# LITHIUM-ION TECHNOLOGY TARGETS PORTABLE POWER

The UL Component Program recognizes the Sonata battery platform, which requires lithium-ion batteries to pass electrical tests under exposure to abusive environmental, mechanical, and electrical conditions.

WORK CLOSELY WITH YOUR LITHIUM-ION-CELL MANUFACTURER AND BATTERY-PACK-DESIGN HOUSE TO DEVELOP SAFETY AND PERFORMANCE FEATURES FOR YOUR SYSTEM'S BATTERY PACK.

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## SPECIFYING, TESTING, AND MONITORING A BATTERY PACK

A typical laptop-computer battery pack can contain more than 50 Whr of energy and requires care in its design, construction, and operation to ensure that it remains safely within its operating limits. Few circuit-design engineers want or need to become battery experts, yet they must ensure that a system's battery pack can safely perform its tasks and that the host system can monitor the pack during operation. To address these constraints, you must understand how to specify a battery pack, what type of test and inspection it requires, and how the application monitors the battery pack's health during operation.

High energy capacity has made lithium ion the dominant battery chemistry for portable consumer devices (**Reference 1**). However, safety concerns also force the need for manufacturers to package the cells in a battery pack that often includes fuses, monitoring circuitry, a fuel gauge, an SMBus (system-management-bus) interface, and authentication circuitry. The industry-standard 18650 cell is about the same size as a AA battery, but even single-cell devices require that cell to be in a battery pack, complete with safety circuits and fusing.

Chemistry and technology features aside, you must select a lithium-ion-cell vendor with a stable supply chain to ensure a reliable source of packs and cells. For a variety of reasons, including recent years' massive recalls, factory shutdowns, and materials shortages, it's increasingly difficult to obtain lithium-ion cells. Couple those problems with increasing transportation costs; a poor exchange rate; increased demand for lithium-ion batteries in consumer electronics, power tools, and cars; and the rising price of cells, and you'll see why you must make a reliable supply chain a priority in selecting a cell supplier.

In the early 1990s, Sony became the first to manufacture lithium-ion cells, and the company, along with Panasonic, remains one of the largest cell vendors. Cost-sensitive, low- to medium-volume products can get by with off-the-shelf battery packs, which are available from thousands of small and midsized Chinese vendors. Don't be a penny-pincher when selecting a battery pack, however: It's seldom cost-effective to attempt to test-in quality at incoming inspection, and battery-pack field failures are dangerous liabilities. For cost-conscious, low-volume applications, an off-the-shelf pack is a valid route, but don't rely on price as the determining factor. High-volume applications can often justify the costs of developing a custom battery pack. In addition, low- to midsized-volume applications requiring high quality and high power, such as medical applications, can command a higher price and also can warrant a custom pack.

You can work with the battery-cell vendor or a battery-pack-design house to develop a custom battery pack. A valuable communication tool when working with your battery-pack vendor is a set of power curves that shows your application's profile over time during different operating modes, including temperature extremes. A power tool might have a discharge curve with high current spikes corresponding to cutting or drilling tasks (**Figure 1**). The magnitude and the duration of the spike vary with the shape of the material. A device that includes a radio transceiver also has spikes during transmission, and a continuous current must power its display and other functions. Ask your battery-pack vendor to demonstrate with prototype packs that its design can meet the demands you specify in all of your power curves.

Some medical-application customers of custom-battery-pack-design and -manufacturing vendor Micro Power Electronics require the company to test every battery and include a full charge-and-discharge cycle to ensure that the company has properly assembled each pack and provided it with sufficient capacity, according to Robin Tichy, marketing manager at Micro Power. In some cases, the company must develop a custom tester for the manufacturing line.

## AT A GLANCE

- Higher-quality cells and more sophisticated battery-management circuitry can pay off in lower battery-pack-production costs.
- Battery characteristics that enhance life cycles and charge times can be differentiating features for your battery pack.
- Higher-priced as well as higher-volume products can justify the higher upfront costs of customized cells and battery packs.

Some customers require just a simple voltage test to ensure proper assembly; others require that the manufacturers perform the tests on only a sampling of products.

