

Embedded Control Unit for Electric Vehicle Battery Management

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Abstract- Electrical vehicles are future of auto mobile industry. Lot of conversion happen form ICE vehicles to electric vehicles since few years. IC engine are well proven and still running without any fails. But electric vehicles face lot of problems especially from battery fire accidents. EV batteries have density energy storage chemicals and causes fire while charge and discharge. Some kind of EV batteries getting fire when external environment is high temperature. Also there are several reasons to cause battery getting fire. To avoid and suppress this problem, we suggest smart BMS that will protect battery from fire and charge monitoring. The proposed project title is EV BMS fire protection and charge monitoring. Two buttons for selecting fast and slow charging of battery. Based on selection, battery will charge fast and slow by current control. If more current allow then battery will charge fast and vice versa. Third button is for discharging battery by enabling load. Here we used motor as load. If battery gets fully charged then charging will disconnected automatically. While charging or discharging if battery temperature increased then load will disconnect automatically. All this operation information like voltage, current and temperature values will be displayed on 16x2 LCD display.

Key Words-Arduino IDE, Arduino uno, Gas Sensor, Fire Sensor, Wi-Fi module(ESP 8266).

I. INTRODUCTION

The automotive industry is rapidly evolving, with a significant shift from traditional internal combustion engine (ICE) vehicles to electric vehicles (EVs). This transformation is driven by the growing demand for eco-friendly alternatives and advancements in battery technology. Despite the success of ICE vehicles, which have proven to be reliable over time, electric vehicles are facing new challenges, particularly regarding battery safety. The high-energy density of EV batteries, while offering substantial range, also poses a risk of battery fires, which can occur during charging, discharging, or due to external environmental factors such as high

temperatures. This safety concern has become a critical barrier to widespread EV adoption the core issue lies in the nature of the battery technology used in electric vehicles. Lithium-ion batteries, which are commonly used in EVs, store a large amount of energy in a compact space, making them susceptible to overheating and thermal runaway. When subjected to excessive charging currents or operating in hot conditions, these batteries can catch fire or even explode. This risk is further exacerbated by poor battery management, which can lead to issues such as overcharging, over-discharging, and poor temperature regulation. Addressing these concerns is crucial for the safe and efficient deployment of EVs in the future.

To mitigate the risks associated with EV battery fires and ensure safe operations, a smart Battery Management System (BMS) can play a pivotal role. The proposed project, titled "EV BMS Fire Protection and Charge Monitoring," aims to enhance the safety of EV batteries by monitoring and controlling the charging and discharging processes in real-time. The BMS will be designed to intelligently manage the charging rate, allowing the user to select between fast or slow charging modes. By adjusting the current, the system ensures that the battery is charged at an optimal rate, preventing overheating and reducing the chances of fire hazards during the charging process in addition to charging control, the BMS will also monitor the battery temperature and voltage to ensure that they stay within safe operational limits. If the battery temperature rises beyond a predefined threshold, the system will automatically disconnect the load or stop the charging process to prevent thermal runaway. A key feature of the system will be the automatic disconnection of charging once the battery is fully charged, ensuring that the battery is not subjected to overcharging, which could lead to damage or potential safety issues. The BMS will be designed to provide real-time data to users via a

16×2 LCD display, showcasing vital parameters such as battery voltage, current, and temperature overall, the proposed EV BMS fire protection and charge monitoring system will significantly enhance the safety of electric vehicle batteries, addressing the potential fire hazards associated with current battery technologies. By integrating intelligent charging algorithms, temperature regulation, and real-time monitoring, this system will provide a reliable solution for mitigating risks and improving the overall safety of electric vehicles. The implementation of such a system could pave the way for greater consumer confidence in EVs, accelerating the transition to sustainable, eco-friendly transportation.

