Getting the Most From Your Lithium Ion (Li-Ion) Battery Technology

Rechargeable battery technology has improved dramatically over the past twenty years. First there were Nickel-Cadmium (NiCad) batteries. Anyone who remembers NiCad batteries knows the frustration of the limited amount of device use and "memory" function that prevented them from taking a full charge without being fully discharged. Then came Nickel Metal Hydride (NiMH). NiMH batteries were a tremendous advance. NiMH was more tolerant of partial discharge and offered longer device usage. Now there are Lithium Ion (Li-Ion) batteries. Li-Ion batteries offer greater energy storage capabilities, are smaller and lighter, and typically provide for longer device use than nickel-based battery technologies.

What's the difference between Li-Ion and NiCad/NiMH batteries?

Li-Ion battery technology is chemically very different from previous battery technologies. All batteries, rechargeable or not, depend on specific, and often proprietary, combinations of different chemical elements. The voltage and charge capacity of each product are the result of those combinations.

The Li-Ion battery chemistry provides greater chargeable capacities from both gravimetric (watt hours per unit weight) and volumetric (watt hours per volume) perspectives. The chemistry also permits Li-Ion batteries to avoid the "memory" problems typical of Ni-Cad batteries and, to a lesser extent, of Ni-MH batteries.

Li-Ion cells have a nominal voltage of 3.6V or 3.7V versus Ni-Cad or Ni-MH cells of 1.2V or 1.25V per cell. This means that one Li-Ion cell can replace 3 nickel cells. Arranged in serial or parallel configurations, they can deliver voltage and capacity able to support multiple application requirements that were impractical and/or cost prohibitive with other technologies.

Because of their higher energy output per volume, Li-Ion cells are also more adaptable to extremely thin form factor batteries.

How long will a Li-Ion battery last?

While it is impossible to make a statement about how long a Li-Ion battery will last in a given device in terms of months or years, it is possible to talk about the number of cycles that a battery is designed to provide effective power.

Battery life is typically measured in cycles, with 300 to 500 full charge/discharge cycles being typical. The range is the result of variables in the device in which a battery is used, environmental conditions, and peak/low energy demands in a given application. LXE's Li-Ion handheld computer batteries' minimum battery life is approximately 500 charge/discharge cycles.

Since Li-Ion batteries do not need to be fully discharged before being recharged, their useful life may appear to be even longer since they can undergo "shallow discharge" and recharging without suffering premature loss of function.

How will temperature affect a Li-Ion battery?

Li-ion batteries are designed for operating environments from 0ºC to 60ºC. Hot spots within the device caused by the terminals components as well as usage in extreme temperatures (either hot or cold) can cause premature degradation of the cells or electronics within the battery. However, it is important to understand that ambient (environmental) temperature and battery (operating) temperature are not necessarily the same. Computers designed for use in cold or hot temperatures may provide a heater (for cold) or coolers (for hot) to maintain proper battery and device operating temperatures.

What else will affect the useful life of a Li-Ion battery?

Improper long term storage of Li-Ion batteries can reduce their effective life. New Li-Ion batteries should be stored in a location with ambient temperatures between 70º to 100ºF and at 40% state of charge or lower. After use, batteries can be stored at higher charge levels but it is recommended that you check with your supplier for details.

Prolonged storage at elevated temperatures and high state of charge will result in the permanent loss of performance of up to 40% per year. Batteries stored in cold environments will have to be stabilized within normal temperature ranges prior to recharging and use.

It is important to understand that all battery chemistries will temporarily lose their state of charge while stored. And with Li-Ion batteries, the hotter the temperatures the faster the discharge. When stored under optimal conditions, outside of the computer, Li-Ion's temporary state of charge loss is <1% per month. Ni-MH can experience losses of >50% within 30 days. It is a good idea that whenever possible, after a lengthy storage period, all batteries should be recharged prior to being placed back into service or use.

You should also consider not storing a battery in a terminal for extended periods of time or leaving a battery in an unused terminal for an extended period of time for the sole reason that the terminal uses current even when the terminal is turned off. Remember you get a finite number of charge/discharge cycles per battery. Why "waste" a cycle to storage if you don't have to.

What can I do to conserve battery life while my computer is being used?

First, be sure you understand power conservation options for your device. Most of these options are based on the device, or some feature of it, being inactive for a certain amount of time. For example, you could:

- set the device to dim the keyboard backlight several seconds after it's used,
- dim the screen backlight a minute after the last screen update,
- allow the device's CPU to go "idle" (essentially, to go to "sleep" until needed) if there's no activity for several minutes, or
- set the device to go into "suspend" mode after being idle for, say, five minutes.

In all cases, the device, keyboard, or screen can be "brought back to life" simply by pressing a key or by providing some other input.

Some applications will be able to take advantage of all the power conservation options while others will be able to take advantage of only some of them. Evaluate your needs and determine which conservation options you can use without affecting operational efficiency.

Do Li-Ion batteries require "reconditioning"?

