EV BATTERY MANAGEMENT SYSTEM WITH CHARGE MONITORING AND FIRE PROTECTION USING ARDUINO UNO

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Abstract : Electric vehicles (EVs) are becoming increasingly popular due to rising environmental concerns and the need for sustainable transportation. Battery safety and monitoring are critical for efficient EV operation. This paper presents the design and implementation of an Electric Vehicle Battery Management System (BMS) with charge monitoring and fire protection using Arduino Uno. The system monitors battery voltage, current, and temperature using sensors and displays the information on a 16×4 LCD display. Fast and slow charging modes are implemented using relay circuits controlled through push buttons. A DS18B20 temperature sensor continuously monitors battery temperature and disconnects the load when overheating occurs to prevent fire hazards. The proposed system provides a simple, reliable, and cost-effective solution for improving EV battery safety and performance.

IndexTerms - **Battery Management System (BMS), Electric Vehicle (EV), Arduino Uno, Charge Monitoring, Temperature Sensor, Voltage Sensor, Current Sensor, Fire Protection System, Relay Control, LCD Display.**

I. INTRODUCTION

Electric vehicles (EVs) are gaining significant importance in modern transportation systems due to increasing environmental concerns and the rapid depletion of fossil fuels [3][2]. Conventional vehicles that use internal combustion engines release harmful gases such as carbon dioxide and nitrogen oxides, which contribute to air pollution and global warming. To overcome these issues, electric vehicles powered by rechargeable batteries have emerged as a sustainable and eco-friendly alternative [3].

The battery is one of the most critical components in an electric vehicle. It acts as the main energy storage unit and directly affects the performance, efficiency, and safety of the vehicle [1][9]. However, EV batteries are sensitive to operating conditions and may face several issues such as overcharging, over-discharging, overheating, and excessive current flow[2][8]. These conditions can damage the battery, reduce its lifespan, and in severe cases may even lead to thermal runaway and fire hazards [8]. Therefore, proper monitoring and protection of batteries are essential to ensure safe and reliable operation of electric vehicles.

A Battery Management System (BMS) is an electronic system used to monitor and manage battery performance during charging and discharging operations [1]. The BMS continuously observes important battery parameters such as voltage, current, and temperature [2][7]. By monitoring these parameters, the system ensures that the battery operates within safe limits and prevents dangerous situations such as overheating or short circuits [3]. In addition, a BMS helps improve battery life, enhances system efficiency, and increases the reliability of electric vehicles [3][7].

Recent developments in embedded systems and microcontrollers have made it possible to design cost-effective battery monitoring solutions. Microcontrollers such as Arduino provide an efficient platform for integrating sensors, control circuits, and display modules in a compact system. By using appropriate sensors and control mechanisms, it is possible to build a reliable battery monitoring system that can detect abnormal conditions and take corrective actions automatically.

In this paper, an EV Battery Management System with charge monitoring and fire protection using Arduino Uno is proposed. The system monitors battery voltage, current, and temperature using sensors and displays the parameters on a 16×4 LCD display [10]. The system also provides fast and slow charging options using relay control and push buttons. A DS18B20 temperature sensor is used to detect overheating conditions, and the system automatically disconnects the load when the temperature exceeds the safe limit [11]. This protection mechanism helps prevent battery damage and reduces the risk of fire accidents.

II. SURVEY OF LITERATURE

Battery Management Systems (BMS) are essential for monitoring and protecting batteries used in electric vehicles [1][2]. Several researchers have studied different methods for improving battery performance and safety.

Lu et al. (2013) reviewed lithium-ion battery management systems used in electric vehicles and highlighted the importance of monitoring parameters such as voltage, current, and temperature to ensure safe battery operation [2]. Hannan et al. (2017) discussed energy management techniques in EV batteries and emphasized the need for efficient monitoring systems to improve battery life and reliability [3].

