IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

BATTERY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLES

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Abstract: The main component in an electric vehicle's battery is the Battery Management System (BMS). This system plays a major role in both safety and performance. It keeps an eye on the battery's health by constantly monitoring voltage, current, temperature, and other factors. This data is key to preventing damage from overcharging, over-discharging, or overheating, which can lead to fires or reduced battery life. The BMS acts like a conductor, regulating how the battery is charged and discharged, and can even isolate weak parts of the battery to prevent them from bringing down the whole system. the BMS also helps the battery perform at its best by balancing energy flow across all the cells within the battery pack, maximizing its efficiency and overall lifespan. By keeping a close eye on the battery's health and performance, the BMS ensures a safe and smooth ride for electric vehicles

Index Terms - Arduion uno, Battery cells,Lcd display,Dc motor,.Matlab simulator.

I.INTRODUCTION

A battery management system (BMS) plays a pivotal role in the operation and performance of electric vehicles (EVs), it works as central nervous system that monitors and controls the health and functionality of the battery pack. The BMS takes care of the individual cells within the battery pack. This involves continuously measuring parameters such as cell voltage, current, and temperature to estimate the state of charge (SOC) of each cell. By monitoring these parameters, the BMS can detect any abnormalities or deviations from normal operation, to determine any potential issues. One of the key functions of the BMS is to balance the charge levels of the individual cells within the pack. Due to variations in manufacturing,operating conditions and aging, some cells within a battery may become more charged or discharged than others, which causes imbalance that can reduce the overall performance and lifespan of the battery pack. The BMS make use of balancing algorithms to redistribute charge among the cells, and make sure that each cells operate within its optimal voltage range. This make the best use of the energy storage capacity of the pack. Safety is a first criteria in EVs, and the BMS plays a critical role in ensuring the safe operation of the battery system. It keeps on monitoring for conditions that could cause a risk, such as over-charging, over-discharging, over-temperature, and short circuits, and performs appropriate mitigation strategies to prevent damage to the cells or the vehicle. This also includes controlling the charging and discharging rates, as well as triggering the safety mechanisms such as cell isolation or thermal management systems to maintain safe operating conditions. The BMS acts as a translator between the battery and the car and lets the car manage energy flow efficiently. It maximizes efficiency and performance while ensuring the longevity of the battery pack. Along with this the BMS provides feedback and diagnostics to the vehicle's onboard computer, which enables predictive maintenance and troubleshooting to identify and address potential issues before they escalate.

II.METHODOLOGY

1. Cell Monitoring and State Estimation:

The BMS continuously monitors individual cells within the battery pack, from tens to hundreds in number. the Voltage, current, and temperature are measured for each cell to assess its State of Charge (SOC) and State of Health (SOH). The SOC shows the remaining energy in the battery, while the SOH gives information about its overall health and capacity degradation over time. Advanced algorithms are used in estimating these values accurately using data gathered over time and considering factors like temperature and aging.

2. Cell Balancing:

Manufacturing variations and usage patterns can lead to imbalances in charge levels in the cells. The BMS make use of cell balancing techniques to redistribute charge and ensure that all cells are operating within specific voltage range. This maximizes the overall energy storage capacity and extends the battery pack's lifespan. Passive or active balancing methods can be used, with the active balancing offering faster and more precise correction.

3.Safety Management:

The BMS prioritizes safety by constantly monitoring for potential risks like:

I.Overcharging Can damage cells and leads to fire incidence.

II.Over discharging can cause permanent cell damage and reduce its capacity, so be cautious.

III.Over temperature, high temperatures accelerate cell degradation and increase the fire risk.

IV.Short circuits; can cause rapid heating and pose a fire hazard.

The BMS implements mitigation strategies like:

I.Limiting charging/discharging rates.

II.Disconnecting faulty cells.

Activating thermal management systems and cooling fans for preventing overheating.

4.Communication and Control:

The BMS facilitates communication between the battery pack and other vehicle systems like the propulsion system (electric motor) for coordinated operation, onboard charger for safe and efficient charging, and vehicle management system for overall control and monitoring. This communication allows for:

i.Optimized energy flow within the vehicle to maximize battery performance and efficiency!!

ii.Real-time feedback & diagnostics to the vehicle computer for preventive maintenance

