

BATTERY THERMAL MANAGEMENT SYSTEM FOR ELECTRIC VEHICLE

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Acharya Institute of Technology 2023-2024

ABSTRACT

This project investigates advanced battery thermal management systems (BTMS) for electric vehicles, focusing on three cooling methodologies: liquid cooling, air cooling, and Peltier modules. Effective thermal management is critical for optimizing battery performance, lifespan, and safety. The study explores the efficiency and practicality of each cooling technique under various operational conditions. Additionally, the project integrates wireless charging technology, providing a comprehensive approach to enhance electric vehicle (EV) sustainability and convenience. Our findings demonstrate significant improvements in thermal regulation and charging efficiency, contributing to the development of more reliable and efficient EVs.

Keywords: Battery Thermal Management System, Electric Vehicles, Liquid Cooling, Air Cooling, Peltier Modules, Wireless Charging, Thermal Regulation, Charging Efficiency.

I. INTRODUCTION

This project aims to design and develop a comprehensive BMS specifically tailored for electric remote-control vehicles, integrating cutting-edge technologies and innovative features to optimize battery performance and prolong lifespan. The proposed BTMS will incorporate multiple cooling systems, including liquid cooling, air cooling, and Peltier module cooling, to regulate battery temperature and prevent thermal runaway, thereby ensuring safe and efficient operation in various environmental conditions.

The core components of the proposed BTMS include an STM32 microcontroller, TFT display, 4s Battery Management System (BMS), wireless charging coil, temperature sensors, relay modules, and various cooling components such as circular copper pipes, RGB fans, and Peltier modules. By leveraging the capabilities of these components and integrating them into a cohesive system architecture, the BMS will provide real-time monitoring and control of battery parameters, wireless charging functionality, and advanced cooling mechanisms. One of the key challenges in the design and development of the BMS is the integration of multiple subsystems while ensuring compatibility, reliability, and efficiency. The STM32 microcontroller serves as

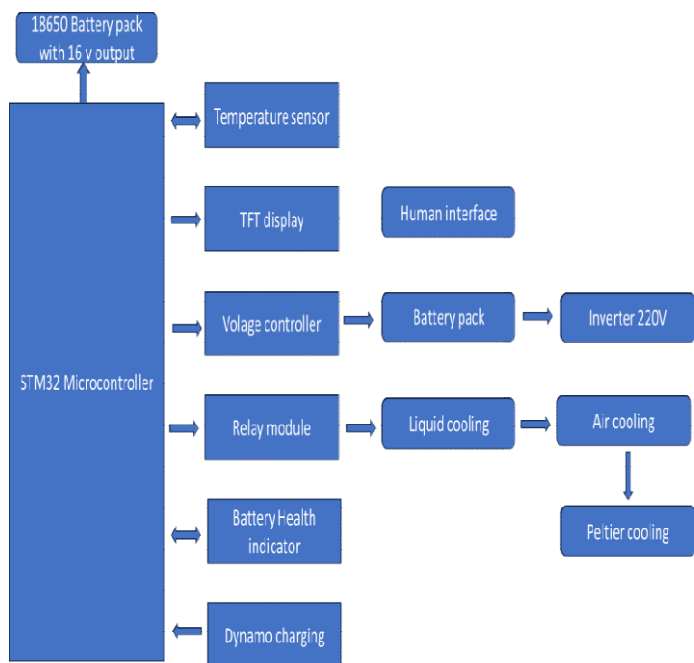
the central processing unit, responsible for data acquisition, processing, and control tasks. The TFT display provides a user-friendly interface for monitoring battery status, charging progress, and temperature conditions, facilitating intuitive interaction with the system.

The 4s BMS module plays a critical role in managing the series-connected battery cells, balancing cell voltages, and protecting against overcharging and over discharging events. Additionally, the wireless charging coil enables convenient and cable-free charging of the battery pack, enhancing the user experience and expanding the deployment scenarios of electric remote-control vehicles. To address the thermal management challenges inherent in high-power battery systems, the proposed BMS incorporates multiple cooling systems tailored to different operating conditions and environmental factors. The liquid cooling system utilizes a circular copper pipe to efficiently dissipate heat from the battery pack, while the air cooling system employs an RGB fan to enhance airflow and thermal dissipation. Furthermore, the Peltier module cooling system offers precise temperature control capabilities, enabling adaptive cooling strategies based on real-time feedback from temperature sensors.

