



ESP32 BASED PORTABLE FIRE DETECTION AND AUTOMATED SUPPRESSION SYSTEM

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Abstract : ESP32-Based portable fire detection and automated suppression system is an advanced battery-powered fire safety solution delivers rapid detection and automatic suppression during fire emergencies. Utilizing an ESP32 microcontroller with MQ-6 smoke sensor, DHT11 temperature sensor, flame sensor and multi-sensor fusion algorithms, the system identifies early fire indicators (smoke >2000 ppm, temperature >60°C, flame detection) and activates visual and auditory alerts through red/green LED status indicators and a buzzer. Upon sustained detection, it triggers a relay after 60 seconds to activate a water motor, releasing water from a connected source for effective fire suppression without human intervention. The fully wireless, battery-operated architecture (2× 18650 Li-ion cells) supports flexible deployment in remote locations, with real-time sensor monitoring, adaptive thresholds, and deep sleep modes ensuring 20-hour reliability. This low-cost, scalable prototype integrates ESP32 processing with electromagnetic actuation to meet modern safety standards, innovating portable fire protection for human life and property.

Index Terms - ESP32 microcontroller, MQ-6 smoke sensor, DHT11 temperature sensor, Flame sensor, Relay module.

I. INTRODUCTION

Fire accidents are a major cause of property damage, environmental loss and threats to human life in residential, commercial and industrial environments. Traditional fire safety systems often depend on manual monitoring or standalone alarms that only provide warnings without initiating suppression. In many situations, delayed human response increases the severity of damage. Therefore, there is a growing need for intelligent fire protection systems capable of early detection and immediate automated action.

Advancements in embedded systems and sensor technology have enabled the development of smart monitoring systems that continuously track environmental parameters. Sensors such as gas sensor, temperature sensor, and flame sensor provide real-time data that can be processed by microcontrollers to identify fire hazards accurately. A sudden rise in temperature, the presence of combustible gases and infrared radiation from flames are key indicators of fire conditions. Combining multiple sensors improves detection reliability and reduces false alarms.

The ESP32 microcontroller has become a widely used and cost-effective platform for smart safety applications due to its high processing capability, low power consumption, and support for various peripherals. When integrated with appropriate sensors, it can efficiently monitor fire-related parameters and control external devices. Unlike conventional alarm systems, integrating an automatic suppression mechanism helps limit fire spread at an early stage.

This project proposes an ESP32-Based Portable Fire Detection and Automated Suppression System that integrates multi-sensor monitoring with automatic water pump activation. The system continuously observes gas concentration, temperature variation and flame presence, generating alerts when abnormal conditions are detected. A 60-second delay allows time for manual intervention before activating the suppression unit. The design is simple, economical and suitable for practical implementation in residential and small-scale commercial environments.

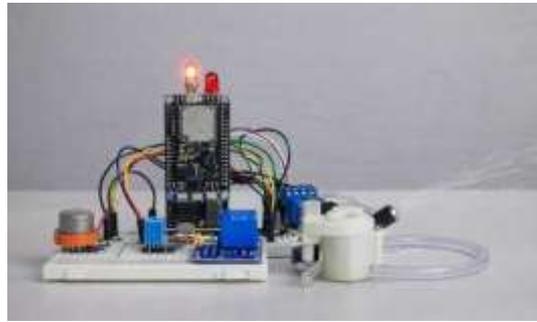


Figure.1. Illustration of the ESP32 based portable fire detection and automated suppression system.

II. LITERATURE REVIEW

Divya Shetty *et al.*, (2021) proposed an ESP32-powered automated car fire and gas detection system aimed at improving vehicle safety through continuous monitoring. The system integrates gas and temperature sensors with the ESP32 microcontroller to detect fire-related conditions inside the vehicle. When abnormal levels are sensed, an alarm is activated and a suppression mechanism is triggered to control the fire. This method helps in preventing major fire accidents by providing early warning and automatic response.

Gupta *et al.*, (2020) introduced an ESP32-based smart fire safety device suggested to detect smoke, heat and flame in indoor environments. The system uses multiple sensors connected to the ESP32 to continuously monitor surrounding conditions. When fire indicators are detected, the system activates an alarm and sends alerts to users through wireless communication. This approach improves safety by providing early detection and real-time notification.

Kumar *et al.*, (2024) suggested a real-time IoT-based smoke, gas and fire detection system using ESP32 and the Blynk platform. The system employs smoke and gas sensors to sense hazardous conditions and sends the data to the ESP32 for processing. When fire-related parameters exceed safe limits, the system triggers an alarm and sends notifications to a mobile application. This solution enables users to monitor fire conditions remotely and respond quickly.

