Smart Battery White Paper

By AVR Applications Team

Summary

This document gives an introduction to the most usual tasks performed by the Smart Battery application, and the resulting requirements for a Smart Battery MCU. This white paper does not go into details regarding the various Smart Battery definitions, but rather make this a simple to-the-point introduction from a design point of view.

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Smart Battery

A Smart Battery (SB) is a battery with a degree of logic. From this definition, a vast number of different applications can be issued. We will concentrate on those requiring an MCU, i.e., more complex than those requiring only a small number of logic components.

Smart Battery Tasks and Resulting MCU Requirements (within Atmel's Scope)
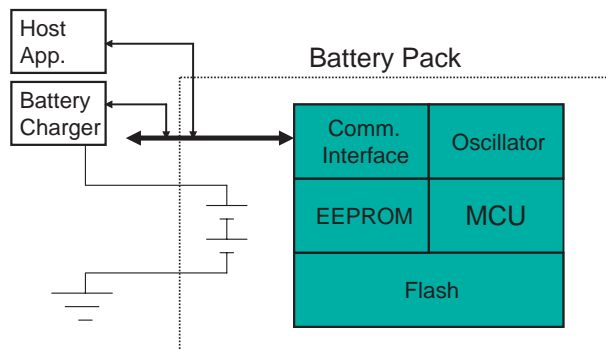
An MCU-realized Smart Battery will perform the following tasks, in order of complexity, i.e., the most basic (most commonly required) tasks listed first. A SB can perform any number of these tasks.

ID Recognition

The application will prompt the SB for an identification string and rejects the operation if the SB doesn't reply with the correct identifier. This task ensures that only the correct type of battery is used, and will thus handle problems related to dangerously incompatible models and counterfeit products.

This task can be made more complex by adding security requirements, making the ID "code" less possible to crack.

Figure 1. ID Recognition

- **Associated MCU requirements**

  – **EEPROM:** For ID string storage. On-chip EEPROM will be more secure than external memory.

  – **Communications interface** compatible with the application asking for identification.

  – **Code space** to calculate/select the ID string.

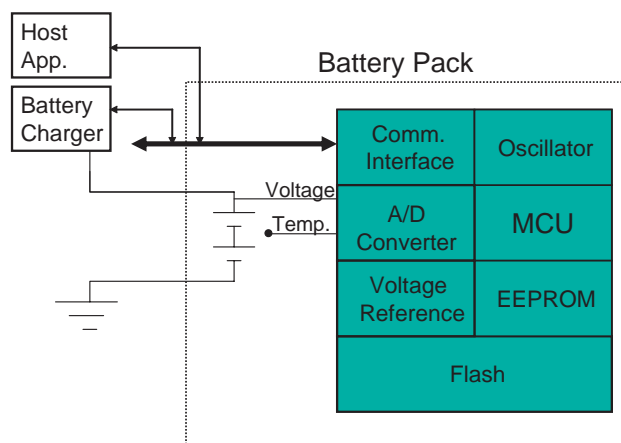 – **Internal clock base** to save cost/board space.

- **Suggested AVR® devices:**

  — ATtiny12

  — ATtiny13

Reporting Battery Voltage

The SB will measure its own battery voltage and report it to the application, which will act accordingly. In this case, the application will decide and act on the information given by the SB.

Figure 2. Reporting Battery Voltage

- **Associated MCU requirements**

  — **High accuracy A/D Converter** to read out the voltage.

  — **On-chip voltage reference** will lower the cost of the design and the autonomy of the SB.

  — **Communications interface** compatible with the application asking for the voltage information.
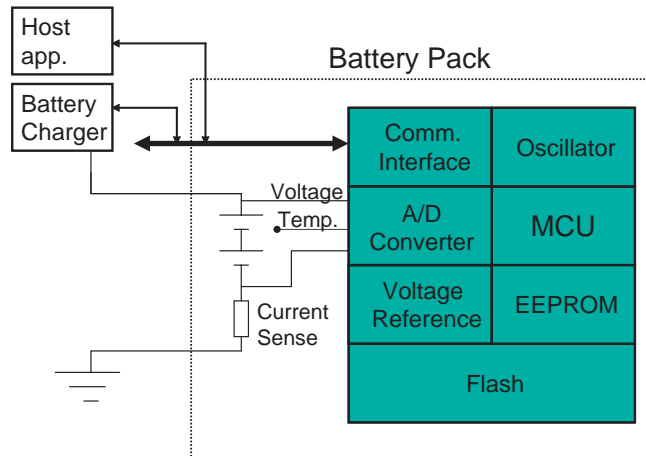
  — **Code space**

- **Suggested AVR devices**

  — ATtiny15

  — ATmega8535

  — ATmega8

  — ATmega16

Reporting Charge/Discharge Current

In addition to voltage, the SB will also monitor the charge current (when the battery is being charged), and the discharge current (when the battery is being drained by the application), and report these figures to the main application.
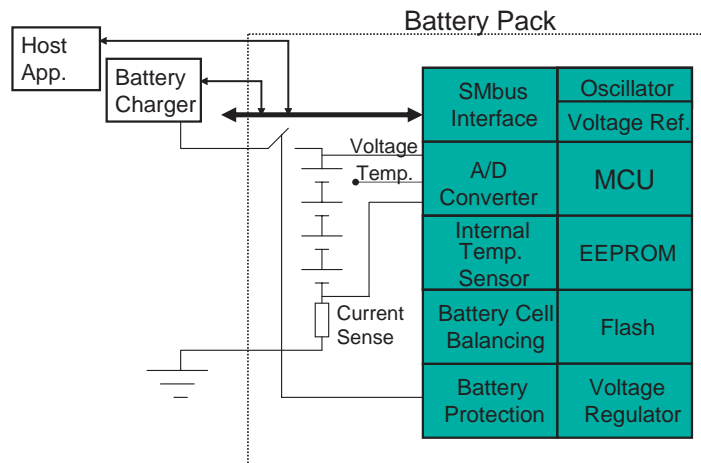
Figure 3. Voltage Current Sense

- **Associated MCU requirements**

  – **ADC** within the resolution requirements of the application.

