International Journal for Research Publication and Seminar

ISSN: 2278-6848 | Vol. 16 | Issue 1 | Jan-Mar 2025 | Peer Reviewed & Refereed Refereed

Special Edition : SPARK 2025 : XXI National Conference on Emerging Technology Trends in Engineering & Project Competition

Optimize Battery Management System For EV

Palash Kuhikar[1], Harsh Kamilkar[2], Pranay Kawale, Vanshita Daduria[4],

1,2,3,4, Student, Department of Electrical Engineering, K.D.K.C.E, Nagpur, India

palashpkuhikar.ee22d@kdkce.edu.in[1], Harshdkamilkar.ee22d@kdkce.edu.in[2], pranayjkawale.ee21f@kdkce.edu.in[3], vanshitasdaduria.ee21f@kdkce.edu.in[4],

+91 8975725902[1], +91 97673 17460[2], +91 97675 55536[3], +91 83809 04839[4]

Abstract

Nowadays Battery Management Systems, commonly known as BMS, are essential for the safe, efficient, and dependable functioning of contemporary devices that run on batteries and electric vehicles. A BMS primarily oversees and regulates important factors related to the battery pack, such as voltage, current levels, temperature, and the state of charge (SOC), which helps in maximizing battery efficiency and longevity. This document investigates the fundamental elements and structure of BMS, placing emphasis on their importance in energy management, safety measures, and preventive maintenance. It also brings to light different types of BMS setups, such as centralized, decentralized, and distributed systems, each offering distinctive benefits and obstacles. Moreover, the paper reviews progress in communication methods, the detection of faults, and techniques for estimating the state of the battery. Finally, the study wraps up with a look at upcoming trends in BMS evolution, especially concerning the incorporation of machine learning and artificial intelligence to improve system performance, as well as the difficulties encountered in the extensive use and management of batteries in electric transportation.

Keywords – Battery Management System (BMS), State of Charge (SOC), Electric vehicles (EV), Temperature monitoring, Battery health monitoring, Arduino Nano, Exhaust Fan.

Introduction

Battery Management Systems (BMS) are a crucial part of ensuring that rechargeable batteries in devices like electric vehicles, renewable energy storage, and portable electronics work safely and efficiently. These systems monitor important factors such as charge levels, temperature, voltage, and overall battery health. By keeping these factors in check, a BMS helps prevent problems like overcharging, deep discharge, and overheating, which could damage the battery or even cause it to fail completely. Besides keeping things safe, a BMS also helps improve the overall efficiency and lifespan of batteries, making it essential in a world that's increasingly dependent on battery technology.

As technology continues to move at a fast pace, ensuring that batteries last longer and perform better has become more important than ever. Batteries face various issues, such as overcharging, overheating, excessive discharge, and high current flow, all of which can reduce their performance and shorten their life. To solve these problems, we need a system that can automatically manage these conditions, boosting both battery efficiency and lifespan. That’s where a Battery Management System (BMS) comes in. It provides real-time monitoring and protection to ensure batteries are used in the most effective way possible.

When we observe the existing BMS options, we realized that many of them are both expensive and tough to maintain. That’s why we’ve set out to develop a more affordable, compact BMS that doesn’t compromise on performance or reliability. By using an Arduino-based design, we’re aiming to create a solution that's not only cost-effective but also simple to use while maximizing the BMS's capabilities. This approach allows us to deliver a high-quality system that balances both price and performance, meeting the needs of those looking for a functional yet budget-friendly option.

