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Development of Voltage and Temperature Monitoring Circuit for Lithium-Ion Batteries Used in Electric Vehicles.

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Abstract
The suggested method explains how to prevent lithium-ion batteries in electric vehicles (EVs) from being overcharged or discharged. It also keeps an eye on the temperature of the batteries, which increases the EV batteries dependability and efficiency. Relay 1 is triggered when there is an overcharge, or when the battery voltage rises above 14V. After that, the charging port is disconnected. Relay 2 is triggered when an over discharge occurs, meaning that the voltage drops below 9 volts. After that, the motor or load is disconnected. In a similar way, the realy3 is triggered when the temperature rises over the safe limit, which in turn triggers the cooling fan to lower the temperature. Additionally, the EV owner receives all of the information. The proposed system includes protection mechanisms for electric vehicles and battery temperature monitoring, ensuring safety during charging and discharging. These mechanisms prevent overcharging preventing overheating.
Keywords: *Lithium-Ion Battery; Over charging; Over discharging; Temperature; Relay.*

1. Introduction
Electric vehicles (EVs') performance and safety depend heavily on the development of effective and dependable battery management systems (BMS). Batteries operate at their best thanks to circuits in the BMS that monitor voltage and sense temperature. In order to monitor voltage and detect temperature in EV batteries, this research provides an integrated solution. To guarantee that each battery cell stays within safe operating parameters, the voltage monitoring circuit continuously monitors each cell's voltage. It detects abnormalities like over voltage or under-voltage situations, which can cause battery degeneration or failure, using robust data processing algorithms and high-precision analog-to-digital converters (ADCs). In parallel, the battery pack's thermal condition is being observed by the temperature sensing circuit. temperature sensors positioned purposefully near the surface of the battery. Batteries made of lithium-ion (Li-ion) are essential to contemporary electric vehicles (EVs). For EV manufacturers, their long cycle life, high energy density, and significant power delivery make them the go-to option. [1-5]

1.1. Objectives and Scope of the Project work
The work carried out in this project mainly aims to maximize the battery efficiency and reliability of the battery. The objectives of the proposed system are,
1. To Design a Protection circuit for overcharge and over discharge for Lithium-Ion batteries in EV Vehicles.
2. To Develop the temperature detection circuit and integrate cooling system for Lithium-Ion batteries in EV Vehicles.

2. Method
1. EV BMS consists of over voltage and under voltage protection, temperature detection and giving protection to battery.
2. Like precaution is better than cure, our aim is giving protection to battery before it catches fire.
3. We used relay to make or break the charging or discharging the battery.
4. Voltage sensor measures the voltage and gives

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information to Arduino UNO.

5. If the measured voltage is more than 14V relay 1 will operate and disconnects the battery from charger.
6. If the measured voltage is less than 9V relay 2 will operate and disconnects the battery from load.
7. To create voltage to our desired value we used 10KΩ potentiometer.
8. Temperature sensor is used sense the battery temperature, if it is more than preset value relay 3 will operate and cooling fan starts to operate.
9. To maintain constant voltage (12V) across cooling fan we used Zener diode. It acts as voltage regulator.
10. Every information is displayed in 16× 2 LCD display.

2.1. Block Diagram of Proposed System

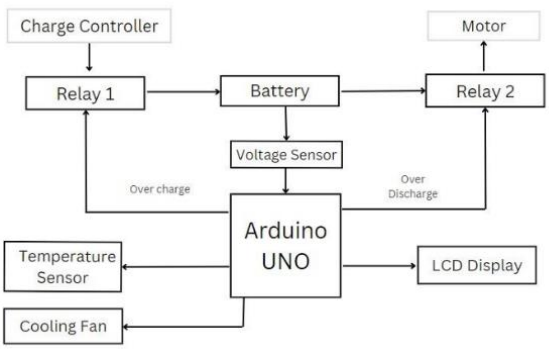

Figure 1 Block Diagram of the Proposed System

The figure 1 represents the block diagram of the proposed system. The block diagram consists of an Arduino UNO as the central processing unit, a Charge Controller managing battery charging, a battery as the energy storage unit, a Motor controlling the load, Relay 1 and 2 as electromagnetic switches, an Voltage Sensor monitoring battery voltage, and a Temperature Sensor measuring the system's temperature for environmental management. This block diagram outlines an electronic control system centered around an Arduino UNO microcontroller. The charge controller manages battery charging, ensuring optimal charging and preventing overcharging or deep discharging. The battery connects to the charge controller via two relays, Relay 1 and Relay 2. Two sensors, a Voltage Sensor and a Temperature Sensor, measure the battery voltage and temperature, respectively. The Arduino UNO processes sensor data and makes decisions based on thresholds. The cooling fan, connected to the Arduino UNO, regulates temperature and activates when the temperature sensor detects excessive heat. The LCD Display provides real-time information to the user or operator. [6-10]