  – **Differential ADC inputs with internal voltage gain** to detect small currents. (Otherwise the same spec as above.)

- **Suggested AVR devices**

  – ATtiny15

  – ATmega8535

  – ATmega8

  – ATmega16

  – ATmega32

Report Refined/Calculated Data to the Main Application

Instead of letting the application perform the necessary assessments based on the voltage/current measurements, the SB can perform these operations itself. Examples are:

- **Remaining battery life** based on the battery parameters (voltage, discharge current) and the battery's charge/discharge characteristics. The latter will be stored in the MCU's Data Memory.

- **Control signals to the application** based on the same parameters, e.g. "too low power – power down app", and "fully charged – turn off charger". Also, dangerous states such as too high charge/discharge current can be reported.

Figure 4. Super Intelligent Smart Battery

- **Associated MCU requirements**

  - **EEPROM** large enough to fit the necessary battery characteristics.

  - **Code space** to perform the necessary operations. Since the SB, in this case, has taken over important and critical tasks, there are higher demands for a **stable clock base** and **run-away and lock-up protection embedded On-chip**. Suggested solutions are **On-chip Oscillator** and **advanced Power-on Reset and Brown-out Detection circuitry,** respectively. (Otherwise the same spec as above.)

- **Suggested AVR devices**

  - ATmega8535

  - ATmega8

  - ATmega16

  - ATmega32

  - ATmega64

Automatically Intervene in Dangerous Situations

This is the logical next step to the previous task: The SB will itself react if a dangerous situation should occur. This will include blocking the charge/discharge of the battery if either current is too high, and completely shut down the discharging of the battery if below a certain level (some battery types are damaged by complete discharging). This will require the battery vendor to program a lot of the core parameters of the battery into the SB application. The advantage is that the SB will be more autonomous and that there will be less need for de-centralized logic in the main application. This means shorter reaction time and less corruptible critical communication.

- **Associated MCU requirements**

    - Necessary data and code space.

    - Highly reliable operation is required since the SB is now not only monitoring but also acting in potentially dangerous situations. The spec above is required.

- **Suggested AVR device**

    - Information available under non-disclosure agreement.

Cell Balancing

Many batteries have more than one battery cell. A typical PC battery has three or four. A requirement for optimal operation is that all cells have the same voltage. It might therefore be required that the SB to perform the so-called cell balancing operation.

- **Associated MCU requirements**

    - **Additional ADC channels** to measure the cell voltages.

    - **Level converters** to bring the individual cell voltage into the appropriate ADC range.

    - **Control signals for individual cell discharge** or **embedded discharge FETs.**

- **Suggested AVR device**

    - Information available under non-disclosure agreement.

Other MCU Requirements Derived from the SB Application Environment

The following MCU requirements derive from the Smart Battery environment: The SB application should naturally draw very little power from the battery since the battery's main purpose is to power the main application.

- **A requirement is therefore very low power operation. Associated requirement**

  - **Sleep modes** to consume very little power whenever the MCU is not in use.

  - **Fast wake-up time** from these sleep modes to minimize the time spent out of sleep.

  - An **internal RC Oscillator** will help the above requirements by providing a very fast, very low-power clock base.

- **It must also have the ability to operate off the main battery voltage, and an internal voltage regulator might be necessary in order to bring the MCU into operating range.**

- **Optional requirements that might enhance the SB operation**

  - **Embedded temperature sensors** to detect another dangerous state: Battery cell overheating.

Summary of MCU Requirements

- **Small physical size.**

- **Low power operation; advanced internal power management (sleep modes, wake-up timers and interrupts).**

- **EEPROM data storage.**

- **Communication interfaces (UART, SMBUS, ...).**

- **Code storage**

- **Clock bases**

  - Fast start-up time.

  - High accuracy for communication and timing.

  - High reliability, internal main source preferable.

- **High A/D Converter accuracy and abilities.**

- **Advanced code run-away protection:**
  Watchdog Timer, Brown-out Detection/Power-on Reset).

- **On-chip temperature monitoring.**

- **On-chip voltage regulator.**

- **High voltage inputs/outputs.**

- **Cell balancing FETs**.

Editor's Notes

About Atmel Corporation

Founded in 1984, Atmel Corporation is headquartered in San Jose, California with manufacturing facilities in North America and Europe. Atmel designs, manufactures and markets worldwide, advanced logic, mixed-signal, nonvolatile memory and RF semiconductors. Atmel is also a leading provider of system-level integration semiconductor solutions using CMOS, BiCMOS, SiGe, and high-voltage BCDMOS process technologies.

Further information can be obtained from Atmel's Web site at www.atmel.com.

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