DESIGN SOLUTIONS
POWER

Advanced Battery Management for the Rest of Us

Introduction

Battery management, like military radars and supersonic jets, is a sophisticated technology which has been out of reach for engineers who don't have special clearance or deep pockets—until now.

Charging and fuel gauging—at the heart of every battery management system—are critical components of any mobile or IoT application. Battery performance relies on a high-quality battery model to drive the fuel gauging algorithm. Extraction of the right model for the chosen battery is difficult, expensive work. In fact, only a few large manufacturers have the resources to develop such models.

The accessibility of accurate models can be a huge barrier to the proliferation of low volume portable applications. This article presents a disruptive approach to cracking the battery management barrier with a quick, cost-effective, high-performance solution.

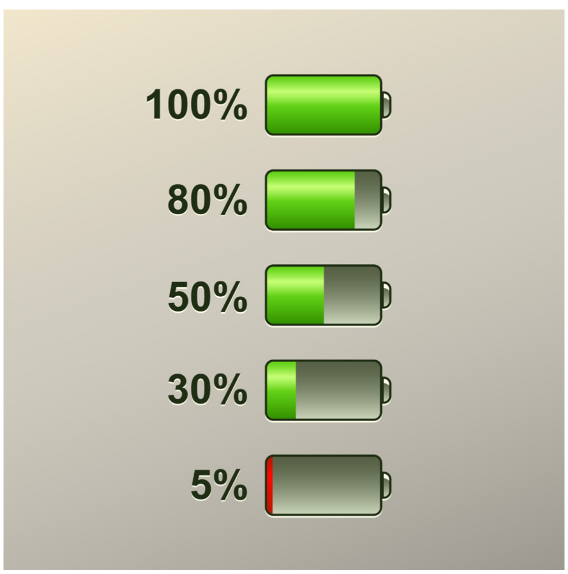

Figure 1. State-of-Charge (SOC) Illustration

Fuel Gauging for the Few

The release of energy from a battery adds up to nothing less than a controlled explosion. The energy stored in the battery (capacity) is dependent upon load and temperature. Hence, developers recognize the importance of characterizing the battery under various conditions. Once a model tuned to the battery behavior is extracted, it is loaded into the fuel gauge chip. This closely supervised process results in accurate gauging and safe battery charging and discharging.

IC vendors have traditionally focused on high volume applications, since a few weeks of lab work are necessary for model extraction. This time-consuming, customized work yields maximum battery performance, in cases such as minimizing the state-of-charge (SOC) error and correctly predicting if the battery is nearly empty. Figure 1 illustrates a battery SOC.

Fuel Gauging for the Many

By studying the characteristics of common lithium batteries, it is possible to develop an algorithm capable of safely handling the majority of these batteries. Such an algorithm can use a battery model tuned to the specific application and can be embedded into the fuel gauge ICs. Subsequently designers can generate the battery models themselves using a simple configuration wizard included in the evaluation kit software. The system designer needs to provide only three pieces of information:

1. Capacity (often found on the label or data sheet of the battery)
2. The voltage per cell, considered the empty point for the battery (application dependent)
3. Whether the battery charge voltage is above 4.275V (per cell, in case of multiple series cells)

With such an algorithm, the system designer's characterization work, already performed by the manufacturer, essentially disappears. Assuming a system error budget of 3% in the prediction of the SOC, the algroithm's model should cover 97% of the test cases.

Additionally, the algorithm should include several adaptive mechanisms that help the fuel gauge learn about the battery characteristics to improve its accuracy even more. One such mechanism guarantees that the fuel gauge output converges to 0% as the cell voltage approaches the empty voltage, thus reporting 0% SOC at the exact time that the cell voltage reaches empty.

For many users, just knowing SOC or remaining capacity (mAhr) is not sufficient. They really want to know how much run-time they can get out of the residual charge. Simplistic methods dividing the remaining capacity by the present or future load can lead to unrealistically optimistic answers. The proposed algorithm should come to the rescue, providing an accurate time-to-empty register based on battery parameters, temperature and load effects, as well as the empty voltage of the application.

The proposed algorithm's advantages are obvious. High-volume manufacturers can use it as a starting point to get development going even before selecting the right battery for the application. They can then turn to a finely tuned battery model at a more mature stage of the development. The small-volume manufacturer can use it to define the model of the battery and run with it, having the confidence that the majority of the batteries out there will be compatible.

Such an algorithm is built into ModelGauge™ m5 EZ ultra-low power, stand-alone fuel gauge ICs by Maxim Integrated. The MAX17201 and MAX17211 monitor a single-cell pack. The MAX17205 and MAX17215 monitor and balance a 2S or 3S pack, or monitor a multiple-series cell pack. A Maxim 1-Wire® interface (MAX17211/MAX17215) or 2-wire I²C interface (MAX17201/MAX17205) provides access to data and control registers.