Methodology

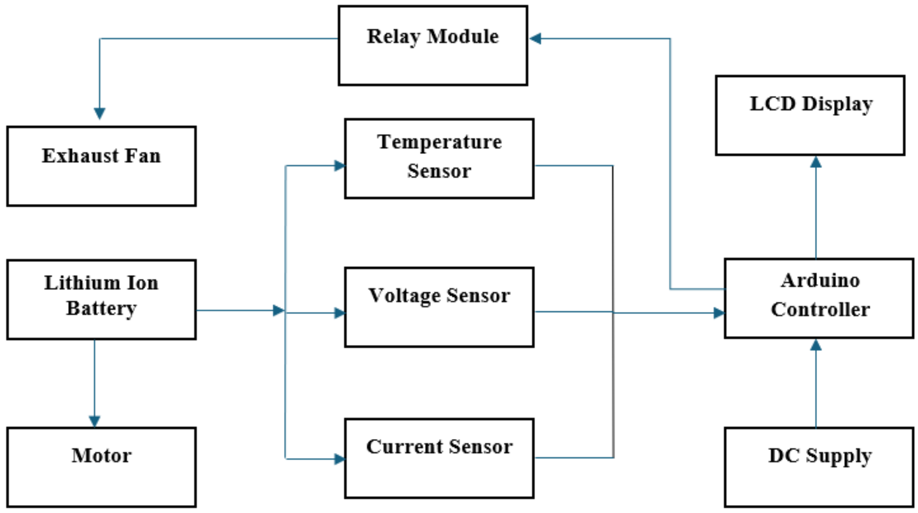

Fig. 1: Block Diagram of Battery Management System

The development and implementation of a Battery Management System (BMS) are essential for ensuring the safe, efficient, and reliable performance of lithium-ion batteries, which are commonly used in a wide range of applications. This section outlines the approach used to design a BMS by integrating components such as an Arduino Nano, temperature and voltage sensors, an LCD display, a relay module, motor load, exhaust fan, and a lithium-ion battery. The goal is to create a cost-effective, user-friendly, and robust system that can effectively monitor and manage the battery's key parameters, preventing failures and optimizing its performance.

A. System Overview and Design Philosophy

The proposed BMS is based on a feedback control system that continuously monitors vital parameters, including the voltage and temperature of the lithium-ion battery. One of the main challenges in developing this system is the integration of various components to create an automated process that can manage the battery's behaviour autonomously under different operating conditions. The system is designed with the following objectives in mind:

- Real-time monitoring of the battery's temperature, voltage, and current.
- Displaying key system information on a 20x4 LCD interface.
- Controlling auxiliary systems such as the motor load and exhaust fan based on the monitored conditions.
- The primary goal is to ensure the health of the battery, extend its lifespan, and protect it from thermal or electrical failures.

B. System Components and Their Roles

The BMS relies on several key components, each playing a crucial role in the system's overall operation:

- **Arduino Nano**: This microcontroller is the heart of the system. It processes data from the sensors and runs control algorithms to manage the battery and auxiliary systems. It reads inputs from the temperature and voltage sensors and triggers actions like activating the relay module to control other components.

Fig 2: Arduino Nano

- **Temperature Sensor**: This sensor measures the temperature of the battery in real-time. Since lithium-ion batteries are sensitive to temperature changes, excessive heat can lead to reduced battery capacity or even safety hazards. If the temperature exceeds a predetermined threshold, the system activates safety mechanisms to cool the battery down.

Fig 3: Temperature Sensor

- **Voltage Sensor**: The voltage sensor monitors the charge level of the battery, providing real-time data on its voltage. This helps the system detect when the battery is overcharged or undercharged, influencing decisions about load connection and charging cycles.

Fig 4: Voltage Sensor

- **Current Sensor**: The Current Sensor is used to monitor the current supplied from the battery to the load. We are using the ACS712 Current Sensor Module which has the capacity of max 30Amp can handle the incoming current from the input source.

Fig 5: Current Sensor

- **LCD Display**: The LCD 20x4 acts as the user interface, offering real-time feedback about the battery's voltage, current, temperature, and system status. It shows essential data, making it easy for the user to assess the battery's condition and act if necessary.

International Journal for Research Publication and Seminar

ISSN: 2278-6848 | Vol. 16 | Issue 1 | Jan-Mar 2025 | Peer Reviewed & Refereed Refereed

Special Edition : SPARK 2025 : XXI National Conference on Emerging Technology Trends in Engineering & Project Competition

Fig 6: LCD Display 20X4

- **Relay Module**: The relay module controls high-power devices connected to the system, such as the motor and the exhaust fan. The relay is triggered based on the system's conditions to ensure the safe operation of the battery and its connected components.