II. OBJECTIVES

The project objective of the Battery Thermal Management System (BTMS) is to design, develop, and evaluate an efficient and reliable system for maintaining optimal operating temperatures of electric vehicle (EV) batteries. The BTMS aims to ensure safety by preventing thermal events and extending battery lifespan and also implement an additional feature to extract the heat generated by the batteries to charge an auxiliary battery used in EV.

1. Design and Development of an advanced BMS
2. Integration of Cooling Systems
3. Wireless Charging Implementation
4. User Interface Enhancement
5. Reliability and Safety Assurance



III. BLOCK DIAGRAM

Fig 1 :- Block diagram

The core components of the proposed BMS include an STM32 microcontroller, TFT display, 4s Battery Thermal Management System (BTMS), wireless charging coil, temperature sensors, relay modules, and various cooling components such as circular copper pipes, RGB fans, and Peltier modules. By leveraging the capabilities of these components and integrating them into a cohesive system architecture, the BMS will provide real-time monitoring and control of battery parameters, wireless charging functionality, and advanced cooling mechanisms. The design and development of an advanced Battery Management System for electric remote-control vehicles represent a multidisciplinary effort combining principles of electrical engineering, embedded systems, thermal management, and control theory. By leveraging state-of-the-art technologies and innovative design approaches, the proposed BMS aims to enhance the performance, efficiency, and reliability of electric remote-control vehicles, paving the way for their widespread adoption in various industrial and recreational applications.

IV. METHODOLOGY

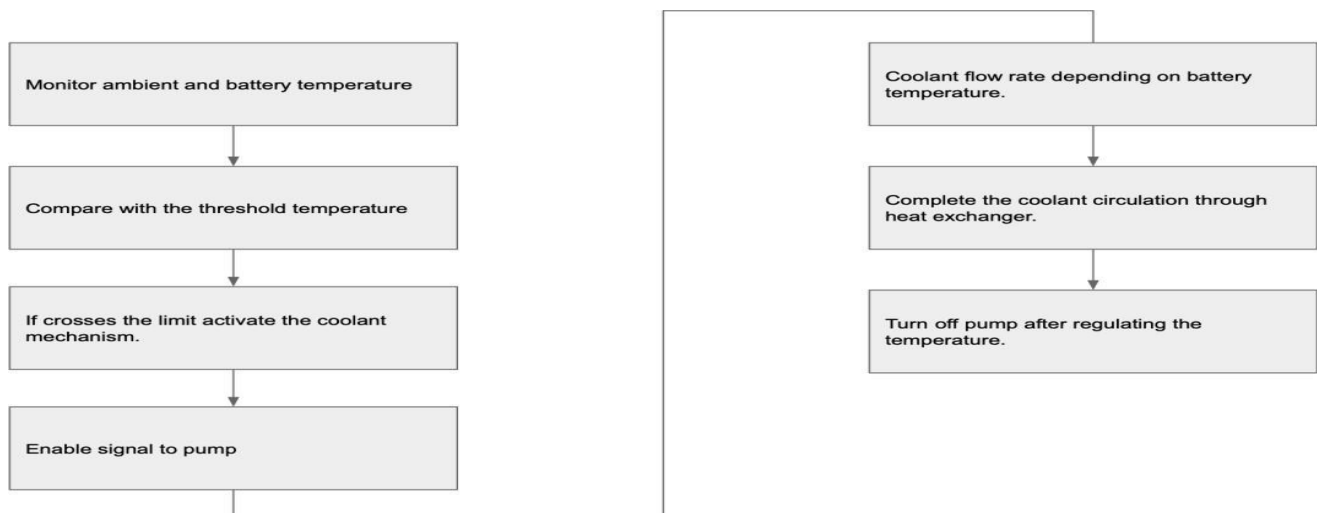


Fig 2 :- Basic Methodology

METHODOLOGY

The Methodology shown in fig which we are going to follow in this project to control the temperature of the Electric Vehicle batteries is Liquid Cooling System, this can be achieved by the following methodology.

