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IoT Based Battery Management System

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ABSTRACT: In our rapidly evolving technological landscape is an efficient and intelligent management of energy storage systems is paramount. This project introduces a modern Battery Management System module to optimize the performance, ensure the safety, and promote sustainability of rechargeable batteries. Leveraging cutting-edge technologies such as microcontrollers and Internet of Things (IoT). The integration of renewable energy sources and the increasing demand for portable electronic devices have led to a growing need for efficient energy storage solutions. This project presents a BMS that employs Arduino microcontrollers and Internet of Things. A BMS is introduced in this paper to continuously monitor and analyses battery temperature during charging and discharging process. The BMS includes block diagrams and uses methods like Coulomb counting for State of Charge estimation and CCCV for State of Health assessment. Data, including battery status, temperature, and voltage, are automatically stored on the IoT platform Thing speak, allowing for thorough battery analysis and prompt issue resolution.

KEYWORDS: Energy Storage Systems, Battery Management System (BMS), Internet of Things (IoT), Battery Temperature Monitoring, State of Charge (SOC), State of Health (SOH), Charging and Discharging.

I. INTRODUCTION

In the imminent future, Electric Vehicles will be the leading form of transportation. Lithium-based rechargeable batteries will be widely used. These battery packs will need to be managed and constantly monitored for the purpose of maintain the safety, reliability and efficiency of the electric vehicle. A battery management system (BMS) consists of: (1) a battery level monitoring system (2) optimal charging algorithm and a cell/thermal balancing circuitry. The voltage, current and temperature measurements are used to estimate all crucial states and parameters of the battery system, such as the battery impedance and capacity, state of health, state of charge, and the remaining useful life.

Batteries in electric vehicles (EVs) degrade over time due to chemical reactions, reducing their energy storage capacity. To mitigate degradation, controlling charging and discharging profiles, especially under varying conditions, is essential. Battery life is also affected by factors like temperature fluctuations and frequent high-current charge/discharge cycles. Despite occasional safety concerns, well-designed EV systems with safety features and automatic cutoffs are generally secure. Flexible Battery Management Systems (BMS) that can cover various battery types and offer comprehensive protection have become a focus of recent EV development. State of charge is a critical parameter for safe battery charging and discharging. It represents the battery's current capacity relative to its rated capacity. SOC helps manage voltage, current, temperature, and other battery-related data. Accurate SOC calculation prevents overcharging and over-discharging, which can damage batteries. Additionally, the safety and sustainability of energy storage solutions are paramount concerns, especially in applications like electric vehicles, renewable energy grids, and portable electronic gadgets.

II. LITERATURE REVIEW

T. Sirisha et al. in [1] discuss the importance of battery monitoring for electric vehicles and introduces a Battery Management System (BMS) that can help ensure the safety and optimal performance of the battery system. The BMS is designed to monitor the battery at all times and measure the temperature at each battery cell during charging and discharging. The State of Charge (SOC) estimation is implemented using Coulomb counting method and the State of Health (SOH) of the battery is determined using CCCV. The paper also discusses the use of IoT to automatically store the battery, temperature, and voltage data on the website of Thing Speak. The authors emphasize the importance of thorough investigation of batteries to quickly address any problems that may arise. Overall, the paper provides a

comprehensive overview of the development of a BMS for electric vehicles and highlights the importance of battery monitoring for the safety and performance of electric vehicles. The authors emphasize the importance of thorough investigation of batteries to quickly address any problems that may arise. Overall, the paper provides a comprehensive overview of the development of a BMS for electric vehicles and highlights the importance of battery monitoring for the safety and performance of electric vehicles.

Raj Patel et al. in [2] provides an overview of Battery Management System (BMS) technologies used in Electric Vehicles (EV) and Energy Storage Systems. The paper discusses the importance of BMS in controlling and monitoring, charging and discharging of batteries and maintaining reliability and safety. The key components of BMS, including feedback and control systems, cell voltage feedback, temperature feedback, and power misfits are explained. The paper also covers State of Charge (SOC), State of Health (SOH), Thermal management, and Battery SOC modelling. Overall, the paper provides a comprehensive understanding of BMS technologies and their importance in EV and Energy Storage Systems. A battery management system consists of: (1) a battery-level monitoring system (2) an optimal charging algorithm and (3) a cell/thermal balancing circuitry. The voltage, current and temperature measurements are used to estimate all crucial states and parameters of the battery system, such as the battery impedance and capacity, state of health, state of charge, and the remaining useful life.

