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Battery Management System and SOC Development of Electric Vehicle

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Abstract: This paper discusses the importance of battery management systems (BMS) and of charge (SOC) development in electric vehicles (EVs). The BMS is crucial for ensuring the safety, efficiency, and longevity of batteries used in EVs. This paper reviews the methodologies used in BMS design, the role of SOC in battery performance, and the impact of these systems on the overall performance of electric vehicles. The findings indicate that effective BMS and accurate SOC estimation are essential for optimizing battery life and enhancing vehicle performance.
Keywords: electric vehicles, battery management system, state of charge.

I. INTRODUCTION

Electric vehicles are becoming more popular as the world shifts towards sustainable transportation. A key component of EVs is the battery, which stores energy and powers the vehicle. The battery management system (BMS) plays a vital role in managing the battery's performance, ensuring it operates safely and efficiently. Understanding the state of charge (SOC) is also important, as it indicates how much energy is left in the battery. This paper explores the development of BMS and SOC in electric vehicles, highlighting their significance in the EV industry.

A. Battery Management System (BMS)

The battery management system is a technology that monitors and controls the battery's performance. It ensures that the battery operates within safe limits, preventing overcharging, overheating, and deep discharging. A BMS typically includes several functions:

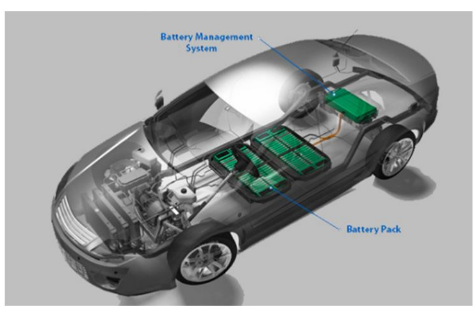

Fig.1.0.BMS of electric vehicle

1) *Monitoring:* The BMS continuously checks the voltage, current, and temperature of each battery cell. This data helps in assessing the health of the battery.
2) *Balancing:* In a battery pack, individual cells may have different charge levels. The BMS balances these cells to ensure they charge and discharge evenly, which extends the battery's life.
3) *Protection:* The BMS protects the battery from conditions that could cause damage. For example, it can disconnect the battery if it detects a fault.
4) *Communication:* The BMS communicates with the vehicle's control system, providing information about the battery's status and performance.

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B. State of Charge (SOC)

The state of charge is a measure of how much energy is stored in the battery compared to its total capacity. Knowing the SOC is crucial for several reasons:

1) *Range Estimation:* SOC helps drivers understand how far they can travel before needing to recharge.
2) *Performance Optimization:* Accurate SOC readings allow the BMS to optimize the battery's performance, improving efficiency and extending its life.
3) *Safety:* Monitoring SOC helps prevent situations where the battery is over-discharged, which can lead to damage.

There are various methods to estimate SOC, including voltage-based methods, current integration, and more advanced techniques like Kalman filtering. Each method has its advantages and limitations, and the choice depends on the specific application.

C. Applications and Use Cases

Battery management systems and SOC development have several applications in electric vehicles:

1) *Electric Car:* BMS and SOC are essential for managing the batteries in electric cars, ensuring they operate safely and efficiently.
2) *Electric Buses:* In public transportation, BMS helps manage large battery packs, optimizing performance for longer routes.
3) *Electric Bikes and Scooters:* Smaller electric vehicles also benefit from BMS and SOC, enhancing user experience and safety.
4) *Energy Storage Systems:* Beyond vehicles, BMS technology is used in stationary energy storage systems, helping to manage renewable energy sources.

D. Comparison with Related Concepts

Battery management systems and SOC are often compared with other technologies in energy management. For instance, traditional fuel gauge systems in gasoline vehicles provide basic information about fuel levels but lack the detailed monitoring and protection features of a BMS. Additionally, while some electric vehicles use simple voltage measurements to estimate SOC, advanced BMS systems provide more accurate and reliable data, leading to better performance and safety.

E. Challenges and Limitations

Despite their importance, there are challenges in developing effective BMS and SOC systems:

1) *Complexity:* Designing a BMS that can handle various battery chemistry and configurations can be complex.
2) *Cost:* Advanced BMS technologies can increase the overall cost of electric vehicles, which may deter some consumers.
3) *Accuracy:* Estimating SOC accurately remains a challenge, especially in varying temperature conditions and usage patterns.
4) *Integration:* Integrating BMS with other vehicle systems requires careful planning and design to ensure compatibility.

