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ALGORITHMS OF BATTERY MANAGEMENT SYSTEM OF ELECTRIC VEHICLES

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ABSTRACT

Electric vehicles are the means of sustainable mobility which works on batteries. Lithium batteries are currently being used for energy storage in the EVs. There are researches going on for best choice of cell materials to have a more efficient battery than lithium batteries. However, this paper focuses on the modeling approaches of managing the performance of lithium ion batteries. Firstly we discuss the need for modeling a management system for the battery and then we focus on the implementation of the BMS model.

Keywords- Active balancing, sensors, microcontroller, state of charge, state of health.

INTRODUCTION

The lithium ion batteries offer some distinct features compared to other types of batteries. The LiFePO4 battery has high energy density, high power density, self discharge rate is much lower than other rechargeable batteries and long life and therefore has wide application in the area of consumer electronics. However, automotive lithium ion batteries are in large serial parallel numbers which poses safety issues. The failure of the Li- ion batteries are generally due to:

- Normal aging of the cells
- Uncontrolled operating conditions
- Short circuit failure
- Overcharge
- Over discharge

This paper focuses on a system that monitors and prevents the failure of the battery packs in the electric vehicles.

COMPONENTS OF BMS

The Battery Management System is a protection module which has the function of:

- Monitoring the battery voltage and current
- To estimate the battery state
- To estimate the health of the battery
- To maximize the battery's performance

- To report the users or external devices connected to it.

The BMS at any cost must prevent each of the battery's voltage from exceeding 4.2 V while charging. It should also prevent each battery's discharging below a certain level, i.e., 3.2V. Overcharging of the batteries also increases the temperature of the battery packs, thereby damaging them and posing safety issues for the users. The BMS also balances the cell for maximizing the capacity of the cell. The cell that is most charged may end up getting overcharged and so the BMS should remove the excess charge from the cell and gives the other cells a chance to get charged. This is achieved by active balancing of the cells. Figure 1 shows the block diagram of the BMS.

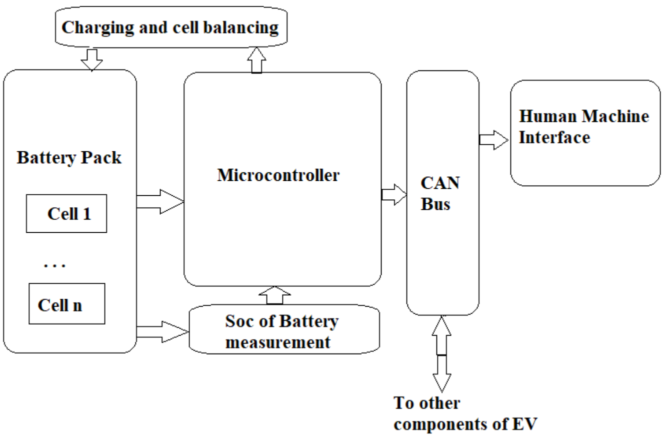

Figure 1 Block diagram of BMS.

The different parameters of the BMS are:

A. Battery parameter measurement

The BMS monitors the current and voltage of individual cell as well as the total battery pack.

B. Battery State Estimation

The battery states such as State of Charge, State of Health of the battery is monitored. The SOC is defined as the current capacity of the battery to the nominal capacity of the battery and is used to state the remaining capacity of the battery. The overview of a number of methods to estimate the SOC of the battery packs.

1) Direct Method:

This method tracks the voltage and impedance of the batteries in the battery pack.

2) Open Circuit Voltage method:

OCV is one of the methods in Direct method, where the SOC is proportional to the open circuit voltage when the load is disconnected to the battery pack. But such a long time for disconnection of loads is not possible to implement. Figure 2 shows the relationship of Soc with OCV. [1]

3) Impedance spectroscopy method :

It measures the battery impedances at different charge and discharge cycles and has its SOC determined through the percent impedance of the battery.

4) Terminal voltage method:

The emf of the battery is linearly proportional to the Soc. The present battery impedances can be compared with known impedances of various Soc levels.