He et al. (2011) proposed battery modeling techniques for accurate estimation of battery performance and state of charge [4]. Similarly, Chen and Rincon-Mora (2006) developed an electrical battery model capable of predicting battery runtime and performance under different operating conditions [5].

Although many advanced battery management systems are available, they are often complex and expensive [7]. Therefore, a simple and cost-effective battery monitoring system is required for small EV applications. The proposed system uses an Arduino-based Battery Management System to monitor battery voltage, current, and temperature while providing protection against overheating and fire hazards.

III. EXISTING SYSTEM

In many conventional battery systems used in electric vehicles, only basic charging circuits are implemented without proper monitoring and protection mechanisms [2][7]. These systems mainly focus on charging the battery without continuously checking important parameters such as battery temperature, voltage fluctuations, or charging current.

Existing systems suffer from several limitations including lack of temperature monitoring, absence of automatic protection mechanisms, and limited user control over charging modes. As a result, batteries may experience overheating or overcharging, which reduces battery life and increases safety risks [2][8]. Therefore, there is a need for a simple and cost-effective battery monitoring system that can improve battery safety and reliability [3].

IV. PROPOSED SYSTEM

The proposed system is an Electric Vehicle Battery Management System implemented using an Arduino Uno microcontroller. The system continuously monitors battery voltage, current, and temperature using sensors [10].
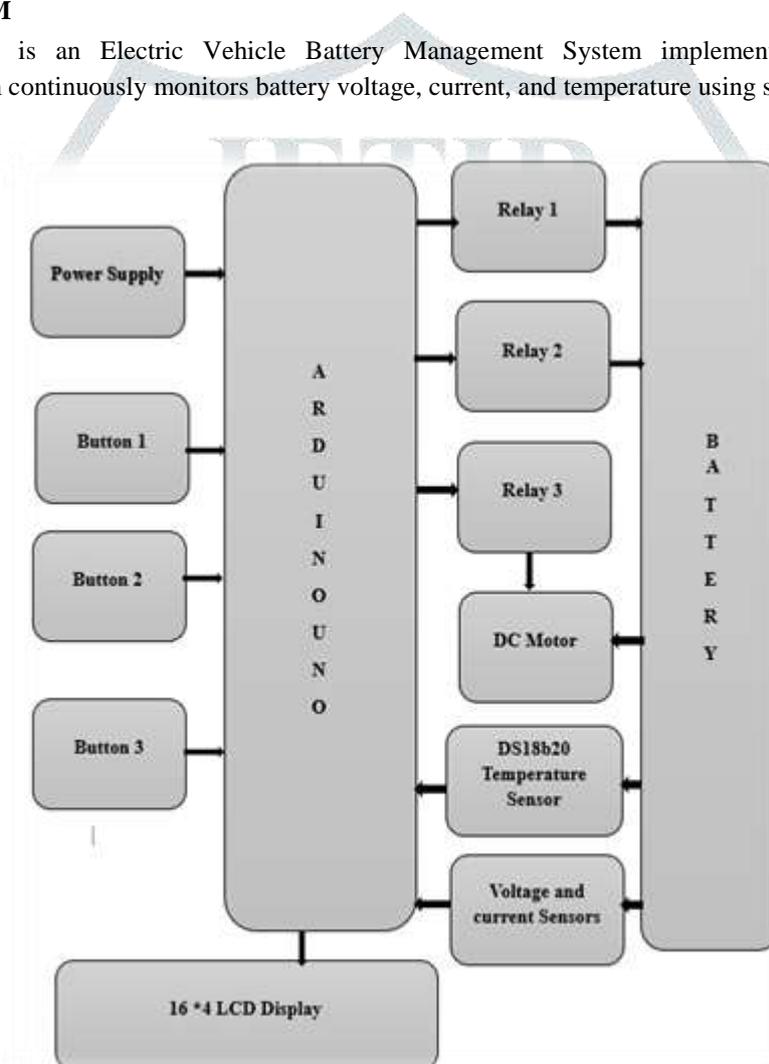
Fig. 1: Block Diagram of EV BMS

A voltage divider circuit is used to measure battery voltage safely. Current measurement is performed using a shunt resistor method. The DS18B20 temperature sensor measures battery temperature with high accuracy [11].

