IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⨳ Vol. 10, Issue 2, February 2022

DOI: 10.17148/IJIREEICE.2022.10206

Battery Management Systems (BMS) for Increasing Battery Life Time

Prof.Vishal V. Mehtre[1], Koushal Kumar Jha[2]

Assistant Professor, Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to be University)

College of Engineering, Pune - 411043 , India[1]

Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to be University)

College of Engineering, Pune - 411043 , India[2]

Abstract: The battery's life span is determined by a number of factors. The internal battery parameters, which are influenced by the battery producers, and the external battery parameters, which are impacted by the battery users, are the two sets of parameters. The extrinsic parameter can have a significant impact on the lifespan. It is possible to adjust external parameters with the goal of extending battery lifetime using a battery management system (BMS). The data acquisition system, battery state computation, electrical management, thermal management, safety/supervisory management, and communication are all described in this study. It is possible to extend battery lifetime if the functions of a BMS are tailored to the battery type and application.

1 INTRODUCTION

A high-reliability power source is required for communications applications. In most cases, the application features a battery-powered backup power supply. Electrochemical batteries, on the other hand, have a substantially shorter life span than the other components. Battery monitoring and battery condition determination are required to detect battery issues in a timely manner. The state of charge (SOC) and the state of health are the two key factors that determine the battery's condition (SOH). The ability to shut the control loop by employing the battery state for electrical management is provided by knowing the battery state (i.e. charge method).

2 PARAMETERS INFLUENCING BATTERY LIFETIME

In general, battery ageing parameters can be divided into two categories: internal and external. External characteristics reflect ageing through operation, whereas internal parameters describe all parts that may be controlled by the battery maker (i.e. Grid-alloy, manufacturing quality, etc.). Temperature of operation, charging technique, maintenance, deep discharge protection, and the electric cycle regime are all examples of external parameters. Internal parameters are outside the control of a BMS, and some exterior parameters are determined by the type of application. However, some external parameters can be adjusted by a BMS in a more or less broad range (i.e. charge method, deep discharge protection). One of the goals of a sophisticated BMS is to optimise these configurable parameters as a function of other operating factors and the environment.

2.1 Temperature

High temperatures, as well as temperature fluctuations between cells, shorten battery life. As a result, the design of an e-hole system (closed cabinet or free standing) has an impact on its lifespan. A thermal management system can be utilised to extend battery life in cases of high current applications and closed cabinet design.

2.2 Charge method

It is common knowledge that charging has a substantial impact on battery life. Overcharging and insufficient charging of lead acid batteries will result in a reduction in battery life. Internal battery parameters, battery temperature, and operating history all influence the best charging method.

2.3 Deep discharge protection

Deep discharge, particularly long periods of rest at low SOC, lowers battery life. Deep discharge prevention is usually relied solely on the battery voltage (sometimes on the current too). However, in the event of tiny discharge currents, these methods do not allow for the detection of critical operation circumstances. Figure l depicts the relationship between

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⁜ Vol. 10, Issue 2, February 2022

DOI: 10.17148/IJIREEICE.2022.10206

battery voltage, discharge current, and DOD for a pasted plate battery at room temperature. The graphic illustrates how a simple voltage threshold can result in significantly varying DOD at the cutoff point. The battery will be over-discharged, especially with tiny discharge currents, resulting in battery damage.

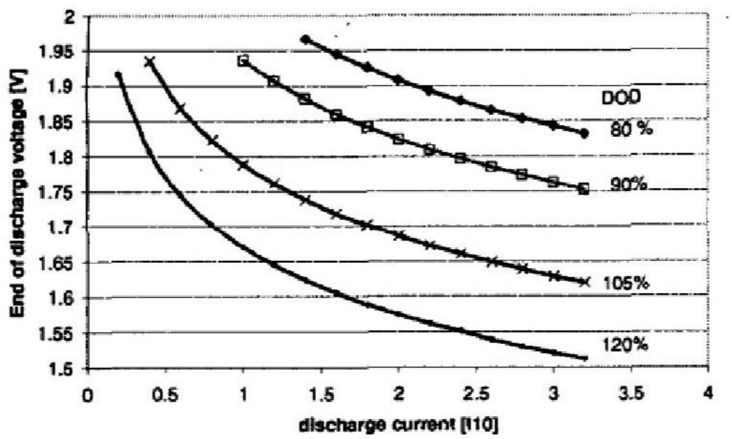


Figure 1: Battery voltage vs. discharge current in relation to the DOD.

2.4 Influence of operation mode

The type of operation (electrical cycling regime) has an impact on battery life. The capacity of three similar batteries (lead acid, vented type, tubular plate) during various test regimes is shown in the diagram below.

