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IoT Based EV Safety System for Fire Prevention and Multiple Fault Detection

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ABSTRACT: This work presents an IoT based electric vehicle safety system focused on fire prevention and multiple fault detection. The proposed system continuously monitors critical parameters including battery temperature, voltage, current, smoke, and gas leakage to identify abnormal operating conditions at an early stage. A microcontroller processes sensor data and triggers protective actions such as battery isolation, cooling activation, and alarm generation when unsafe thresholds are exceeded. Real time data is transmitted to a cloud platform for remote monitoring and instant alerts through a mobile application. The system enhances vehicle reliability, reduces fire risk, and supports predictive maintenance and reliability enhancement, thereby improving overall safety and user confidence in electric vehicles.

1. Introduction

IoT-based systems represent a significant advancement in electric vehicle (EV) safety by integrating continuous sensing, real-time data acquisition, and intelligent decision-making. By monitoring critical battery parameter such as temperature, voltage, current flow, smoke, and gas leakage these systems can proactively identify abnormal operating patterns that signal internal faults or environmental risks. When safety thresholds are breached, microcontrollers can immediately initiate automated protective actions, including isolating the battery, activating cooling mechanisms, and alerting the driver, thereby preventing catastrophic failures without human intervention. Furthermore, cloud connectivity enhances this architecture by enabling remote health monitoring for owners and fleet operators. Real-time alerts via mobile or web applications ensure prompt responses to emerging issues, while long-term data storage facilitates predictive maintenance by identifying recurring fault patterns. The modular nature of these IoT frameworks also ensures scalability, allowing for future integrations of machine learning-based anomaly detection and adaptation to evolving regulatory standards. Ultimately, by providing a transparent and reliable safety framework, IoT-driven systems address consumer concerns regarding battery fires, fostering greater user confidence and accelerating the global transition to sustainable transportation.

2. Objectives

To design and develop an IoT based safety system for electric vehicles to prevent fire hazards and detect multiple faults effectively. To continuously monitor battery temperature, voltage, current, smoke, and gas parameters in real time. To identify abnormal conditions at an early stage and initiate automatic protective actions such as battery isolation and alerts. To enable remote monitoring through cloud connectivity and mobile applications. To improve battery life, support predictive maintenance, increase overall user confidence in electric vehicle safety systems for modern sustainable transportation ecosystems worldwide. Safety, confidence, and independence for visually impaired individuals during daily navigation.

3. Literature Survey

The IoT-based electric vehicle (EV) safety system highlights a significant shift from traditional, reactive protection circuits to intelligent, proactive monitoring frameworks. Recent research by Arun Kumar P. and Shalini S. S. (2025) emphasizes the integration of AI-driven fault diagnosis with IoT to identify thermal anomalies and internal short circuits more accurately than threshold-based systems. Similarly, Nathiya S. et al. (2025) propose using machine learning to distinguish between normal operational variations and critical safety risks, thereby reducing false alarms.

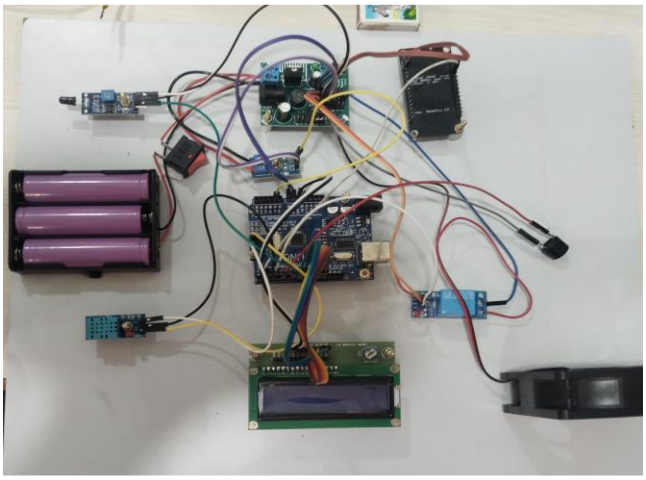
Safety during charging is another focal point, with Sanjana R. et al. (2025) introducing proactive charging schedulers that detect short circuits in real-time, while Jegatheesan K. et al. (2025) focus on dynamic cooling systems triggered by real-time heat sensing to prevent battery degradation. Centralized management is explored through platforms like Smart Drive, which unifies various vehicle subsystems into a single IoT ecosystem for simplified fault detection and improved coordination. Yamuna K. et al. (2025) demonstrate the benefits of integrating driver safety monitoring and adaptive speed control within the IoT framework to prevent accidents caused by fatigue. Studies by Kabilamani P. (2025) on wireless charging stations and Bharathiraja M. et al. (2025) on fire-specific safety management further underscore the role of cloud connectivity in providing remote alerts and long-term data logging for predictive maintenance. Collectively, these works confirm that combining real-time sensing with cloud-based intelligence is essential for addressing the safety challenges of modern sustainable mobility.

