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Electrical Vehicle Battery and Fire Projection Management System

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Abstract

A battery management system (BMS) is an essential component of electric vehicles (EVs) and other devices powered by batteries. By controlling and monitoring its functioning, it ensures the battery pack's longevity, safety, and maximum performance. Since it stores the energy required for an electrical vehicle to operate, battery storage is the most crucial component of any electrical vehicle. Therefore, an effective battery management system is required to maximize a battery's output and guarantee its safe functioning.

The "Electrical Vehicle Battery and Fire Protection Management System" project focuses on developing a comprehensive safety and monitoring system for electric vehicle (EV) batteries. Utilizing an Arduino Uno microcontroller, this system integrates various sensors to continuously monitor the health and performance of the EV battery. Key components include a current sensor for measuring current flow, a voltage sensor for tracking battery voltage levels, and a Dallas temperature sensor (DS18B20) to monitor the battery temperature. In case of abnormal readings such as high temperature or overvoltage, the system triggers a 5V relay to disconnect the battery and prevent further damage or potential fire hazards. A CPU fan is also integrated to help cool the battery when temperatures rise above safe levels. A buzzer provides an audible alert for the user in case of any critical conditions. The system displays real-time data on an LCD screen, offering an interface for monitoring battery conditions. By ensuring timely detection of critical issues such as overheating, this system enhances the safety and reliability of electric vehicle batteries, preventing potential fire hazards and maximizing the battery’s lifespan.

Keywords: Electric Vehicle(EV), Lithium-ion battery, BMS, Aurdino UNO

1. Introduction

The "Electrical Vehicle Battery and Fire Protection Management System" is designed to address the critical need for safety and monitoring in electric vehicle (EV) batteries. Ensuring the dependability and security of electric vehicles' battery systems has become crucial due to their growing popularity.

This project integrates advanced monitoring technologies to safeguard against potential hazards such as overheating and electrical faults. By utilizing an Arduino Uno microcontroller, along with sensors for current, voltage, and temperature monitoring, the system provides real-time feedback on battery health and performance. In the event of abnormal readings, the system can trigger protective actions, such as disconnecting the battery and activating cooling mechanisms, to prevent damage or fire risks. This comprehensive solution aims to enhance both the safety and longevity of EV batteries, providing users with peace of mind and reliable performance.

The "Electrical Vehicle Battery and Fire Protection Management System" is designed to address the critical need for safety and monitoring in electric vehicle (EV) batteries. With the increasing adoption of electric vehicles, ensuring the reliability and safety of their battery systems has become paramount. This project integrates advanced monitoring technologies to safeguard against potential hazards such as overheating and electrical faults. By utilizing an Arduino Uno microcontroller, along with sensors for current, voltage, and temperature monitoring, the system provides real-time feedback on battery health and performance. In the event of abnormal readings, the system can trigger protective actions, such as disconnecting the battery and activating cooling mechanisms, to prevent damage or fire risks. This comprehensive solution aims to enhance both the safety and longevity of EV batteries, providing users with peace of mind and reliable performance.

1.1 Literature Survey

The electric vehicle (EV) industry has made lithium-ion batteries its mainstay because of their exceptional energy and power density, long lifespans, high voltage output, and low rates of self- discharge.

However, because to their aging and sensitivity to temperature changes, these batteries require careful management to avoid physical damage, thermal runaways, and premature aging. (Bhowmik et al., 2020).

A crucial component of EVs' proper operation, especially when it comes to protecting lithium-ion batteries, is the Battery Management System (BMS). Numerous duties are required by an efficient BMS, including user interface feedback, data acquisition, temperature regulation, communication with battery components, , prolonging battery life, fault diagnosis and handling.

Suyash S. Hujare Vol. 12, Issue 4, April 2024 Introduced a battery management system (BMS) that monitors voltage and temperature to prevent battery failures. While effective in data collection, these systems often lack real -time danger prevention mechanisms. Other researchers have discovered IOT-based battery monitoring, where data is sent to cloud platforms for remote access. However, IOT-based solutions rely on Internet connectivity, making them less reliable in remote areas where network coverage is limited.