Muhammand Nizam et al. in [3] provide an overview of the design of a Battery Management System (BMS) for Lithium-Ion batteries. It discusses the importance of BMS in prolonging the lifespan of Lithium-Ion batteries and ensuring their safe operation. The paper reviews the basics, progress, and challenges of Lithium-Ion batteries, and their use in electric vehicles. It also provides an overview of the application of BMS in smart grids and electric vehicles. The paper discusses the classification and overview of commercial Lithium-Ion battery charging strategies, including constant current charging, constant voltage charging, and pulse charging. It also explores the use of Battery-based neural and particle networks for predicting the useful life of Lithium-Ion batteries. Overall, this paper provides valuable insights into the design of battery management systems for Lithium-Ion batteries and the challenges and opportunities associated with their use in electric vehicle system and smart grids.

Harish. N et al. in [4] is titled "IOT Based Battery Management System" and was published in the International Journal of Applied Engineering Research in 2018. The paper discusses the use of Internet of Things (IoT) technology to monitor and manage the performance of vehicular batteries, with a focus on lead-acid batteries. The authors propose a system that uses sensors to monitor important battery parameters such as voltage and temperature, and sends this data to the cloud for analysis. The system also includes a control unit that can take actions such as disconnecting the battery from the vehicle in case of overcharging or overheating. The authors conclude that their system can help improve the performance and lifespan of vehicular batteries, and can be extended to other types of batteries as well.

S. Prabakaran et al. in [5] discuss the importance of monitoring the battery's state in electric vehicles and how battery monitoring system based on IoT can help ensure efficient and reliable use of EVs. The proposed system consists of various modules, including a power supply, ATMEGA328P microcontroller, battery, voltage sensor, temperature sensor, smoke sensor, NodeMCU, relay, DC motor, LCD, and buzzer. The system tracks the health of the battery by monitoring various parameters such as voltage, temperature, and smoke levels. The data is transmitted to a cloud-based server using the NodeMCU module, where it is analyzed and used to generate alerts and notifications for the user. The paper also discusses the benefits of using an IoT-based battery monitoring system for electric vehicles, including improved battery life, reduced maintenance costs, and increased safety. The system can help prevent battery failures and extend the life of the battery by providing real-time data on its health and performance. The cloud-based server can also be used to generate reports and analytics, which can be used for the improvement of overall efficiency of the electric vehicle and optimizes the performance of the battery. The paper includes references to various studies and research papers on battery management systems and IoT technology, including a study by Hu et al. on the use of IoT-based systems for management of battery in electric vehicles.

III. METHODOLOGY

III.1 BLOCK DIAGRAM

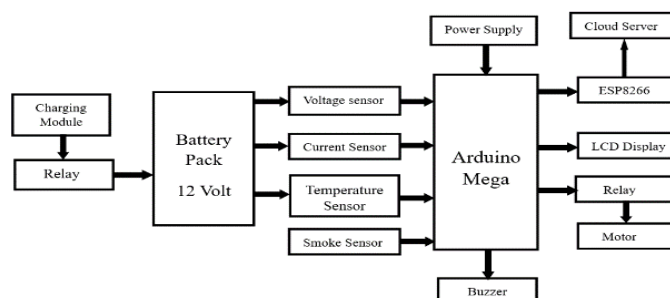


Fig. 1 Block diagram of IoT based battery management system.

- Battery Pack Design:**
 Design 12V Battery pack Using Lithium-ion cell. a lithium-ion cell voltage is typically 3.7V (usage voltage varying from 3.1V to 4.1V) and cell Capacity is 3.4 Ah (cylindrical). There two Battery packs formation 1) nPmS battery pack 2) mSnP battery pack. So we select nPmS battery pack because npms is Cell balancing is easy, so no balancing issue in this technique. Auto-balancing occurs between cells in a module all the time. npms connection also good for EVs battery.
- Circuit Design:**
 Connect voltage sensors to measure the voltage of each battery cell. Connect a current sensor to measure the total charging and discharging current. Use relays to control charging and discharging circuits. Add temperature sensors for monitoring the battery temperature. Include necessary resistors, capacitors, and diodes for protection and filtering.
- Arduino Programming:**
 Write Arduino code to read voltage, current, and temperature values from sensors. Implement algorithms to calculate individual cell voltages, total pack voltage, state of charge (SoC), state of health (SoH), and temperature. Set up thresholds for overcharging, over-discharging, overcurrent, and high-temperature protection. Implement a communication protocol to send data to the IoT platform.
- IoT Integration:**
 Set up an account on your chosen IoT platform and create a new project. Configure the IoT module (ESP8266, ESP32) to connect to your Wi-Fi network and the IoT platform. Send sensor data (voltage, current, temperature) to the IoT platform using the chosen communication protocol. Implement a secure method for receiving commands from the IoT platform to control charging and discharging processes.
- User Interface and Remote Monitoring:**
 Create a web interface or mobile app using the IoT platform's tools to remotely monitor the battery status. Implement user interaction for setting custom parameters or receiving notifications/alerts.
- Safety Features:**
 Implement safety features like overvoltage, undervoltage, overcurrent, and high-temperature protection. Include fail-safes to prevent unintended discharging or charging of the battery pack.
- Documentation:**
 Document your circuit diagram, components used, and the code. Provide instructions for assembling the circuit, uploading the code to the Arduino board, and configuring the IoT platform.
- Deployment and Monitoring:**
 Integrate the BMS into your 4-cell battery system. Deploy the system and monitor its performance remotely through the IoT platform.