II. EMBEDDED SYSTEM

Embedded system is made up of micro-controller and microprocessor, associated with hardware and software. It was created specially to carry out specialized tasks, it is a part of bigger mechanical and electrical system. It is software driven, real time, control system, reliable, human-operated or network interactive. This system is used for various operations on physical variables and in diverse environments. They are typically solid in competitive and cost-conscious markets. The purpose of this system is to control the device and enable user interaction with it. An embedded system is not a computer system mainly designed for processing tasks, it is not a software application on a PC or UNIX operating system, nor is it a conventional business system or a particular application. This system are used for various applications like telecommunications, smart cards, missiles, satellites, computer networking , and digital consumer electronics , automobiles .

A. Block Diagram

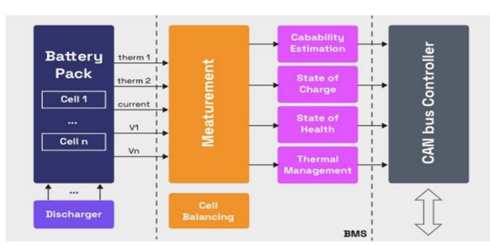

Fig 2.1. Block diagram

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III. HARDWARE

1) ARDUINO NANO BOARD
2) A T mega 325P
3) Battery
4) LCD
5) LED
6) Micro controller
7) Relay
8) Rectifier
9) Voltage regulator
10) Temperature sensor

A. Arduino Nano Board

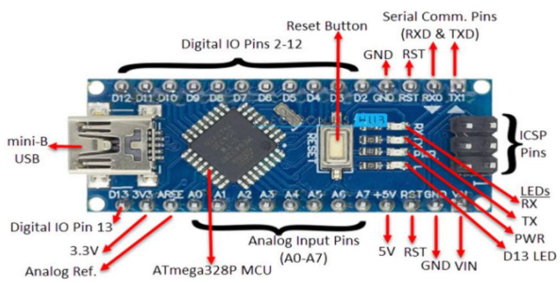

Fig 3.1. ARDUINO NANO BOARD

The Arduino NANO is a small, complete, and breadboard-friendly micro controller board based on the ATmega328.It's essentially a smaller version of the Arduino NANO, offering many of the same functionality but in a more compact package. It is a micro controller-based device with 16 digital pins that can be used for various purposes. It can be used to perform tasks, industrial scale projects and also used for developing new applications . In this project it is connected to two batteries.

B. AT mega 325p

The ATmega325P is an 8-bit micro controller produced by Microchip Technology . It's a mostly used for embedded systems due to its low power consumption, robust performance, and rich feature set.
FEATURES:

Operating voltage	5v
Analog IN pins	8
EEPROM	1kB
Input voltage	7-12v
Digital I/O pins	22
Power consumption	19 m A
PWM output	6
PCB size	18X45 mm

C. Battery

It is a device consisting of one or more elector-chemical cells that converts stored chemical energy to electrical energy. Batteries can produce electricity, they are smaller, safe. It consists of positive and negative endings; we need to connect them in correct way to make battery work. Batteries are widely used in many indoor and outdoor applications like household, industrial, communication, auto mobiles etc. The disposable batteries are primary batteries , rechargeable batteries are secondary batteries .

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Fig. 3.3. Battery

In this project we have used two batteries which are 15v each , here if one battery voltage is less than the threshold voltage then the instructions passed through the micro controller will make the batteries charge automatically and when the batteries are fully charged then the power supply will be disconnected this is done automatically so that the batteries will be safe and the supply to the load will be reliable .

D. LCD (Liquid Crystal Display)

Fig 3.4.16*2 LCD Display

It is an electronic display module; it is used to find a wide range of applications. 16*2 LCD is a very basic module, used in devices and circuits. As shown in Fig. 3.4. is a form of flat panel display that uses the liquid crystal for its functioning. Liquid crystals do not emit light by themselves; instead, they rely on a reflector to create colour or images. They are commonly applicable in smart phones , televisions , computer monitors , instrument panels .

