Batteries for R/C Jets by Art ARRO

Batteries are an important component in R/C jets due to the critical requirements of turbine starting, running, cool down and the radio control functions. Most jets utilize multiple servos, many of which are digital with coreless motors. The receiver performance is also tied to the voltage levels and any dips or brownout may result in a failsafe or loss of the radio link. This article aims to describe the various battery types and their application to modern R/C jets. Personal preferences in selection, charging and maintenance of R?C batteries is also discussed. Finally I have included several useful websites for further information on these subjects.

I'll start with a bit of history and science to begin this article. The first batteries were discovered in Sumerian ruins dating back to the year 25 BC and found near Baghdad, Iraq. A clay jar with a copper cylinder was found to produce about 1.1 volts when filled with an electrolytic solution of vinegar or even grape juice. This reaction produces an electrochemical reaction with a voltage and current flow. During the 1800's a battery was made by Alessandro Volta using discs of copper and zinc in a glass tube filled with a suitable electrolyte. These batteries were used to electroplate objects, mostly jewelry and for scientific experiments. Basically a battery consists of two dissimilar conductive materials, electrodes, separated and immersed in a suitable electrolyte. Differences in the electrodes and electrolyte produce different voltage outputs and capacities. The batteries may be primary as in the case of carbon-zinc with an ammonium hydroxide electrolyte packaged in a cylindrical shape as for a common non-rechargeable flashlight battery. Secondary batteries can be recharged and the most common are the lead acid (PbS) batteries used to start and maintain vehicles such as cars and trucks. For R/C use, nickel cadmium cells are the most popular due to their ruggedness, and ability to deliver high current values at a wide range of operating temperatures. The downside of nickel cadmium is the environmental problems caused by their disposal of their heavy metals, notably cadmium. Nickel metal hydride (NiMH) chemistry is replacing the standard NiCads that were in near universal use for R/C applications. Recently, the demand for portable computer laptops, cell phones and cordless tools has resulted in the development of modern battery types such as Lithium Polymer (LiPO), Lithium Ion (LiIon) and Lithium Nano Phosphate (LiNP) chemistry. Several of these modern battery types have excellent applications for R/C in general and jets in particular. They also require special charging and handling procedures to prevent fire and or injury. These battery types and procedures will be discussed in this article.

NiCads have been around for decades and they have a good history of reliability for R/C applications. These are generally sealed cells of various sizes denoted by alphabet letters, AA, A, sub-C, D and F sizes. The capacity or electrical energy output is a function of the internal construction of each cell. An AA size cell may have a capacity (C) ranging from 500 to 1600 milliampere hours (maH) depending on the plate construction and separator thickness. The cell impedance or resistance to electrical flow directly varies with capacity. That is, a high capacity AA-size NiCad will generally have a high internal resistance and may not be able to deliver high currents demanded by multiple coreless digital servos. What happens is that their voltage output becomes depressed which may result in a receiver failsafe or brownout condition. The solution is to use larger capacity batteries with lower impedance for airborne applications. Another solution is to use a dedicated battery for the receiver power and a separate low impedance battery for operating the servos. There are several devices on the market (Power boxes and Power Backers) that do just that but they add cost and complexity to the airborne installation. On the other hand, the current demand of most R/C transmitters is relatively low and constant so the high impedance and capacity NiCds can be used in this application to extend their run time. NiCads, and their NiMh cousins, can be charged equally using the C/10 chargers (wall warts) that come with the R/C system. The problem develops when high capacity batteries are used and these chargers are unable to charge the batteries or the charge process takes an inordinately long time – measured in days. A high output variable rate charger is the answer and various suppliers offer them to the modeler. I've had good results with the Dual Metered Vari-Charger and Heavy Duty Vari Chargers HD-500 sold by Ace R/C. There are modern versions of these chargers available from Hobbico and Ace R/C. Just set the charge rate at 1/10 the rated battery capacity, ie, 140 ma for a 1400 maH battery typically used in R/C jets. This is the minimum capacity that I recommend. The charge time for a totally depleted battery is 14-16 hours at this rate. Note that these chargers are a constant current type providing a steady current during the entire charge process. NiCads or NiMh batteries can also be fast charged at a 3C rate or 3 times 1400 ma or 4.2 amperes. This is about the limit for standard R/C connectors and charge receptacles. This type of charger should have peak detection circuitry to sense when the battery is fully charged and taper back the charge rate or cut it off entirely. The NiMh batteries exhibit a softer peak than many fast chargers can not detect resulting in excessive heat and pressure followed by safety venting of the battery. This venting of electrolyte is a safety hazard and also shortens the overall like of the battery. I do not fast charge NiMh batteries and limit my fast charge rate to 1C or less with NiCds. This yields the longest cycle and calendar life of these batteries. The initial charge of NiCad and NiMh should be at the C-10 rate to form the chemistry within the battery. I form charge and discharge every battery several times before installation in my jets to ensure reliability. The discharge rates are set at 500mA or 0.5A to simulate a high load as experienced in a typical R/C jet. I record the initial discharge capacities on a Avery-type sticky label attached to the battery pack itself. Some battery suppliers offer a log sheet to record this information for future use. The best method of determining when NiCd or NiMH batteries are fully charged is to sense their temperature. After the charge state reaches 100% additional current serves to raise the battery temperature. It should feel warm, not hot, to the touch. Some chargers even employ a temperature probe and reduce the charge rate when it senses this rise in temperature. I personally don't feel the need for trickle charging NiCds or NiMH batteries.