III .HARDWARE

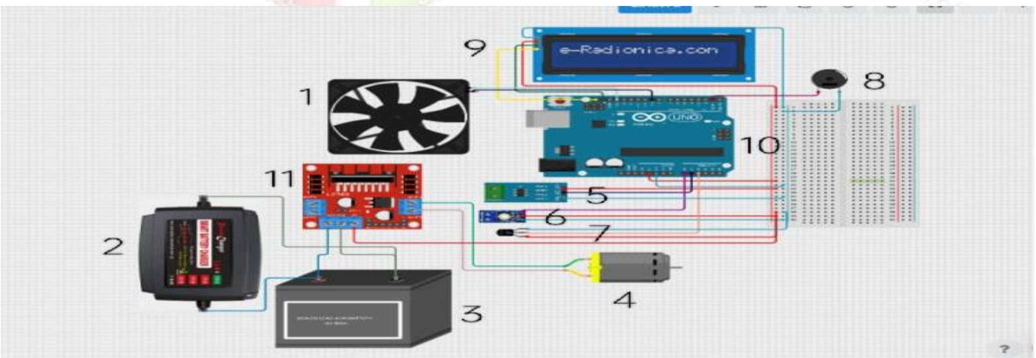

Fig:-1 Circuit diagram for thermal protection of BMS

COMPONENTS USED

1. 12v Battery cell:- A 12V battery is a rechargeable battery that provides a nominal voltage of 12 volts DC (Direct Current). it is made up of several cells wired in series to achieve a total voltage of 12 volts. where individual cells produce 1.3 to 3.7 volts. They are widely used in various applications due to their versatility and ability to store a decent amount of energy. some of their applications are Powering 12V DC devices, DC-to-DC converter in solar power systems,etc…

Fig 2:- 12v cells

2. Arduino Uno :- The Arduino Uno R3 is a popular microcontroller board commonly used in electronics projects and prototyping features.

I.Microcontroller: Arduino Uno R3 is powered by the ATmega328P microcontroller, running at 16 MHz clock speed, offering 32KB of flash memory for program storage and 2KB of SRAM for variable storage.

II.Digital I/O Pins: It features 14 digital input/output pins, among which 6 can be used as PWM (Pulse Width Modulation) outputs, allowing for control of devices like motors and LEDs with varying intensity.

III.Analog Inputs: Arduino Uno R3 has 6 analog input pins, enabling the reading of analog sensors and signals, with a resolution of 10 bits (providing 1024 different values).

IV.Interfaces: It includes a USB interface for programming and serial communication, as well as a power jack for external power supply. Additionally, it has an ICSP (In-Circuit Serial Programming) header for advanced programming.

V.Compatibility: Arduino Uno R3 is compatible with a wide range of sensors, actuators, shields, and libraries, making it ideal for beginners and professionals alike in the fields of electronics, robotics, automation, and IoT (Internet of Things) applications.

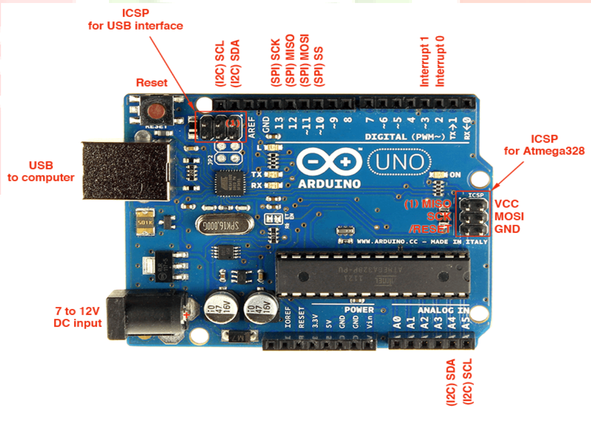

Fig 3:-Arduino Uno

3.Current sensor:-A current sensor is used to detect and measures the electric current passing through a conductor. It turns the current into a quantifiable yield, such as a voltage, current, or computerized flag, which may be utilized in a assortment of applications for checking, control, or assurance.

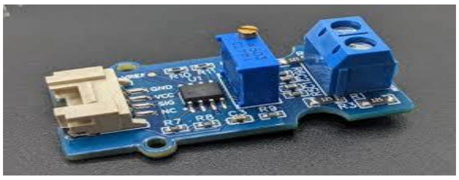

Fig 4:-Current sensor

4. Voltage sensor:--A current sensor is used to detect and measures the electric current passing through a conductor. It turns the current into a quantifiable yield, such as a voltage, current, or computerized flag, which

may be utilized in a assortment of applications for checking, control, or assurance.