Fig 7: Relay Module

- **Motor (Load)**: The motor simulates an electrical load that is applied to the battery. It helps test the system's ability to manage power distribution and monitors how the battery performs when under load. This ensures that the battery's capacity isn't compromised by excessive power demand.
- **Exhaust Fan**: When the battery's temperature exceeds safe limits. Overheating can lead to internal damage, reduced battery life, or even fire risks. The exhaust fan helps maintain the battery's temperature at safe levels by dissipating heat, thus ensuring safe operation.

Fig 8: Exhaust Fan

C. System Operation and Control Logic

The operation of the BMS can be broken down into several key stages, with the system continuously monitoring the battery and making real-time decisions to keep it functioning optimally. The Arduino Nano constantly reads data from the voltage and temperature sensors. The temperature sensor keeps track of the battery's current temperature, while the voltage sensor provides real-time voltage levels.

D. Decision-Making and Control Algorithm:

- **Voltage Management**: The voltage data collected by the sensor is compared to predefined safe thresholds. If the battery's voltage drops too low (indicating it's nearly depleted), the system triggers a warning or disconnects the load to prevent deep discharge. On the other hand, if the voltage exceeds safe levels, the load is disconnected to avoid overcharging.

International Journal for Research Publication and Seminar
ISSN: 2278-6848 | Vol. 16 | Issue 1 | Jan-Mar 2025 | Peer Reviewed & Refereed Refereed
Special Edition : SPARK 2025 : XXI National Conference on Emerging Technology Trends in Engineering & Project Competition

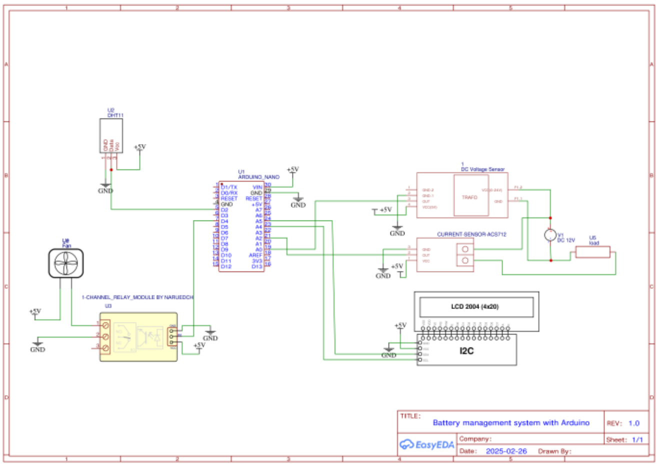

Fig. 9: Circuit diagram of Battery management system

- **Temperature Control**: We have added the temperature sensor to monitor the battery temperature when it will increased the threshold limit then Arduino trigger the relay circuit to turn on the exhaust fan to cool down the batteries.
- **Motor Control (Load Management)**: The system manages the motor (acting as the load). When the battery's voltage is within an acceptable range, the motor can operate. However, if the voltage drops below a critical level, the system cuts off the motor to prevent excessive drain on the battery.

E. Safety Mechanisms: The system includes several safety features to protect the battery from both electrical and thermal damage:

- **Over-Temperature Protection**: If the battery's temperature exceeds safe levels, the exhaust fan is triggered to help cool the battery, ensuring it stays within operational temperature limits.
- **Under-Voltage and Over-Voltage Protection**: The system prevents both deep discharge and overcharging by disconnecting the load when necessary. This protects the battery from potential damage and helps extend its life.

F. User Interface: The system's real-time data—such as the battery's voltage, temperature, and overall status—is displayed on an LCD screen. This allows the user to monitor the battery's health and take action if needed. If any abnormalities (like excessive temperature or low voltage) are detected, the display alerts the user to the issue.

G. . Power Management and Efficiency

Power management is a key part of the BMS, ensuring that the battery operates within its safe charging and discharging limits. The system makes sure that:

- The battery doesn't drain too quickly by controlling the motor load.
- The charging process is carefully regulated to avoid overcharging, which could lead to overheating and shorten the battery's lifespan.
- The battery is protected from deep discharge conditions, which could cause permanent loss of capacity.

This combination of monitoring, control, and safety mechanisms ensures that the battery is used efficiently while also extending its life and reliability.

