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BATTERY MANAGEMENT SYSTEMS (BMS)

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ABSTRACT

This project aims to design and develop battery management system which gives cell balancing and also provides all cell voltage and current via google sheet and display . For IOT purpose we are using ESP32 Wifi module to access data of users through online mode. Develop a maximizing battery life, ensuring optimal performance, enhancing safety, monitoring and controlling the charging/discharging process efficiently

Keywords: Battery Management System , cell balancing , overcharging, over discharging, Wifi, IOT

1.INTRODUCTION

In recent years, the demand for battery-powered devices and systems has surged exponentially, driven by the growing need for sustainable energy solutions and the electrification of various industries such as automotive, aerospace, and renewable energy. Central to the efficient and safe operation of battery-based systems is the Battery Management System (BMS), a critical component that monitors, controls, and protects battery cells or packs throughout their lifecycle.

The battery pack could be damaged by overcharging or over discharging. This could lead to a shortened lifespan, reduced capacity, or even complete failure.At the time of charging and discharging battery cell are produce heat or temperature due to over temperature chances of battery damage or fire.

The BMS will perform on functions mentioned bellow

Cell Balancing:
Cell balancing is the process of equalizing the state of charge (SOC) of each cell in a battery pack to ensure its longevity and safety. Several techniques have been proposed to balance the cells, including passive and active balancing.

SOC Estimation:
The SOC of the battery pack is a crucial parameter that needs to be accurately estimated for the BMS to perform its functions effectively. Several techniques have been proposed for SOC estimation, including the open circuit voltage (OCV) method, coulomb counting method, and model-based methods.

Thermal Management:
The temperature of the battery pack plays a significant role in its performance and longevity. The BMS is responsible for monitoring the temperature of the cells and ensuring that they stay within a safe range. Several thermal management techniques have been proposed, including passive and active cooling. Advanced cooling systems, phase change materials, and thermal modeling approaches are being employed to regulate battery temperature and ensure safe operation across a wide range of operating conditions.

Communication Protocols: The BMS needs to communicate with other components of the EV such as the motor controller, charger, and vehicle management system.

2. PROBLEM STATEMENT

To design system which is control the cell overcharging, over discharging and cell balancing in the battery unit

3. LITERATURE REVIEW

In Early Development stage, the concept of BMS emerged alongside the development of rechargeable batteries in the mid-20th century. Initially, basic protection circuits were used to prevent overcharging and over-discharging of batteries. With the advancements in electronics and microcontroller technology in the late 20th century, more sophisticated BMS designs became feasible. These systems could monitor individual cell voltages, temperatures, and other parameters. The commercialization of lithium-ion batteries in the 1990s spurred the need for more advanced BMS due to the unique characteristics and safety concerns of these batteries. The widespread adoption of electric vehicles (EVs) in the 21st century further accelerated the development of BMS to manage large battery packs efficiently and ensure safety and longevity.
There are various existing Technologies in Battery Management Systems are present like Various cell balancing techniques such as passive balancing, active balancing, and hybrid balancing are employed to equalize the state of charge (SOC) among individual cells within a battery pack. SOC estimation algorithms based on Kalman filtering, coulomb counting, and impedance spectroscopy are commonly used to accurately determine the remaining capacity of a battery. Temperature sensors are integrated into BMS to monitor the temperature of battery cells and ensure optimal operating conditions to prolong battery life and prevent thermal runaway. BMS incorporates fault detection algorithms to identify abnormalities such as cell degradation, short circuits, or faulty temperature sensors, enabling timely maintenance and preventing catastrophic failures.
There are various recent Advancements in Battery Management Systems are done like AI-based algorithms, including machine learning and neural networks, are increasingly being employed in BMS for predictive analytics, fault prognosis, and optimization of battery performance. BMS with wireless communication capabilities enable real-time monitoring and remote diagnostics of battery packs, facilitating proactive maintenance and enhancing safety and reliability. Integration of BMS with energy management systems allows for optimized utilization of battery energy storage systems (BESS) in various applications, including renewable energy integration and grid stabilization. Modular BMS architectures with scalability features enable easy integration into different battery pack configurations, making them suitable for a wide range of applications from small consumer electronics to large-scale energy storage systems.