Three push buttons are used to control system operation:
- Fast charging mode
- Slow charging mode
- Load activation for battery discharge

Relay circuits are used to control the charging and load circuits. If the battery temperature exceeds the safe limit, the Arduino automatically disconnects the load to prevent overheating and fire hazards.

V. CIRCUIT DIAGRAM OF THE PROPOSED SYSTEM

The circuit diagram of the EV Battery Management System shows the connections between Arduino Uno, sensors, relays, LCD display, and other components **[10]**. The voltage sensor and current sensor are connected to the analog input pins of the Arduino to measure battery parameters **[2]**. The DS18B20 temperature sensor is connected to a digital pin to monitor battery temperature. The relay modules are used to control the charging circuit and load operation. The LCD display shows real-time battery parameters such as voltage, current, and temperature **[11]**.
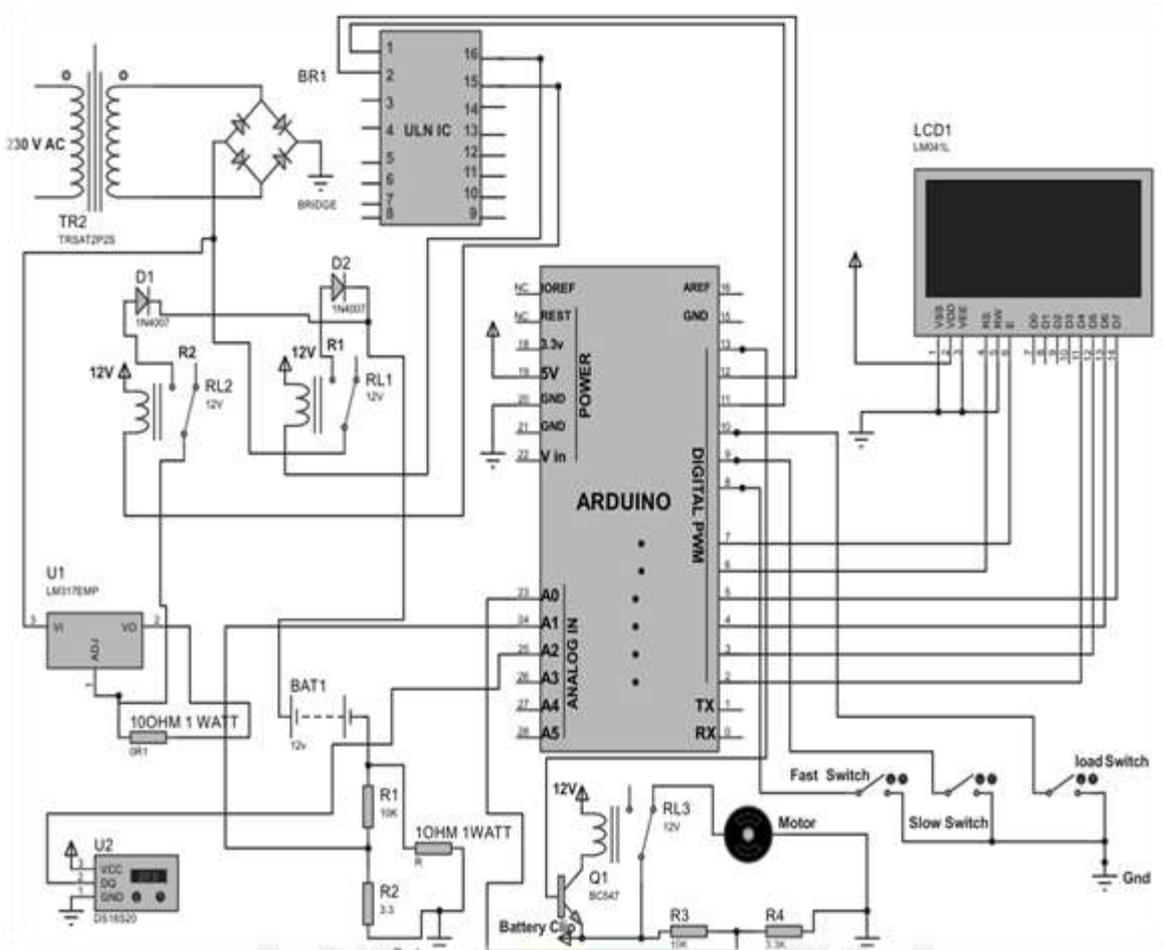