IV. EXPERIMENTAL RESULTS

Figures shows the results of Iot based battery management system Figs. 2 (a) shows the all voltages, total voltage and current. (b) shows discharge rate, temperature, battery percentages, gas detected and SOC.

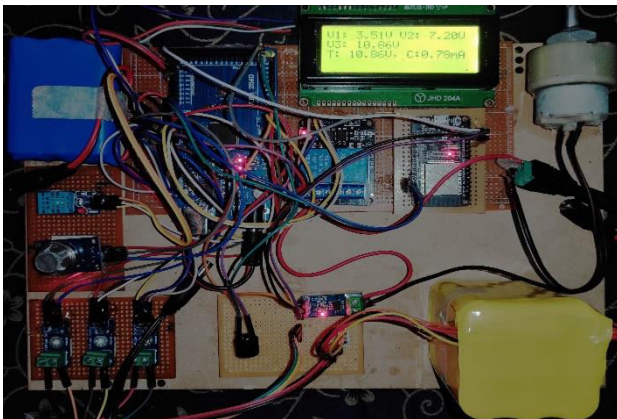


Fig. 2(a)

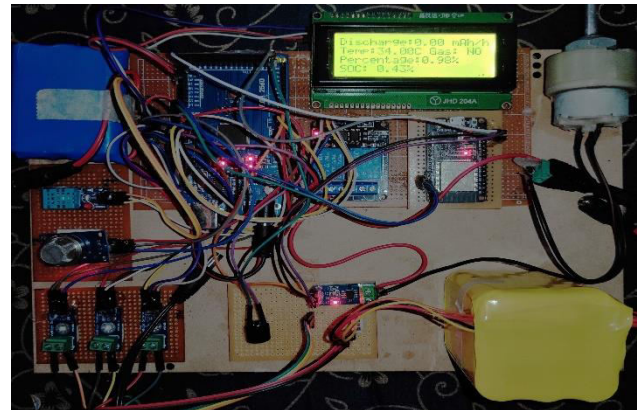


Fig. 2(b)

Figures shows the results of Iot based battery management system Figs. 2 (a) shows the all voltages, total voltage and current. (b) shows discharge rate, temperature, battery percentage, gas detected and SOC.

Figures shows the results of Iot based battery management system Figs. 3 shows the Thingspeak server data graphs.

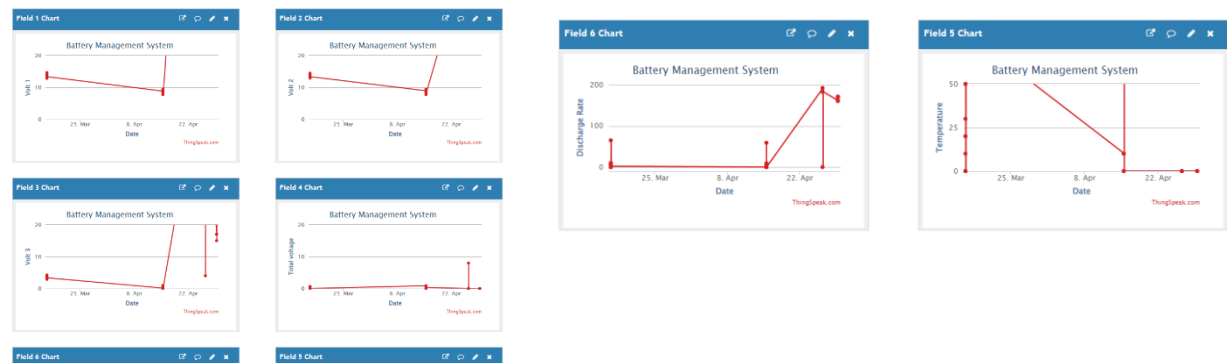


Fig. 3 Thingspeak server data

V. CONCLUSION

In conclusion, this paper comprehensively discusses IoT-based battery management system(BMS) technologies. The development of an embedded battery monitoring system for electric vehicles was covered in this project. This will enable online monitoring of battery performance degradation. It represents the battery's current capacity relative to its rated capacity. SOC helps manage voltage, current, temperature, and other battery-related data. Accurate SOC calculation prevents overcharging, over-discharging and Overcurrent, which can damage batteries.



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