Introduction to A123 batteries

The latest trend in powering the electrical systems on giant scale aircraft is to use packs made of what are now known as A123 cells.

The Name

The name “A123” is derived from the first term in the mathematical formula which describes the chemical reaction that occurs within the cells. The cells are also known as lithium-nano-phosphate. They are NOT the same as LiFeP04, which is a different (but similar in many ways) chemistry.

Differences from other lithium cells

A123s differ from lipo or lithium-ion cells in several ways, most obvious is their output voltage. A123 have an output in the range of 3.2 to 3.3 volts. Fully charged they are 3.6 volts which almost instantly drops down to 3.3v as soon as they are put under a load. In radio control system applications they are used in 2 cell series-wired packs, all these numbers are therefore doubled. A fully charged pack is 7.2 volts which drops quickly to 6.6.

The table below illustrates the differences between different battery types that are in common use. As you can see the A123 packs have an ideal set of attributes for a R/C plane.

Cell Type	Voltage Range (R/C flight pack)	Fully charged peak voltage	Physical attributes	Current Capability	Charge Rate	Safety
A123	6.4-6.6	7.2	Rugged laser welded aluminum case	30C	Up to 5C	Excellent, no fire or explosion
LiFeP04	6.4-6.6	7.2	Rugged laser welded aluminum case	15C	2C	Excellent, no fire or explosion
Li-Ion	6.8-8.2	8.2	Metal case with vents	3C	1C	Good but can burn if case is punctured
Li-Poly	6.8-8.4	8.4	Plastic wrapped vulnerable to puncture	10-20C	2C (may vary with cell type)	Dangerous, easily damaged and can explode/burn
NiMH	5.8-6.9	7.1	Metal case	2C-burst to 3C	1C	Safe

Other chemistries have these drawbacks

Li-Ion has poor current capacity and their voltage is above what is specified for most servos, therefore needing voltage regulators.

Li-poly has frail packaging and also has the higher voltage requiring regulators. They can explode if charged incorrectly or if damaged.

Nimh have poor current capacity and are heavier than other cells, require careful maintenance to avoid losing capacity.

With Li-Ion and Nimh you are required to carry much more mah capacity than you need in order to get the current output that is required in a large scale plane.

With Li-poly the current capacity is there but they require regulators and must be charged very carefully.

A123 has the right voltage for R/C applications without regulators, they have high current capacity, can be fast charged safely, are ruggedly packaged, and they do not catch fire if overcharged.

Some “TERMS”

To have a discussion of these batteries you need to understand some of the terms used, this is very important.

VOLTAGE is the electrical pressure in a circuit, sort of like water pressure in a pipe.
CURRENT is measured in AMPS (or milliamps, 1/1000 of an AMP) is the amount of flow of electrons. Using the “water in a pipe” analogy current would be the amount of water flowing through the pipe.

MAH is milliamp-hours, a measure of capacity that is calculated from how many milliamps can be delivered in 1 hour. A 2000mah battery pack is rated to deliver 2000 milliamps for 1 hour or 1000 milliamps for 2 hours, etc. In fluid terms this would be analogous to the size of your fuel tank, it represents the total amount of power available.

“C” is another way of referring to MAH, or “C”apacity. A battery produces electricity from a chemical reaction and therefore can not deliver it’s entire capacity instantly, it takes time to generate and deliver that power. A battery’s current delivery ability is rated as a multiple (or submultiple) of C. For example a 1500mah battery pack with 2C current capacity can deliver current at 2 times the mah capacity or 3000ma or 3 amps. This is important in large planes with high current demands from large power hungry servos.

How much do I need?

With the older battery chemistries like Nimh, the total capacity you had to carry was determined by the current load. If you needed 10 amps burst you had to have at least 3300mah capacity in a 3C chemistry like Nimh in order to get the power that you needed. The amount the plane used overall was somewhat irrelevant, because you usually had to carry more than you would need.

With A123s you can carry as little as you want and still have plenty of current capacity. An A123 cell can deliver up to 30C. That means a 2300mah pack can deliver almost 70 amps, far beyond what any plane we use today might need. Of course it would only deliver this amount for 20 seconds.

In any battery, as you draw more current from the cell the voltage drops. I usually limit my battery pack selections to what can be delivered without dropping below 5 volts. An A123 2300mah pack will deliver approximately 20 amps and still remain at or above 5 volts. If your plane will ever require more than 20 amps, even for just a millisecond, then you should have at least 2 packs. If your application never draws more than 20 amps it will work reliably on a single pack if wired properly. This does not take into account duration.

To know how much duration is available (how long you can fly safely) you can calculate from how much battery capacity carry. A typical 50cc plane uses 20-25mah per minute of flight time. A 35% plane will use 25-35mah per minute, and a big 40%+ plane can use over 50mah per minute. And it’s good to leave a 25%+ margin for safety.

You need to decide how much flight time you want between charges. Keep in mind that these battery packs can be recharged in 10-15 minutes, so recharging at the field is a very viable option.

I typically will fly about 3 or 4 10 minute flights in any day at the field. If I am flying a 35% plane, 40 minutes of flight time will use up maybe 1400mah of capacity, so for me in this scenario a single 2300mah pack is plenty. If I were going to use more than this adding a second pack would be a good idea.