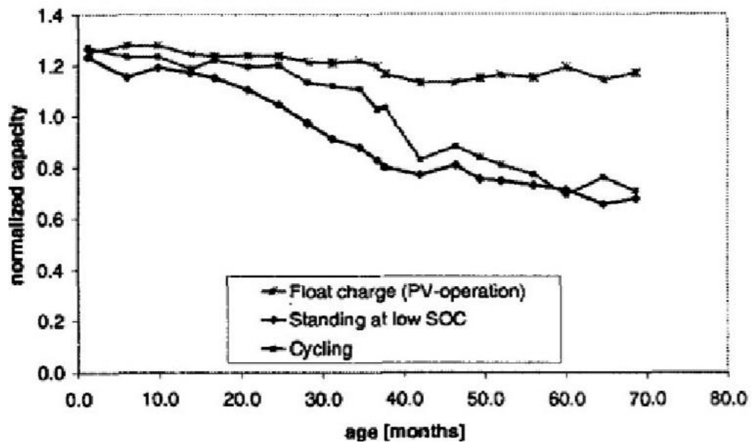


Figure 2: Capacity vs. life time of a LAB for
‹different operation modes
reference battery: float charge (2.25V/cell) cycling battery:PV related cycling standing battery: Rest at low SOC (30%)

3 BATTERY MANAGEMENT

3.1 General

External battery parameters must be managed in order to extend the battery's life. This is true not just for lead-acid batteries, but also for modern battery systems such as lithium and high-temperature batteries. As a result, a battery management system (BMS) is necessary, which takes into consideration the 3- 1 unique needs of battery technology. Voltages, currents, and temperatures are measured as input signals. A battery management system's function can be divided into the following tasks:

- Data acquisition
- Battery state determination
- Electrical management
- Thermal management (not always necessary)
- Safety management

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ∺ Vol. 10, Issue 2, February 2022

DOI: 10.17148/IJIREEICE.2022.10206

- Communication

Figure 3 shows a simplified schematic drawing of a BMS.

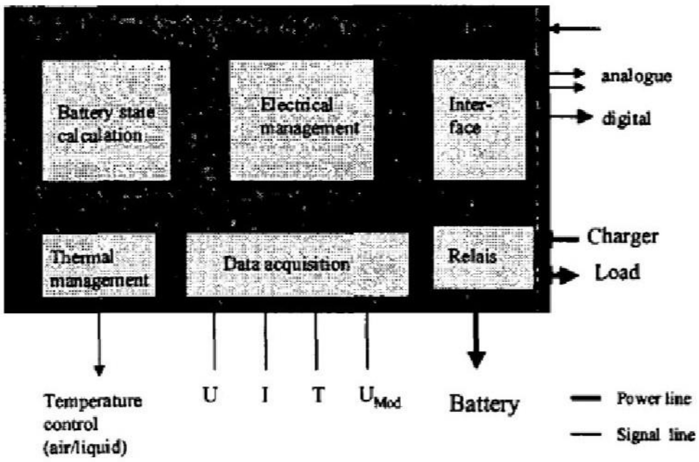


Figure 3: Schematic structure of a battery management system (BMS)

In case of small batteries some of the above mentioned functions are available as single or ultiple chip solutions [l]. For example Li-Ion battery packs for cellular phones and laptop computers contain as a minimum a safety management system. In case of larger battery systems, the battery management system is more complex and BMS systems must individually developed for the battery technology and the application[2].

3.2Data acquisition

The BMS uses measured and calculated data as input information in all of its algorithms. As a result, the accuracy, sample rate, and characterization of front end filtering are all critical and vary depending on the application. For example, EV applications employ sampling rates of less than one sample per second, but photovoltaic or UPS applications use sampling rates of less than 0.2 samples per second.

Single cell/module failures are a significant point in UPS applications, resulting in shortened operation time. As a result, module- or cell-voltage measurements are critical and integral to UPS control system. . Two different architectures are known for module measurements:

- The measurement unit is placed within the BMS in a centralised system. The lower material costs are a benefit of this technology. The wiring between the BMS central unit and the battery cells is the biggest drawback (modules).
- In a decentralised system, measuring units are divided into cell/module oriented units. A digital communication bus connects these units to the central BMS. The key benefit is that there is less wiring and the system may be expanded. Furthermore, the decentralised units can measure the temperatures of the cells/modules for a low cost. This additional data allows for a more accurate, but also more difficult, battery state estimation. In the case of larger batteries, decentralised solutions become more cost-effective.

