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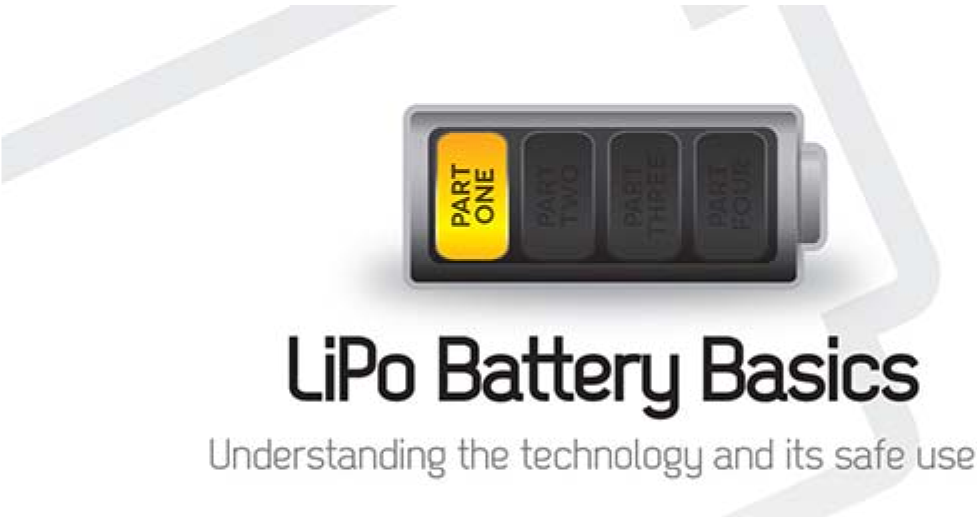

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Understanding the technology and its safe use
Article, photos, and design by Greg Gimlick.
Read the full article in the July 2015 issue of Model Aviation.

There are two items everyone entering electric flight has to deal with: batteries and connectors. On the surface, it’s simple, but it causes more confusion and questions than practically anything except motor designations. I will shed some light on these and I hope to clarify things. This is for the electric newbie who wishes to understand and make the right choices for his or her requirements.

Battery Types

Everyone is familiar with the batteries he or she uses around the house. Most are alkaline in AA, AAA, C, D, or 9-volt formats. Others are rechargeable Nickel Cadmium (Ni-Cd) or Nickel Metal Hydride (NiMH). In the dark ages of electric flight, we used Ni-Cd and NiMH batteries, but now the standard is Lithium-ion Polymer (LiPo) and that will be the focus here. These batteries are sometimes referred to as battery packs or simply packs.

There is another type of battery chemistry called a Lithium Iron Phosphate (LiFePO4) that some use for flight packs, but are more often found in receiver and transmitter packs. They are usually referred to as LiFe packs or A123 packs, referencing their makeup and brand name.

Each type has its advantages and disadvantages, but because LiPos are the de facto standard in electric flight, I’ll concentrate on them.

Safety First

Rumors abound about safety, or lack thereof, when using LiPo batteries. Much of that is leftover from the early days of LiPo packs and the lack of information available to the user at the time.

Incorrect chargers were used, incorrect voltage cutoffs were used, and they were being discharged at levels that the packs couldn't support. As chemistries, protective circuits, and information improved, LiPo batteries have become a safe and suitable source of power. Here are a few simple rules for increasing your safety:

- Always store batteries in a fire-safe container.
- Always charge with an appropriate charger designed for LiPos.
- Always follow the manufacturer's instructions for charging and discharging rates.
- Always size a pack according to its usage.
- Never overcharge.
- Never overdischarge.
- Never use a puffed pack.
- Never use a pack that has visible damage (dents, cracks, etc).
- Never charge a pack unattended.
- Never disassemble or reconfigure a damaged pack.

Most accidents involving LiPo packs are the result of not following one of these rules. Understand the charger you're using and follow the manufacturer's guidelines and they will serve you well. Charge safely.

Understanding the Labels

Labels contain plenty of information, but understanding them is often confusing. A few simple definitions will help you.