Nguyen *et al.*, (2025) described a combined beam-type flame sensor system integrated with an ESP32 microcontroller for early fire warning. The system continuously monitors flame intensity using optical sensing techniques. When flame signals are detected, the ESP32 processes the data and activates warning indicators. This design enhances early fire detection accuracy and reduces response time in critical environments.

Patel *et al.*, (2025) explained an ESP32-based fire extinguisher robot for mining applications that integrates gas sensors and a water pump mechanism. The robot detects hazardous gas levels and fire presence in mining areas and automatically activates the pump to suppress fire. The system improves safety in underground environments by reducing human exposure to dangerous conditions.

Rahman *et al.*, (2023) developed an ESP32 smart automatic fire extinguisher system using a DHT11 sensor and relay-controlled water pump. The system monitors temperature changes and detects fire-related conditions. When abnormal temperature levels are observed, the relay activates the pump to release water for fire suppression. This method provides an automatic and quick response to fire incidents.

III. DESCRIPTION OF EXISTING SYSTEM

The existing IoT-enabled flame and gas detection system continuously monitors environmental conditions through flame and gas sensors to detect fire, LPG leaks or smoke. The sensor signals are processed by a Wi-Fi-enabled microcontroller, which compares the values with predefined thresholds to identify hazardous conditions. When unsafe levels are detected, the system activates a local alarm such as a buzzer or LED and simultaneously sends alert notifications to a smartphone via the internet for remote monitoring. Powered by a regulated 5–9 V DC supply, the system enhances safety through early detection, on-site warning and real-time remote alerts, helping to reduce response time and minimize accident risks.

CHALLENGES IN THE EXISTING SYSTEM

One of the major challenges in the existing IoT-based flame and gas detection system is its complete dependence on alert-based response without any automatic suppression mechanism. The system only provides notifications and alarms, requiring human intervention to control the fire or gas leakage, which may delay action during emergencies. Another challenge is the possibility of false alarms caused by sensor sensitivity or environmental factors such as dust, humidity, or temporary smoke presence. Continuous Wi-Fi connectivity is also required for remote monitoring; network failure can prevent real-time notifications. Power supply interruptions may further reduce system reliability. Additionally, fixed threshold values limit adaptability to varying environmental conditions, making the system less efficient in dynamic situations. These limitations highlight the need for a more intelligent, autonomous and reliable fire safety system with automated response capability.

IV. PROPOSED SYSTEM

The proposed ESP32-Based Portable Fire Detection and Automated Suppression System is designed to overcome the limitations of conventional fire safety systems by integrating multi-sensor fire detection with an automatic suppression mechanism. The system utilizes the ESP32 microcontroller as the main control unit, which is connected to an MQ-6 gas/smoke sensor, a DHT11 temperature sensor and a flame sensor to ensure reliable and comprehensive fire detection. By combining readings from multiple sensors, the system improves detection accuracy and reduces false alarms. When fire conditions are detected, the system

immediately activates visual and audible alerts. A green LED indicates normal operation, while a red LED signals a fire alert. A buzzer is also triggered to warn nearby occupants.

In addition to detection and alerting, the system includes an automated fire suppression feature. After confirming a fire condition, a 60-second delay is initiated before activating the water pump motor. This delay allows occupants time to manually assess and extinguish minor fires, thereby minimizing unnecessary water discharge and potential property damage. If the fire persists beyond the delay period, the motor is automatically activated to suppress the fire, ensuring protection even in the absence of human intervention. The system is portable, cost-effective and suitable for residential, commercial and small-scale industrial applications. When the measured parameters exceed the predefined thresholds, the ESP32 activates the following alert and suppression mechanisms:

- Red LED – Indicates fire or smoke detection.
- Green LED – Indicates normal system status.
- Buzzer – Provides an audible alert during emergencies.
- Relay Module – Activates the water motor after a 60-second delay for automated suppression.