4. DESIGN AND OBJECTIVES

- **DESIGN**

Design part of the prototype mainly includes the circuit diagram and all the major parts that are integrated together to form the final circuit.
The circuit diagram mainly includes 7 major parts which are as follows

1. Microcontroller Atmega 16A

fig.1 Atmega 16A

Microcontroller used in the project is Atmega 16a because of its compatibility and suitability to the project. The microcontroller mainly does the job of processing all the data that is fetched from all the major parts of the
circuit and then providing it to the LCD display.
The ATmega16A features an 8-bit AVR microcontroller, has 16KB of Flash program memory,1KB of EEPROM, and 1KB of SRAM for temporary data storage. It also has a 16 bit timer/counter along with various peripherals like GPIO pins
USART,SPI and I2C.

2. Current sensing and signal conditioning
This part of the circuit mainly includes LM358P which is a differential amplifier and a potentiometer to adjust the potential in the circuit and some resistor and capacitors. The main purpose of this part is to sense the amount of
current that is flowing through to the battery of the vehicle.

3. Voltage sensing and signal conditioning
This part of the circuit mainly includes mainly a potentiometer to adjust the potential in the circuit and some resistor and capacitors. The main purpose of this part is to sense the amount of voltage that is flowing through
to the battery of the vehicle.

4. Battery charging control unit
This unit is mainly used to control the charging of the battery and thus turn it on and off whenever required. Thus mainly relay is used in this circuit which uses the principle of magnetic field to induce the coil and thus act as a switch.

5. WIFI module

fig.2 WIFI Module ESP32

Wifi module used is ESP32 and the major purpose is to access data of users through the internet. Develop a reliable and secure method for user identification and authentication.

6. 16*2 LCD Unit

fig.3LCD 16*2

LCD Unit is mainly used to display all the data that has been provided on the screen. This display mainly has read and write pins and many data pins for fetching the data from microcontroller. LCD Display unit also requires a 5V power
supply for its functioning.

5. OBJECTIVES

The objective of this project is to design , develop and implement the BMS system :-
The objective for a battery management system is typically involves the maximizing battery life , ensuring optimal performance , enhancing safety , monitoring and controlling the charging / discharging process efficiently , and integrating with the boarder system seamlessly.This could encompass areas like smart energy management sustainability and meeting specific project requirements.
.Data Monitoring and Management: Develop a monitoring system to trac… energy consumption, solar power generation, battery state of charge, and EV charging sessions. Provide real-time data to station operators.
Optimize Battery Performance: The primary objective of BMS is to optimize the performance of battery systems by maximizing energy efficiency, enhancing charge/discharge capabilities, and extending battery lifespan. This includes accurately monitoring and controlling key parameters such as state of charge (SoC), state of health (SoH), temperature, and voltage to ensure optimal operation under varying conditions.
The main goal of BMS is to keep the battery within the safety operation region in terms of voltage, current, and temperature during the charge, the discharge, and in certain cases at open circuit.
The oversight that a BMS provides usually includes:
 Monitoring the battery
 Providing battery protection
 Estimating the battery's operational state
 Continually optimizing battery performance
 A battery management system allows users to monitor individual cells within a battery pack.
 The BMS monitors and manages a battery pack in order to protect it from damage, prolong its life, and keep the battery operating within its safety limits. These functions are key to efficiency, reliability, and safety.
 A BMS can measure different figures such as current, voltage, temperature, and coulomb count With these measurements the system can assess the . health of the battery and readjust operations as needed to protect the pack
Protect the battery from damage
Prolong the life of the battery
 Keep the battery operating within its safety limits
 Choose the best-fit hardware topology for an aimed final battery application
 List the most important BMS components and their value for the system
 Elaborate on the working principles of the standards on functional safety.
Battery management system is essential for following reasons :-
1. Maintain the safety and the reliability of the battery
2. Battery sate monitoring and evaluation
3. To control the state of charge
4. For balancing cells and controlling the operating temperature
5. Management of regenerative energy