Fig 5:- Voltage sensor

5. 16x12 Lcd display:-A 16x2 LCD display is a small Liquid Crystal Display (LCD), it displays up to 16 characters on 2 lines, providing a total of 32 characters of information. some of the applications are Information displays, Control panels, Timers and counters, etc…

Fig 6:- 16x12 Lcd display

6. Temperature sensor:- A temperature sensor is a device that is used to measure the degree of hot or cold in an object. The working of a temperature meter depends upon the voltage across the diode. The temperature change is directly proportional to the diode's resistance.

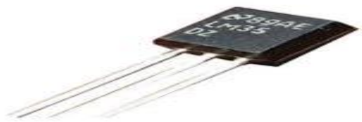

Fig 7:- Temperature sensor

7. Dc Fan:-A 5V DC fan is a small fan that runs on direct current (DC) at 5 volts and consumes 0.1to0.2A.These are commonly used in electronics for cooling purposes. some of their applications are cooling electronic devices, 3D printers,Audio/video equipment,etc..

Fig 8:-Dc Fan

8. Dc motor:-A DC motor, or direct current motor, is an electromechanical device that converts electrical energy from a direct current (DC) source into mechanical energy in the form of rotational motion. motorused in this project is of 100rpm dc.

Fig 9:-Dc motor

IV. SOFTWARE

MATLAB is a software which is used for simulating and analyzing active cell balancing:

Active cell balancing is a crucial technique employed in Battery Management Systems (BMS) of Electric Vehicles (EVs). It addresses imbalances in the charge levels of individual cells within the battery pack. These imbalances can arise due to manufacturing variations, aging, and usage patterns.

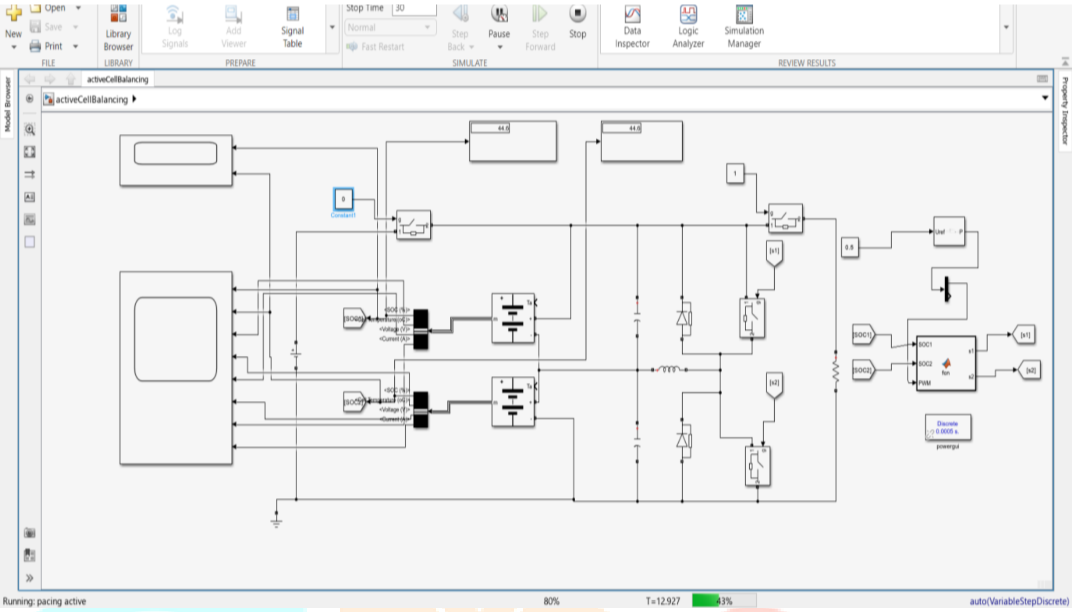

Fig 10:-Mat lab simulation for active cell balancing

V. WORKING

A battery management system (BMS) plays a critical role in ensuring the safe and efficient operation of batteries by incorporating thermal protection features. Here's how it works:

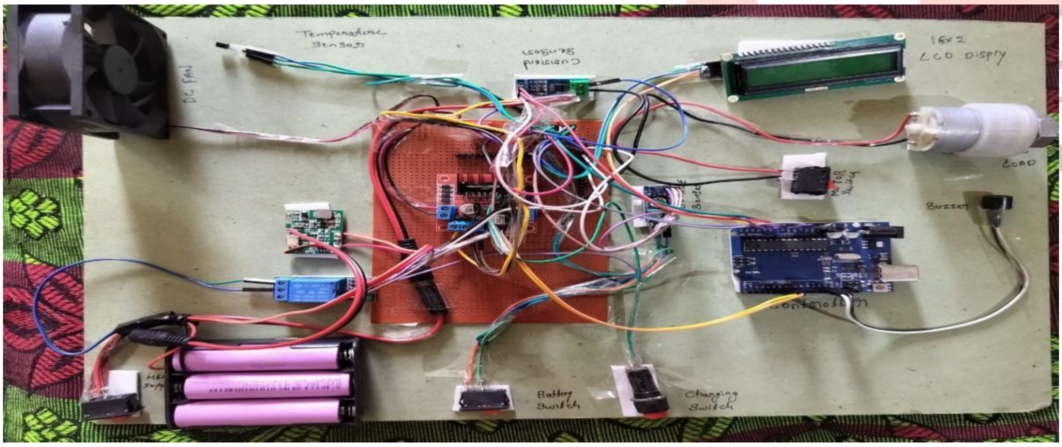

Fig11:-Hardware for thermal protection in BMS

Monitoring:

The BMS utilizes temperature sensors, voltage sensors, and current sensors embedded within the battery pack to monitor the temperature, voltage, and current of individual cells or groups of cells and continuously collects data from these sensors and converts it into usable readings by the main processor.

Control and Protection:

Based on the measured temperature, the BMS takes corrective actions. If the temperature is within the optimal range (often between 15°C and 35°C), the BMS allows normal operation and if the temperature exceeds the safe limit, the BMS initiates protective measures.

This involves activating cooling systems (active thermal management) by triggering active cooling systems like fans or pumps to circulate coolant and dissipate heat and limit or slow down the charging or discharging process until the battery is back to a safe temperature zone.

Simulation for active cell balancing

During charging of the battery .

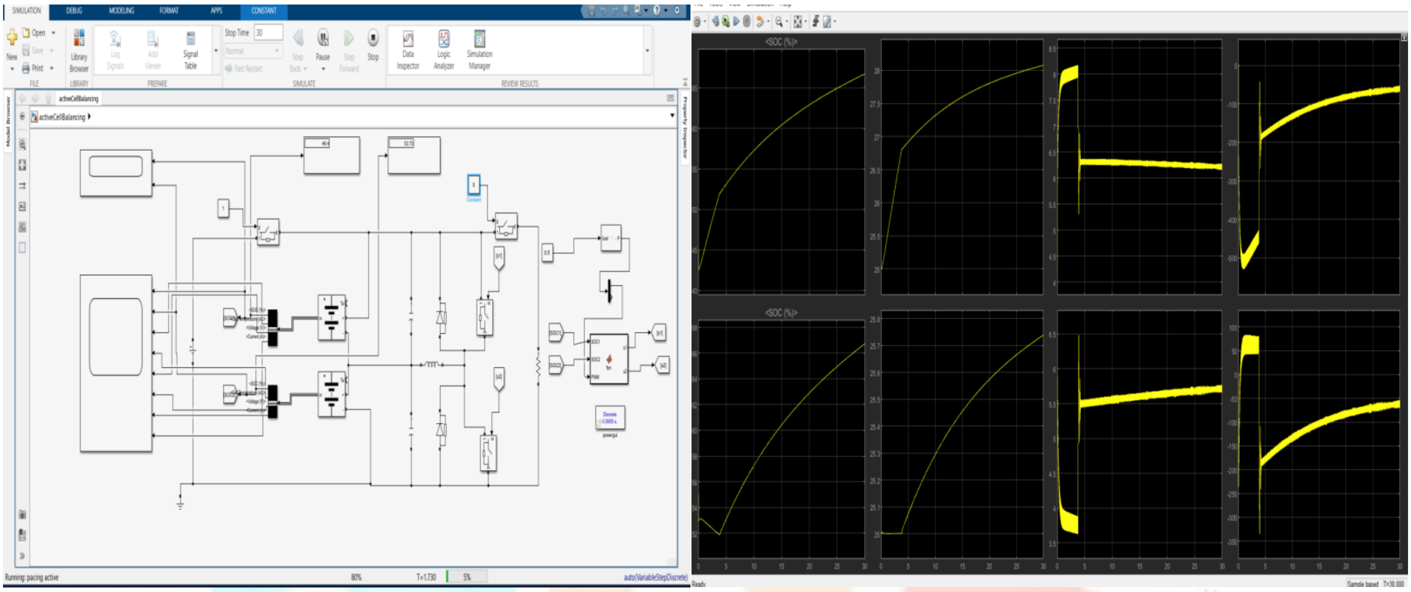

Fig 12:- Circuit and output for Active cell balancing during charging

During discharge of the battery .