If your battery-pack design calls for a relatively inexpensive fuel-gauge IC that counts coulombs by calibrating the pack and by measuring the charge to and from the battery, then you must individually charge and discharge each battery pack after assembly. This calibration increases production cost and the overall battery-pack price. Tichy suggests that you weigh the trade-offs of a more expensive fuel gauge, such as Texas Instruments' Impedance Track family, which requires no initial charge-and-discharge cycle.

IEEE standard 1625 for rechargeable batteries for portable computing covers testing requirements for laptop-computer-battery packs (**Reference 2**). After Dell, Hewlett-Packard, Apple, and other laptop-computer manufac-

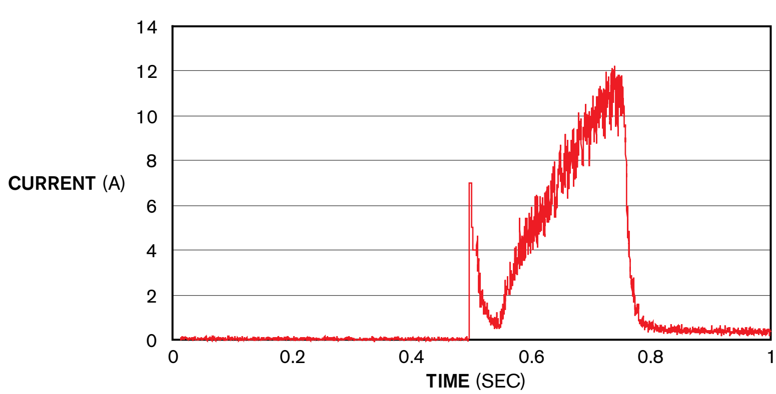


Figure 1 The system designer documents how the application uses power through power, or "discharge," curves. In this example of a battery pack for a screwdriver with a set screw, high current spikes correspond with cutting or drilling events. These events change depending on the duration of the spike and the material the drill is cutting.

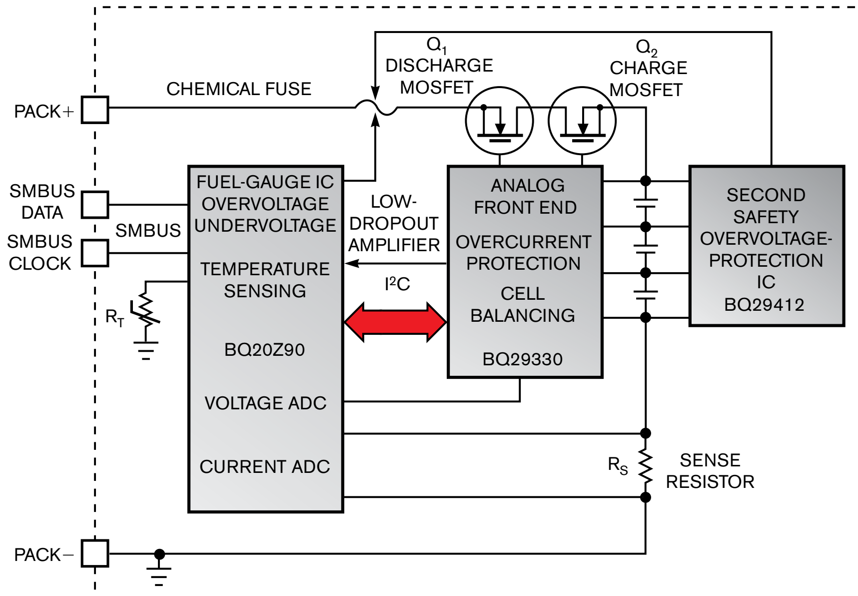


Figure 2 Smart-battery-pack electronics include a fuel gauge, an analog front end, and an overvoltage-protection IC. If the pack exceeds any of several safety conditions, such as overvoltage, overcurrent, or overtemperature, the pack can temporarily disconnect the lithium-ion cells through the safety MOSFETs or permanently disable the battery pack by blowing the chemical fuse.

turers recalled battery packs, the IEEE announced in late 2006 that it was revising the test requirements that IEEE 1625 specifies. The organization is still revising the standard and plans to release it in 2009 (**Reference 3**). Another standard, IEEE 1725, targets cell-phone and battery-pack testing. In addition, UL (Underwriter Laboratories) 1642 covers electrical, mechanical, and environmental tests for lithium-ion batteries. Rick Chamberlain, vice president of engineering at battery vendor Boston-Power, says that the industry views the UL 1642 specification as the minimum test, especially in the laptop-computer market, and most manufacturers in that segment do more testing to ensure battery-pack safety.

