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Arduino-Based EV Battery Protection System Using Sensors and Safety Mechanisms

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A B S T R A C T :

Electric vehicles (EVs) are becoming the future of transportation, but their batteries are vulnerable to various hazards such as overheating, gas leaks, and fire incidents. To enhance the safety of EVs, this project proposes an Arduino-based EV battery protection system utilizing DHT11, gas sensor, and flame sensor to monitor temperature, gas leakage, and fire, respectively. Additionally, the system integrates an air cooling mechanism, a carbon dioxide extinguisher system, a central lock breaching system, and a buzzer as an alert system. The real-time monitoring and automated response mechanisms provide an efficient way to prevent battery-related accidents and ensure user safety.

Keywords: Electric Vehicles, Arduino, Battery protection, Sensors

1. Introduction

With the rising popularity of electric vehicles (EVs), the safety of battery systems has become a major concern. Lithium-ion batteries, which power most EVs, are prone to thermal runaway, leading to overheating, gas emission, and even fire hazards. Traditional monitoring methods are often inadequate, necessitating an advanced automated protection system. This project aims to design a smart protection system using an Arduino microcontroller along with multiple sensors and safety mechanisms to ensure the safe operation of EV batteries. The growing use of electric vehicles is driven by the need for eco-friendly transport and better battery technology. However, EV batteries can overheat, release harmful gases, or catch fire, posing safety risks. Lithium-ion batteries, commonly used in EVs, can fail dangerously if not monitored properly. Ensuring battery safety helps prevent accidents, extend battery life, and boost consumer trust. Most EV battery protection systems only monitor risks without taking action. A better approach is to use an active system that detects dangers and responds immediately. This study proposes an Arduino-based EV battery protection system that uses sensors and automatic safety features to improve battery safety [1].

The system includes a DHT11 sensor for temperature and humidity, a gas sensor for detecting emissions, and a flame sensor for fire hazards. To counter these risks, it has an air cooling system for temperature control, a carbon dioxide extinguisher for fire suppression, and a central lock breaching system for emergency access. A buzzer alerts users of dangers. An Arduino microcontroller processes sensor data and triggers safety actions when needed. This real-time monitoring and automated response system improves battery security and reliability.

The goal of this study is to create a low-cost, efficient battery protection system that reduces risks from overheating, gas leaks, and fire. Testing and simulations will show its effectiveness. By making EVs safer, this system supports the wider adoption of electric transportation [2].

The Battery Management System (BMS) in an electric vehicle (EV) is responsible for monitoring, protecting, and optimizing battery performance. It tracks key parameters such as voltage, current, temperature, and state of charge (SoC) to prevent overcharging, deep discharging, and overheating. The BMS ensures cell balancing by distributing charge evenly across all battery cells, which extends battery life and improves efficiency. It also manages thermal control to prevent overheating using cooling or heating mechanisms. Additionally, the BMS provides safety protection by detecting faults like overvoltage, undervoltage, and short circuits, taking corrective actions to prevent damage. It also estimates State of Health (SoH) and State of Charge (SoC) to optimize power usage and extend battery life, making it a crucial system for the safety, reliability, and efficiency of EV batteries [3][4].

2. Methodology

The proposed system consists of hardware and software components that work together to detect and mitigate potential hazards.

2.1. Hardware Components:

The Arduino microcontroller serves as the brain of the system, collecting data from various sensors and triggering safety mechanisms when necessary. The DHT11 sensor monitors battery temperature and activates the air cooling system if overheating is detected. A gas sensor detects harmful emissions, while a flame sensor identifies fire hazards and triggers the carbon dioxide extinguisher to suppress flames. In case of severe danger, the central lock breaching system unlocks the battery compartment for emergency access. Additionally, a buzzer provides an audible alert to warn users of any detected hazards, ensuring enhanced safety and quick response in critical situations [5]

2.2. Software Implementation:

The Arduino microcontroller continuously reads data from the sensors. Predefined threshold values for temperature, gas levels, and flame detection are set in the microcontroller. When an abnormal condition is detected, the corresponding safety mechanism is activated automatically. The system can also send alerts to a connected display or mobile device for user awareness.

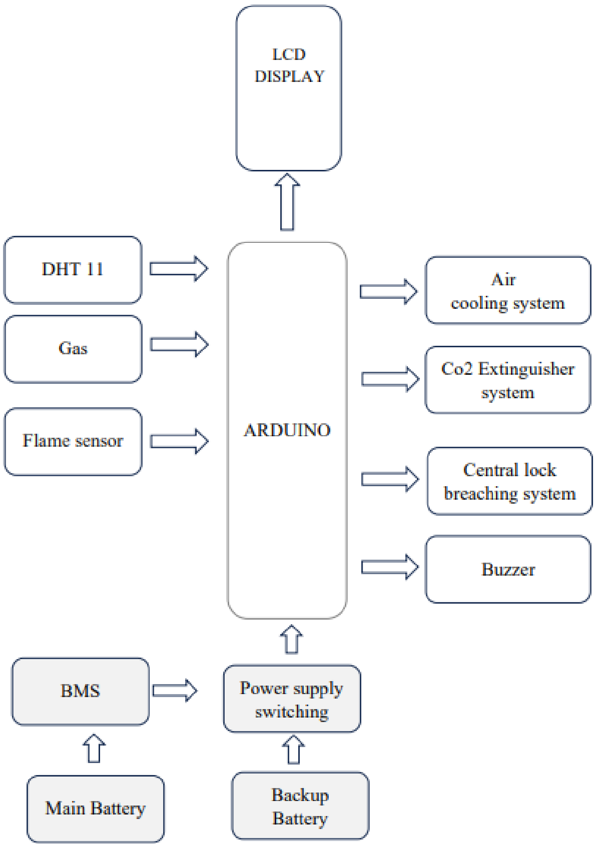

Fig. 1 - Block Diagram of presented system.

3. Results and Discussion

The implemented system successfully detects and responds to various hazardous conditions affecting EV batteries.

The DHT11 sensor effectively monitors temperature changes, and the air cooling system activates accordingly to prevent overheating. The gas sensor accurately detects harmful gas emissions, triggering an alert and ensuring timely intervention. The flame sensor provides a rapid response to fire hazards, activating the carbon dioxide extinguisher system to suppress potential flames. The central lock breaching system proves crucial in ensuring passengers' safety during emergencies by allowing easy exit. The buzzer alert system enhances user awareness by providing immediate audible warnings in case of abnormalities. The integration of these components ensures a multi-layered safety approach, reducing the risk of battery failure and enhancing overall EV safety.Equations and formulae should be typed in Mathtype, and numbered consecutively with Arabic numerals in parentheses on the right hand side of the page (if referred to explicitly in the text). They should also be separated from the surrounding text by one space.

4. Conclusion

This project successfully demonstrates an efficient Arduino-based EV battery protection system capable of detecting overheating, gas leaks, and fire incidents in real-time. The combination of sensors and automated safety mechanisms such as air cooling, fire suppression, emergency unlocking, and alerts significantly enhances the security of EVs. Future enhancements could include wireless communication for remote monitoring and AI-based predictive maintenance for further efficiency improvements. The proposed system is a promising solution for ensuring the safe operation of electric vehicle batteries and mitigating potential hazards effectively.

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