3.1 Proposed Methodology

The proposed methodology for the IoT-based EV safety system centers on a proactive, multi-layered approach to fire prevention and fault detection. The system architecture is designed around an ATmega328P microcontroller, which serves as the central processing unit to coordinate sensing, decision-making, and communication. The core process begins with continuous real-time data acquisition from a distributed sensor network that monitors critical battery health indicators, including voltage, temperature, and the presence of flames. This monitoring layer is essential for the early identification of abnormal patterns such as thermal runaway or overcharging that precede catastrophic failures.

Once collected, the sensor data is processed locally by the microcontroller and compared against predefined safety thresholds. If these limits are breached, the system is programmed to bypass human intervention and immediately trigger autonomous protective actions. These responses include activating a relay module to physically isolate the battery from the load, engaging cooling mechanisms to mitigate heat, and providing local feedback through an LCD display and audible buzzer alerts.

The methodology leverages an ESP8266 Wi-Fi module to bridge the vehicle with a cloud-based platform. This IoT integration allows for the seamless transmission of real-time diagnostics and the delivery of instant alert notifications to mobile applications, ensuring users remain informed even when the vehicle is unattended. Furthermore, the system utilizes cloud storage to log historical operational data, creating a robust foundation for long-term trend analysis and predictive maintenance strategies. This integrated framework of local embedded intelligence and remote connectivity provides a scalable, cost-effective solution for enhancing the reliability and safety of modern electric mobility



4. Results and Discussion

The implementation results of the proposed IoT-based electric vehicle safety system demonstrate exceptional performance in continuous monitoring, fault detection, and protective response. By accurately processing real-time data from voltage, temperature, and flame sensors, the microcontroller maintained stable operations under normal conditions while providing transparent local monitoring via an LCD display. When abnormal conditions such as elevated temperatures or voltage fluctuations were introduced during testing, the system responded instantly. The embedded control logic successfully initiated critical safety measures, including activating relays to isolate the battery, triggering audible buzzers, and displaying fault messages, thereby preventing potential escalation. A key highlight of the results is the seamless integration of the IoT module, which facilitated the real-time transmission of sensor data to a cloud platform. This connectivity enabled reliable remote monitoring through a mobile interface, ensuring that instant alert notifications reached users even when the vehicle was unattended. Furthermore, the system successfully logged historical data, providing a robust foundation for analyzing operational trends and fault occurrences. Over extended testing periods, the system exhibited high stability and precision, with no false alarms, confirming the accuracy of its sensor calibration and threshold configurations. Ultimately, these findings validate the system's modular design and its ability to provide a practical, cost-effective, and reliable solution for early fire detection and battery safety. By combining local hardware intelligence with cloud-based awareness, this architecture significantly enhances the safety standards and operational reliability required for modern electric vehicle environments.

4.1 Preparation of Figures and Tables

Fig 1. illustrates the architecture of an IoT based electric vehicle safety and monitoring system designed to detect abnormal battery conditions and initiate protective actions in real time. The system is centered around an ATmega328P microcontroller, which serves as the main processing and control unit. All sensing, decision making, actuation, and communication functions are coordinated through this controller, enabling reliable and autonomous operation of the safety framework. The diagram represents the interaction between power supply components, sensing modules, output devices, and IoT connectivity elements in a structured and systematic manner.