This system offers an intelligent, automated and scalable approach to fire detection and suppression. It not only provides immediate alerts but also promotes preventive safety measures through continuous environmental monitoring. The system's simplicity, affordability and ease of deployment make it suitable for diverse applications

BLOCK DIAGRAM

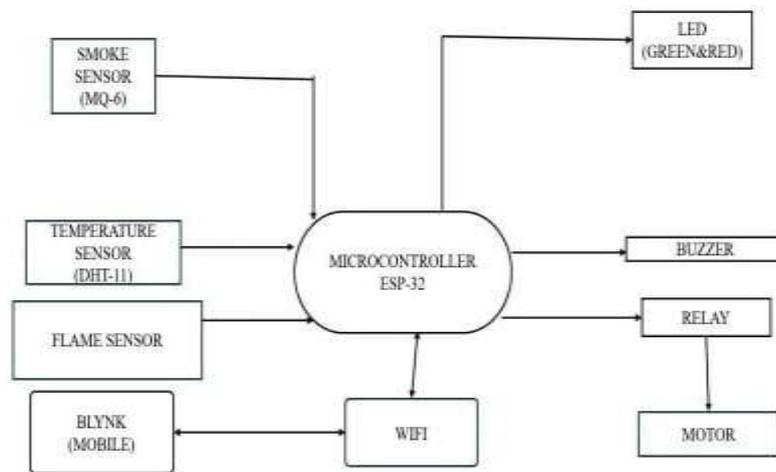


Figure.2. Block diagram of the Proposed system

A. HARDWARE IMPLEMENTATION

Below mentioned hardware components are used for the development of the Proposed System of ESP32 based portable fire detection and automated suppression system:

- ESP32 Microcontroller
- Smoke Sensor (MQ-6)
- Temperature Sensor (DHT11)
- Flame Sensor
- Red and Green LED
- Buzzer
- Relay Module
- Water Motor

1) ESP32 Microcontroller

The ESP32 is a powerful, low-cost microcontroller with built-in Wi-Fi and Bluetooth capabilities. It serves as the central processing unit of your water tank cleaning system. Operates at 3.3V logic level, can be powered via 5V input. The ESP32 development module is a powerful, low-cost microcontroller featuring a dual-core 32-bit operates at frequencies up to 240 MHz, providing exceptional processing capabilities for IOT applications. Figure 3 Shows the image of ESP32 Microcontroller.

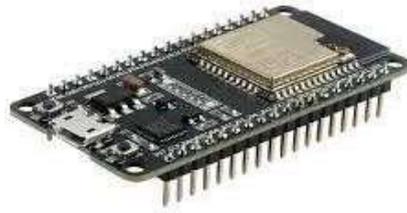


Figure.3. ESP32 Microcontroller

2) Smoke Sensor (MQ-6)

The MQ-6 is a metal oxide semiconductor (MOS) gas sensor designed specifically for detecting LPG, butane and propane gases. It is highly sensitive to liquefied petroleum gas and is commonly used in gas leakage detection systems. The sensor changes its resistance according to gas concentration, allowing early detection of combustible gases before ignition occurs. Figure 4 Shows the image of Smoke sensor.



Figure.4. Smoke Sensor (MQ-6)

3) Temperature Sensor (DHT11)

The DHT11 is a low-cost digital device designed to measure both temperature and humidity. It uses a thermistor to detect temperature and a capacitive humidity sensor to measure moisture levels. The sensor delivers calibrated digital signals and communicates via a single-wire communication protocol, allowing simple interfacing with microcontrollers like the ESP32. Figure 5 illustrates the DHT11 sensor.

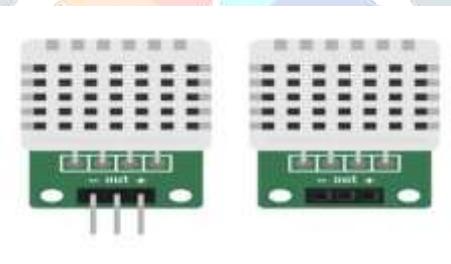


Figure.5. Temperature sensor (DHT11)

4) Flame Sensor

The Flame Sensor module is designed to identify fire or flame sources within a particular wavelength range. It is sensitive to infrared radiation emitted by flames (760nm – 1100nm). The module provides both Analog and digital outputs and is commonly used in fire detection and safety systems. Figure 6 Shows the image of Flame sensor.



Figure.6. Flame sensor

5) Red and Green LED

The LED (Light Emitting Diode) is used as a visual indicator to display the system status and alert when fire is detected. Red LEDs are typically used for fire alerts, while green or blue LEDs indicate normal operation. Figure 7 Shows the image of LED.



Figure.7. Red and Green LED

6) Buzzer

A buzzer is an electromechanical component that generates audible alerts. It consists of an electromagnetic coil that produces a magnetic field when current flows through it. This coil is attached to a thin metal or plastic diaphragm that oscillates to produce sound. When the coil energizes and de-energizes at audible frequencies, the magnetic field pulls and releases the diaphragm. This rapid movement creates vibrations in the air, producing sound waves. The buzzing or beeping noise is generated by these vibrations. Figure 8 shows a buzzer. Buzzers are commonly used in alarms, timers and electronic devices.