In the Liquid Cooling System of Electric Vehicle batteries, the measurement of, batteries and ambient temperature is important, this can be done by using few thermistor or temperature sensors around the batteries and it is compared with the threshold temperature set in the program, if the measured temperature crosses the limit, the coolant mechanism is activated and the liquid pump is turned on. The rate of circulation of liquid depends on the measured temperature. Once the temperature is brought back to its nominal value, the Liquid pump is turned off. Battery management system (bms) design and development (prototype for electric remote-control vehicle) We will do study into existing methods and technology throughout this. The attention Then shifts to what can be designed and executed to enhance BMS operation & attempt to develop a system for enhanced performance and precision. Evaluation of the prototype will there after be conducted.

Wireless charging

Developing wireless charging method for battery charging In this phase, we will learn and comprehend the capacity, type, and characteristics of battery packets. On the basis of this, wireless technology, select what must be implemented in the system, and then test it.

HARDWARE IMPLEMENTATION

Components Used

- STM32 MICROCONTROLLER
- SENSORS
- BUCK AND BOOST CONVERTER
- BATTERY
- COOLING SYSTEM
- RELAY
- CAPACITOR
- WIRELESS CHARGING

SOFTWARE IMPLEMENTATION

MATLAB AND SIMULINK

Simulink is a graphical extension to MATLAB for modeling and simulation of systems. In a MATLAB simulation block designed for battery cooling control, several key parameters and processes are modeled to ensure efficient battery temperature management system.

this simulation, the pack cooling load (i.e., the amount of heat generated by the battery) is an essential factor impacting the overall thermal behavior. By modeling these interactions, the MATLAB.

Simulation can provide insights into optimal cooling strategies and help assess thermal management system designs. This block likely encapsulates a system of differential equations that consider heat transfer, coolant flow, and temperature gradients within the battery pack. The goal is to optimize battery performance and safety by controlling temperatures effectively under various operating conditions, aiding in the design and evaluation of battery thermal management strategies.

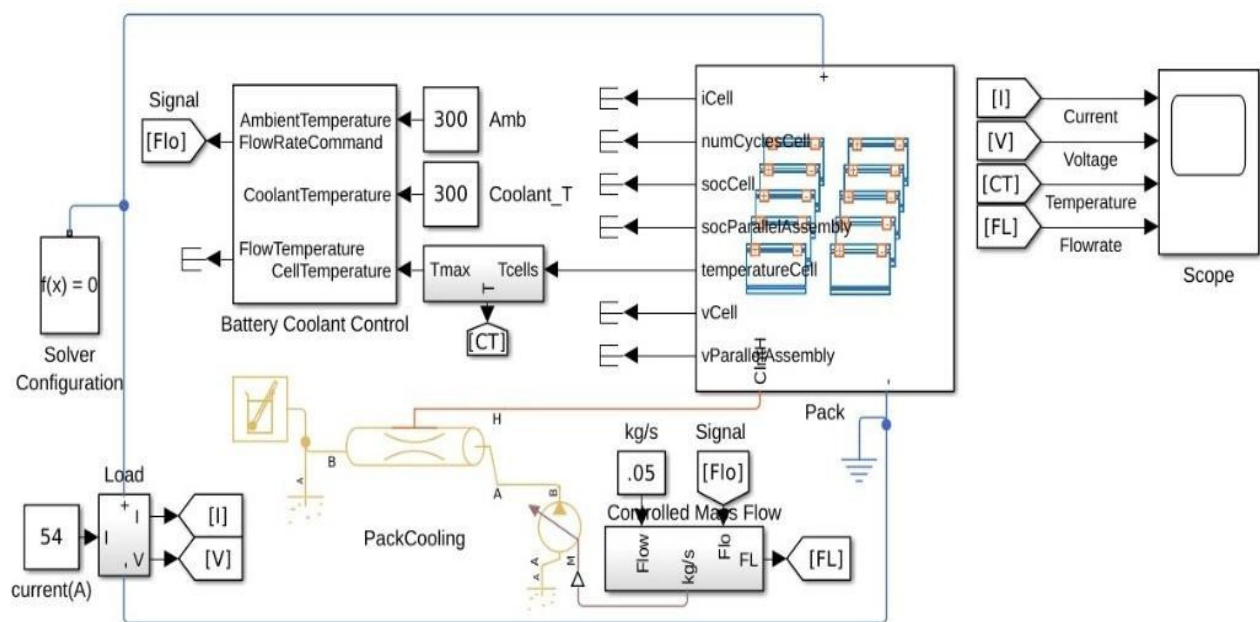


Fig 4 :- Simulation Circuit

The simulation incorporates ambient temperature and flow rate as inputs, crucial for calculating the coolant's inlet temperature and subsequently its impact on the cell temperature within the battery pack.

