# Presentation on Battery Chemistries and Charging
# 11/5/13

This is a generic discussion intended for hobby modelers, and is a discussion of what I think I know. I am not claiming to be all knowledgeable nor will I accept responsibility for use of this information. That said, I have researched the topics discussed and feel it is safe to share.

1) Definitions
    a. A battery is made up of multiple cells. In this discussion, we will mostly talk about batteries, with some reference to individual cell specifications.
    b. Battery Capacity is a measure of the total energy available for use from a battery, usually given in mA-Hr measurements. This is the battery C rating.
    c. Discharge Current is another use of C rating that can confuse first time LiPo users. This is the maximum current the battery can deliver without damage as a multiple of the C rating.
    d. Burst Current is the maximum short term current the pack can deliver without damage, again as a multiplier of the C rating
    e. Example: A 4 cell, 2000mA-hr, 20C, 30C Burst LiPo pack has a C rating of 2 amp-hours (2 amps for one hour) and can deliver a maximum constant discharge current of 40 amps, with a short term current of 60A. Note that battery temperature will be the actual limit to any of these specifications, which all really relate to internal resistance of the pack.

2) Battery Types (Chemistry)

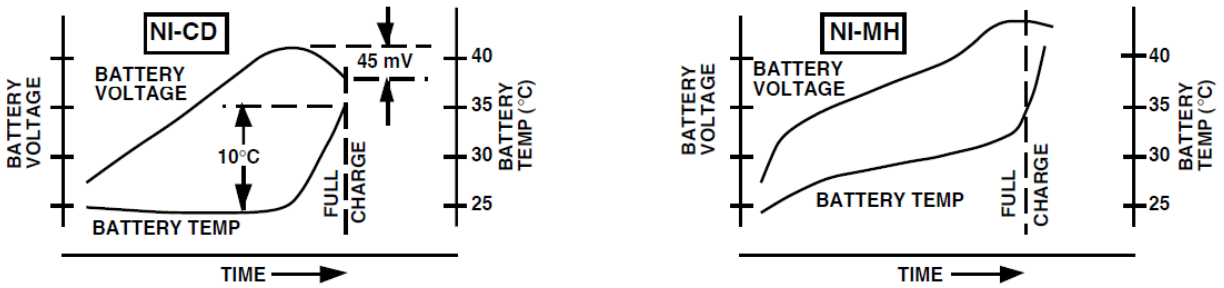
    a. Most of us are familiar with NiCd (Nickel Cadmium) and NiMH (Nickel Metal Hydride) batteries. We use them to power receivers and ignitions, and they have been around for some time. I will consider these types to be similar enough to lump into the same category for the purposes of charging discussion. To note, NiMH will provide slightly more current and will not develop as much of a “charge memory” as NiCd, usually also meaning a longer life span. The charging profile and method are very similar.
    b. Lithium based (Li-ion, LiPo, LiFe, etc.) are similar as far as charging method, but do require setting your charger to the correct parameters. The underlying chemistry is similar, but various differences achieve desired form factors and energy density. Typical hobby uses for Li-ion and LiFe include receiver and ignition power, while LiPo is usually used in electric powered craft. This could become an exhaustive topic by itself, but I will limit the discussion to the currently typical battery types and charging characteristics. With proper care, these types can be used and charged safely, but care must be taken or damage can occur both to the battery and to equipment.

3) Charging of different types

    Different types of batteries require different charge modes and charge settings. A good quality

charger must be used that has the capability of charging the specific battery type. Many small chargers are available for specific types only, such as a low current LiPo balance charger that charges only through the balance port. Higher capacity and multi-chemistry chargers charge through the main connector and use the balance port only to control charge to each individual cell. Multi-chemistry types may also be referred to as CV/CC, or constant voltage/constant current types.

a. Charging NiCd or NiMH types is actually difficult in terms of detecting the charge termination point. These types are charged primarily in a constant current mode. In modern chargers, the termination is detected by pulsing the charge current while monitoring the battery voltage. When a negative delta V is seen, the charge current is reduced to a trickle for a period of time, then is shut off entirely. Note NiMH types will be damaged by long duration of trickle charge, where NiCd could handle that, so don't use old NiCd chargers on NiMH packs! Conversely, NiMH chargers are safe for NiCd packs.




i. Note that temperature is another termination variable, and using the thermal sensor of your charger is another safety feature.