Another important area of research focuses on GPS-based vehicle tracking for theft and navigation. Studies have shown that integrating GPS with GSM allows real -time tracking, which is beneficial for emergency response. However, most existing GPS-based systems do not include battery safety features, leaving a difference in real-time danger and prevention.

Several studies have investigated the detection of fire and overheating in the lithium-ion battery using temperature and flame sensors to detect potential hazards. While these systems effectively identify overheating conditions, they often lack automatic response mechanisms. Research has shown that applying active cooling systems can help regulate the battery temperature, but many existing designs do not include automatic control.

Our proposed system creates battery safety monitoring, automatic cooling, fire dangerous prevention, GSM-based SMS alerts, and GPS tracking by integrating in a single, cost- affected solution on these existing studies. Unlike previous approaches, it ensures real -time danger detection, immediate response and distance monitoring without the need for internet connectivity. The purpose of this research is to provide an efficient and practical solution to improve EV security through an automated and intelligent monitoring system.

1.2 Existing System

Currently, electric vehicle (EV) battery management systems often rely on manual checks and basic monitoring mechanisms that track only battery voltage or temperature. These systems may not provide real-time monitoring or address multiple critical parameters like current flow or overheating in a comprehensive manner. Drawbacks of existing methods include delayed response times to overheating or voltage fluctuations, lack of automated safety measures to prevent potential fire hazards, and limited monitoring capabilities, often requiring manual intervention. Additionally, many existing systems do not offer continuous feedback on battery health or provide alerts when the battery is at risk, making them less efficient in terms of long-term battery protection and safety.

1.2 Proposed System

The proposed system integrates real-time monitoring of battery voltage, current flow, and temperature using a combination of sensors, including Dallas temperature sensor (DS18B20), voltage sensor and current sensor.

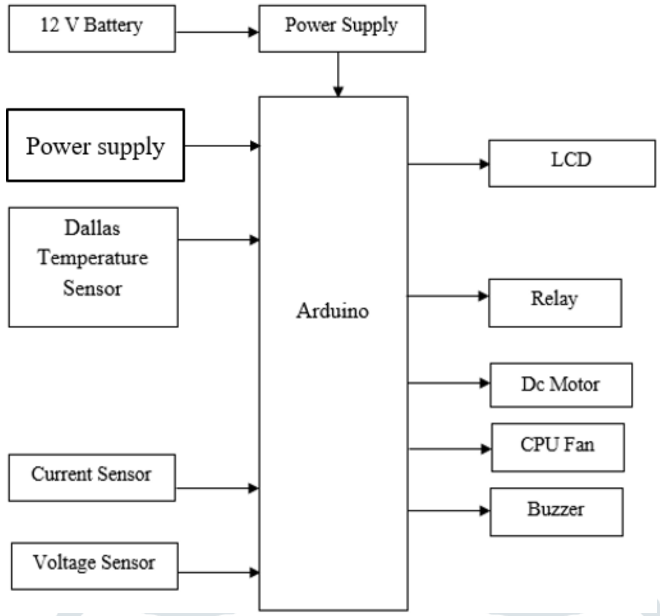

Figure 1: Block Diagram for proposed method

The system is controlled by an Arduino Uno microcontroller, which continuously checks these parameters and activates safety measures like a CPU fan for cooling or a 5V relay to disconnect the battery if critical thresholds are exceeded. In case of hazardous conditions, such as overheating or excessive voltage, the system triggers a buzzer for an alert and disconnects the battery to prevent damage or fire hazards. The system's data is displayed on an LCD, ensuring real-time visibility for users, making it a comprehensive solution for monitoring and protecting EV batteries.

