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ELECTRIC VEHICLE BATTERY MANAGEMENT SYSTEM WITH CHARGE MONITERING AND FIRE PROTECTION

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Abstract: The EV Battery Management System using Arduino Uno is designed to monitor and protect battery performance. It tracks voltage, current, and temperature to prevent overcharging, deep discharge, and overheating. The system also includes fire protection through automatic cutoff during abnormal conditions. This ensures improved safety, efficiency, and longer battery life for electric vehicle applications. The EV Battery Management System using Arduino Uno monitors voltage, current, and temperature to ensure safe operation. It prevents overcharging, deep discharge, and overheating, and includes fire protection with automatic cutoff. The system improves battery safety and lifespan.

Keywords—Arduino, Bomb Disposal Robot, Flex Sensor, Human Motion Synchronization, RF Communication, Robotic Arm, Servo Motor, Wireless Control, Artificial Intelligence

I. INTRODUCTION

The rapid growth of electric vehicles (EVs) has increased the need for efficient and reliable battery management systems (BMS). A Battery Management System plays a major role in monitoring battery parameters such as voltage, current, temperature, and charging status to ensure safe and efficient operation. Improper charging, overheating, and short circuits can lead to batterydamage and fire hazards, making safety an important concern in EV applications

This project presents an EV Battery Management System with charge monitoring and fire protection using Arduino Uno. The system continuously monitors battery conditions and provides real-time protection against overcharging, overheating, and abnormal conditions. Fire protection features are included to improve battery safety and reduce the risk of accidents. The proposed system enhances battery life, improves performance, and ensures safe operation of electric vehicles.

The proposed system also improves battery efficiency by maintaining proper charging and discharging control. Fire protection mechanisms increase the overall safety and reliability of the EV battery pack. This project provides a cost-effective and smart solution for battery monitoring, making electric vehicles safer, more efficient, and more reliable for daily use.

The main objectives of the proposed system are:

1. To design and developan EV Battery Management System (BMS) using Arduino Uno..
2. To monitor important battery parameters such as voltage, current, temperature, and charging status..
3. To prevent battery overcharging, deep discharge, and overheating conditions.
4. To implement a fire protection system for improving battery safety.
5. To improve battery performance, efficiency, and lifespan.

II. Literature Review

Electric Vehicles (EVs) mainly depend on Lithium-ion batteries because of their high energy density and long life cycle. However, improper charging, overheating, and cell imbalance may reduce battery life and create fire hazards. To overcome these issues, Battery Management Systems (BMS) are widely used in EV applications for monitoring and protection.

Several researchers have focused on SOC (State of Charge) and SOH (State of Health) estimation methods for improving battery performance and reliability. Traditional methods such as Coulomb Counting and Voltage-Based Estimation are commonly used due to their simplicity, while advanced methods like Kalman Filter and AI-based estimation improve accuracy under varying load conditions.

Recent studies also emphasize thermal management and fire protection systems in EV batteries. Temperature sensors, smoke sensors, and automatic cutoff circuits are integrated into the BMS to detect abnormal temperature rise and prevent thermal runaway conditions. These systems improve passenger safety and battery reliability.

Researchers have implemented Arduino-based BMS systems because Arduino Uno provides a low-cost and easy-to-program platform for real-time monitoring of voltage, current, temperature, SOC, and SOH parameters. LCD displays, relays, buzzers, and GSM modules are also integrated for warning and protection purposes.

Literature also shows that charger monitoring plays an important role in preventing overcharging and deep discharging of batteries. Smart charging techniques help maintain battery efficiency and extend battery lifespan by continuously monitoring charging voltage and current.

III. Proposed Methodology

A. System Design and Component Selection:
The proposed EV Battery Management System is designed using Arduino Uno, voltage sensors, current sensors, temperature sensors, smoke sensors, relay modules, LCD display, and buzzer unit. Each component is selected based on accuracy, reliability, and low power consumption.

B. Battery Data Acquisition:
Sensors are connected to the battery pack to continuously measure battery voltage, charging current, and temperature. The sensor outputs are converted into digital values using the controller for further analysis.

C. Real-Time Monitoring:
The controller continuously monitors battery conditions during charging and discharging operations. The measured values are compared with predefined safe operating limits.

