

INTELLIGENT BATTERY THERMAL MANAGEMENT SYSTEM FOR SMART ELECTRIC VEHICLES

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Abstract: Technology is an ever-evolving process. Designing systems using advanced technology that improve energy efficiency and safety in electric vehicles is a valuable contribution to society. This paper presents the design and implementation of an intelligent, low-cost, and efficient battery thermal management system (BTMS) for smart electric vehicles. The system is built using a microcontroller-based control unit, with temperature sensors and cooling mechanisms connected through control circuits.

Communication between sensors and the controller is carried out in real-time to monitor battery temperature continuously. The system is designed to be cost-effective and scalable, allowing integration with various electric vehicle battery packs. To ensure safety, automated control strategies are implemented to prevent overheating and maintain optimal battery performance.

Keywords: Battery Thermal Management; Electric Vehicles; ESP32; Sensors; Cooling System

I. INTRODUCTION

A battery thermal management system (BTMS) involves the use of control systems and sensors to regulate the temperature of batteries in electric vehicles. The rapid advancement of electric vehicle technology has increased the need for efficient temperature control to ensure safety, performance, and long battery life.

Thermal management systems reduce overheating risks, improve efficiency, and enhance battery lifespan. Initially, cooling methods were simple and passive; however, modern systems are designed to actively monitor and control temperature using intelligent techniques.

An efficient BTMS can maintain battery temperature within a safe operating range, preventing thermal runaway and performance degradation. Research shows that maintaining optimal battery temperature significantly improves efficiency and reliability.

The proposed system is designed using an Arduino-based controller, temperature sensors, cooling devices such as fans or thermoelectric modules, and a monitoring system. Sensors continuously measure battery temperature, and the controller processes the data to activate cooling mechanisms when required.

II. SYSTEM DESIGN

The main components used in this project are:

- Arduino Uno
- Temperature Sensors (e.g., LM35 / DS18B20)
- Cooling Fan / Thermoelectric Cooler (TEC)
- Relay Module
- Heat Sink
- Battery Pack
- Power Supply (12V Adapter)
- LCD Display
- Buzzer (for alert system)

III. WORKING

The intelligent battery thermal management system operates in three modes: automatic mode, manual mode, and alert mode.

The Arduino Uno serves as the central processing unit, managing all operations. Temperature sensors continuously send real-time data to the controller. When the temperature exceeds a predefined threshold, the Arduino activates the cooling system through the relay module.

Cooling devices such as fans or thermoelectric modules reduce the battery temperature effectively. Once the temperature returns to a safe range, the system automatically turns off the cooling mechanism.

The LCD display shows real-time battery temperature and system status. In alert mode, if the temperature crosses critical levels, a buzzer is activated to notify the user.

IV. RESULT

The intelligent battery thermal management system was successfully designed and tested. The system effectively maintained the battery temperature within a safe operating range.

The temperature sensors provided accurate readings, and the cooling system responded quickly to temperature changes. The relay-controlled cooling mechanism ensured efficient heat dissipation.

The LCD display showed real-time updates without delay, and the alert system worked reliably during high-temperature conditions. Overall, the system demonstrated stable performance, quick response, and improved battery safety.

V. CONCLUSION

The intelligent battery thermal management system for smart electric vehicles was successfully developed and implemented. The integration of temperature monitoring, automatic cooling, and alert mechanisms ensures safety and efficiency.

The system effectively prevents overheating, enhances battery life, and improves overall vehicle performance. This project can be further enhanced by integrating IoT-based monitoring and AI-based predictive thermal control for advanced applications.

ACKNOWLEDGMENT

I express our sincere gratitude to the management and faculty of Andhra Loyola Institute of Engineering and Technology, Vijayawada, for providing the necessary facilities to complete this project.

We are especially thankful to our project guide, Ms, for his valuable guidance, support, and encouragement throughout the project.

We also extend our thanks to our friends for their support.

REFERENCES

- [1]. B. A. Farhan et al., "Design and Implementation of a Training Educational Board for Electromagnetic Control Experiments," ACA Conference, 2023.
- [2]. D. Kataria et al., "Fundamentals of Automation Engineering," Int. Journal of Electrical Engineering Education, 2020.
- [3]. J. Lee et al., "Energy-Efficient Thermal Management in EV Batteries," IEEE Sensors Journal, 2019.
- [4]. S. Rajput et al., "Data Security in IoT-Based EV Systems," IEEE Communications Magazine, 2020.
- A. Sharma et al., "Interoperability Issues in EV Systems," IEEE IoT Journal, 2021.
- [5]. S. Gupta et al., "Scalability of EV Battery Systems," IEEE Transactions on Industrial Informatics, 2020.
- [6]. R. Patel et al., "Smart Battery Management Using IoT," IEEE Transactions, 2022.