E. LED (Light emitting diode)

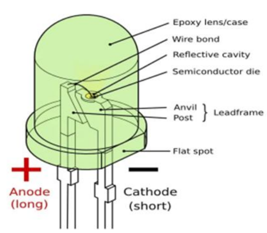

Fig. 3.5. LED

Fig.3.5. show the LED it is similar to transistors and diodes, are semiconductor devices composed of silicon. The introduction of some amount of chemical impurities like gallium, arsenide, indium, and nitrite are converted into silicon material that will make LED to emit the light. When electric current flows it releases the protons. The electric bulbs will generate light by heating a metal filament, LED s are more efficient as they directly produce protons without relying on heat.

F. Micro Controller

Micro controller is a chip-based module which is used to control electronic devices. It is a type of microprocessor emphasizing self-sufficiency and cost effectiveness, in contrast to a general-purpose microprocessor. It contains the memory and interfaces needed for a simple application to perform various functions and it needs additional chips to be connected. It also has some key features like.

1) Central processing unit ranging from 8-bit processor to 32-bit, 64-bit processor. It is a central or main processor, set of complex electronic circuitry runs the apps and machine, operating system. The processes and execution instructions are from the hardware and software programs running on the device.
2) Input /output interfaces are serial ports.

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3) RAM for data storage.
4) ROM, EEPROM or flash memory to store programming.
5) Clock generator is an oscillator for quartz timing crystals, RC circuit, resonator.

G. Relay
It is simply as a switch it mostly used as a switch in electric and electronic circuits, it can operate manually and automatically as per consumer requirement. It is an electro-chemical switch it performs on and off function without human interaction. This are used to control a circuit by a low- power signal, it is also used where several circuits are controlled by one signal.

Fig . 3.7.Relay

In this project will be operated as per the battery voltages, when the battery voltage is less than the threshold voltage the relay will be operated and will change it condition to ON state, when the battery voltages are high and fully charged it will be switched OFF.

H. Rectifier
This is combination of diodes to convert AC to DC It will allow current to flow in one direction only and blocks in another direction. By arranging different didoes in different configuration will create different rectifiers. Rectifiers are very essential for battery management system for battery charging, isolation, power conditioning. The type of rectifier to be selected is based on battery type, charging current ,system requirements , voltage levels . The most commonly used rectifiers are diode rectifiers, bridge rectifiers, and controlled rectifiers. Rectifiers are typically integrated into the charging section of a BMS. The BMS controls the charging process by regulating the charging current and voltage based on battery parameters like state of charge (SOC), state of health (SOH), and temperature.

Fig. 3.8. Rectifier

I. Voltage regulator
Voltage regulator is also called as potential variable , it is electronic circuit designed to maintain constant output irrespective of changes in input voltage and load changes .It ensures that the load or device connected to it should receive constant steady and reliable power supply , it constantly monitors the output power/voltage and adjust the input voltage accordingly .voltage regulators are used in battery chargers , automotive systems , power supplies , micro-controller and integrated circuits . In this project its mainly used to monitor battery output voltage maintain constant even if there are any changes in input system , increase in load .

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J. Temperature Sensor

Fig 3.10. Temperature sensor

The above figure shows a temperature sensor, it is a device that converts the temperature into an electrical signal. This can be connected to micro-controller or any other devices to monitor or it will be connected to any temperature source. It is a very important parameter in battery management systems. It affects safety, lifespan, and battery performance. The role of temperature sensor is to monitor, balancing, Thermal management, alarm and protection .

IV. RESULT

Battery management system and soc state of charge development are obtained as shown in Fig.4.1. When power supply is given or when the battery management system is connected to electric vehicle the batteries are setup with some threshold voltage value and the whole battery management system is maintained and monitor through a code which was given to the microprocessor. When the load applies the battery charge will be varies so when the battery voltage is less than the threshold value then the relay will be operated and turned on and make the battery to charge, when the battery voltage is fully charged then the relay will be turned off and the charging of the battery is disconnected. In this way the batteries are maintained safe and provide reliable power supply so that the electric vehicle will be operated without any disturbance or failure. We can connect this to a smart phone or laptop to monitor it remotely by generating a code that will send the battery values to the smart phone we can see the changes and take frequent safety measures before any fault occurs.