What about my ignition?

You can use the A123 batteries to power your ignition also. Normally a separate pack is required, however with all known 2.4 ghz. receivers it is possible to power both the receiver and ignition from the same pack. On smaller planes like 50CC this is very practical, saves weight, cost, and complexity. You only need to charge 1 battery which reduces the possibility of errors considerably.

How do I test my batteries?

Living with A123 batteries is a little different from other battery types because of the very flat discharge curve.

Other battery types show a marked voltage drop as they discharge. This drop is easy to see on a volt-meter and can be used as an indicator of their state of charge. But the A123 cell looks almost exactly the same when it is 10% charged as it does when it is 90% charged, it's very hard to tell the difference with a meter.

So how do I know if my batteries have enough power to fly safely?

The chargers that are used with A123s will all show you how much power was put into the pack during a charge cycle, and this number will match very closely the amount that was withdrawn since the last charge. So checking the pack is done this way;

Start by fully charging your new pack. When you charge it the charger will probably tell you that something like 1500mah was added to your new 2300mah pack, they are shipped with a charge of about 25% of capacity. There is no self discharge with A123s so they should arrive at your place with the same charge level that they left the distributor.

If your new pack seems to not take a charge, it may be fully charged already. Use a load of some type to discharge it at least half way. A small motor or 1 or more electric light bulbs can be used to drain the pack somewhat. Then recharge it.

Now it should be safe to make 1 flight with the battery in your plane.

After 1 flight recharge the pack and note how much power you put back into the pack. It should be in the range of 200-400 mah for a 50-100cc plane and a 10+ minute flight. If it's not in the range of "reasonable" then there is something wrong, figure it out before you fly again.

Recharge the pack and now make 2 flights, then recharge. The mah put into the pack should be roughly 2x the first flight. Recharge and repeat making 3 flights. Recharge.

At this point you should have a very good idea of how much power your plane consumes in a flight. You can safely use 60% of the pack's capacity with no worries, more if necessary.

A 2300mah pack begins its voltage decline at about the 2000mah point, I suggest never take your batteries past that point. I set 1500mah total used as my cutoff point, I will not start a new flight with batteries that have been discharged 1500mah or more. This way I always have more than 25% of the usable capacity available when I start a flight.

If you are using 2 battery packs on a plane do this procedure on both packs, their capacity will be added together. 2x 2300mah packs will have usable capacity of 4000mah (2x 2000). The smaller 1100mah packs are good for 900 mah before they begin to decline, so two of them will have 1800mah available.

How do I charge them?

A123 lithium cells require charging using a system called "CCCV" or Constant Current/Constant voltage. Their cutoff voltage is 7.2 volts (3.6 volts per cell), so it is necessary to verify that your charger will stop at 7.2 volts. Most Lithium cells require a 4.2 volt cutoff, so be sure your charger is designed to support the lower cutoff voltage. Normally the charger will have a "LIFE" setting which is the same as A123 for charging profile.

A123 cells will not explode or catch fire. You do not need to remove them from the plane or put them in a protective container during charging.

2300mah cells can be charged at up to 10 amps, however most chargers that we use are limited to about half that. With popular Top Modelteknic charger that Wild Hare sells we usually set it to charger at 4 amps which is sufficient to recharge a totally discharged cell in about 35 minutes. Topping off a pack after a few flights can be done 1n just 1a few minutes. For this reason it is more practical to use only a single pack, if you need to recharge at the field it takes about as long as it does to refuel and stretch your legs.

A123 packs can be charged using either a balancing charger or unbalanced. Some chargers require balancing, others do not. The battery packs that Wild Hare sells provide two power connectors. One is a two wire heavy duty lead with Deans connectors, this is normally connected to the receiver. It can be used with NON-balancing chargers only. We normally charge through that connector if no balancing is needed.

Is balancing necessary? It is not necessary to balance your pack every time you charge, but it is known that some cells can have small differences, some peak out higher than others. When multiple cells are charged in series, the charger is looking for a total pack voltage. Stronger cells will overcharge to a higher voltage and weaker ones may never reach a full charge. Every time you charge the difference becomes larger. Balancing corrects these differences. If you never balance the differences will grow larger with each recharge until one cell fails to perform at all. Therefore we recommend that you perform balanced charging whenever possible, but for a quick field recharge it is unnecessary.

The other connector/lead on our packs is a conventional JR type male servo connector. This lead has 0V on the black wire, +6.6v on the center wire, and the third (normally signal) wire is the balance wire, it carries +3.3v relative to the black or brown wire and –3.3v relative to the signal wire.

The pack's charge lead can also be used to power lower power devices such as electronic ignition, smoke pump, etc. **Be careful using the charge lead because there is voltage on what is normally the signal line.** Most devices like switches don't really care about the third wire, but shorting yellow (signal/ balance) wire to one of the other wires will result in melted connectors and wires.

A note about high charging currents; The specified charge current (lets say 5 amps) is only applied until the pack gets to 7.2 volts, after that the charge current is reduced to maintain that voltage until the current going into the pack is almost zero. As a result, charging at currents higher than 4 amps does very little good, since the voltage is quickly reduced to whatever is needed. Just because you are using a 8 amp charge current doesn't mean the pack will charge in half the time of using 4 amps, it doesn't work that way.