Figure.8. Buzzer

7) Relay Module

A relay module is an electrical switching device that enables low-voltage control signals from a microcontroller to manage high-voltage loads. It provides electrical isolation between the control circuit (ESP32) and high-power devices like water motors. Figure 9 Shows the image of Relay Module.

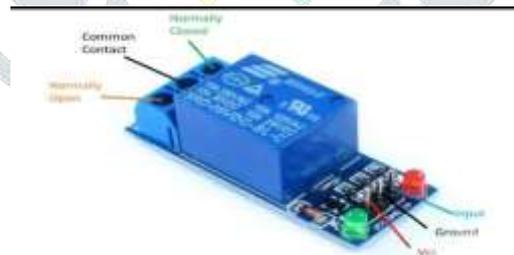


Figure.9. Relay module

8) Water Motor

A water motor (DC water pump) is used to pump water automatically when triggered by the control system. In fire suppression systems, it is activated through a relay to spray water when fire is detected. Figure 10 Shows the image of Water Motor.



Figure.10. Water Motor

B. WORKING OF PROPOSED SYSTEM

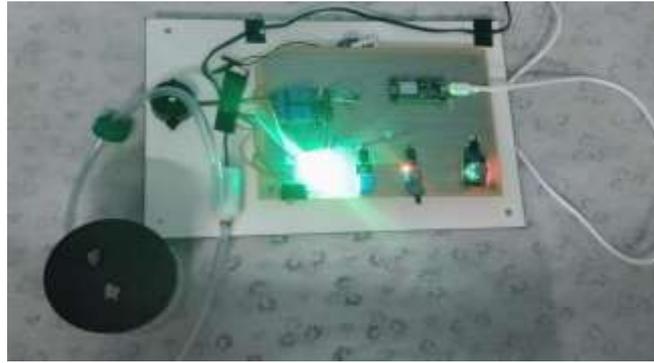


Figure.11. Proposed System

The proposed ESP32-Based Portable Fire Detection and Automated Suppression System works by continuously monitoring gas levels, temperature changes and flame presence using sensor connected to the ESP32. Based on inputs from the MQ-6, DHT11 and a flame sensor, the system detects fire conditions and activates visual and audible alerts. After a 60-second delay, the water pump is automatically triggered through a relay module.

C. OPERATION OF PROPOSED SYSTEM

The system begins its operation by continuously monitoring environmental conditions through sensors connected to the ESP32. The MQ-6 senses combustible gases, the DHT11 measures temperature variations and the flame sensor detects the presence of fire. During normal conditions, a green LED indicates safe status.

If any sensor reading exceeds its predefined threshold, the controller identifies a potential fire hazard and immediately activates a red LED and buzzer to alert occupants. A 60-second delay is then initiated to allow time for manual intervention. If the abnormal condition persists beyond this delay, a relay module is energized to switch on the water pump motor for fire suppression. Once the environment returns to safe levels, the pump and alert indicators are turned off and the system resumes monitoring. Adequate electrical isolation between the low-voltage control section and the high-power motor circuit ensures safe and dependable operation.

V. RESULTS AND DISCUSSIONS

Experimental testing was performed under controlled fire simulation conditions to evaluate detection accuracy, response time and suppression performance. The ESP32 continuously processed sensor inputs and compared them with predefined threshold limits. The MQ-6 identified combustible gas presence, the DHT11 monitored temperature increases and the flame sensor detected infrared radiation emitted by open flames. Alerts were triggered immediately after threshold values were exceeded. The programmed 60-second delay function executed as intended prior to motor activation. A relay module efficiently controlled the water pump while maintaining stable microcontroller operation. Proper electrical separation between the low-voltage control unit and the high-power motor circuit guaranteed operational safety. Despite minor fluctuations in sensor readings due to environmental variations, the system demonstrated stable and dependable performance. The use of multiple sensors enhanced detection reliability and minimized false alarms compared to single-sensor configurations.

VI. CONCLUSION

This project successfully demonstrates the design and implementation of an ESP32-Based Portable Fire Detection and Automated Suppression System using embedded and multi-sensor technology. By integrating the ESP32 with an MQ-6, a DHT11 and a flame sensor, the system enables real-time fire detection and automatic suppression. The 60-second delay mechanism allows manual intervention before activating the water pump, ensuring safety and minimizing unnecessary damage. Relay-based control and proper electrical isolation further enhance operational reliability. The project supports Sustainable Development Goal 9 by promoting innovative and cost-effective safety infrastructure and contributes to Sustainable Development Goal 11 by improving fire safety in residential and commercial environments. Overall, the system provides a practical, reliable and scalable solution for modern fire protection applications.

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