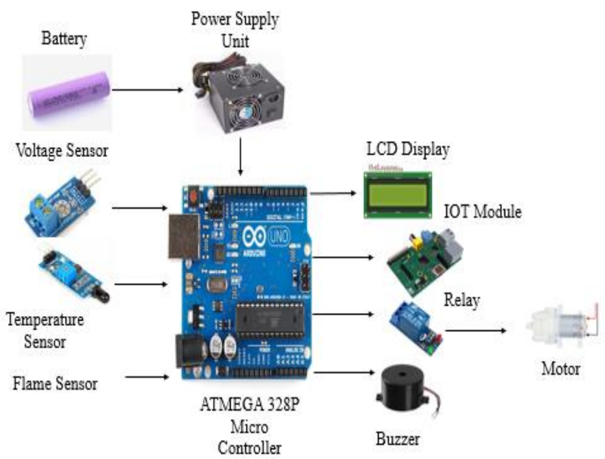


Figure 1: *Block Diagram*

4.1.1 Formatting Tables

Table 1 summarizes the hardware architecture and components of the IoT-Based EV Safety System is built upon a modular framework that integrates intelligence, sensing, and automated protection. At its core, the ATmega328P microcontroller serves as the system's brain, processing real-time data from a specialized sensing layer consisting of voltage, DHT11 temperature, and flame sensors. These sensors work in unison to detect critical threats such as overvoltage, thermal runaway, or active combustion. To ensure a proactive response, the system utilizes a relay module to physically isolate the battery during faults, while a buzzer and 16x2 LCD provide immediate audible and visual alerts to the driver. This hardware setup is further enhanced by the ESP8266 Wi-Fi module, which bridges the gap between the vehicle and the cloud, enabling remote monitoring and data logging. Supported by a stable regulated power supply, this integrated hardware solution ensures continuous, reliable operation, effectively transforming a standard battery setup into an intelligent, safety-monitored system.

Table 1: *Hardware Components Used*

Component	Specification	Function
ATmega328p	5v I/P,32kb Memory, speed:16MHz	Process the sensor data
Lithium-ion Battery	High energy Density	Primary energy source.
ESP8266	Wi-Fi enabled	Remote Monitoring, Data processing
DHT11	Temp range:0-50	Tracks thermal variation
Relay Module	Electromagnetic switch	Automatically Isolates
Power Supply	Regulates raw input into stable +12V and +5V DC outputs	stable voltage supply for the microcontroller and peripheral modules
Liquid Crystal Display(16x2 LCD)	16 characters x 2 lines; 5V DC supply;	Provides local visual feedback of system parameters
	5x8 pixel character size	messages for users.
Buzzer	Audible Alarm	Delivers clear audible warning
Flame Sensor	3.3V to 5V DC	Detect flame on battery. Enhance signal give to the system.

5. Conclusion

This conclusion highlights the design and implementation of an IoT-based electric vehicle (EV) safety system dedicated to battery protection, fault detection, and fire prevention. By integrating a suite of sensors, a microcontroller, and cloud connectivity into a unified framework, the system successfully monitors critical parameters such as voltage, temperature, and flame presence. The experimental results confirm that the architecture identifies abnormal operating conditions early, allowing for a reliable and prompt response to potential hazards. A central strength of the system is its automated protective capability. By facilitating immediate battery isolation, alarm generation, and status indications, the system ensures that faults are addressed autonomously before escalating into catastrophic failures. This reduces the dependency on human intervention and significantly enhances operational safety. While a local LCD and buzzer provide immediate situational awareness for the user, the integration of IoT technology extends functionality by enabling real-time data transmission to a cloud platform. This connectivity addresses a common limitation in existing EV safety systems, which often lack remote monitoring capabilities. Furthermore, the cloud-based data storage supports long-term analysis and provides a foundation for future predictive maintenance strategies. The proposed system is characterized by its scalability, cost-effectiveness, and modular architecture, making it adaptable to various EV models and diverse operating conditions without requiring a total redesign. By improving the reliability and transparency of battery safety, this intelligent solution fosters greater user confidence and supports the global transition toward sustainable electric mobility. Ultimately, the successful combination of real-time sensing, embedded intelligence, and cloud connectivity represents a vital contribution to the safety and efficiency of modern electric vehicle technology. and offers potential for future enhancements such as advanced navigation intelligence and improved sensor integration.

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