

FRAUNHOFER INSTITUTE FOR INTEGRATED CIRCUITS IIS

# **BATTERY MANAGEMENT AND MONITORING**





Renewable Energy for Electric and Hybrid Vehicles

### **OVERVIEW**

Batteries are present in all kinds of electronic devices and applications, from small watches, laptops, mobile phones, power tools, satellites, hybrid cars up to uninterruptible power supplies (UPS).

They can be built with various technologies like lead-acid, nickel-cadmium, nickel-metal hydride or lithium-ion, just to name the most common ones. Their capacities start in the microampere-hour range (µAh) and are related to their size and weight. Their performance is strongly dependent on temperature.

Due to the internal chemical processes they must be handled with care when charged or discharged. Thus special electronic circuits are required to protect them and get the most energy out of them, maximizing their operation time and lifetime.

To increase voltage, current or capacity several batteries are combined in series or parallel connections. Especially in such systems, sophisticated battery management systems (BMS) are essential.

#### **Battery Management**

Batteries require specific charge profiles to achieve maximum energy density during charging and to avoid damage or destruction.

The constant current, constant voltage (CCCV) charge profile is commonly employed for lithium cells, which generates a phase with constant voltage after the charging phase with constant current.

To avoid overcharging or deep discharge, protection circuits are required to handle short-circuits, overvoltage, undervoltage and overtemperature.

#### **Cell Balancing**

When the designed cell voltage is not sufficient to power a certain application, several batteries have to be connected in series. Due to material, manufacturing and temperature differences, these cells do not accept or release charge in the



Functional Block Diagramm of a Battery Management System



Battery Monitoring

same quantity. Accordingly their voltage will differ sooner or later, leading to one cell being already at the end of discharge and limiting the capacity of the whole system.

Cell balancing circuits equalize these varying cell voltage levels to restore the primary designed battery capacity. There are different cell balancing techniques which differ in power efficiency, hardware effort and electronic board space.

#### **Battery Monitoring**

The measurement of different battery parameters like charge and discharge current, cell voltage, resistance and temperature allows a prediction of the remaining capacity of the battery. Important battery parameters like state-of-charge (SOC), stateof-health (SOH) or state-of-function (SOF) can be derived this way. Combining these measurements with battery model data and aging information improves the accuracy of the battery parameter values. Depending on the chosen algorithms, different levels of system performance will be achieved.

#### **Battery Management Systems**

Battery Management Systems (BMS) incorporate all the required building blocks to carry out the mandatory actions and functionalities. Measurement of the battery parameters like cell voltage, temperature and impedance are processed to calculate SOC and SOH. Appropriate interfaces like CAN, LIN, SPI or SMBus provide the data for the system control of the application. Protection circuits with different safety levels ensure a proper operation of the battery cells. By avoiding misuse scenarios like over-charge, over-discharge and short-circuit the lifetime of the battery cells is maximised and damage or destruction is prevented.



Battery Management System for a 4-Cell Battery System

## SERVICES

Fraunhofer IIS has expertise in various fields of battery management and monitoring systems.

- We analyze applications and suggest appropriate techniques and algorithms.
- We evaluate required functional blocks and sub modules.
- We develop application specific battery management and monitoring systems, both hardware and software optimized for the preferred battery technology, cell numbers and application.
- We provide demonstrators and prototypes, available from various research and development projects.

For more information please visit

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