- 3S, 4S, etc.: Battery packs are composed of a number of cells in series and this number represents that. If the pack is listed as a 3S pack, then it has three individual cells connected in series within the pack, each with a nominal voltage of 3.7 volts. The pack's total will then be listed as an 11.1-volt pack. A 4S pack would be 14.8 volts, etc. (four cells x 3.7 volts = 14.8)

- Capacity: The capacity rating of a LiPo battery tells its output potential, or how long you can take power from the battery at a given rate before it reaches the cutoff voltage, or is discharged. The faster you take power from the battery, the less time it will last.

  Many times, our batteries' capacities are listed in milliampere hours (mAh) instead of ampere-hours (Ah). This is merely a metric conversion to a smaller unit—1 ampere hour = 1,000 milliampere hours, so 2.2 Ah is 2,200 mAh.

- Discharge rating: "C" represents a measure of the rate at which a battery can be discharged relative to its maximum capacity. If the battery is discharged at a rate higher than the discharge rating, the battery may be damaged, or worse, could pose a safety hazard, like a fire.

If a battery's discharge rating is 15C, it means that the most power that can be drawn from it at one time is equal to 15 times its capacity. Using the example of a battery which has a capacity of 2,200 mAh, this means that greatest flow of electricity you can safely get from the battery is 15 x 2,200 = 33,000 milliamperes (or 33 amperes).

The discharge rating listed on the battery's label is based on what the manufacturer believes the pack will handle during discharge without degrading the pack. These discharge ratings, sometimes mistakenly referred to as C ratings, can be optimistic and are best used as a guideline. Packs with higher discharge rates have lower internal resistance (IR), which is a good thing.

Many batteries with provide two discharge ratings such as 30C/60C. These represent the continuous and burst ratings.

The first number means that it will continuously support a 30C discharge, and for short bursts (typically less than 15 seconds) it should support 60C. This allows for spikes during rapid throttle changes, but shouldn't be something you use regularly. If you need higher current levels, buy a higher capacity/rated pack.

• Internal Resistance: This represents the internal resistance of a cell or pack. Some chargers will test the IR for each cell within a pack during the charge cycle. As internal resistance increases, the battery efficiency decreases. So as a general rule, the lower the resistance the more punch a battery will provide. It's nice to know, but not something to get hung up over as a beginner. As a rule, packs advertising a high discharge capacity will have a lower IR.

Battery pack labels are often the manufacturer's attempt to put its product in the best light. A pack rated as a 65C pack and sporting small-gauge wires to the connectors won't really handle that amount of current. Sometimes packs come with large-gauge wires, but they're soldered to tiny tabs inside the pack, which negate the benefit of those monster wires. Shop carefully and use the best battery you can afford.

Memory

If you're beginning to fly electric-powered aircraft and your only experience has been with Ni-Cd or NiMH packs, you're probably wondering about memory effect. Older Ni-Cd and NiMH batteries suffered from an effect termed memory in which the way the battery had been discharged in the past would affect its performance in the future, even after being fully recharged. The good news is with LiPo and LiFe packs, there is no such concern.

Sizing Your Battery Pack

If you're new to electric-powered models, you will probably follow the manufacturer's recommendation for an appropriate pack for your aircraft. That's what you should be doing.

As you expand your hangar, you may decide to add a bigger battery or need something that isn't specified. You need to do enough research to get a feel for what type of current the setup will pull under full throttle and size your pack accordingly.

If your airplane requires a 3S setup using a typical 2,200 mAh pack and you change to a "hotter" motor—meaning one that is more powerful and will pull more current—you need to see if your current packs can handle it. If your current power system is pulling 20 amps with your 2,200 mAh 15C pack, but your next motor upgrade will pull 35 amps, that pack won't be happy. Let's look at why.

The 15C pack is technically capable of pulling 33 amps (2,200 mAh x 15 = 33,000 mAh or 33 amps), so your 20-amp requirement was well within its limits. Now looking at the new setup with the motor requiring 35 amps, you see that the pack is undersized, if only by a couple of amps. That's enough to cause problems that can be costly in the long run.

I recommend buying a quality LiPo pack that is well beyond the projected requirements of the setup. Running a pack at its limit will guarantee a short life and wasted money. Pay attention to the label and notice if it gives two ratings such as 30C/60C. These represent the continuous and burst ratings as previously mentioned.