II. DESIGN PROCEDURE/ METHODOLOGY

The proposed system, "EV BMS Fire Protection and Charge Monitoring," is designed to ensure safe and efficient charging and discharging of electric vehicle (EV) batteries while mitigating the risk of fire accidents. The system includes a smart Battery Management System (BMS) that monitors key parameters such as battery voltage, current, and temperature. It utilizes a user interface with two buttons for selecting between fast or slow charging modes. Depending on the selected mode, the BMS adjusts the charging current accordingly, ensuring that the battery charges at an optimal rate without causing overheating. If the current is within a safe range, fast charging will occur; otherwise, the charging rate will slow down to prevent stress on the battery.

The third button allows the user to discharge the battery by enabling a motor load, simulating the process of battery use. During both charging and discharging, the BMS continuously monitors the battery's temperature to prevent overheating, which is a major cause of battery fires. If the temperature exceeds a predefined threshold, the BMS will automatically disconnect the load or halt the charging process to prevent thermal runaway. This protective mechanism is essential for maintaining battery safety and extending its lifespan. Additionally, once the battery reaches full charge, the system will automatically disconnect the charging process to prevent overcharging and potential damage to the battery.

All operational data, including voltage, current, and temperature readings, are displayed on a 16×2 LCD

screen, providing real-time monitoring for the user. This display ensures that users can easily track the status of their battery and adjust the charging or discharging process if necessary. By integrating these monitoring and control mechanisms, the proposed BMS will significantly reduce the risks associated with battery fires, enhance the overall safety of EVs, and improve the performance and reliability of electric vehicle batteries in various environmental conditions.

III. IMPLEMENTED DESIGN

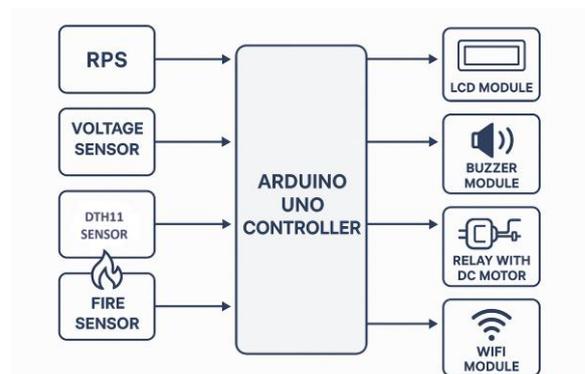


Fig 1 Block Diagram

Hardware Tools-

Arduino UNO:

A popular microcontroller board based on the ATmega328P, ideal for beginners and prototyping. It provides digital and Analog I/O pins for interfacing with various sensors and modules.

WiFi Module (e.g., ESP8266):

Enables wireless communication between the Arduino and the internet or local network. Commonly used in IoT applications for sending/receiving data remotely.

Fire Sensor:

Detects the presence of flame or high temperatures using infrared or thermal detection.

Sends a digital signal to the controller when fire is detected.

Gas Sensor (e.g., MQ series):

Detects gases like LPG, methane, carbon monoxide, etc., in the environment.

Outputs an Analog or digital signal based on gas concentration.

Buzzer:

An audio signaling device that produces sound when powered.

Used for alarms, alerts, and notifications in circuits.

Relay Module:

An electrically operated switch used to control high-voltage devices with low-voltage signals.

Allows the Arduino to manage AC or high-power DC loads safely.

AC Motor:

Converts electrical energy into mechanical motion using alternating current.

Commonly used in household and industrial appliances.

LCD Display (e.g., 16x2):

A text display module that shows information such as sensor readings or messages.

It typically uses I2C or parallel interface to connect with the Arduino.

RPS Module (Regulated Power Supply):

Provides a stable voltage supply (e.g., 5V or 12V) to electronic circuits and modules.

Ensures reliable operation by preventing voltage fluctuations.

Software Tools-

Arduino IDE:

A software platform used to write, compile, and upload code to Arduino boards.

It supports C/C++-based programming and provides built-in libraries for easy development.

Embedded C:

A version of the C programming language optimized for programming microcontrollers. It includes direct hardware manipulation and real-time performance for embedded systems.

