# Charging Forward With Lithium-Ion Battery Technology

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**Enhancements in protection methods and power densities, combined with reduced costs have medical device manufacturers looking at lithium-ion battery technology to solve a number of design challenges for their portable devices. This article reviews a variety of advantages of this technology, and examines recent advances that make it well suited for this industry.**

Advances in lithium-ion battery technology have created new opportunities for the development of portable medical devices. Not only are these new devices required to perform under demanding circumstances, they also require extended battery life. In addition to improved battery pack performance, portable devices are becoming increasingly compact. These increased challenges have prompted design engineers to seek the latest innovations in battery development.

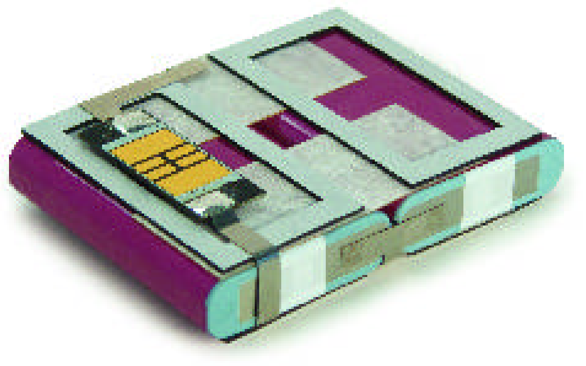

**Figure 1: 103450 prismatic cell Li-ion cell protection**

Key battery pack design drivers for compact, low power medical systems are cell mechanical characteristics, weight, and current handling capabilities. Until recently, nickel metal hydride (NiMH) cells were the battery chemistry of choice for portable systems. They provided improved power density over nickel cadmium chemistry, exhibited reduced memory effect, and provided a significant cost advantage over lithium-ion technology. Lithium-ion battery technology has progressed over the past decade and now offers improved protection methods, higher power densities, and significantly reduced costs, making it the primary choice among cell chemistries.

**Compact Designs Through Increased Power Density**

One way of balancing a compact design with higher power requirements is to increase the power density of the battery pack. The common method of evaluating power density is to consider the amount of Watt-hours per kilogram (Wh/kg). State of the art AA nickel metal hydride cells, commonly used in portable devices, offer approximately 100 Wh/kg. Latest lithium-ion cells, however, yield more than 240 Wh/kg.

In addition to power density, lithium-ion solutions supply at least double the amount of energy per unit of weight. Li-ion cells provide a standard nominal voltage of 3.7 V/cell and a potential voltage of 4.2 V/cell as compared to only 1.2 V/cell available in NiMH cells. As many as three NiMH cells would be required to meet the nominal voltage of a single Li-ion cell, and more than six NiMH cells would be needed to provide a similar power density. Using a lithium-ion solution creates smaller, lighter, and more streamlined battery packs.

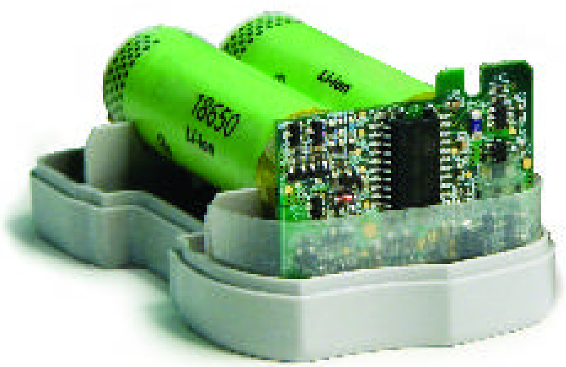


**Figure 2: Microcontroller-based protection for 18650 cylindrical Li-ion cells**

### Negating Memory Effect
In addition to improved power density, lithium-ion chemistries do not exhibit the so-called memory effect. Memory effect is the tendency of cells to lose capacity as a result of improper discharging and charging cycles. This causes reduced run times and degraded cell cycle life. Although many NiMH vendors claim that such cells do not exhibit capacity loss, the reality is they require very specific discharge and charge cycles in order to avoid this effect.

Lithium-ion cells, on the other hand, can be discharged to any level of the relative state of charge, as long as all safety considerations are met. The cells must be used within the tolerance levels of permissible discharge currents and must not be discharged below certain voltage thresholds, but otherwise, shallow or deep discharges followed by charge cycles do not induce the memory effect. It must be noted that all chemistries, including NiMH must be used within the specified tolerance levels; therefore, limitations of Li-ion chemistries are negligible.