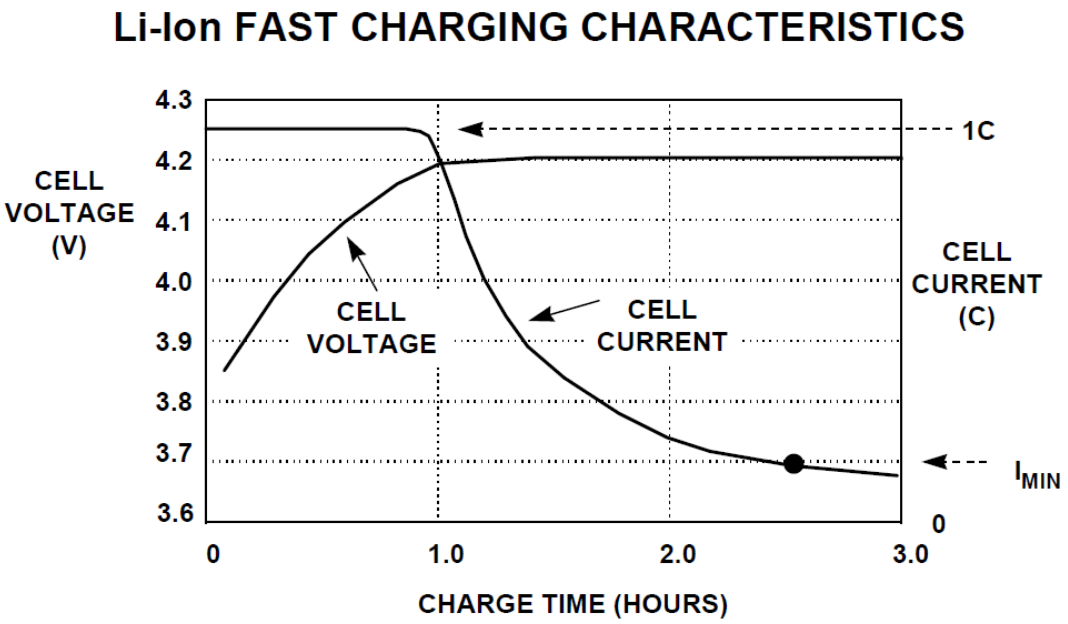
ii. There is no balance control circuitry in Ni types, the overall charging process and chemistry allows for balancing to happen without individual cell controls.

iii. What is maximum charge rate? A good question with less than a single concrete answer. The old rule of thumb was C/10, which still always applies to the end trickle rate due to the recombination structure inside the cell. With modern cells and chargers, that rate can safely go up to 1.2C with proper care (must reduce to trickle rate and stop at end of charge). Manufacturer ratings of your particular cells should be used. The real issue is to charge it hard enough to get warm, but not hot. As an example, I generally charge my NiMH 2300mAH packs at about 0.6A which usually take between 1-2 hours to fully charge. I have gone up to 1.5A to top off at the field within 30 minutes, but I watch the temperature at that rate. The chemistry won't like a rise of more than about 2°C/Min. A slightly higher charge rate helps the charger detect the stop point.

b. Lithium types are charged primarily in a constant voltage mode. Modern smart chargers will initially assess the battery voltage and usually begin charging in CC mode, then when the voltage levels rises to a point, switch to the CV mode. In this mode the charger applies voltage to the battery and limits the current. Termination is reached when the battery voltage, cell balance, and current draw reach determined points.

i. Even though we enter CV mode, the battery voltage cannot change instantly, so the voltage displayed will not match the endpoint until charging is nearly complete.

ii. ALWAYS double check charger settings match current limit and voltage target for the specific battery under charge.
iii. NEVER charge a Lithium type with the charger set on a different battery type. That WILL start a fire!
iv. Again, a temperature probe is a good safety item that will also terminate charging if an issue arises.
v. Charge rate for most Li types is 1C, although some new types advertise up to 5C.
vi. Li types should be brought to storage level, about 75% charge, if not to be used for several weeks. This will greatly improve their life span. Cycling is not normally required, but it has been known to improve performance for some packs nearing end of life.




4) Other Topics
   a. Power rating of chargers should be considered when purchasing. Some have AC supplies built in and can be powered with AC or DC, others are DC only. Some have different output power ratings whether on AC or DC inputs. Realize the Power = Voltage x Current, and don't exceed the power rating of the charger even if the battery can handle more. One person blew the AC power supply because specs weren't clear about the AC power being only 50W, while allowing for 80W if DC powered.
   b. Older NiCd chargers cannot detect the stop point for NiMH, don't use them in this way. Conversely, newer NiMH chargers will work fine for NiCd, some even have both types.
   c. Temperature sensors come with most smart chargers and should be used as an extra safety device. This will allow the charger one more method of detecting a problem and avoid venting a battery.
   d. Smart chargers also use a timer as a last resort to avoid damage. Set it accordingly for your charging purpose.
   e. A reference table below that I made for myself some time ago, take the numbers as a guide.

| TYPE | Min. V per Cell | Nominal Working V Range | Max. V per cell | Charge Rates |
|---|---|---|---|---|
| LiPO | 3.0 | 3.1 - 4.0 | 4.2 | 1C, balancing<br>Some newer tech's can go up to 5C |
| LiFE | 2.8 | 3.0 - 3.3 | 3.6 | Max 1C, balancing |
| NiMH | 1.0 | 1.15 - 1.35 | 1.4 - 1.6 | C/10 normal<br>1C with temp probe, limit 2ºC per minute |
| NiCD | 1.0 | 1.15 - 1.35 | 1.45 | C/10 normal<br>1C with temp probe, limit 2ºC per minute |
| NiZN | 1.2 | 1.6 | 1.9 | C or C/2 with NiMH profile but set cutoff to 1.9V/cell |