salt water solution for a few days then discarded at a recycle center.

Discharge

If I don't plan on using the batteries for a few weeks or more, it is best to store them at half capacity. This is how the batteries come from the manufacturer. The proper voltage to store lipos is 3.8 volts per cell. For example, a 5S1P pack should be stored at 19 volts, a 6S1P pack should be stored at 22.8 volts. An FMA CellPro 10S charger does not have a "Discharge" feature. We simply run the batteries in a model for a few minutes and then check for storage voltage.

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