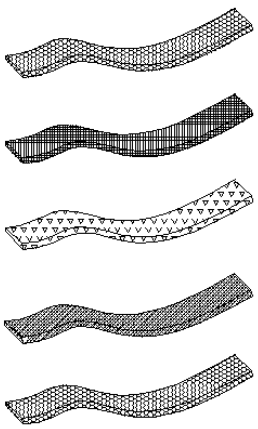
6.0 Lithium Polymer (Li-Pol)

A Lithium polymer is technically a lithium-ion polymer battery. It is very similar to the lithium ion battery but without some of the shortcomings. It can sustain a significant amount of abuse. For example a fully charged Lithium Polymer battery can be punctured with a nail without explosion or fire.

It originally used a plastic anode material and SPE (Solid Polymer Electrolyte) as the electrolyte. This comparatively new technology is rapidly evolving and improving. Currently we use a gelled electrolyte and separator. The data below is based on the current technology at the time of publication.

Figure: 6.0 Lithium Polymer Cell Construction



6.1 Lithium-Polymer Principles of Operation

The lithium-polymer electrochemistry currently covers a wide range of active materials such as $LiCoO_2$, $LiNiO_2$, and its Co doped derivatives. Harding uses $LiCoO_2$ chemistry.

Rather than the traditional metal can used by other small rechargeable cells, Lithium Polymer Batteries employ a thin (110 µm), polymer-based packaging material to contain the electrochemical materials. This allows the system to have a flat thin (2 to 5 mm) form factor. It is also possible to make the footprint of the cell large (e.g. 70mm by 100mm), this being ideally suited to handheld devices such as PDA's.

Since the case of the cell starts as a sheet of polymer-laminate, changing the footprint of the cell is cost effective. Also, if the Lithium Polymer cell uses a 'stacked' construction, adjusting the electrode/electrolyte structure is also easy. In this way, Lithium Polymer cells exhibit flexibility in their mechanical properties and flexibility in their construction.

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6.2 Charging Chemical Reaction

When Lithium Polymer cells are first charged, lithium ions are transferred from the layers of the lithium cobaltite to the carbon material that forms the anode.

Figure 6.2 Initial Charge

$$LiCoO_2 + 6C \rightarrow Li_{1-x}CoO_2 + Li_xC_6$$

Subsequent discharge and charge reactions are based on the motion of lithium ions between anode and cathode.

6.3 Discharging Chemical Reaction

Figure 6.3

$$Li_{1-x}CoO_2 + Li_xC \leftrightarrow Li_{1-x+dx}CoO_2 + Li_{x-dx}C$$

During charge/discharge Li+ ions are transported back and forth between two insertion electrodes

6.4 Overcharge

A strict charging regime is necessary to properly and safely charge Lithium Polymer batteries. Most batteries contain a protective circuit to prevent overcharge and over discharge. This circuit limits the charge voltage to a maximum 4.2 Volts. The circuit also contains a thermal sensor, which disconnects charge if the temperature reaches 90 °C (194 °F). If a cell is inadvertently overcharged, the cell may heat up and vent with a flame.

6.5 Over Discharge

Cell should cutoff at 3.0 Volts.

6.6 Discharge Characteristics

Operating temperatures for Discharging are -10°C -60°C

6.6.1 Temperature

Temperature is a significant factor on available capacity as shown on Figure 6.6.1.

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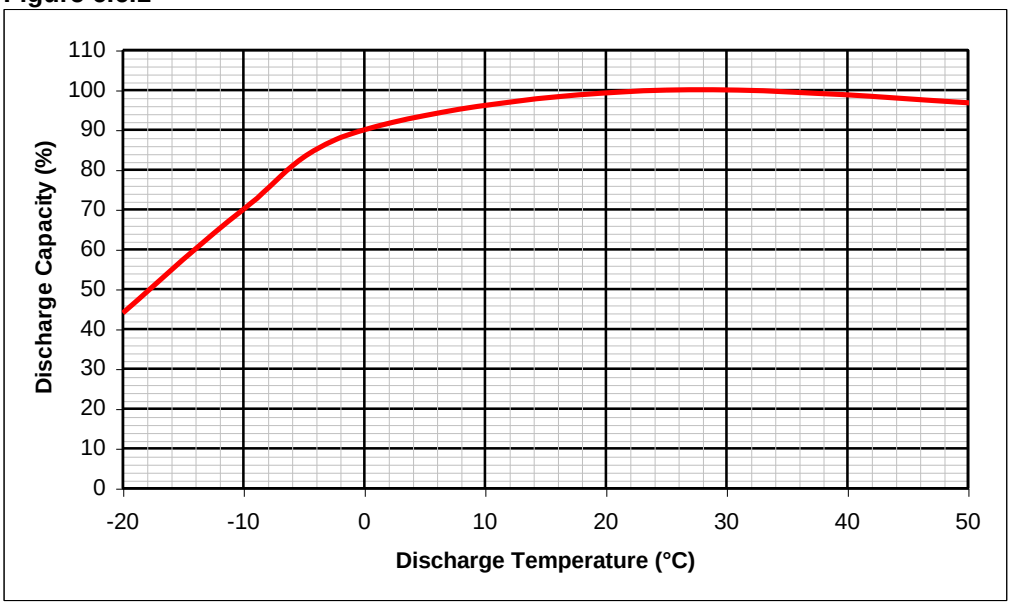
Figure 6.6.1



6.7 Charging Characteristics

- You must use a charger designed for Lithium Polymer Batteries. Do not use a charger intended for NiCd/NiMH batteries - you will damage the cells permanently.
- Lithium Polymer cells cannot be "fast charged". Never charge at a mA higher than the capacity of the battery (1C max charge rate). For best charging, low charge rates should be used when possible. You must not over discharge your Lithium Polymer cells or they may become permanently damaged
- Charge at a constant current until the battery voltage reached the 4.2 voltage limit at which time the current is reduced to maintain 4.2 volts.
- Operating temperatures for charging are 0°C to 45°C

6.7.1 Charge Cycle

The Charge cycle called a CC/CV two-stage charge cycle must be performed to fully charge the battery.