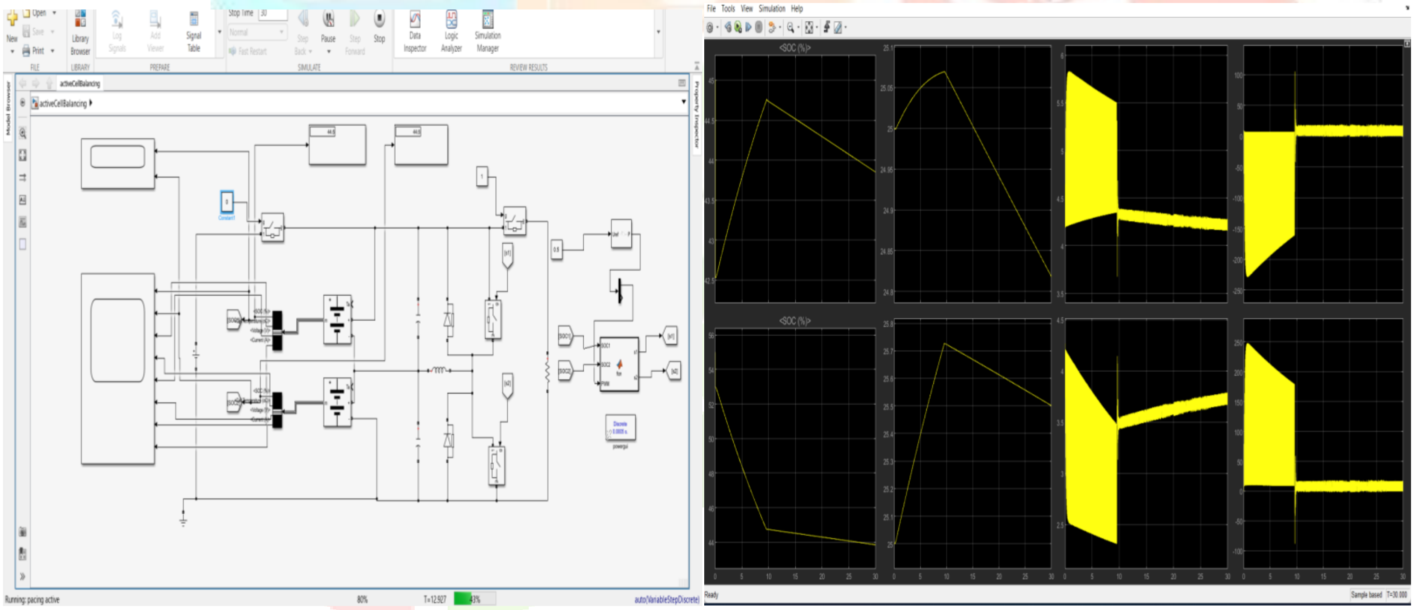

Fig 13:- Circuit and output for Active cell balancing during discharging

A Battery Management System (BMS) is crucial for ensuring the safe and efficient operation of rechargeable batteries, especially those with multiple cells connected in series and parallel. One of its key functions is active cell balancing, which helps maintain an equal State of Charge (SOC) across all the cells in the pack.

BMS with active cell balancing works:

1. Monitoring and Measurement:

The BMS contiuously monitors the values of voltage, current, and temperature of each individual cell in the battery pack.

By tracking these parameters, the BMS can identify any cells that are lagging behind or exceeding the others in terms of charge level.

2. Balancing Strategy and Control:

The BMS control unit analyzes the cell data and determines the appropriate balancing action.

It activates the balancing circuits to move charge from fully charged cells to partially charged cells until a balanced state is achieved.

This strategy can be implemented during charging, discharging, or even both depending on the system design.

VI. CONCLUSION

Thermal protection and active cell balancing are two essential features of a BMS that work together to safeguard the battery, optimize performance, and ensure a safe and extended driving experience for electric vehicles. The thermal protection acts as a guardian, constantly monitoring the temperature of each cell within the battery pack. By keeping a close eye on temperature levels, the BMS can prevent overheating, a condition that can severely degrade battery health and lead to safety hazards. If necessary, the BMS can take corrective actions, such as reducing charging or discharging rates, or activating cooling systems to maintain optimal temperatures and the active cell balancing works hand-in-hand with thermal protection to optimize battery performance and lifespan. It addresses the issue of uneven charge distribution among cells, which can arise due to manufacturing variances or usage patterns. The BMS employs active cell balancing techniques to redistribute charge and ensure all cells operate within a safe and healthy voltage range. This not only prevents overcharging or over-discharging of individual cells but also maximizes the overall energy storage capacity of the battery pack, ultimately extending its usable life.

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