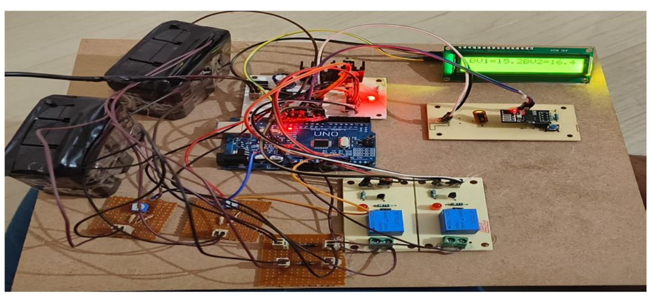

Fig 4.0. Hardware Kit

SL.NO	BATTERY 1 VOLTAGE	BATTERY 2 VOLTAGE	RELAY ON / OFF
1	10	15	OFF
2	7	10	ON
3	8.0	5	ON
4	24	24	OFF

Table 4.0. shows the battery and relay conditions as per the change in voltage

1) The threshold voltage is 8v
2) The fully charged voltage is 24v

Whenever the battery voltage is below threshold voltage the relay will be turned on and battery will be charged by turning on the switch and connecting to the power supply.

Whenever the battery voltage is fully charged then the relay will be turned off and battery will be disconnected from the power supply .

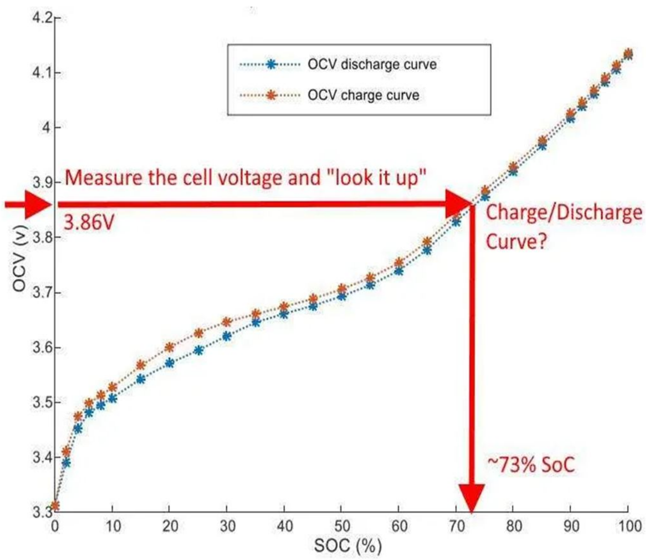

Fig 4.1. state of charge vs output current voltage .

Fig.4.1. shows the graph drawn between state of charge and output current voltage during the charging and discharging of batteries. we can see that the state of charge increases that means even if the batteries get charged or discharged due the load variation or battery utilization the output voltage is maintained constant that we can observe by the graph .

So we can understand that the output voltage can be maintained constant irrespective of load conditions. this improves the efficiency, reliability , stability .The voltage variations can be monitored by connecting a hotspot or wireless hotspot connection , battery one and battery two voltages can be known and we can the stored data whenever we need .

The software monitoring by hotspot connection can be viewed in the figure 4.2.The battery one voltage and battery two voltage are shown in Fig. 4.2. You can see that the results are stored in the app. We can the battery voltages which time we needed that total data with including the time, date , are noted in the app connected through the hotspot .By this whenever we need we can monitor and also can check the battery charging so that the complete discharge of battery will not be faced and battery will be safe .That increases the life span of the electric vehicle and the batter system .