- The first stage of the charge cycle is a Constant Current charge until the battery voltage reaches 4.1 to 4.2 volts.
- Upon reaching this peak voltage, a Constant Voltage charge is initiated until the charge current reduces to 3% of the rated current. Upon completing charge, a top off charge may be used to insure to counteract the self-discharge of the battery and protective circuit. This top off charge may be initiated when the open circuit voltage of the battery reaches less than 4.05 volts and terminate upon reaching the full charge voltage of 4.1 to 4.2 volts. Depending on the battery, this top off charge may be repeated once every 20 days.

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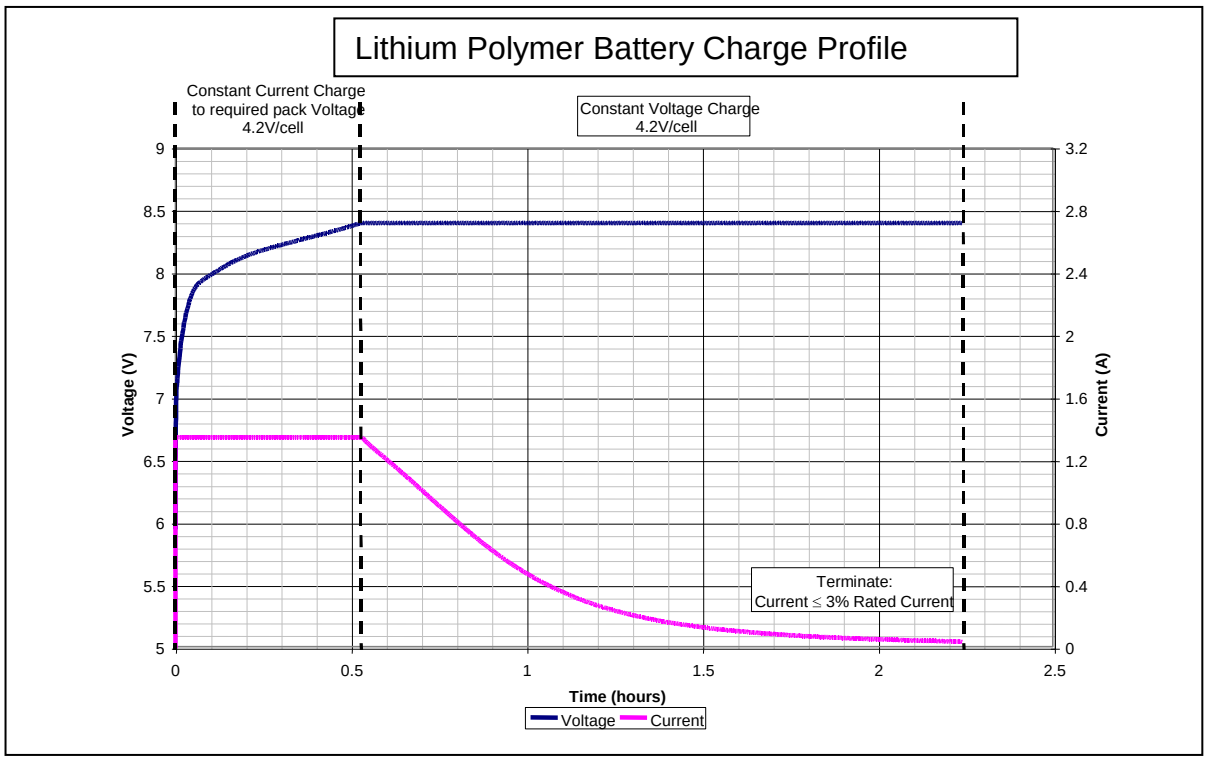
Figure 6.7.1: Charge Profile of Lithium Polymer Battery Pack



6.8 Lithium Polymer Storage Guidelines

- Store the cell in a dry location between –20°C and 30°C. Keep out of direct sunlight.
- When storing for an extended period, store between 10°C to 30°C
- Store at 40% of capacity.
- When charging the first time after long-term storage it may take several cycles to achieve original performance.

6.9 Protection Circuit

Malfunction may be caused by the unstable Lithium Polymer battery structure when it is overcharged or over discharged. Accordingly, a protection circuit is necessary to fend off this malfunction. By monitoring voltage of each battery, charging or discharging is limited by breaking the current when the monitored voltage deviates from normal levels. The flow of current is cut off in the case when the current flow is excessive. This is done with an IC, FET, Fuse and/or PTC Thermal Fuse.

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6.10 Lithium Polymer Cautions

Lithium Polymer Batteries and packs that are abused may cause damage to the pack or the device resulting in personal injury.

- Do not expose the battery to extreme heat
- Do not short circuit battery
- Do not puncture or modify the battery or pack
- Do not immerse the battery pack in water
- Never reverse charge the battery
- Charge only with charger specified by equipment manufacturer

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