D. Charge Monitoring and Control:
The system tracks battery charge level and charging status to avoid overcharging and deep discharge. A relay control mechanism is used to disconnect the battery when unsafe charging conditions occur.

E. Temperature and Fire Detection:
Temperature and smoke sensors are used to identify overheating and possible fire hazards. If the temperature exceeds the threshold value or smoke is detected, the protection system immediately activates.

F. Protection Mechanism:
During abnormal conditions such as over-temperature, short circuit, or fire indication, the system triggers a buzzer alarm and disconnects the power supply using relay control to improve battery safety.

G. Display and User Interface:
An LCD module displays real-time battery parameters including voltage, current, temperature, and charging condition. Warning messages are also displayed during fault situations.

H. Prototype Development:
The complete hardware circuit is assembled and programmed using the Arduino IDE. Proper wiring and testing are carried out to ensure accurate operation.

I. Performance Testing:
The developed system is tested under various charging and temperature conditions to analyze monitoring accuracy, response time, and fire protection performance.

J. Result Analysis:
The obtained readings and system responses are analyzed to evaluate the efficiency, reliability, and safety improvement of the proposed EV Battery Management System.

IV. Experimental Results

The proposed EV Battery Management System successfully monitored battery voltage, current, and temperature in real time using the Arduino IDE and Arduino Uno controller

- The charge monitoring system accurately displayed battery status and prevented overcharging by automatically controlling the charging process
- Temperature sensors detected abnormal heat conditions during battery operation, and the fire protection system activated immediately when the temperature exceeded the safe limit.
- The warning system, including buzzer and alert indications, responded quickly during fault conditions, improving battery safety and reliability.
- Experimental testing showed stable battery performance, reduced risk of thermal runaway, and efficient energy management under different operating conditions.
- The developed prototype demonstrated low-costimplementation, easy operation, and suitability for small-scale electric vehicle applications

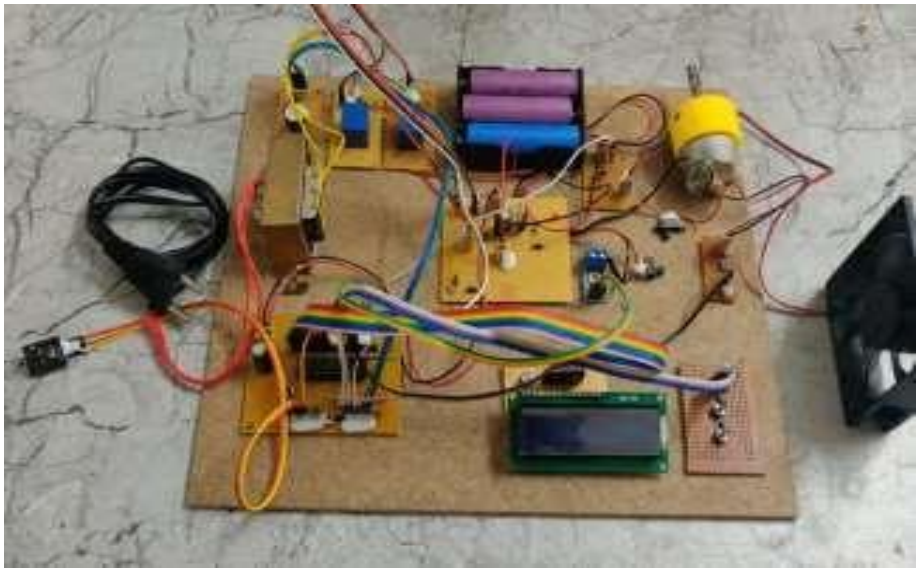

Fig.1. EV BMS MODEL

V. Conclusion

This project presents an efficient and intelligent EV Battery Management System with charge monitoring and fire protection using Arduino Uno. The developed system effectively monitors battery voltage, current, temperature, and charging conditions to ensure safe and reliable battery operation. The inclusion of fire detection and protection featureshelps in identifying abnormal conditions at an early stage and minimizes the risk of battery damage and fire accidents. The system improves battery life, enhances charging efficiency, and provides better safety for electric vehicles. The experimental analysis confirms that the proposed model responds quickly to overheating and fault conditions while maintaining stable battery performance.

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