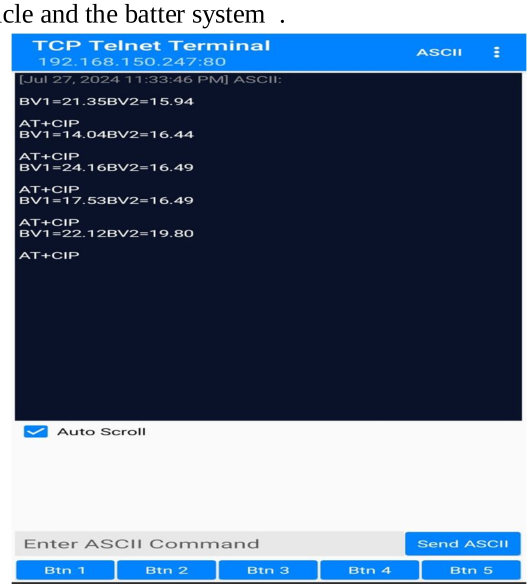

Fig 4.2. software stored result

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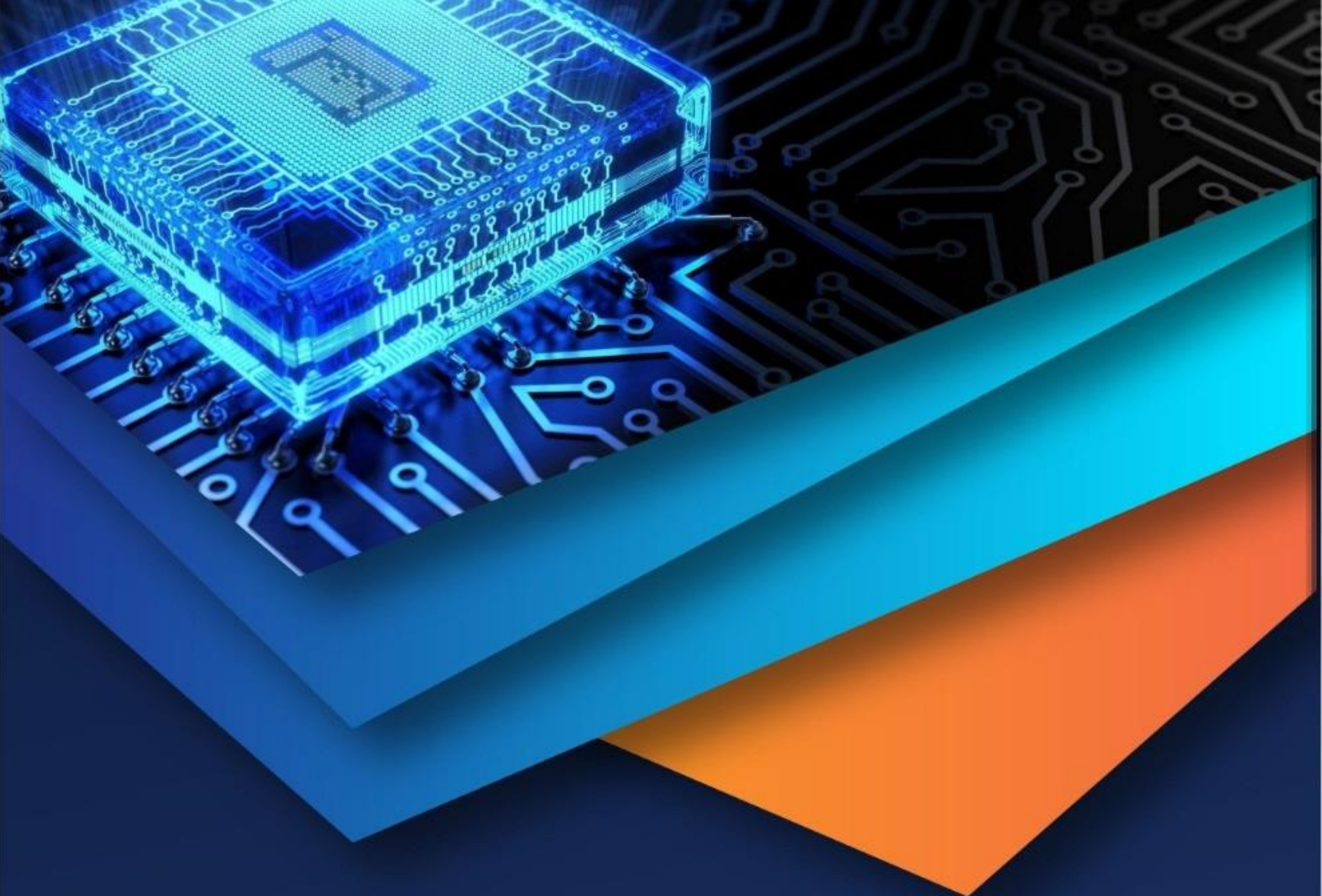

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