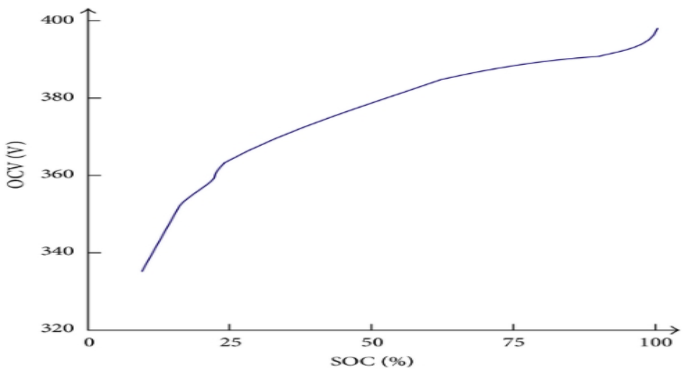

Figure 2 Graph stating the relationship between OCV and SOC.

5) Fuzzy logic method:

This method is generally modeled for complex and non-linear systems. The data obtained by coulomb counting or impedance spectroscopy are analyzed using the fuzzy model.[4]

6) Coulomb counting method:

[5]This method begins with measuring the voltage and current of the battery and the historic data of the battery is read from the memory. The battery operation mode is estimated by the direction of current. The DOD, i.e., depth of discharge is the ratio of discharged capacity to the nominal capacity of the battery. The SOC can be expressed as :

SOC (t) = 100% - DOD (t)

During the discharging mode of the battery, the DOD adds up the drained charge. If the voltage of the battery is more than 3V and current is less than zero, then the battery is in charging mode. The state of health (SOH) is measured by the sum of the charge accumulating in the battery during charging mode. Then the SOC is given by the expression:

SOC (t) = SOH (t) - DOD (t).

7) Back propagation neural method:

Due to emergence of Artificial Intelligence, new adaptive methods have come forward. These systems have ability of self learning, self organization and non-linear mapping. They can predict the current SOC of the battery based on the historic data of battery, i.e., current, temperature and voltage.[6]

8) Fuzzy neural network method:

Wein Heing Wang [7] has experimented on the fuzzy neural network, which is designed to solve the complexity of multiple inputs by merging a number of small fuzzy networks.

C. Battery equalization

This includes the equalization of battery charging, discharging through balancing. As mentioned earlier, every battery in a pack has different SOC. The different balancing methods are active balancing and passive balancing.

1) Passive cell balancing

In [8],[9], the circuit for passive balancing is as per the ones used in commercial EVs. The circuit consists of resistors connected parallel with the batteries. The batteries with charges greater than the batteries with low charge or from a set value, has its charge discharged through their respective resistors.[10]

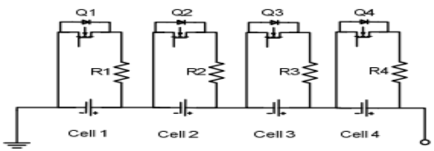

Figure 3 shows the passive balancing circuit.

2) Active cell balancing

The active balancing uses pack-to-cell topology The circuit has a fly back transformer with two secondary windings. The relays are connected to the cell to control the flow of current to the selected cell. The microcontroller checks the difference in cell voltage every 60 seconds. If the difference in cell voltages exceeds 40Mv, it calculates the average voltage of the cells. The cell which deviates more from the average voltage, gets discharged by the MOSFETs through the fly back converter to the cell strings. This method eliminates the loss of energy unlike passive balancing. The life of the cells is elongated and provides fast charging of the battery packs.[10]

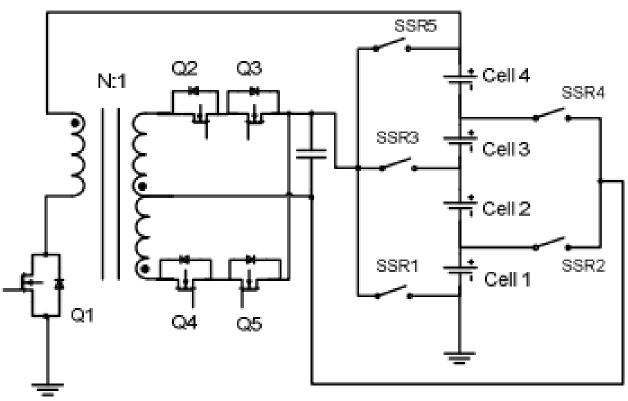

Figure 4 shows the active balancing of cell [10]

CONCLUSION

This paper quantitatively presents different algorithms for modeling the SOC model as well as the cell balancing model. Different paper selected to emphasize on the different methods of SOC calculation as well as for balance equalization of the batteries in battery packs.

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