



# EV Battery Fire Detection Using Smoke and Temperature Sensors

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**Abstract--** Electric vehicles (EVs) are increasingly used worldwide due to their environmental benefits and energy efficiency. However, battery-related fire accidents remain a major safety concern, mainly caused by thermal runaway, short circuits, and battery overcharging. Early detection of fire hazards is essential to prevent catastrophic damage and protect human life. This paper proposes a low-cost fire detection and suppression system for electric vehicle batteries using smoke and temperature sensors. The system integrates an MQ2 smoke sensor and a temperature sensor with a controller to monitor abnormal conditions in real time. When smoke or excessive temperature is detected, the system activates an alarm and triggers an actuator connected to a fire extinguisher to suppress the fire automatically. The proposed system improves safety by providing early warning and rapid response to potential battery fire hazards in EVs. The developed prototype demonstrates effective fire detection and response capabilities suitable for automotive and industrial safety applications.

**Keywords--**Electric Vehicles, Fire Detection System, Smoke Sensor, Temperature Sensor, Battery Safety, Arduino Controller.

## I. INTRODUCTION

The rapid growth of electric vehicles has significantly transformed the transportation sector. EVs rely heavily on lithium-ion battery systems that provide high energy density and efficiency. However, these batteries can be prone to thermal runaway, overcharging, and short circuits, which may lead to fire hazards.[2]

Battery fires are difficult to control because they involve high temperatures, toxic gases, and rapid flame propagation. Therefore, early detection and immediate response are critical to minimize damage and prevent loss of life.

Fire detection systems typically rely on sensors capable of identifying early signs such as smoke, abnormal temperature rise, or gas emissions.

Integrating such sensors with automatic fire suppression mechanisms can significantly improve vehicle safety.

This study proposes an EV battery fire detection system that combines smoke and temperature sensors with a microcontroller-based control system. When abnormal conditions are detected, the system activates an alarm and automatically releases a fire extinguishing agent.

## II. LITERATURE REVIEW

Several researchers have explored fire detection and prevention systems for industrial and automotive applications.

Kiruthika et al. (2023) proposed an Arduino-based vehicle fire protection system using

sensors and a fire extinguisher valve to detect and suppress fires automatically.

Gaikwad et al. (2022) developed a smoke and temperature monitoring system for industrial chimney protection that provides early warning signals during abnormal conditions.

Rakshit Shah et al. (2019) designed a smoke detection system integrated with a mobile notification system using a Wi-Fi module.

Habib et al. (2019) developed a smart fire alarm and extinguishing system using temperature and flame sensors with real-time alerts.

Although these systems provide fire detection capability, many existing solutions lack integrated automatic suppression mechanisms specifically designed for EV battery safety. This study aims to address this gap.[3]

## III. SYSTEM COMPONENTS

The proposed system consists of the following components:

### 3.1 Smoke Sensor (MQ2)

The MQ2 sensor detects smoke and combustible gases such as LPG, propane, and hydrogen. It provides both analog and digital outputs for integration with microcontrollers.



### 3.2 Temperature Sensor

The temperature sensor continuously monitors battery temperature and detects abnormal thermal conditions.

### 3.3 Relay Module

The relay module acts as a switching device that activates the fire suppression mechanism when triggered by the controller.

### 3.4 Buzzer

A buzzer provides an audible alarm to alert passengers or nearby personnel during fire detection.

### 3.5 Fire Extinguisher

An automatic extinguisher system releases fire suppression agents to control the fire.

### 3.6 Power Supply

A battery provides the required electrical power to operate the sensors and control system.

## IV. WORKING PRINCIPLE

The system continuously monitors environmental conditions around the EV battery using smoke and temperature sensors.

1. The temperature sensor measures battery temperature.
2. The MQ2 sensor detects smoke or combustible gases.
3. Sensor signals are transmitted to the controller.
4. If smoke or temperature exceeds a predefined threshold:
  - The buzzer activates to provide an alert.
  - The relay module triggers the actuator.
  - The actuator releases the fire extinguishing agent.

This process ensures early fire detection and rapid suppression to prevent the spread of fire.

## V. DESIGN METHODOLOGY

The system design follows the following steps:

1. Selection of sensors suitable for fire detection.
2. Integration of sensors with the controller.
3. Development of control logic for threshold detection.
4. Integration with a fire extinguishing system.
5. Prototype fabrication and testing.

The design emphasizes reliability, low cost, and ease of installation in EV battery compartments.

## VI. ADVANTAGES

- Early fire detection
- Automatic fire suppression
- Low cost implementation
- Easy installation
- Improved EV safety
- Reduced risk of battery explosions

## VII. APPLICATIONS

- Electric vehicles
- Battery storage systems
- Industrial electrical panels
- Charging stations
- Substations and power control rooms

## VIII. FUTURE SCOPE

Future improvements can include:

- IoT-based fire monitoring system
- GSM alerts to emergency services
- AI-based fire prediction
- Integration with vehicle safety systems

## IX. CONCLUSION

The proposed EV battery fire detection system provides an effective solution for early detection and suppression of fire hazards in electric vehicles. By combining smoke and temperature sensors with automatic fire extinguishing mechanisms, the system improves vehicle safety and reduces the risk of catastrophic fire accidents. The prototype demonstrates reliable performance and can be further enhanced using IoT technologies for real-time monitoring and remote alerts.

## REFERENCES

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