System architecture and components

a. The system is designed using the following components:

i. **Arduino UNO**: Acts as a central controller, processes the sensor data and triggers automated actions.

ii. **Voltage Sensor**: Overvoltage monitors the battery voltage to detect conditions.

iii. **Temperature Sensor (Dallas DS18B20):** Continuous measuring battery temperature to prevent overheating.

iv. **Fire Sensor**: Finds the dangers of fire and triggers emergency functions.

v. **Cooling Fan**: If the battery temperature is more than 75 ° C, it is automatically turned on.

vi. **Motor Control Relay**: In case of fire detection, the motor cuts power.

vii. **Current Sensor**: This enable real-time monitoring of current flow, ensuring system stability, safety and efficiency.

viii. **LCD**: This process enables the display of text with high clarity and energy efficient.

ix. **Buzzer**: Buzzer is used as alarm to notify the abnormal condition raised in the system.

x. **Relay**: It is used to control high-power device with a low-power signal.

b. Sensor data acquisition and processing

The system consistently reads sensor data and checks for unusual situations: The voltage sensor measures the battery voltage, ensuring that it remains within a safe range. The temperature sensor tracks the heat level of the battery. If the temperature crosses 75 ° C, an automatic cooling fan is active. The fire sensor detects the dangers of fire. If the fire is detected, the system immediately cuts the motor power to prevent further risks.

c. Automatic Dangerous Prevention and Control

If overheating is detected, the cool fan is turned on to reduce the temperature. If the fire is detected, motor power is cut to prevent further damage. These safety mechanisms operate autonomous, without the need for user intervention.

d. Remote Notification and Location Tracking

When an abnormal situation is detected, the GSM module sends SMS alerts to the user or emergency contacts. The message includes details such as temperature, fire detection status and battery voltage. The GPS module provides real -time space tracking, allowing users to detect vehicles in an emergency.

e. Implementation and Testing

The system is tested under various circumstances including overheating, fire detection and unusual voltage levels to verify automatic responses and remote information efficiency. The response time for activating the cooling fan, cutting the motor and sending SMS alert is measured to ensure real

-time operation. This functioning ensures continuous monitoring, immediate danger prevention and efficient emergency response, making the system a reliable solution for EV battery safety and tracking.

2. Related works

Energy Management in Embedded Systems:

- Studies on optimizing power consumption in microcontroller-based systems using multiple power supplies for improved efficiency.

Arduino-Based Control Systems**:**

- Research papers highlighting Arduino applications in automation, environmental monitoring, and industrial control.

Sensor Integration Projects:

- Projects integrating temperature, voltage, and current sensors for real-time monitoring in smart home, healthcare, and industrial systems.

Battery-Powered Systems in Electronics:

- Techniques for stabilizing voltage and current in battery-operated devices to ensure component longevity and reliability.

Dual Power Supply Architectures:

- Research addressing the advantages of dual power supplies in maintaining system stability and ensuring critical components are consistently powered.

Motor and Fan Control Techniques:

- Existing methodologies for controlling DC motors and fans in embedded designs for efficient thermal management.

Alert and Notification Systems:

- Studies showcasing the implementation of buzzers and LCD displays for real-time alerts and system status monitoring.

3. Methodology

This project focuses on developing a reliable and efficient safety and monitoring system for electric vehicle (EV) batteries. The scope encompasses designing a system that continuously monitors key parameters of the battery, such as voltage, current, and temperature, using advanced sensors and microcontroller integration. To ensure reliability, the system underwent rigorous testing under different conditions. Each component was calibrated to improve accuracy, and the response time of output devices was evaluated to ensure timely operation. This structured methodology ensures the system effectively manages power distribution, environmental monitoring, and automated control, making it suitable for various real-time applications.

By addressing critical safety issues like overheating, overvoltage, and potential fire hazards, the system ensures enhanced protection for EV batteries. The project leverages real-time data processing to detect abnormalities and triggers automated mechanisms, such as a relay system to disconnect the battery under unsafe conditions. Thermal management is an integral part of the system, achieved through a cooling mechanism that maintains the battery's temperature within safe operational limits. Additionally, the system incorporates user-friendly features, such as a visual interface on an LCD display and audible alerts through a buzzer, providing real time updates and warnings to users.

3. Results and Evaluation

The proposed system integrates real-time monitoring of battery voltage, current flow, and temperature using a combination of sensors, including Dallas temperature sensor (DS18B20), voltage sensor and current sensor.

The system ensures that the battery remains within safe voltage limits, preventing issues like overcharging or undercharging. When the voltage falls below a certain threshold, or if an over- voltage condition is detected, the Arduino triggers the buzzer to alert the user.