6. METHODOLOGY

Battery management system (BMS) is the crucial system in electric vehicle because batteries used in electric vehicle should not be get overcharged or over discharged. If that happens, it leads to the damage of the battery, rise in temperature, reducing the life span of the battery, and sometimes also to the persons using it. It is also used to maximize the range of vehicle by properly using the amount of energy stored in it. Battery management systems (BMS) are very important for optimizing battery performance. Some popular theories and practices include state of charge (SOC) estimation, cell balancing, temperature monitoring, and voltage/current regulation .Cell Balancing: BMS ensures that all cells in a battery pack are charged and discharged evenly, preventing capacity imbalance and maximizing overall battery performance Temperature Monitoring: BMS continuously monitors the temperature of the battery cells to prevent overheating, which can degrade battery life and pose safety risks .Voltage Monitoring: BMS measures the voltage of each cell to detect any abnormalities or imbalances, allowing

for prompt corrective actions .Current Monitoring: BMS measures the current flowing into and out of the battery, enabling accurate tracking of energy flow and preventing overcharging or over-discharging. State of Charge (SOC) part in a BMS uses various algorithms and models to estimate the remaining capacity of the battery, allowing for accurate monitoring and control. SOC estimation is crucial for accurately determining the remaining energy in a battery & advanced algorithms integrate multiple data sources such as voltage, current, temperature. Nowadays, lithium-ion batteries are used in various applications, ranging from personal electronic devices, like cell phones, to the emerging class of electric vehicles. Because of the fragile nature of these types of batteries, when compared to lead-acid, , comparatively advance monitoring is necessary for safe operation .The complexity of a battery management system strongly depends on the individual application. In addition, the basic parameters like cell voltage, cell temperature and current have to be measured. Nevertheless, advanced algorithms are needed, as e.g the available energy has to be determined in order to reliably calculate the cruising range.

This work focuses on the hardware aspects of battery management systems for lithium-ion batteries, which provide the described functions. The first section introduces a set of requirements on the hardware portion of a BMS, taking into account measurement of needed values and electromagnetic interference, as well as galvanic isolation, contractors
and redundancy aspects. an overview of possible BMS topology is presented. In that section of the paper, differences between simple use cases, as portable electronic devices and more complex Battery management systems (BMS) are used in various instrument to monitor and control the charging and discharging of rechargeable batteries which makes the operation more imp.Battery management system keeps the battery safe, reliable and increases the senility without entering into damaging state. BMS interfaces with external systems such as vehicle control units, inverters, and energy management systems through standardized communication protocols . .Here, the system requires battery management to extend run times, management safety, and maximize battery -life.