Battery-pack characteristics can also serve as differentiating features that your customers may be willing to pay more for or that may simply influence their purchasing decision. For example, customers may be willing to pay more for a product with a battery pack that offers a longer runtime between charges or a shorter charge time. Similarly, the total cost of ownership of a battery pack for the end user encompasses more than just the cell, power-management circuit, and packaging; it also includes the number of life cycles: More cycles mean a longer battery life.

Lithium-ion cells are not commodity items, but you can fine-tune them by varying their anode and cathode chemistry, their thickness, and their internal-separator composition. Chamberlain suggests that system designers interview cell suppliers and battery-pack designers to select the cell or even to custom-design a cell to target the performance needs and form factor of their designs. Boston-Power's initial product offering, which it announced in 2007, was the Sonata battery pack, which designers could use in available notebook-computer designs. Sonata's debut coincided with Dell's and Sony's battery recalls. Sonata's safety features included more-stable chemical reactions within the cells, proprietary current-control circuits, new thermal fuses, and pressure-relief vents.

Chamberlain points to the cell configuration within the Sonata as an example of how safety concerns complement performance needs in battery-pack design. "A typical notebook battery pack will have an arrangement of six cells in a three-series, two-parallel configuration," he says. "The current splits as it goes through the paralleled cells, and, because there are slight differences in the impedance characteristics of those cells, the current goes through those cells in slightly different ways and can lead to differences in cell aging and safety concerns. The Sonata cell has a larger [than normal] format: We put three cells in series and have no parallel cells. That [arrangement] sounds relatively simple, but that type of change can offer a lot of performance and safety improvements in a battery pack."

Another example of cell customization is electrode thickness: By controlling the thickness, you can optimize for either high energy storage or high power. The leadtime for including a customized cell needn't be long: You can tweak one of the chemicals in the cell with as little as six months leadtime, according to Chamberlain. Other more significant changes could take more time. "Unless you have that discussion [with a cell supplier]," however, he says, "you'll never know."

Because a battery pack comprises electronics as well as lithium-ion cells, it's important that the system designer and battery-pack designer collaborate and understand the role the pack's power-management electronics play in ensuring both safety and performance. Smart battery packs, which can communicate with the host to report the battery's state of charge and battery-health conditions, such as life cycle, temperature, charge and discharge current, and voltage thresholds, offer the highest level of safety and performance. This electronic circuitry is usually part of the battery-pack fuel gauge, the same circuit responsible for the battery-life symbol on a laptop computer's or a cell phone's display.

A battery-pack electronic circuit can have a fuel-gauge IC; an analog front end, including overcharge protection and cell balancing; and an overvoltage-protection IC (**Figure 2**). If a battery pack's temperature exceeds a preset limit, usually 50°C, then the fuel-gauge-safety circuit will temporarily shut down the pack through one of the two charge-and-discharge safety MOSFETs that are in series with the pack cells. Once the temperature drops to within the operating-temperature range, the circuit turns the MOSFET back on, and the battery pack recovers.

You may have experienced this situation when your cell phone or laptop computer shuts down after exposure to the sun or after sitting too long in a hot car. The unit then comes back to life after a cool-down period. However, if its temperature remains high or the current remains in an unsafe range, then the circuitry can permanently disable the battery pack by blowing a chemical fuse. Once the chemical fuse blows, the pack is unsalvageable, and its next stop is the recycling center. EDN

+ For more on accurate lithium-ion-battery fuel gauges, go to www.edn.com/blog/1470000147/post/550029855.html.

+ For more on requirements for large-format lithium-ion-battery tests, visit www.edn.com/blog/1470000147/post/430029643.html.

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