Fuel Gauging for All

A logical next step to simplify the design of a battery system is to put it on an Arduino® form factor shield, as shown in Figure 2. Maxim's MAXREFDES96 IoT Power Supply is an Arduino form factor shield, powered by a 660mAh Li-ion battery for running an untethered Arduino system. The design features both of Maxim's premier battery management technologies: a highly integrated battery charger (MAX77818) and a ModelGauge™ m5 EZ fuel gauge (MAX17201). Additional products provide system management and power supply functions.

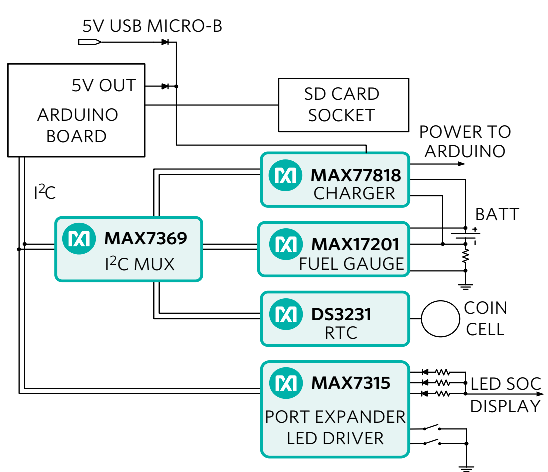

Figure 2. MAXREFDES96 Arduino IoT Power Supply Shield Block Diagram

These technologies enable superb charging and accurate feedback of battery capacity to maximize performance. The MAXREFDES96 (Figure 3) may be charged through the host board USB connector, the host board power adapter, or via the on-board power connector. Furthermore, the system accommodates any single cell Li-ion battery, allowing for development with batteries of different sizes from different manufacturers. Free firmware supports operation with Arduino and mbed.org platform boards.

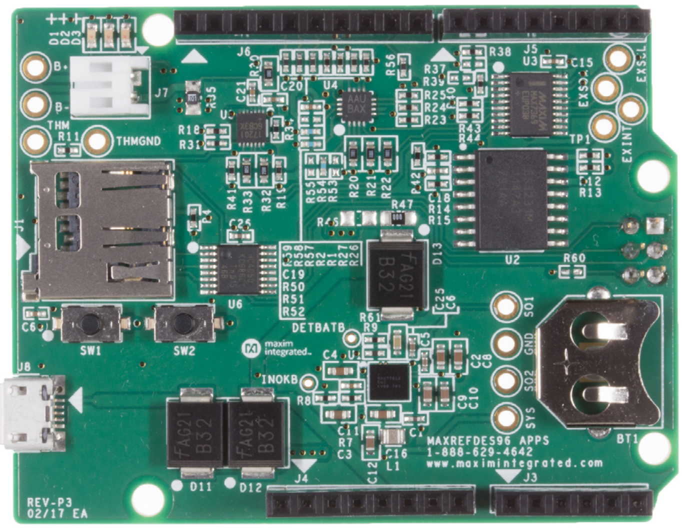

Figure 3. MAXREFDES96 Arduino Shield Fuel Gauge System

With the MAXREFDES96 the battery model can be directly stored in nonvolatile memory on the MAX17201, or on the Arduino board. In the latter case, the models are transferred from the board to the shield at power up. This flexible arrangement allows for the use of a variety of batteries. The Arduino platform enables the use of many available software drivers, further extending the range of possible applications.

An untethered Arduino board is appealing to the largest possible range of applications and users, including hobbyists and enthusiasts. The system can be leveraged for its portability and deployed in a remote location for data gathering; for its transportability, by moving a running test between locations without interruption; or as a back-up system in case the main power fails at a critical time of the development. In all cases, the system provides high-performance battery management, resulting in quick charging, accurate fuel gauging, and long battery life.

Conclusion

We have highlighted the critical importance of battery modeling for an effective fuel gauge system. We discussed the barriers to obtaining these models, which impedes the proliferation of low-volume battery applications. A disruptive approach, based on the ModelGauge m5 EZ algorithm and the MAXREFDES96 Arduino shield, makes battery system development easy to implement, cost effective, provides good battery performance, and is available to all.

Glossary

Arduino: An open-source electronics platform or board and the software used to program it. Arduino is designed to make electronics more accessible to artists, designers, hobbyists and anyone interested in creating interactive objects or environments.

IoT: Internet of Things

Shield: A board that can be plugged on top of the Arduino PCB extending its capabilities.

Learn more:

MAX17201 Ultra-Low Power, I^2C, Stand-Alone Fuel Gauge IC Monitors a Single-Cell Pack

MAX17211 Ultra-Low Power, 1-Wire, Stand-Alone Fuel Gauge IC Monitors a Single-Cell Pack

MAX17205 Ultra-Low Power, I^2C, Stand-Alone Fuel Gauge IC Monitors and Balances a 2S or 3S Pack

MAX17215 Ultra-Low Power, 1-Wire, Stand-Alone Fuel Gauge IC Monitors and Balances a 2S or 3S Pack

MAXREFDES96 Arduino Power Supply

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Maxim Integrated
160 Rio Robles
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