The coolant flow rate influences how effectively heat is dissipated from the battery cells. The simulation likely includes thermal dynamics equations to predict cell temperature based on cooling effectiveness and load conditions. Within

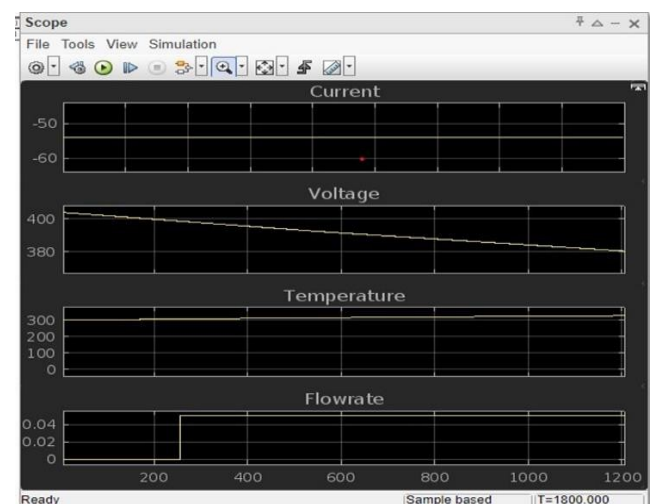


Fig 5:- Simulation Result

V. PROTOTYPE MODEL

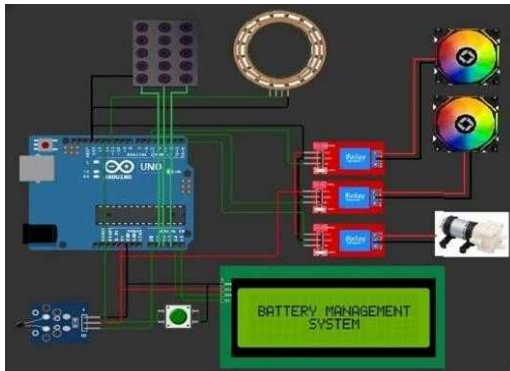
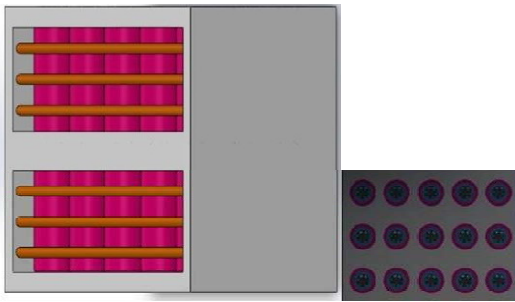


Fig 5 :- Working model

VI. Applications

1. Aerospace and Defense :- Mission Critical Systems, Performance Optimization.
2. Marine Applications :- Electric Propulsion Systems, Safety
3. Inverter

VII ADVANTAGES, DISADVANTAGES & LIMITATION

Advantages:-

1. Improved Battery Performance
2. Extended Battery Lifespan
3. Fast Charging Capability
4. Energy Efficiency
5. Safety Considerations

Disadvantages:-

1. Cost
2. Space
3. Maintenance

Limitation:-

1. Complexity
2. Weight and Space Constraints
3. Dependence on Ambient Conditions
4. Technological Advancements

CONCLUSION

In conclusion, our project represents a significant step forward in the development of electric vehicles and renewable energy technology. By integrating advanced battery management, wireless charging, and cooling systems into an electric remote-control vehicle prototype, we have demonstrated the feasibility and potential of these technologies to improve performance, efficiency, and sustainability in the transportation sector. While challenges and limitations remain, the opportunities for further research, innovation, and collaboration are vast, offering promising prospects for a cleaner, greener, and more sustainable future.

VII. Future scope

1. **Smart Grid Integration:** Integration of electric vehicles with smart grid technologies for bidirectional energy flow, vehicle-to-grid (V2G) capabilities, and demand-side management to optimize energy use, reduce grid congestion, and support renewable energy integration.
2. **Materials and Manufacturing:** Research into novel materials and manufacturing techniques for batteries, cooling systems, and other EV components to improve performance, reliability, and sustainability while reducing environmental impact and resource consumption.

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