7. BLOCK DIAGRAM

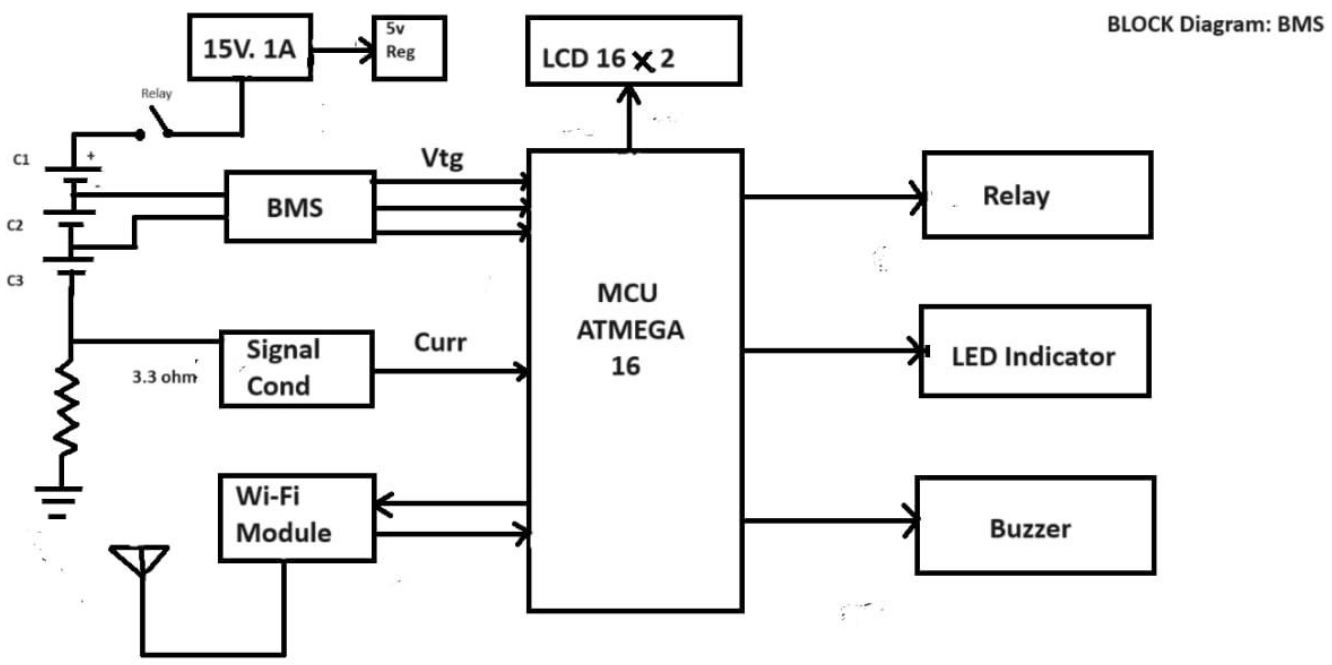
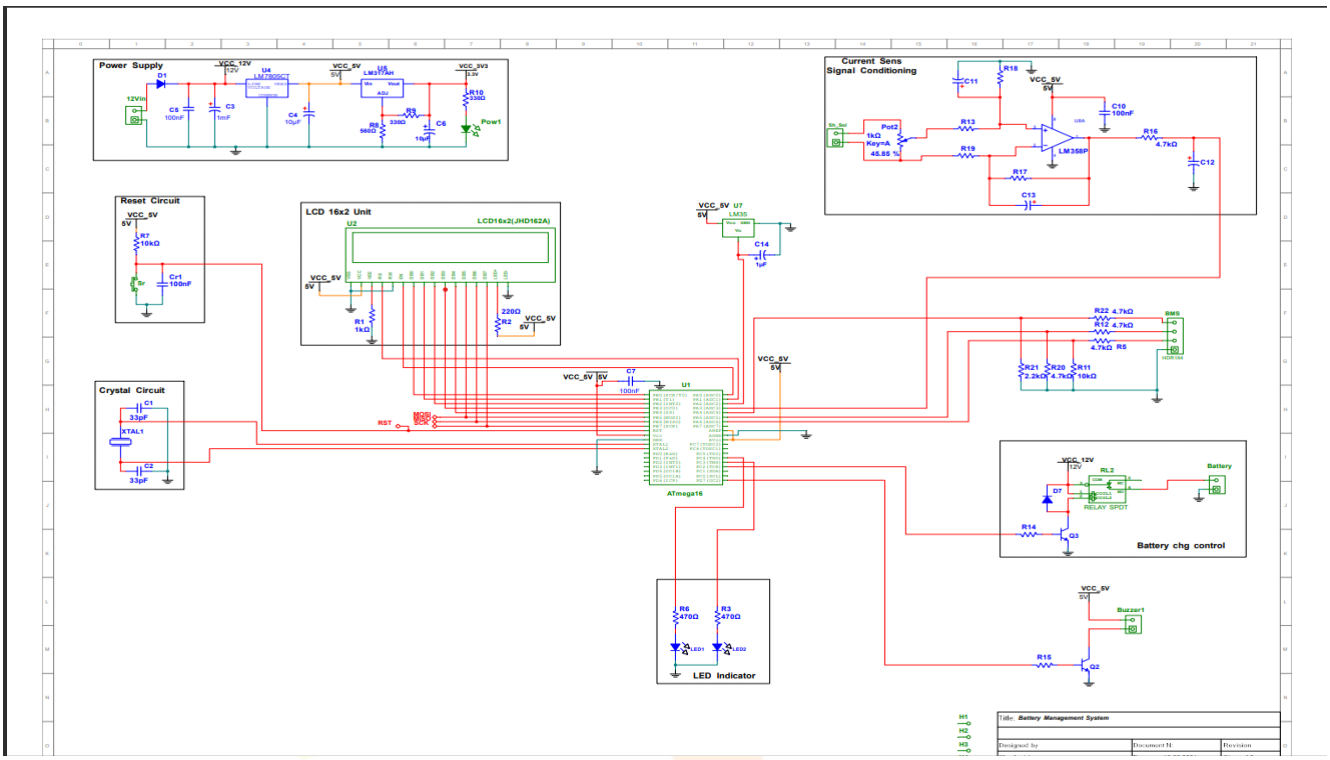


