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EV BMS WITH CHARGE MONITOR

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Abstract:

In the world of electric vehicles, ensuring safety and performance of the battery is key. Our project focuses on creating a smart system specifically designed for these vehicles. This system does a few important things. Firstly, it monitors how the battery charges to keep it in good shape and maximize its life. Secondly, it guards against overheating, which can be risky. To tackle this, we've developed a special circuit that stops charging automatically if the battery gets too hot. When this happens, a buzzer alerts the rider. To cool down the battery, we've integrated a cooling system. Another notable feature of our system is a display screen that shows how well the battery is performing. We've connected sensors to track the battery's power levels and how much electricity is flowing in and out. All of this is managed by a small computer called Arduino UNO.

Keywords — **Safety, Battery Management System, Arduino UNO.**

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I. INTRODUCTION

The increasing demand for electric vehicles (EVs) has resulted in the need for advanced battery management systems (BMS) that ensure efficient charging, monitoring, and protection of battery cells. One of the key challenges in EV systems is maintaining battery health while maximizing performance and lifespan. An efficient BMS monitors various parameters like voltage, temperature, and current to ensure the battery operates within safe limits.

The EV BMS with Charge Monitoring Project aims to design a system that automatically controls and monitors the charging process of an electric vehicle's battery. It uses sensors for voltage, temperature, and current measurements, displays real-time data on an LCD screen, and integrates safety features like over-voltage, over-temperature, and over-current protection. This system enhances battery life, improves safety, and provides the vehicle owner with key charging information.

II. DESIGN AND CONSTRUCTION

The Battery/Battery Pack to be monitored is Connected with multiple monitoring sensors (Voltage sensor, Current sensor, Temperature sensor) to get the constant SOH (**State of Health**)

A. *Current Sensor:* Measures the current flowing into or out of the battery, helping to track charge/discharge cycles, capacity, and potential overcurrent conditions.

B. Voltage Sensor: Monitors the battery's voltage, which can indicate state of charge, capacity, and potential overvoltage or under voltage conditions.

C. Temperature Sensor: Tracks the battery's temperature, which can affect its performance, lifespan, and safety. Elevated temperatures can accelerate degradation. These Sensors are connected with Arduino UNO and they give an analog signal of the parameters they measure which is then converted into appropriate reading values for the safety system to work and During any anomalies like e.g., Overvoltage/Current or during high temperature the Arduino UNO sends an signal to switch on/off the relay which in turn cuts the supply to the battery, ensuring safety of the battery and simultaneously the user gets notified by the Buzzer.

III. WORKING PRINCIPLE

The EV Battery Management System (BMS) with Charge Monitoring is designed to ensure safe, efficient, and reliable battery charging by continuously monitoring critical parameters such as voltage, temperature, and current. Here's a step-by-step explanation of how the system works:

1. Initialization:

When the system is powered on, the Arduino initializes the components, including the LCD display, relay, and sensors. A welcome message is displayed on the LCD for a few seconds to indicate that the system is starting up. Once initialized, the system enters the main monitoring and control loop.

2. Monitoring Battery Parameters:

The system continuously monitors the battery's:

A. Voltage: The voltage sensor (implemented using a voltage divider) reads the battery's voltage. This value is scaled down to a level suitable for the Arduino's analog input pin. The Arduino processes this input to calculate the actual voltage.

B. Temperature: The LM35 sensor provides a voltage proportional to the battery temperature. The Arduino converts this analog signal to temperature in Celsius.

C. Current: The ACS712 current sensor detects the current flowing through the battery during charging. It outputs a voltage proportional to the current, which is then converted to amperes by the Arduino. These values are displayed on the LCD for real-time monitoring.

3. Decision-Making Based on Thresholds:

The Arduino compares the monitored parameters against predefined safe thresholds:

A. Voltage Threshold: If the voltage exceeds the maximum allowed value (e.g., 10.0V), the system deactivates the relay, halting the charging process. The buzzer is activated to alert the user of the overvoltage condition. Once the voltage drops below the safe limit, with hysteresis applied, the relay is reactivated.

B. Temperature Threshold: If the battery temperature rises above the maximum safe level (e.g., 200°C), the relay is turned off, and the buzzer sounds. Charging resumes only when the temperature falls below the threshold, accounting for hysteresis.

C. Current Threshold: If the current exceeds the maximum safe level (e.g., 5.0A), the relay is turned off, and the buzzer is activated. When the current returns to safe levels, the system resumes charging.

3. Relay Control:

The relay serves as a switch to control the power supply to the battery. Based on the monitored parameters, the Arduino determines whether to turn the relay ON or OFF:

If all parameters are within safe limits, the relay is ON, allowing the battery to charge.

If any parameter exceeds its threshold, the relay is turned OFF, halting the charging process to protect the battery.

4. *Audible Alerts:*

The buzzer acts as a warning mechanism. It provides an audible alert whenever any unsafe condition is detected, such as overvoltage, overheating, or overcurrent. This ensures that the user is immediately informed of any potential hazards.

5.Data Display on LCD:

The I2C LCD screen provides real-time feedback to the user, displaying:

*Battery voltage (in volts) *Battery temperature (in Celsius) *Charging current (in amperes) *Relay status (ON/OFF)

The clear and concise display allows users to monitor the charging process at a glance.