Fig.2: Circuit Diagram of EV BMS

VI. COMPONENTS

1. Arduino Uno

Arduino Uno is the main microcontroller used in the proposed EV Battery Management System. It acts as the central controller that reads data from various sensors such as voltage, current, and temperature sensors. Based on the sensor readings, the Arduino processes the data and controls the relays, LCD display, and other components. It is widely used in embedded systems due to its simple programming environment and open-source platform **[10]**.

2. Battery Pack

The battery pack is the primary power source of the system. In this project, a rechargeable battery is used to store electrical energy and supply power to the load. During the charging process, the battery stores energy, and during discharging, it supplies energy to the connected load. Proper battery monitoring improves battery life and ensures safe operation in electric vehicles **[1][12]**.

3. Power Supply Unit

The power supply unit provides the required DC voltage to operate the electronic components of the system. It converts AC voltage from the mains supply into regulated DC voltage that can be used by the Arduino and other devices. A stable power supply is necessary for the proper functioning of sensors, microcontrollers, and display modules **[6]**.

4. Step Down Transformer

The step down transformer is used to reduce the high AC voltage from the mains supply to a lower AC voltage suitable for electronic circuits. For example, it converts 230V AC to around 12V AC. This reduced voltage is then supplied to the rectifier circuit for further processing **[6]**.

5. Bridge Rectifier

The bridge rectifier is used to convert alternating current (AC) into direct current (DC). It consists of four diodes and they are connected in a bridge configuration. The rectifier ensures that the output voltage always flows in one direction, which is necessary for operating electronic circuits such as microcontrollers and sensors [6].

6. Filter Capacitor

A filter capacitor is used to smooth the pulsating DC voltage obtained from the rectifier. It removes voltage ripples and provides a steady DC output. The capacitor stores energy when the voltage increases and releases it when the voltage decreases, thereby maintaining a stable voltage supply [6].

7. Voltage Regulator (7805)

The 7805 voltage regulator is used to provide a constant 5V output voltage required for operating the Arduino and other electronic components. It regulates the input voltage and ensures that the output voltage remains stable even when the input voltage fluctuates [6].

8. Voltage Sensor

The voltage sensor is used to measure the battery voltage in the system. Since the battery voltage may be higher than the safe input range of the Arduino, a voltage divider circuit is used to reduce the voltage before sending it to the Arduino analog input pin. The Arduino then calculates the actual battery voltage based on the sensor reading [2].

9. Current Sensor

The current sensor measures the amount of current flowing through the battery during charging and discharging operations. In this system, a shunt resistor method is used to measure current. The voltage drop across the resistor is measured by the Arduino and converted into current values using Ohm's law [2][7].

10. DS18B20 Temperature Sensor

The DS18B20 is a digital temperature sensor used to monitor the temperature of the battery. It provides accurate temperature readings and communicates with the Arduino using a one-wire communication protocol. If the temperature exceeds the predefined safe limit, the system automatically disconnects the load to prevent overheating and fire hazards [11].

11. ULN2003 Driver IC

The ULN2003 is a high-current driver IC used to control devices such as relays and motors. Since the Arduino cannot supply sufficient current to drive relays directly, the ULN2003 IC amplifies the current from the Arduino output pins and safely drives the relay circuits [6].

