BMS for Electric Vehicle

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A Battery management system (BMS) is an electronic system that manages the charging and discharging of a rechargele battery cell or battery pack, such as by protecting the cell or the battery pack from operating outside the safe operating region, monitoring SOC state, reporting that data, controlling its environment, authenticating it and/or balancing it. The battery pack consists of a huge amount of cells. The large number of cells that are initially different in voltages make it difficult to Manage. The difference in initial voltage of cells damages the battery pack; if the battery pack gets damaged, then the electric vehicle is of no use.

Keywords: SOC (State of Charge), EV (Electric Vehicle), BMS (Battery Management System)

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1 Introduction

Due to their very low to zero carbon emissions, low noise, great efficiency, and flexibility in grid operation and integration, electric vehicles (EV) are a viable technology for creating a sustainable transportation sector in such a short time. When comparing electric motors to internal combustion engines, the latter has a higher density, implying that it produces more energy per unit of fuel density. The Battery of an EV consists of huge cells made from Li-ion.

A portable power supply, particularly lithium-ion batteries, has become an important part of today's technology world. Electric motors outperform combustion engines in every way and are more durable and cost-effective[1]. A battery management system (BMS) is an electronic system that manages a rechargeable battery by controlling the charging and discharging cycles of the battery, determining, and monitoring its state and battery life, calculating secondary data, reporting that data, controlling its environment, authenticating it and balancing it [2]. SOC forms an important prospect of any battery to ensure the safe charge and discharge of any battery. SOC is defined as the current capacity of a battery expressed in terms of its rated capacity. By maintaining the voltage range the BMS also protects the batteries from overcurrent and thermal heating. Therefore, the BMS is the most convenient solution for charging and discharging the batteries[3-4].

2 Literature Survey

The battery is an essential component as it's a very efficient and compact power source that helps to operate electronic equipment on the go. Various cell chemistries are available depending on the equipment's requirements, thus the appropriate one is chosen for a specific application. Since any battery is a power source and any power source must be constrained to provide the required output, or else it can damage the equipment. Hence, nowadays battery management systems are used in almost every portable electric machine-like laptops, cellphones, power banks, portable hand drills, and electric vehicles [5]. BMS can be widely classified based on the number of cells they can handle.

2.1 Conditioning and Testing of Rechargeable Battery Cells

System and Method: Authors in [6] described The cell interface block, which includes a cell interaction system and a circuit unit, which can be included in the cell-group conditioning module. As a consequence, the circuit module may be positioned adjacent to the cell contact module and is set up to give electricity to cells. The cell-group conditioning module can also include a cell platform configured to handle a variety of cells, as well as an actuation process coupled to the cell interface block or the cell platform and designed to lower the distance between the cell interface block and the cell platform, enabling the cell contact module to establish electrical contact with the cells.

2.2 Research on Battery Management System for Light Electric Vehicle

Authors in [7] discussed that the use of signal cells in electric vehicles works longer than a battery pack; their research demonstrates that voltage discrepancy between batteries is the main reason rechargeable batteries have a short life. To eliminate this, they used State Of Charge (SOC) estimation and Equalization Control. The test object for this article was a 3.2V/15Ah lithium-ion battery. The fully charged battery discharged at 0.2C, 1C, and 3C constant current respectively, until the tip of the discharge. Their system uses the Ah counting method during the batteries' charging and discharging and uses the electrical circuit voltage method to estimate the initial SOC value when the batteries have rested for a half-hour or more and fix the influence of temperature, and self-discharge, aging, and other factors.

2.3 Batteries and Battery Management Systems for Electric Vehicles

M. Brandl et al., proposed issues within the design and management of batteries for electric vehicles and also the challenges in modeling a cell. Several problems that occur during the modeling of cells for preventing different types of modeling approaches are used first is the black-box approach[8]. This leads to fast computation models. The electrical lumped model comes next. This type of modeling enables for quick calculations. To match the model's properties into the cells', highly sophisticated look-up tables are required to deal with parameter change with temperature, state-of-charge, current density, and lifetime. The third method is to create a model of the electrochemical system. A model is derived using detailed physical and chemical properties in the following sections.