fig.4 block diagram

CIRCUIT DIAGRAM



16. Tactile switches
17. POTENTIOMETER, 1kΩ

8. COMPONENT LIST

1. AVR Microcontroller ATmega16
2. DW01-P
3. CAP_ELECTROLIT, 1µF
4. CAP_ELECTROLIT, 1mF
5. CAP_ELECTROLIT, 10µF
6. CAPACITOR, 100nF
7. CAPACITOR, 100nF
8. DIODE, 1N4007
9. Buzzer
10. Li Ion Battery 11.4V
11. Current sensor
12. Relays
13. LCD, LCD16x2(JHD162A)
14. LED, LED_3
15. OPAMP, LM358P

18. POTENTIOMETER, 10kΩ
19. Relay, RELAY SPDT
20. AC-DC Adapter 12V,2A
21. RESISTOR, 2.2kΩ
22. RESISTOR, 3.3kΩ
23. RESISTOR, 4.7kΩ
24. RESISTOR, 10kΩ
25. RESISTOR, 10kΩ
26. RESISTOR, 22kΩ
27. RESISTOR, 220Ω
28. RESISTOR, 330

9. RESULTS AND DISCUSSION

Interpretation of result :- Our battery management project is improving the battery cell lief and working capacity .We are use three lithium ion cell in this project . Battery management system is only work on the lithium ion cells only .Battery management system means protect the battery cell from over charging and over discharging ,Battery is made from number of cell , each cell not equal parameter with each other . Number of free electrons in each cell are not same , so the each cell power capacity is not same .

When we charging regular battery ,that means without battery management system , those cell have less free electronics this cells are quickly charge or fully charge , but at the same time some cells have more free electrons this cells are not fully charge . So final result of battery charge is not full .We continue the charging and less capacity cell are over charging and increase the chances of damaging the cell or battery . The same process is happened in the discharging also .To avoiding the over charging and over discharging we required the battery management system .