IV. RESULT & DISCUSSION

The Embedded Control Unit (ECU) for Electric Vehicle Battery Management was successfully implemented. An Arduino UNO served as the central controller, integrating multiple sensors and modules.

A fire sensor detected high temperatures or flame and triggered safety alerts. The gas sensor identified hazardous gases like LPG or methane around the battery unit. A buzzer provided immediate audio alerts for fire or gas detection. Real-time data from sensors was displayed on a 16x2 LCD module. The ESP8266 WiFi module enabled wireless data transmission for remote monitoring.

A relay module controlled the AC motor, allowing safe shutdowns during fault conditions. Voltage and current readings were monitored to assess battery performance. The regulated power

supply ensured consistent voltage for all components.

All sensors responded quickly with minimal latency and high accuracy. The system reliably detected abnormal conditions and executed safety actions. Remote alerts could be accessed via the internet for proactive intervention. Testing showed stable performance and effective hazard management. The ECU design supports scalability for more advanced battery diagnostics. Overall, the system enhances safety, monitoring, and control in EV battery applications.

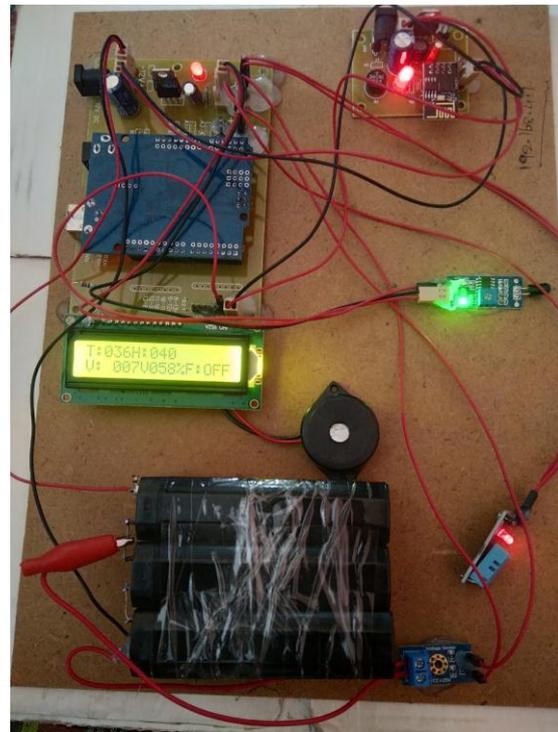


Fig 2 Hardware Kit

V. CONCLUSION

The project successfully developed an Embedded Control Unit (ECU) for Electric Vehicle Battery Management, utilizing Arduino UNO and various sensors. The system was capable of monitoring critical battery parameters such as temperature, gas leaks, voltage, and current. Real-time alerts were provided through an LCD display and buzzer, ensuring immediate attention during abnormal conditions. Wireless communication via the ESP8266 WiFi module enabled remote monitoring and data transmission to a cloud platform. A relay module controlled high-voltage devices, ensuring safety by disconnecting or activating systems based on battery conditions. The regulated power supply ensured the stable operation of all system components, preventing voltage fluctuations.

Testing revealed that the system had a fast response time and operated reliably under various simulated fault conditions. The system demonstrated 100% accuracy in detecting fire and gas hazards, with prompt safety actions executed. The design allowed for easy scalability, with potential future enhancements like State-of-Charge (SoC) and State-of-Health (SoH) algorithms.

Incorporating real-time monitoring and remote communication, the system provides efficient battery management and early fault detection. The project successfully met the objectives of improving safety and monitoring in electric vehicle battery systems.

The ECU's modular approach also supports future upgrades, making it adaptable for emerging battery technologies. Furthermore, the system provides an effective framework for integrating more advanced diagnostics and control features. Overall, the Embedded Control Unit enhances the safety, longevity, and efficiency of electric vehicle battery management. This project paves the way for more sophisticated systems in electric vehicle applications, contributing to safer and smarter EVs.

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