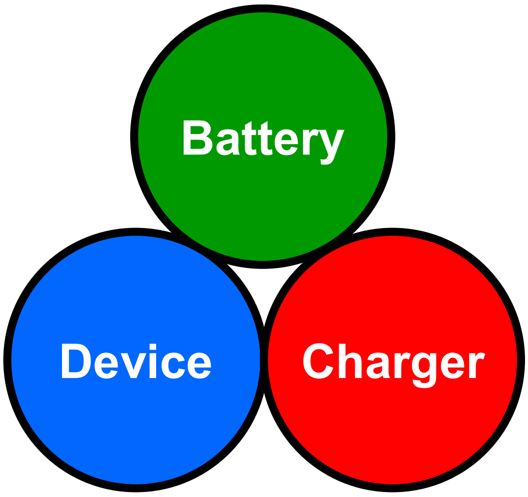
What is a 'Smart Battery System' and why do we need it?

Neil Oliver, Senior Technical Manager for Moltech Power Systems discusses the reasons why device designers should embrace smart battery technology and take the guesswork out of power management…



Are Batteries the Limiting Element?

If rechargeable cell technology had moved at the same pace as microprocessor technology, batteries for handheld electronic devices would be the size of match heads, light as feathers, and would hardly ever need charging. The reality is somewhat less fantastic. Although Lithium Ion and Lithium Ion Polymer technologies have made significant energy density increases in recent years, the demands of OEM's and consumers mean that every mAh increase in battery power is soon consumed by the latest colour screen, DVD drive or USB device.

Strategic thinking requires many OEM's to source their rechargeable batteries from a number of different suppliers, which usually means that the cells in these batteries will be different. Cells from different manufacturers do not have the same electrical characteristics and they will behave differently in the charger and device. The device designer now has a problem, because they cannot identify which battery may be used in the device, the charger and device fuel gauge must be programmed with 'one size fits all' algorithms to manage these important functions. The more diligent designer will factor in such parameters as the effect of temperature on battery performance to improve fuel gauge calculations, but this still does not take into account many other important criteria including the effect of variable loading on the deliverable capacity of the battery. Other concerns such as periodic cell capacity increases, performance increases or even a total cell chemistry change are hardly ever considered or ignored completely.

A Smart solution?

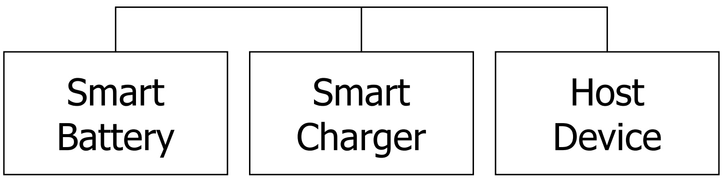
Smart batteries have emerged as part of the solution towards solving some of the issues experienced by device designers. The embedding of specialised circuitry that continuously monitors the electrical and environmental state of the battery allows the internal microprocessor to communicate this information to the rest of the 'smart battery system' (comprising Smart battery, Smart Battery Charger and Host Device). By allowing the devices to work in close harmony, provides a higher state of charge per cycle and allows the host device to use all the available energy in the most efficient way possible.

Smart Batteries are currently used in a number of consumer, medical and industrial devices, and their use will continue to expand as customers demand greater reliability, predictability and run-time from their electronic devices.

What are the SBS Specifications?

Introduced in 1994, the SBS (Smart Battery System) Specifications enable co-ordination of the smart battery elements at the device system level. They define the bus, smart battery data set, BIOS interface, charger commands and multi-battery selector commands, thereby allowing batteries from multiple suppliers to "speak a common language," and contribute to system power management.

Figure 1. Devices in a Smart Battery System



What are the main reasons to adopt a Smart Battery system?

- Maximise battery runtime in the device.
- Minimise unexpected loss of battery power to the device.
- Provide the device and user with remaining device run-time under a particular discharge condition.
- Enable safe and efficient charging where the battery controls the charger.

- Improve battery performance over life.
- Allow device designers to improve device power management by requesting specific information from the battery.
- Future proof the device and charger through true chemistry independence.

What are the features and benefits of using a Smart Battery?

The features of a smart battery are controlled by the smart battery specifications which can be downloaded at sbs-forum.org. Simply, the features and benefits are best described in terms of the interaction between the different devices in the system:

Smart Battery ⇔ Smart Charger

Smart Battery ⇔ Host Device.

- **Smart Battery ⇔ Smart Charger**

The Smart Battery has the ability to control a Smart Charger. When properly configured, the Smart Battery will instruct the Smart Charger to set it's output voltage and current to levels required by the battery. As the battery charges, it may decide to change these levels as required. It will finally instruct the charger to terminate charge when it is 'full'.