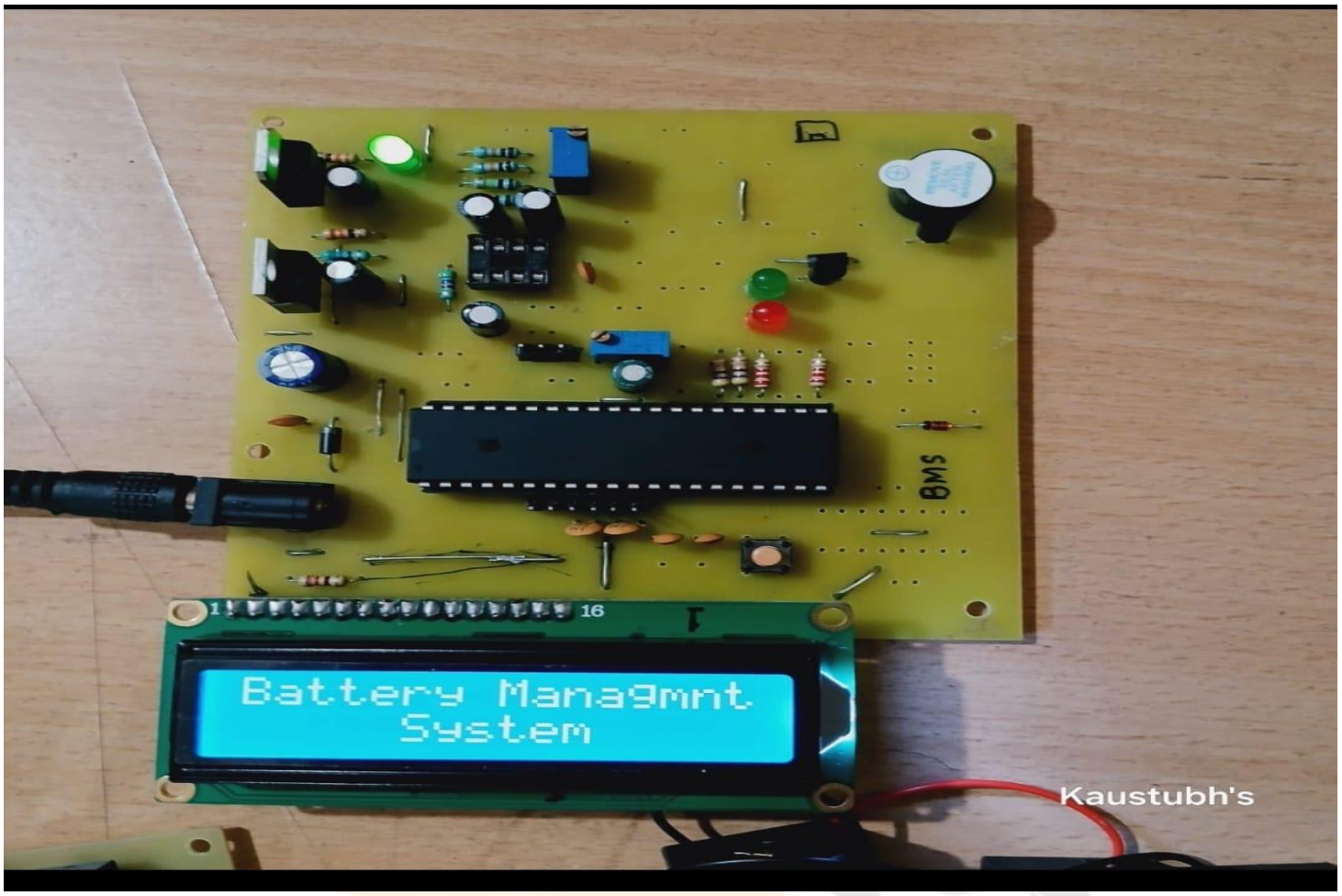
Limitations of finding :- In conducting our study on the development and implementation of battery management system project that works on the cell balancing and control the charging and discharging of cell , The main limitation of battery management system is its only work on the lithium ion cells only. The Battery management system working on state of charge so the change the battery temperature parameter also .Battery management system designs is complex , making cost also high , difficult make for some application .

Suggestions for Future Research :- Future research in the battery management system one promising avenue is we could use the integration of artificial intelligence and DS.

The temperature in the cell is high at time of charging and discharging , If temperature is high then increase the chances damage the cell or battery . So the temperature is require in limited range .

Another point is making cost of battery management system is high ,if we making on the cost efficient Battery Management System then battery management system is use in all application .

Battery Management System is working on limited cells materials ,if we are finding soulution of this problem the cost is reduces .



10. Conclusion

Concluding the battery management system project , it is best technology of battery for good performance . battery management system project is improving the performance of battery .As well as improve the life of battery . Battery management system is also improve the safety of battery . In the battery management system project we successfully developed a solution over charging and over discharging battery cell , it is help to protect the cell from damage . If over charging and over discharging is has done then hit generated and due to hit cells are damage or some time battery cells are ignited , it is very dangerous user . using the battery management system life of battery is increases and we can save money .

11. REFRENCES

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