2.2 Circuit Diagram of Proposed System

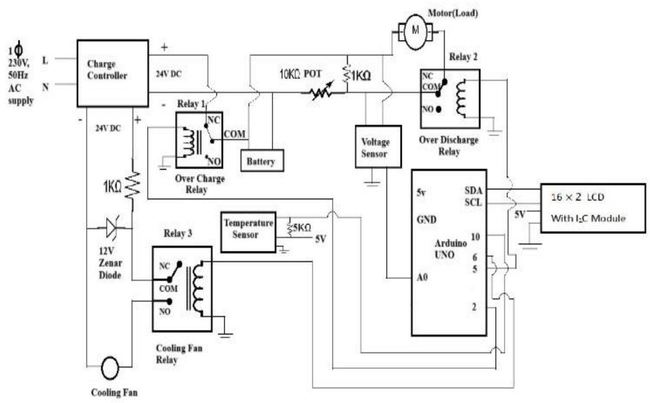

Figure 2 Circuit Diagram of Proposed System

Figure 2 represents the circuit diagram of proposed system. The device consists of a Charge Controller, Battery, Motor, Voltage Sensor, Relays, Temperature Sensor, Cooling Fan, LCD Display. The circuit consists a potentiometer subcircuit. The circuit diagram outlines a battery charge controller system that manages the charging process for a 14V battery from an AC supply (240V, 50Hz). The AC supply and transformer inputs 240V, 50Hz AC voltage, which is converted to 24V DC by a bridge rectifier. The charge controller ensures safe and efficient charging by regulating the charging current to prevent overcharging or deep discharging. Key components connected to the controller include the battery, temperature sensor, overcharge voltage sensor, and cooling fan relay. A potentiometer and Arduino UNO microcontroller board interface with various components, managing charging based on sensor inputs and potentiometer settings. An overcharge relay plays a role in safety or control

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mechanisms related to overcharge protection. The system's key components ensure safe and efficient charging. The 240V AC supply undergoes transformation via a transformer, reducing voltage to 24V DC and Converting AC to DC. The overcharge voltage sensor monitors the battery voltage, taking corrective action if it detects excessive voltage. The voltage detection sensor, connected to a 1k ohm resistor, uses a potentiometer to manually control overcharge and over discharge. The potentiometer adjusts the voltage across the resistor, activating relays based on the voltage limit. The relay serves as an emergency cutoff, interrupting the charging process in critical conditions like overvoltage. Over charge Relay activates when voltage exceeds 14V, and disconnects the charging port. Over discharge Relay activates when voltage drops below 9V, then disconnects the motor. Safety mechanisms prevent catastrophic battery failure. The system features a 16x2 LCD with an I2C module for user interface and communication. It displays charging status, battery health and temperature. And the working model is shown in figure 3. [11-14]

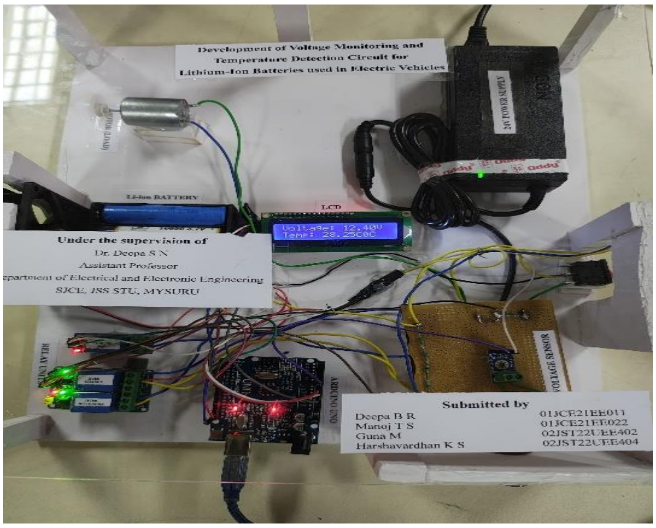

Figure 3 Working Model

3. Results and Discussion

3.1. Results

The project successfully developed a circuit for monitoring voltage and detecting temperature in EV batteries. If voltage level greater than or less than safety voltage, relay acts and disconnects from overcharging the battery and disconnects from motor. And temperature sensor, sense the temperature of battery, if the temperature is greater than the safety temperature cooling fan starts to operate. [15-16]

3.2. Discussion

Case1: The battery overcharging protection circuit monitors the terminal voltage of a battery to prevent damage. When the lithium-ion battery charging exceeds 14V, the circuit disconnects the battery from the charger by the relay action.

Case2: When a lithium-ion battery over-discharges, it can lead to irreversible damage. To prevent this, when the voltage drops below 9v, the relay2 get activates and disconnecting the motor. This action safeguards the battery by halting power flow, ensuring its longevity and preventing potential hazards associated with over-discharge.

Case3: Before battery catches fire, battery should heat up, it is indicating point to catch fire. when battery get heating up temperature sensor senses the temperature and if it is greater than 30-degree Celsius temperature, relay 3 operates, and cooling fan rotates and cools the battery.

Conclusion

The proposed system is designed to protect Electric Vehicles (EVs) by preventing overcharging, over discharging, and maintaining optimal battery temperature. The Battery Management System (BMS) continuously monitors the battery's voltage, current, and temperature, triggering relays to disconnect the charging port when the battery reaches its maximum charge level and engage when the voltage drops below a preset threshold. The BMS also tracks battery temperature, triggering relays to activate a cooling fan when the temperature exceeds safe limits, preventing thermal damage and ensuring the battery's longevity and reliability. This integrated system not only ensures efficient charging but also protects the battery, enhancing safety and overall performance in EVs. By regulating the charging and discharging process, tracking the battery's state of charge and overall health, and guarding the battery from harm caused by overcharging or overheating, the BMS aids in ensuring the safe and effective operation of the battery.

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