This helps prevent damage to the battery, ensuring its longevity and safety. In terms of current monitoring, the current sensor helps track the charging and discharging rates. By measuring the flow of current, the system can detect if the battery is being charged too quickly or discharging too heavily, which could lead to thermal stress or reduced battery life.

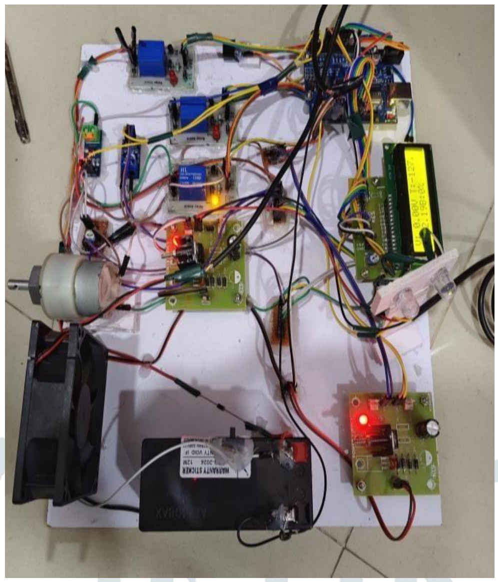

Figure 2: Result

Figure 3: Result

The temperature sensor is another key component, as it monitors the temperature of the battery, which can be a critical factor in battery health and safety. Elevated temperatures can lead to thermal runaway or even fire risks. The BMS system immediately alerts the user via the buzzer if the temperature exceeds a predefined safe level, helping to prevent overheating. This real-time temperature data, displayed on the LCD, also helps users make informed decisions about battery usage and charging cycles. As the temperature exceeds the level then immediately the fan gets on and makes the motor off and protect the vehicle. Overall, the system demonstrated robust performance in managing multiple devices with efficient power distribution. The combination of accurate sensing, stable power regulation, and reliable control mechanisms makes this design suitable for real-time applications in industrial automation, smart home systems, and environmental monitoring.

4. Discussion

The results obtained from the system's evaluation highlight the effectiveness of the proposed design in achieving reliable monitoring and control. The integration of a dual power supply system proved to be a significant factor in ensuring stable performance, especially when multiple output devices such as the DC motor, CPU fan, and buzzer operated simultaneously. This design effectively distributed the power load, preventing voltage fluctuations and ensuring consistent functionality.

The system's ability to respond promptly to temperature variations demonstrates its potential for applications in environments requiring active cooling mechanisms. The Dallas Temperature Sensor provided precise readings, enabling accurate control of the CPU fan to maintain optimal conditions. The inclusion of a buzzer further enhanced the system's reliability by providing immediate alerts during abnormal conditions.

While the system performed well in controlled environments, certain limitations were observed. For instance, the system's performance may vary under extreme temperature conditions or in environments with electrical noise interference. Additionally, the power consumption could be optimized further to enhance battery life, especially in continuous operation scenarios.

Future improvements may include implementing advanced algorithms to enhance the decision- making process and integrating wireless communication modules for remote monitoring and control. Overall, the system demonstrates a strong foundation for real-time applications, combining efficient power management, accurate sensing, and responsive control mechanisms.

6. Conclusion

In conclusion, the "Electrical Vehicle Battery and Fire Protection Management System" provides a comprehensive and effective solution for ensuring the safety and longevity of electric vehicle batteries. By continuously monitoring key parameters such as current, voltage, and temperature, the system can detect abnormal conditions in real-time and take corrective actions, such as disconnecting the battery or activating cooling mechanisms, to prevent overheating and fire hazards. The integration of a CPU fan, buzzer, and LCD display further enhances the system's

ability to protect both the vehicle and its user, ensuring a safer and more reliable electric vehicle experience while maximizing battery lifespan.

Through testing and evaluation, the system demonstrated reliable performance with minimal delays and accurate sensor readings. While the design performs well under standard conditions, future enhancements such as improved power optimization and remote monitoring capabilities can further expand its applications.

This project highlights the potential for integrating microcontroller-based designs in real-time monitoring systems, making it suitable for applications in home automation, industrial control, and environmental monitoring.

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