Hardware Setup

Conclusion

The research presents a Battery Management System (BMS) that effectively monitors and Manage lithium-ion battery performance. Utilizing temperature and voltage sensors alongside an Arduino Nano microcontroller, it incorporates safety features such as a relay-operated motor and exhaust fan. The system provides real-time monitoring to enhance battery efficiency and longevity, making it a cost-effective and scalable solution for small to medium applications requiring BMS capabilities.

Reference

[1] T. N. Seelam V. S. V. Prabhu Deva Kumar Krishna, Sunkara Srinivasa Rao and Liuchen Chang, “Powering the Future: Advanced Battery Management Systems (BMS) for Electric Vehicles”, https://www.researchgate.net/publication, July 2024.

[2] Rupesh Somase, Vaibhav Wavare Guided by Harshal Shelar Sir, “ Smart Battery Protection System for Electric Vehicles”, Department of Electrical and Electronics, school of Engineering and Technology, Sandip University, Nashik, Maharashtra, India, pp: 748-752, Volume 5, Issue 5 May 2023.

[3] V Karkuzhali, P Rangarajan, V Tamilselvi and P Kavitha , “Analysis of battery management system issues in electric vehicles”, IOP Conference Series: Materials Science and Engineering, Volume 994, International Conference on Recent Developments in Robotics, Embedded and Internet of Things (ICRDREIOT2020) 16- 17 October 2020, Tamil Nadu, India.

[4] Payal Kadu, Tejal Jejurkar, Harshal Patil, Harshvardhan Deshmukh, Monal Gadakh, “Arduino-Based Battery Monitoring System with State of Charge And Remaining Useful Time Estimation”, International Research Journal Of Modernization In Engineering Technology And Science, Volume-04, Issue-05, May-2022

[5] Samyak Nagrale, Ankit Waghmare, Tanmay Sahare, Achal Nagwanshi , Ishika Sakhale and Dr. Jyoti Sathe, “Literature Survey On Ev Battery Management System” vol 9, issue 2. IJARIIE, SSN(O)-2395-4396, 2427-2430, 2023

[6] Abhishek Prakash, Unnati K More, Sarita Kushwaha, Aviraj B Gholap, Prof Kishore Muley, “EV Battery Protection System”, International Research Journal of Engineering and Technology (IRJET), Department of Electrical Engineering Sandip University, Nashik, India, Volume: 09 Issue: 06, June 2022.

[7] Shivanand Basgonda Patil, Akshay Sanjay Kamme, Aniket Sunil Patil, Vaibhav Ravso Patil, Apurva A Londhe, “Design of Battery Health Monitoring System Using Arduino Uno” International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), 1539-1550 Volume 9, Issue 6, June 2020.

[8] Pham, V.L.; Nguyen, T.T.; Tran, D.H.; Vu, V.B.; Choi, W. Anew cell-to-cell fast balancing circuit for Lithium-ion batteries in Electric Vehicle and Energy Storage System. In Proceedings of the 2016 IEEE 8th International Power Electronics and Motion ControlConference (IPEMC-ECCE Asia), Hefei, China, 22–26 May 2016; pp. 2461–2465.

[9] Park, S.H.; Park, K.B.; Kim, H.S.; Moon, G.W.; Youn, M.J. Single-Magnetic Cell-to-Cell Charge Equalization Converter with Reduced Number of Transformer Windings. IEEE Trans. Power Electron. 2012,27, 2900–2911.

[10] Sagar Sutar, Ramkrushna Shinde, Dhanashree Patil, Sayali Jamdade, Rutuja Chougule, Prof. Sanjay Dhaygude, Rohan Doshi, “BATTERY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLE” International Research Journal of Modernization in Engineering Technology and Science Department of Electronics Engineering, Walchand Collage of Engineering, Sangli, Maharashtra, India, Volume:05/Issue:04/April-2023.

[11] A. Hariprasad, Priyanka, R. Sandeep, V. Ravi, O. Shekar, “Battery Management System in Electric Vehicles”, International Journal of Engineering Research & Technology (IJERT), Department of Electrical and Electronics Engineering, Vignan Institute of Technology and science, Telangana, Vol. 9 Issue 05, May-2020.