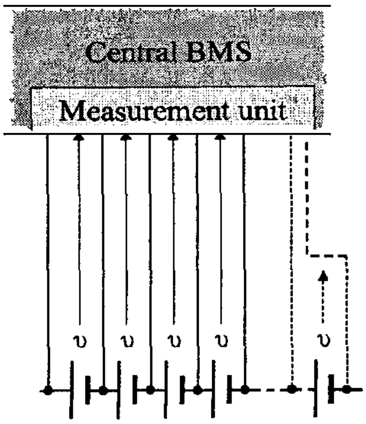


Figure 4: Centralised data acquisition

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 7.047 ⚟ Vol. 10, Issue 2, February 2022
DOI: 10.17148/IJIREEICE.2022.10206

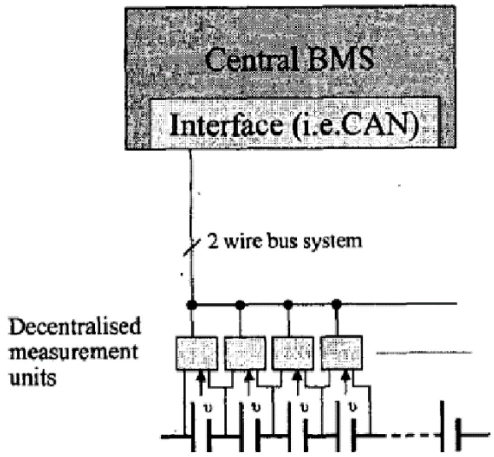


Figure 5: Decentralised data acquisition

3.3 Battery state calculation

The battery state is an important parameter for the user as well as an input parameter for the electrical management. As a result, the battery condition can be utilised to determine the bridging time or the battery's estimated lifetime. The state of the battery can be simplified described by the following two parameters:

- State of charge (SOC)
- State of health (SOH)

Both parameters are not independent and influence the battery performance (i.e. available capacity). The relationship is shown in Figure 6.

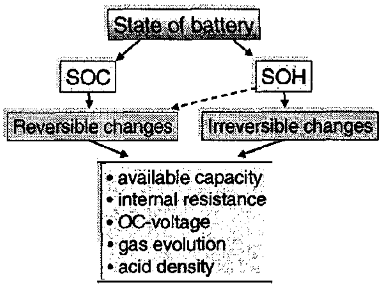


Figure 6: Relation between SOC and SOR

For SOC determination in most cases Ah counting, including charge loss estimation are used[3]. For SOH determination a couple of more or less good working methods are known and used. It depends strongly on the battery technology and the kind of application which method is useable.
Figure 7 shows a method using an optimum filter algorithm for SOC and SOH determination. Other methods like fuzzy clustering and neural networks were also developed and tested [4].

A Kalman Filter is used as the best filter. A numerical battery model is the foundation of such a filter. The Kalman Filter takes into account the statistical knowledge of the parameters as well as the measurement. Differential equations, which are included in a battery model, are used to describe deterministic knowledge. Statistical knowledge corrects this model. The most important

Impact Factor 7.047 ⋇ Vol. 10, Issue 2, February 2022
DOI: 10.17148/IJIREEICE.2022.10206