### Options for Portable Devices
Determining the appropriate cell often depends on the power requirements of the portable device. One very common compact cell is the 103450 form factor prismatic (Figure 1). The designation of the cell refers to its dimensions, which are approximately 10 × 34 × 50 mm, with a weight of approximately 40 grams. Latest

generation 103450 cells offer up to 2,000 mAh of nominal capacity and a nominal voltage of 3.7 V/cell (4.2 V fully charged). Its low profile, high power density and low weight characteristics make this cell ideal for compact medical devices, which require approximately 2 A of discharge current due to their steady state current consumptions characteristics.

If nominal and peak current requirements exceed 2 A, engineers should consider the cylindrical 18650 cell (Figure 2). Considered a “work horse” of the industry, the 18650 lithium-ion cell has a nominal diameter of approximately 18 mm with a length of 65 mm. Although slightly heavier than the 103450, it offers the structural rigidity of a metal can along with additional safety. Most 18650 cells have an integrated positive thermal coefficient (PTC) protection device, often considered the first level of safety protection for Li-ion packs. A PTC acts to impede or block current flow in situations where the load exceeds safe levels. In addition, 18650 cells can sustain higher steady state and peak currents than smaller prismatic cells. Being the industry standard, this cell is available from multiple vendors with a wide variety of capacity ratings.

If the design requires the safety of a metal can along with the potential interchangeability of AA cells, from a form factor standpoint, a very viable option is a cylindrical 14500 cell. Although not as common as the 18650, this cell offers a few advantages. First and foremost, it is much smaller with a nominal diameter of 14 mm and a length of approximately 50 mm. It is less than half the weight of the 18650 at approximately 20 g, but it also offers half the capacity–750 mAh.

**Safety**
Due to their volatile nature, lithium-ion cells cannot be used on a stand-alone basis and require additional layers of safety. As mentioned above, a PTC provides just one level of protection. Medical devices need to provide uncompromised reliability, usability, and safety; therefore, additional layers of protection are often mandatory.

Sophisticated lithium-ion battery packs often integrate chemical fuse protection. Triggered by a separate protection circuit, chemical fuses respond to extreme events during pack exploitation and automatically open to permanently disable the battery pack. Although such actions seem extraordinary and will render the pack unusable, this protection is necessary in cases where high levels of safety and reliability are required.

**Advantages of Development Partners**
Although lithium battery technology offers multiple advantages over other commonly available chemistries, their properties require much more development expertise. There are many off-the-shelf products specifically designed for Li-ion battery pack protection and fuel gauging, but proper application and pack configuration is complex and hard to achieve.

Since product development timeframes and budgets are shrinking at an alarming pace, it is often advantageous to partner with a reputable lithium-ion battery pack developer. Not only are such partners able to provide a custom-tailored solution rapidly, but they often provide overall cost advantages as well. Companies, such as

International Components Corp., work closely with their clients to analyze all aspects of the system and develop battery pack solutions precisely configured for the end application. This encompasses all levels of safety, protection thresholds, fuel gauge precision, system communication, and mechanical rigidity requirements.

In addition to solving critical engineering challenges, an expert battery pack developer can manage the entire agency certification process. Medical standards for battery technology often involve elaborate and lengthy certification processes with nuances that can add months to development time if all agency parameters are not properly considered during initial design phases. Battery pack integrators provide the necessary expertise on such requirements as a primary service.

**Conclusion**
Device makers are consistently challenged to reduce size, increase the feature set, and simultaneously improve the battery pack lifespan. This places the demand on the design engineer to reduce the overall system power consumption and improve battery management methods, but there is only so much that can be achieved through innovative design.

This article has outlined the benefits of lithium-ion battery technology for wireless medical devices. Design engineers can achieve a compact design and extended battery life through proper cell selection and improved battery management.

Due to the volatile nature of the lithium-ion chemistry, proper battery pack designs require additional layers of safety. Based on the complexity of the today's battery pack design, OEMs will find it advantageous to partner with an expert in battery pack development. These companies provide device makers with state-of-the-art battery pack designs that solve today's design challenges.

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