Through an extensive literature survey, the key problem with BMS is a higher number of cells poses a major amount of risk if exposed to damaging conditions[9]. Cells can trigger a series of reactions and possess enough energy to cause irreversible damage to a Battery Pack. The limitation of the papers is that the overcharging and over-discharging weren’t taken into consideration while designing the BMS

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3. Batteries used in Electric Vehicles

Nickel Cadmium, Lead-acid, Nickel-Metal-Hydride, and Lithium-ion batteries are the most commonly used kinds of batteries [10]. To determine which type of battery is appropriate for a system, a comparison of battery dynamics and other parameters is necessary.

A. Lithium-ion (Li-ion) battery

The anode is made of graphitic carbon with a layered structure and is separated from the positive electrode by a polyethylene separator. The negative electrode (cathode) of this type of cell is made of lithiated metal oxide, which is composed of copper collectors on the face of which is deposited, the active material, while the anode is made of graphitic carbon with a composite material and is dispersed from the positive electrode by a polyethylene extractor. The nominal voltage is 3.7 volts, and the specific energy is 80 watt-hours per kilogram.

B. Lead-Acid battery

Negative electrodes composed of metal lead, positive electrodes made of lead oxide, and separators used to prevent passage between plates all contribute to higher internal resistance. This battery has the benefit of working in a wide temperature range. Another advantage is how simple it is to install. It is typically found in hospital equipment, wheelchairs, and other similar products.

C. Nickel-Cadmium battery

Nickel hydroxide (NiOOH) is the conductive material, metallic cadmium is the negative terminal, and potassium hydroxide is the electrolyte (KOH) 40-60 Wh/kg is the specific energy. They are capable of delivering exceptionally high currents and may be charged fast. Communication systems, diagnostic equipment, professional recording devices, and power tools are among the most common applications. This battery also has the problem of having toxic metals, rendering it environmentally unfriendly.

4. LI-ION Battery Problems And Challenges

Lithium-ion batteries provide a lot of benefits, but they also have a lot of drawbacks. The protective circuitry used, the battery's cost, the memory effect of partially drained cells, the environment's impact, and recycling are all issues faced by Li-Ion batteries. Temperature (A) In batteries, chemical processes generate heat. Unusual temperature rises or drops harm the chemical properties of cells and, in the worst-case scenario, can result in an explosion. As a result, an effective temperature mechanism is required. Higher temperatures in batteries can induce aberrant behavior, while lower temperatures can impact the battery's charging and discharging currents, as well as the battery's power handling ability, due to a slower chemical reaction rate[11].

5. Proposed Method

5.1 The Proposed system of Battery Management System has shown in Fig. 1 Battery

Management System is divided into three sections:

Stages of Project:-

1. The Input Supply.
2. Controlling the charging and discharging path.
3. The output of the BMS

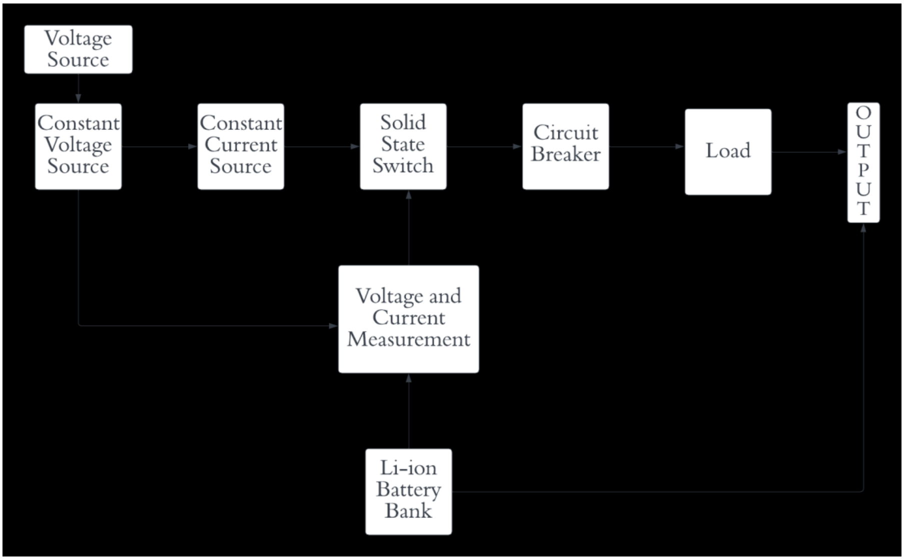

Fig.1: Block diagram of BMS

5.1.1 The Input Supply

To provide an input supply, there can be two different types of supplies, one by using the AC supply with the help of Switch Mode Power Supply (SMPS) and the second by using the Solar supply with the help of MPPT charger. The voltage obtained by the Switch Mode Power Supply and Solar supply is very unstable so to stabilize this voltage use a constant voltage source. The output of a constant voltage source is then given as an input to the constant current source. Therefore, by using a constant voltage source and a constant current source get a stable output which is the most required parameter to charge the batteries. Also, providing a stable voltage and current for charging the batteries protects them from any kind of damage which is our utmost priority.