The newer Li-Po, Li Ion or Li NP batteries are also suitable for R/C jet applications due to their low impedance for high current draw, long charge retention and relatively light weight. However, the charge process and the use of these batteries require different procedures. The LiPos have a narrow operating voltage range where overcharge or over depletion can result in a severe fire or conflagration. The charging technique uses a Constant-Current/Constant Voltage method and requires a special charger. The charge current is at the C-rate up to certain voltage and is reduced to maintain a critical voltage until the current drops to zero. Due to their sensitivity to voltage, LiPo's batteries require that each individual cell be balanced in voltage to others in the battery. During the charge process, if one cell is lagging in charge then the overall pack voltage will be low and the sensing point for switchover to the constant current mode will be affected. The charger will continue charging looking for that point and drive the already charged cells into heat, venting and possible fire. The safest chargers for Lithium-based battery chemistries charge through the balancing plug to equalize the charge across all cells in the battery. It is possible to use a simple balancer, such as the Astro Blinky, to balance Lithium batteries prior to use and charging. If the Blinky or similar balancer indicates an imbalance condition then the Li Po should be slow charged at the C/10 rate; or 210 mA for a 2100 MaH LiPo battery. Lithium batteries should not be depleted more that 80% of their rated capacity for the best performance and cycle life. The best way of checking this is to discharge the battery at some known rate and recharging it to note amount of maH to fully charge it. For example, a 2100 MaH could be discharged at some safe level then note the amount of charge being put back in. If the charge amount is 1680 MaH then this equates to 80% which is an acceptable value. LiPo batteries also like a short break-in where the first discharge is about 50% of capacity, about 1050 MaH for the 2100 MaH battery under discussion, and increasing the depletion by 10% increments until you reach the 80% level for maximum performance and cycle life. This procedure is of primary concern to high end EDF pilots with a very expensive set of LiPo batteries to care for. Battery temperature is another parameter to judge how hard you've used LiPo batteries. A comfortable level is 125F with a maximum temp of 140F measured immediately after a flight or discharge cycle. The greatest temperature rise is the last few % of available capacity. Another factor with Lithium chemistry is that the charge voltage is 4.235 V per cell and a fully charged 2S , as in series, battery yields over 8.4 volts which is hard in the servos, gyros and gear sequencers used in most R/C jets. A voltage regulator can be used to reduce this voltage to a safe operating level of about 5.0 Volts. Again these regulators add complexity and cost to the radio installation. They may also have a maximum wattage dissipation to prevent thermal runaway and shutdown. I personally don't use LiPo's for receiver or servo power. However, those with kero-start turbines may require them for ECU batteries due to the high current draw of the fuel igniters. Check with you turbine manufacturer if LiPo's can used for ECU batteries and if the ECU requires an upgrade for these battery types.. The Li-Ion and LiNp batteries are somewhat safer as they have a metal shell with safety vents. These batteries also require the Constant Voltage/Constant Current method but at different voltage/ current transition levels. The LiPo, LiIon batteries should be stored at 50% capacity in a cool place. Do not freeze this chemistry but 40F is OK for long term storage. Be sure to bring them up to room temperature before use or charging.

The latest technology is the LiNP for Lithium Nano Phosphate and these appear to have the greatest application for R/C system and turbine ECU applications. Their nominal voltage is 3.3Vper cell and a 2S battery yields 6.6 Volts which is about the same as a 5 cell NiCd or Ni Mh battery. These batteries have long charge retention, measured in months, with a high (up to 30A) discharge current and very safe due to their construction. . LiNP batteries are commonly called A123. Their downside is a limited cell size, but they can be mated together in series and parallel arrangement for most R/C applications. I've heard good results with A123 batteries and will equip my scale and sport jets with these batteries for the coming season.

For chargers, I've already mentioned the ACE DMVC and HD-500 for NiCd and NiMh charging and I'm satisfied with the Multiplex LN-5014 Digital Charger/Cycler for my low-end LiPo batteries. This charger operates off 12V DC for field use and measures the MaH used to peak the batteries. It does not have a balancing feature and I use the Astro Blinky for this purpose with my LiPos. For high-end LiPo EDF charging, up to 10S, I have a TME Extrema with all their balancers and attachments. The Extrema is a dedicated Lithium charger and I've had it upgraded, for free, to handle the new A123 batteries. Most recently, I've bought the FMA Revolution Cell Pro balancing charger for dedicated A123 batteries up to 4S. The Cell Pro also handles LiPo, Li Mn and Li ION chemistry as well. It is an auto-magic type charger for ease of field use.

I've had the best results and battery life by purchasing my batteries from reputable sources such as Hangtimes Hobbies (NoBS Batteries) and SR Batteries. Batteries purchased in hobby shops exhibit low shelf life as they have been sitting for some time after manufacture and distribution. I have my receiver and ECU batteries custom made to my requirements. The receiver batteries all have dual leads which are connected to two JR Deluxe Heavy duty Switches and inserted into two open ports on the receiver. I try to avoid voltage regulators, power boxes, etc whenever possible.

I perform voltage checks after charging and before every flight using an Ace Voltmaster II at the 500 mA setting. I check the no-load voltage initially, then apply the 500 mA load for about 10 seconds, and assess the bounce back to a resting voltage. If everything is fine, then I fly. Otherwise, I'll quick charge and check again. I do not fast charge transmitter batteries, but always carry a fully charged battery in my transmitter carrying case.

Cycling of NiCd and NiMh is done periodically during the flying season at monthly intervals. During our 5-6 month winter season, I cycle bi-monthly or at least 3 times before flying commences. These batteries are removed from the model and are stored in my cool workshop. LiPo's are stored at 50% of charge and I haven't had enough experience with the A123 batteries. I've heard conflicting storage charge values at 50% and 100% for these batteries.

In closing I've listed below several web sites for more information on R/C batteries.

www.rcbatteryclinic.com, www.hangtimes.com, www.electrodynam.com, www.bvmjets.com.

I trust this article was useful in the selection and use batteries for R/C jet applications.