Charging and Storage

Always balance charge when you can. Balance charging evenly distributes the energy stored in the battery across the multiple cells inside. This will prolong your pack's life and ensure better service from it. You can get away with fast charging at the field without balancing if your regular routine is balance charging at home.

There are debates about charging and storage levels, but the safe bet is to store batteries at something other than fully charged or fully discharged. Most good balancing chargers offer a storage mode that takes them to a level of approximately 3.8 volts per cell. The important thing is not to leave them fully charged or discharged for long periods of time.

The Secret to Long Life

The secret, at least for your batteries, is to charge to 4.1 volts per cell as opposed to the full 4.2 volts per cell, and never discharge them to full discharge level. Working your packs in between the two ends of the charge/discharge levels will greatly increase their lifespan.

Engineer/charger/ESC designer Doug Ingraham described it this way: “There are several things that cause degradation of lithium batteries. One is heat and for the purposes of RC modeling, this is most likely the one that causes the greatest degradation. The others have to do with the effects on the materials at both ends of the state of charge.

“The lithium ions are forced into the carbon material on the plates at both ends of the state of charge. This causes a breakdown in the material, and in future charge cycles less ions can be held causing degradation in capacity. It is mostly at the ends (full and empty) that this damage occurs so staying away from the ends even a little can help extend the life of the cells.”

Several chargers offer a charge cutoff labeled “Long Life” or something similar and they stop the charge at 4.1 volts per cell. From Doug’s explanation, you can see that using the 4.1 volts keeps you off the top end and setting an ESC low-voltage cutoff above the traditional 3 volts per cell will keep you off the bottom end. Unless you’re a competitor trying to squeeze every last bit out of your flight, this will serve you well and save you money.

Disposal

When your batteries get to the point that they need to be disposed of, one of the simplest options is using a no-cost used rechargeable battery and cellphone collection program offered with a network of more than 34,000 collection sites throughout North America.

Call2Recycle accepts NiMH, Lithium Ion (Li-Ion), LiPo, and Ni-Cd batteries weighing up to 11 pounds. Simply visit the program’s website, www.call2recycle.org [2], and enter a ZIP code to find a collection center near you. If you don’t have Internet access, call (877) 273-2925.

Drop-off centers are located at corporate offices, healthcare facilities, manufacturers, military bases, and at major retailers such as The Home Depot, Lowe’s, Staples, and Best Buy.

Connecting It

The connectors you choose for your model are as important as any other piece of equipment. Connectors are designed for certain sizes or gauges of wire. As such, they are rated for specific maximum electrical throughput, just as wire is (as you learned in the terminology table). Like wires, if more electricity is put through a connector than it was designed for, resistance and heat will increase.

You can use the connector table to find out what type of connectors you have and what their capabilities are. There are many types of connectors available, and most beginner models come from the factory with some type of preinstalled connector. This connector may or may not match the battery you have. Adaptors are available for many types of connectors and existing connectors on models or batteries can even be completely replaced with a connector of your choice.

Many modelers with multiple airplanes try to keep the same type of connectors on all of their models and batteries for simplicity.

Ultimate Low-Tech Tester

Your hand is one of the best meters to gauge how your setup is doing. The magic temperature for a danger threshold is 140° on LiPo packs, and that is darn hot if you touch it. If your battery feels too warm, it probably is.

Heat is wasted energy and a sign of trouble. If your motor is too hot to touch, it's probably over-propped. If the ESC is too hot to touch, it's probably undersized, as is the battery if it's hot. If your connectors are warm, they're a choking point in the circuit, causing high resistance and lost efficiency.

Heat is a natural byproduct of our setups, but we need to size things accordingly to keep it at a minimum. A small, inexpensive IR temperature gun can be a valuable tool when troubleshooting.

Wrapping It Up

Don't make your world more complicated than it has to be when trying electrics. Information abounds on the Internet, as do rumors and conjecture. "Experts," and even experienced modelers, tend to load up newcomers with more information than they need to get started, and do it out of their exuberance for the hobby.

Do your homework, study the manufacturer's information, and try to make the best decision you can. Don't obsess over it! Most Plug-N-Play systems work well and are well matched. There's plenty of time to venture out on your own.

Don't overtest your batteries on the bench. That doesn't replicate actual flight conditions.

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