Reconditioning a battery involves completely discharging the energy from a battery then recharging the battery. Li-Ion batteries do not require reconditioning to maintain good battery performance since Li-Ion does not have a memory effect. It is necessary to complete drain and then recharge a Li-Ion battery in order to determine its current capacity level, but that is not the same thing as reconditioning the battery. Li-Ion batteries do not have a condition that needs to be reconditioned.

Do I have to worry about overcharging Li-Ion batteries?

Although over charging batteries can be a problem with any battery chemistry, a well-designed Li-Ion system will include a power management circuit in the charger that can accurately detect when the battery charge cycle is completed and will terminate the charge. Ask your vendor if your system includes a power management circuit.

With Li-Ion batteries, a method called “Constant Current / Constant Voltage” (CCCV) shut-off helps assure users of not risking over-charge concerns.

It's important to recognize that the battery supplied with your device is part of a total energy system designed specifically for the device, the internal and external chargers. Substituting an aftermarket battery could jeopardize worker safety and device life.

Can I use Li-Ion batteries in any device?

Some older devices may not be capable of providing the energy management required by Li-Ion batteries. It is best to consult the device manufacturer to be sure you can use Li-Ion batteries. The older the device, the less likely it is you will be able to upgrade to Li-Ion.

Li-Ion batteries contain electronic circuits that provide for power management, charging and safety. Many Li-Ion batteries are classified as “smart” batteries. Electronics in these batteries provide various levels of intelligence for anything from fuel gauging to cell balancing.

Li-Ion batteries also use a different method for controlling charging and charge cut-off than previous chemistries. Not all devices are capable of adequately using or understanding these power management and safety features.

Can I use my old battery charger? (External vs. internal chargers)

For the same reasons that older devices cannot necessarily use Li-Ion technology, chargers designed for Ni-Cad or Ni-MH cannot be used for Li-Ion.

Li-Ion batteries use a different charging algorithm that is not compatible with the ones used with other rechargeable technologies. For that reason, when systems are upgraded from Nickel (Ni-Cad or Ni-MH) to Li-Ion, batteries are designed so that mechanically they will not be able to be used in the existing chargers.

When should I replace my batteries?

The standard recommendation is that batteries should be replaced when they are no longer capable of holding 80% of their original capacity.

Determining when this occurs can be difficult since not everyone has the equipment to provide this measure. Therefore, users should consider how frequently a battery is recharged.

A rule of thumb is that daily use results in 200 to 250 charges per year. This level of use should result in batteries lasting 18 – 24 months. If the batteries are used 24/7 and recharged every other shift then annual replacement is recommended. If the batteries are used less frequently, stored for periods of time or are used in a back-up role, then batteries may last three or more years before being replaced.

What should I look for in making sure my Li-Ion batteries are safe?

Li-Ion batteries are more complex electronically than batteries of any other chemistry. Li-Ion batteries frequently employ sophisticated power management systems to improve or optimize the overall functionality of the energy delivery system. The basic functions of the power management circuits are:
• Control of energy flow into and out of the battery
• Prevention of abusive conditions so that user safety comes first
• Monitoring critical parameters and communicating that information to the system.

Since most of the risk occurs during charging, charger design has become more and more recognized as a critical component in the overall system safety matrix. The battery safety circuits used today provide protection for over voltage, under voltage, over current, and for excess thermal conditions.

Key to product safety is to use only those batteries designed for the original product by the original manufacturer. These batteries are thoroughly tested and qualified for the devices in which they are used. This provides the end user the best assurance of both the safe and optimal performance of the system.

How do I dispose of old batteries?

Disposal of all types of rechargeable batteries is regulated by local, state and/or federal regulations. Proper disposal of used batteries and electronics, particularly nickel-based batteries, is critical to ensuring environmental safety.

Requirements and options vary greatly in different countries and in different parts of the U.S.

Many locations have facilities or companies set up for receipt of old batteries. The web is your best source for guidance on local regulations and disposal options.

What's next in batteries?

As the demand for portable energy continues to outpace current capabilities, the energy industry continues to experiment and drive new technologies. The industry is constantly testing and evaluating new technologies. These processes can take from five to ten years to move from the lab to the manufacturing line.

At this point, several possible technologies have excited interest but are not ready for commercial distribution. Currently, manufacturers are working with new formulations of existing basic chemistries to expand the limits of the cells now in use.

Many of the research efforts today are focused on the battery's cathode material. The cathode is based on cobalt, an expensive material. Manufacturers are working to minimize the cobalt content of their batteries to help keep costs down.

Other areas of innovation are at the cell level and include new safety features and designs that accommodate high current for applications such as power tools.

Conclusion

As mobile computing and data collection technologies continue to become more sophisticated, integrate more features, and offer higher performance, they require battery technology that offers higher performance, lower weight, longer effective usage times, and absolute consistent reliability.

The choice of battery chemistry is critical for performance, reliability, cost and safety. For these reasons, more designers have turned to advanced formulations, such as Li-ion.

With each advance in battery technology, battery manufacturers include more features to ensure safe and effective operation. For example, Li-Ion batteries also contain advanced circuitry that monitors power levels to prevent overcharging and overheating. The power monitor, or fuel gauge, also ensures that the battery receives an optimal charge and provides the greatest possible device use.

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