12. Transistor

A transistor is used as an electronic switching device in the circuit. It controls the flow of current through the relay coil. When a signal is received from the Arduino, the transistor switches ON or OFF and activates the relay accordingly [6].

13. IN4007 Diode

The IN4007 diode is used for protection purpose in the relay circuit. When the relay coil is switched OFF, a high voltage spike may be generated due to the collapsing magnetic field. The diode prevents this voltage spike from damaging the electronic components [6].

14. Relay Module

A relay is an electromechanical switch used to control high-power circuits using low-power signals from the Arduino. In this system, relays are used to control fast charging, slow charging, and load operation. They allow the Arduino to safely switch high-current circuits [6].

15. Push Buttons

Push buttons are used as input devices that allow the user to control different modes of the system. In this project, push buttons are used to select fast charging mode, slow charging mode, and load operation.

16. 16×4 LCD Display

The LCD display is used to show real-time information about the battery system. It displays parameters such as battery voltage, current, temperature, and charging status. This allows the user to easily monitor the condition of the battery [10].

17. DC Motor

A DC motor is used as a load to simulate the operation of an electric vehicle motor. If the system activates the load mode, the DC motor runs using battery power. This helps demonstrate the battery discharging process in electric vehicle applications [6].

18. LED Indicator

The LED indicator is used to show the power status of the system. When the circuit receives power, the LED turns ON to indicate that the system is active. LED indicators are commonly used in electronic circuits for status indication and system monitoring because of their low power consumption and high reliability [6].

19. Jumper Wires

Jumper wires are used to connect different electronic components in the circuit. They provide electrical connections between sensors, Arduino, relays, and other modules during circuit assembly and testing. These wires are widely used in prototyping and embedded system development for establishing temporary connections between circuit components [10].

VII. RESULTS AND DISCUSSION

The EV Battery Management System was successfully implemented and tested. The system monitors battery parameters and displays them on the LCD screen [2][3][7].

Fig.3: Display of Battery during Slow Charging
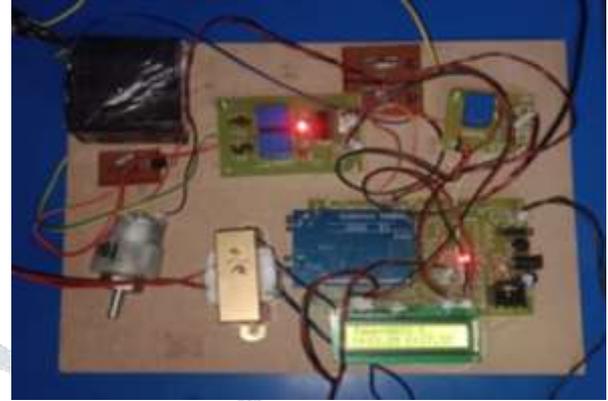
Fig.4: Display of Battery during Fast Charging

Fig.5: Display of Battery during Discharging

Fig.6: Detection of High Temperature of Battery

The experimental results show that:
1. Battery voltage gradually increases during charging.
2. The DC motor acts as a load during battery discharging.
3. Temperature monitoring works effectively [11].
4. When the battery temperature exceeds the safe limit, the relay automatically disconnects the load to prevent overheating.

These results demonstrate that the proposed system improves battery safety and monitoring in electric vehicle applications.

VIII. CONCLUSION

The EV Battery Management System with charge monitoring and fire protection was successfully designed and implemented using Arduino Uno. The system continuously monitors battery voltage, current, and temperature and displays the information on an LCD display.

The system also provides fast and slow charging options and automatically disconnects the load during overheating conditions. This helps prevent battery damage and fire hazards. The proposed system offers a low-cost and reliable solution for improving EV battery safety.

Future improvements may include integrating wireless communication modules such as Wi-Fi or GSM for remote monitoring and implementing advanced battery balancing techniques.

IX. ACKNOWLEDGMENT

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