5.1.2 Controlling the charging and discharging path

The Controlling System of BMS is then divided into several parts which are the Solid-State Switch shown in Figure 4.1, The Battery Bank, The Voltage, and the Current Measurement, each of the blocks has its own characteristics, the solid-state switches are MOSFET based switch which is used to charge and discharge the batteries. The voltage measurement and the current shunt with the ADC give the voltage and current data of the batteries. This data is then transmitted using the serial bus communication. Microcontrollers are used to process this data, the data is processed by Atmel 89s52 which gives us data for the charging or discharging process by triggering the MOSFET. With the help of the Atmel 89s52 Microcontroller, this process has been carried out smoothly, which ensures that the BMS system does not stop working.

5.1.3 The Output of the BMS

There are two different types of output ports: The first is the protected port and the second is the bypass port. As shown the protected port has a circuit breaker in the path which disconnects the load from the source. The circuit breaker breaks the connection, and it will only start when an external input is applied manually to the BMS while charging. There are 3 led indicators that are used in our BMS are red, orange, and green. When the red and orange LEDs are ON the BMS is working properly with all the protection in place. If the orange led turns off, then the BMS indicates that there is some problem in the protection circuit or there is a short in the load. The green led indicates that the battery is low and the BMS will switch off the supply at any time in 10 to 15 minutes.

6. System Implementation

6.1 Development of Battery-Pack

6.1.1 Cell Selection

There are many types of lithium-ion Batteries with different chemistries available in the market. The two major types of cells that are used the most are the Li-Ion 18650s and the $LiFePO_4$. The Li-Ion 18650s has many advantages over the $LiFePO_4$ cells[12]. One of the most important advantages is the high energy density. Electric vehicles also need battery technology that has a high energy density. Moreover, the Li-Ion often gets higher discharge rates i.e., more power and it is rated to approximately 3c value. Whenever going for the high power, the Li-Ion cell does not heat up i.e., it has good thermal protection. Hence, the Li-Ion cells have been used in our project.

Table 1 lists the battery specifications.

Table 1. The Battery Details.

MODEL	N18650CL
VOLTAGE	3.6V-4.2V
CAPACITY	29000mAh

6.1.2 Constant Current Source

It is a source of power to the circuit, which provides a constant level of current regardless of the impedance of the load, i.e., even if there is a change in charge of the impedance of the load the current into the circuit/load will not change.

Types of Constant Current Source:

1. **Independent Current Source**: The current produced is not dependent on any of the variables in the circuit, throughout the current produced by it is constant and fixed.

2. **Controlled Current Source**: The current produced can be controlled by a control voltage element, i.e., this form of current can be controlled by an external factor.

6.1.3 Constant Voltage Source

It is a voltage source that provides the constant voltage to the load, even if there is a change or variance in the load resistance which means the voltage at the output of this circuit is steady even if the load resistance varies. Thus, it is an important part to charge the battery. It is a power generator whose internal resistance is very low as compared to the load resistance.

6.1.4 Solid State Switches

These are MOSFET-based switches that play an important role in the BMS system by selecting which battery needs to be charged or discharged at a particular instant. And this switching process is done with the help of the ATtiny85 microcontroller.

Components used:

1. IRF3205 MOSFET
2. Heat sink

7. Conclusion

Electric vehicles (EVs) are projected to play a significant part in sustainable transportation due to their efficient energy use and zero-emission operation. The battery determines the driving range of electric vehicles and has a significant impact on their performance. As a result, the battery technology used and its effective application are critical. A Battery Management System (BMS) can be built in a variety of ways. A generic design process for the Smart Battery Module, on the other hand, works well. Because of its cell connecting ability and battery equalization capabilities, the suggested system comprises a Battery Pack of Li-ion cells, which ensures that all battery cells receive uniform charging and the energy produced by the battery string is maximized. Voltage, current, the status of charge, state of health, state of life, and temperature are all important characteristics to control in electric vehicles.

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