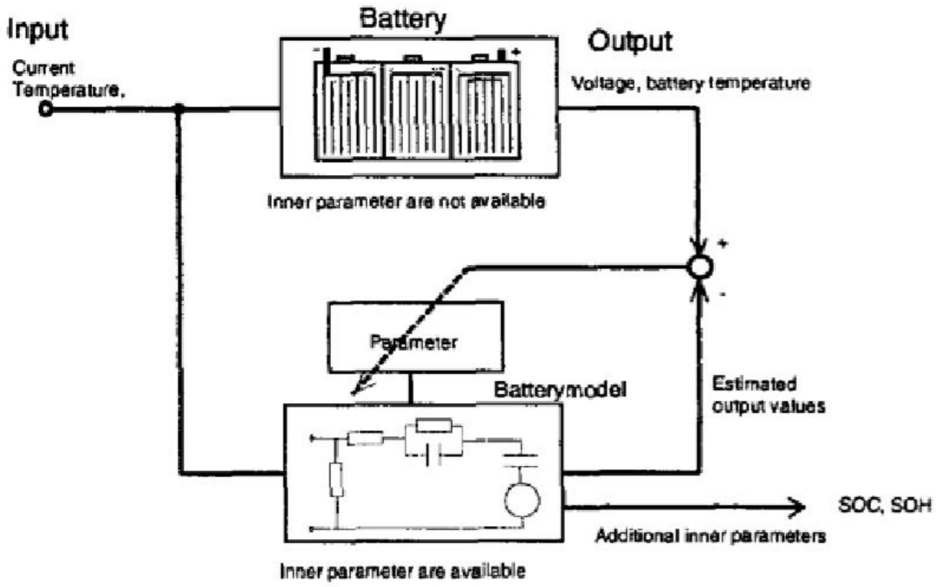


Figure 7: Adaptive method for battery state determination

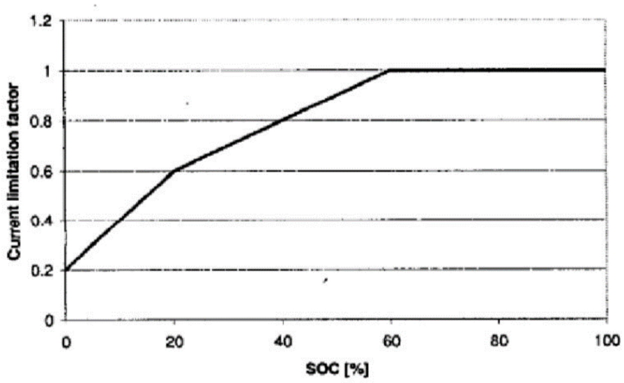
In comparison to Ah-coimting, the advantage of this method is that the state of charge calculation is not influenced during long-term operation.

3.4 Electrical management

Cunent, voltages, temperatures, SOC, and SOH are used as input parameters in electrical management to control the charge and discharge process. . The following tasks must be fulfilled:

- Control of the charge process, including equalization charge and Ooat charge
- Control of the discharge.

The charge control process and the discharge limitation depends strongly on the used battery technology and the battery type. For UPS systems the recharging of the battery must be adapted to the deep of the previous discharge, the temperature and optionally to the battery age. Quick recharge in combination with lowest aging are the main targets. Additionally the control of the float charge is very important.
Figure 8 shows the limitation of the discharge current in case of an electric vehicle. In case of UPS applications the discharge can only be controlled by a priority controlled cut off of the loads.



3.5 Safety and supervisor management

The safety management has to protect the battery against critical operation conditions. In case of an BMS for an electric vehicle, the tasks of the safety management system are:

- Prolection against deep discharge

DOI: 10.17148/IJIREEICE.2022.10206

- Prolection of single cells against overdischarge
- Prolection against overtemperature (thermal runaway)
- Battery turn off in case of a crash

Overcun'ent and overvoltage should also be detected by the safety management.

3.6 Thermal management

Most high-power applications and high-temperature batteries require thermal management. The thermal management system's functions include temperature equalisation between cells, battery cooling, and in some cases, such as high temperature batteries, battery heating. As a result, liquid or air-based (fan) systems are employed. Because the thermal resistance of the electrolyte and the plastic cell housing is quite high, heat transfer from the inside of the battery cells to the outside is a major issue.Equalization of cell temperatures is the most important function of a thermal management system in UPS systems. . In case of a closed unit containing the rectifier, the inverter and the batteries high temperature gradients within the battery are possible. In case of larger UPS systems where the battery is not located together with power electronics in a cabinet, thermal management is less important.

3.7 Communication

The communication between the BMS and oaer onboard and off-board devices is another important task of the BMS. Depending on the application different interface systems for data exchange are used:

- Analogous signals
- Pulse wide modulated signals
- Serial Interface

Newer UPS systems use serial interfaces like CAN (control area network). This communication interface gets more and more popular for automaton systems and automotive use. A lot of hardware components are available supporting this interface standard.

4 CONCLUSIONS

A battery management system must meet a certain requirements, according to this presentation. It is feasible to improve battery lifespan if the functions of a BMS are tuned for the battery type utilised and the application for which it is used. The state of charge determination and battery lifespan prediction are essential factors in UPS systems. Predicting one's life span, in particular, is a difficult and unsolved topic. New approaches for estimating battery age and predicting lifespan based on optimal filter technology and fuzzy algorithms are being developed at ZSW.

5 REFERENCES

[1] Philips Semiconductor: Data Sheet SAA 1502ATS, Safety IC for Li-ion, Eindhoven, the Netherlands, 1998
[2] D. Heinemann at a1.: A new design of a battery management system including a range forecast, EVS 14, 1997 [3] A. Jossen et al.: Battery Control Unit with State of Charge Indicator, 10" European Photovoltaic Solar Energy Conference and Exhibition, 1991, Lisbon
[4]J. Garehe at aI.: Failure modes and the detection of the state of health of lead-acid batteries in PV-systems, LABAT, 1996