There are a number of advantages to implementing this system; firstly, only one battery charger design is required for multiple battery types, cutting costs for the device manufacturer. Secondly such a system is totally chemistry independent. As long as the voltage and current operating envelope for the charger is designed wide enough, all chemistries are catered for by one charger. The charger does not need to be programmed with a myriad of different battery characteristics as the battery itself stores all of this information. Thirdly, battery capacity is maximised per cycle because the battery controls it's own charge rate and termination point which has been optimised by the battery manufacturer. Battery capacity is not restricted by a charger which might prematurely terminate it - or worse, put it into overcharge which would shorten its life.

- **Smart Battery ⇔ Host Device**

The ability for the Smart Battery to communicate with a host device opens up a wide range of power management options which are not available when using dumb batteries. Both fixed and dynamic data is available to the host device, the latter being supplied after internal measurements and calculations have been performed by the on-board microprocessor.

- **Data Functions**

Device Name, Manufacturer Name, Manufacture Date and Serial Number: This information is useful when a manufacturer is supplied with batteries from multiple suppliers. It can also be used to log battery usage patterns or validate customer warranty claims.

Design Voltage and Design Capacity: The nominal voltage and capacity of the battery at its time of manufacture.

Device Chemistry: Identifies the chemistry of the cells in the battery (NiCd, NiMH, LiIon etc)

At Rate Time To Full/Empty: When being charged, the host device can request the expected charge time based on a charge current set by the host. Similarly, when being discharged the expected remaining time will be given based on a discharge current set by the host. An additional feature is the ability for the battery to signify whether it is possible to supply an *additional* discharge current for 10 seconds operation – useful if the host device wants to perform a high current operation close to end of discharge.

Charging Current and Charging Voltage. Based on the chemistry, state of charge and environmental condition, the battery will request appropriate voltage and current from a smart charger.

Max Error: Based on recent calibration data, the battery will predict it's current fuel gauge accuracy as a percentage

Full Charge Capacity: Returns the predicted pack capacity in mAh or mWh. When compared with the original Design Capacity, it is a useful indication of battery life deterioration.

Cycle Count: The battery stores a cycle count based on usage (one cycle is a level of discharge activity equal to the Design Capacity). This feature is very useful for OEM's wishing to monitor battery usage or for validating warranty claims from customers.

Absolute State Of Charge and Relative State Of Charge: The battery returns it's ASOC (expressed as a percentage of the Design Capacity) or it's RSOC (expressed as a percentage of the Full Charge Capacity).

Remaining Capacity: The battery returns it's current state of charge in mAh or mWh.

Temperature: Internal battery temperature expressed in °K

Current: The instantaneous current flowing in or out of the battery expressed in mA.

Average Current: The battery returns a one-minute rolling average current expressed in mA

Voltage: Battery terminal voltage in mV

- **Alarm Functions**

The smart battery is capable of broadcasting a number of alarms when it is critical that the host device or charger should take some form of action.

Over Temperature Alarm: If the battery is getting too warm inside the device it is able to broadcast an over-temperature alarm which the host device should respond to by reducing discharge current or suspending operation.

Remaining Capacity Alarm: When the remaining capacity falls below the low capacity value, the battery will broadcast a Remaining Capacity Alarm. The host system can signal the user that battery capacity is running low and that they should consider shutting the system down or putting the battery onto charge. The low capacity value is programmable.

Remaining Time Alarm: When the Average Time To Empty falls below the remaining time value, the battery will broadcast a Remaining Time Alarm. The host system can signal the user that battery capacity is running low and that they should consider shutting the system down or putting the battery onto charge. The remaining time value is programmable.

Terminate Discharge Alarm: If the battery continues to discharge past the Remaining Capacity Alarm, the battery will eventually signal a critically low capacity by broadcasting a Terminate Discharge Alarm. This alarm is used by the host device to take control of the system and initiate a controlled shutdown before battery power completely fails.

Terminate Charge Alarm: When connected to a Smart Battery Charger, the battery will broadcast a Terminate Charge Alarm once it has reached top of charge. The charger should respond by setting it's output to zero.

Conclusions

The supporting argument for implementing a smart battery system is very strong given the information above. Without such a system, power management is limited to a high level of guesswork on the part of the host device and the charger with the user of the host device being unable to rely on the information being presented. The non linear characteristics of battery performance require the intelligence to be imbedded in the battery - only with this level of integration will users fully benefit from the light weight and high capacity of today's rechargeable batteries.

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