6. *Hysteresis Implementation:*

To prevent frequent relay switching due to minor fluctuations in sensor readings, hysteresis is applied to the thresholds. For example:

The relay turns off when the temperature exceeds 200°C but will only turn back on when the temperature drops below 190°C (10°C hysteresis).

Similarly, for voltage and current, hysteresis is implemented to maintain stable operation.

7. *Safety Features:*

The system ensures safety by automatically cutting off the charging process when any parameter exceeds the defined limits. This prevents:

*Overcharging, which can damage the battery. *Overheating, which can lead to thermal runaway. *Overcurrent, which can cause electrical failures.

8. *System Recovery:*

Once the unsafe condition is resolved, the system automatically resumes normal operation. For example, if the temperature drops back to a safe level or the voltage returns to within limits, the relay is reactivated, and the charging process continues.

9. *Continuous Operation:*

The system operates continuously in a loop, ensuring that the battery is always monitored during charging. This real-time feedback and control mechanism enhances the safety, efficiency, and reliability of the EV battery charging process.

The combination of real-time monitoring, decision-making, and user feedback ensures that this BMS provides a robust solution for managing EV battery charging. The system protects the battery, improves its lifespan, and ensures optimal performance.

IV. COMPONENTS

Here are the components used in EV BMS Battery With Charge Monitor.

1. *Arduino Uno:*

The Arduino Uno is a microcontroller board based on the ATmega328P chip. It acts as the brain of the system, processing data from sensors and controlling outputs like relays and buzzers. The board has 14 digital I/O pins and 6 analog input pins, making it versatile for various applications. In this project, it reads voltage, current, and temperature values, processes the data, and controls the charging process. Its ease of programming and compatibility with numerous libraries makes it an ideal choice for this system.

2. *Voltage Sensor (Voltage Divider Circuit):*

The voltage sensor is implemented using a voltage divider circuit consisting of two resistors. It scales down the battery voltage to a range that can be safely read by the Arduino's analog input. The Arduino uses this input to calculate the actual battery voltage. This is crucial for monitoring the battery's charging status and ensuring the voltage remains within safe limits.

3. *Temperature Sensor (LM35):*

The LM35 is an analog temperature sensor that provides a linear output proportional to the temperature in Celsius. It is connected to the Arduino's analog pin and monitors the battery's temperature during charging. This helps to prevent overheating, ensuring safe operation. The sensor is highly accurate and requires no external calibration, making it easy to integrate.

4. *Current Sensor (ACS712):*

The ACS712 is a Hall-effect-based current sensor that measures the current flowing through the battery during charging. It outputs a voltage proportional to the current, which is read by the Arduino. This component helps monitor current levels and prevent overcurrent conditions, enhancing the battery's safety and lifespan.

5. *Relay Module:*

The relay module acts as an electronic switch, controlling the power supply to the battery. The Arduino controls the relay based on sensor readings, turning it ON or OFF to manage the charging process. The relay provides electrical isolation between the high-voltage battery circuit and the low-voltage Arduino circuit, ensuring safety.

6. *Buzzer:*

The buzzer provides audible alerts when unsafe conditions are detected, such as overvoltage, overcurrent, or overheating. It is controlled by the Arduino and serves as a warning mechanism to inform users of potential battery hazards. The buzzer's small size and simple connection make it a reliable addition to the system.

7. ***I2C LCD Display:***

The I2C LCD display is a 16x2 module that uses the I2C communication protocol for efficient data transfer. It displays real-time information about voltage, temperature, and current, allowing users to monitor the charging process.

8. ***Resistors (R1, R2):***

Resistors are used in the voltage divider circuit to step down the battery voltage to a safe level for the Arduino. Their values are chosen carefully to ensure accurate voltage scaling. They play a crucial role in protecting the Arduino's analog input pins from high voltage.

9. ***Power Supply:***

The power supply provides the necessary energy to operate the Arduino and other components. For this project, a regulated 5V or 12V power supply is used.

10. ***Connecting Wires:***

Connecting wires are used to establish electrical connections between various components. They ensure efficient signal transfer and power delivery throughout the system.

V. CONCLUSIONS

The EV Battery Management System (BMS) with Charge Monitoring project provides a robust solution for managing and optimizing the charging process of rechargeable batteries, ensuring safe, efficient, and reliable operation. The system incorporates key features such as real-time voltage, temperature, and current monitoring, as well as safety mechanisms like overvoltage, overcurrent, and over-temperature protection. By continuously tracking critical parameters, the system enhances the longevity of the battery, prevents damage from unsafe conditions, and provides users with vital feedback through the LCD display.

Through its easy-to-understand interface and cost-effective components, the system offers a highly adaptable solution for a range of applications, from electric vehicles (EVs) to renewable energy storage systems, power tools, and consumer electronics. The ability to monitor and manage battery health in real-time empowers users to make informed decisions about charging, maintenance, and usage, extending battery life and reducing the risk of costly replacements or failures.

Overall, the EV Battery Management System with Charge Monitoring is an effective, reliable, and user-friendly tool that enhances battery performance and safety while reducing the risk of damage or failure. With future improvements and integrations, it holds great promise in the ever-evolving field of energy storage and management, helping users optimize the performance and longevity of their batteries across various industries and applications. The project serves as a stepping stone towards creating more intelligent and sustainable battery management solutions that can meet the growing demands of modern energy systems and electrification.

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