# Adaptive Li-ion battery management systems

Keywords : Hybrid Li-ion battery; Power management; Reconfigurable architecture.

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***Abstract – We develop a new class of hybrid Li-ion batteries, displaying unique energy and power characteristics for mobile and stationary energy applications. Additionally, an adaptive battery management system [BMS] is under scrutiny and aims to improve the power conversion efficiency, safety, reliability and maintenance cost compared with conventional electrochemical energy storage systems. At the heart of the developed BMS there is a unique switching matrix providing selective connection, isolation and protection to the multi-cell battery pack. In particular, it allows cells to be connected in specific configurations providing the maximum energy, the maximum power or a balanced energy/power output. Our study applies adaptive reconfiguration principles to novel Li-ion battery chemistries and architectures.***

Application-driven supercapacitors, Li-ion cells and battery packs are complex electrochemical devices [1,2], and developing technologies to cost-effectively monitor and manage important performance parameters, while precisely predicting product life, is a key challenge (Fig. 1).

An efficient battery management system ensures electrical safety during operation, while increasing battery lifetime, capacity and thermal stability. Conventional BMSs are designed to accommodate stacked multi-cell battery topologies. This approach offers limited safety, reliability, power conversion efficiency and maintenance costs.

To solve these issues, a reconfigurable battery architecture strategy is employed for the deployment of hybrid supercapacitors/Li-ion batteries in realistic environments. A reconfigurable architecture applied to micro-scale batteries was introduced recently [3]. We propose a different topology using the minimum number of switches in order to achieve the maximum flexibility in terms of voltage and capacity. A first prototype was built in order to evaluate the performance and feasibility of such system (Fig. 2) for scalable, stationary energy storage.

The proposed adaptive battery management system evaluates physical internal states of the Li-ion batteries (especially hybrid supercapacitors/Li-ion batteries [1]) fast and accurate, enabling thus the measured data to be useful in making decisions about how to control and optimize the battery packs in real time. Based on the current battery pack status and the load demand, the system will select the optimal cell configuration to maximize the battery capacity over time and minimize system power consumption.

The core of the adaptive battery management system is a Field Programmable Gate Array [FPGA] and a Real Time Operating System [RTOS] in order to manage the battery modeling algorithms and the configurability of the battery pack. In its current version, the system can manage four cells and can be upgraded to work with more cells by using more modules.

Through an adaptive reconfiguration algorithm, the BMS can isolate the faulty or damaged cells from the battery pack in order to enhance the battery dependability and safety.

In conclusion, we proposed an adaptive battery management system that can change its internal topology in order to deliver the maximum voltage, the maximum capacity or a balanced power/energy output. The goal of this technology is the development of intelligent Li-ion cells and hybrid supercapacitor/Li-ion batteries in tandem with battery management systems using novel control techniques and modeling software to decide how high power/high energy modules are connected, charged and discharged in the battery pack.

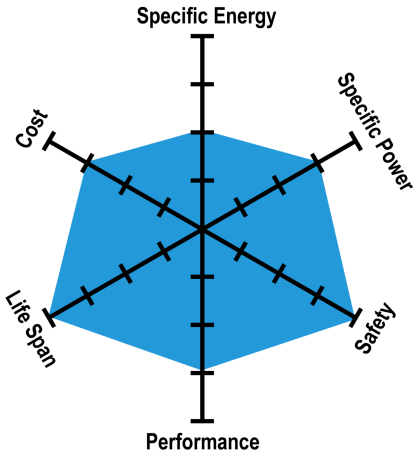


Figure 1: Lithium iron phosphate battery characteristics.

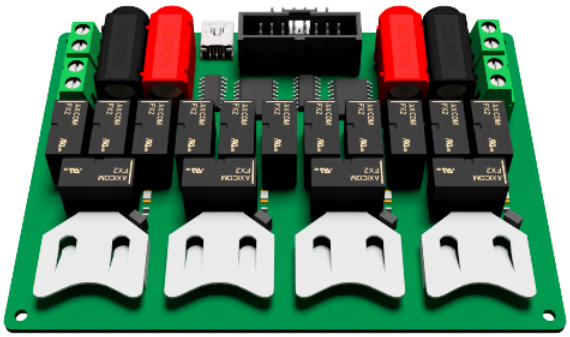

Figure 2: 3D model of the adaptive battery management system printed circuit board designed for four coin/pouch cells.

## References

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