

Study On Fire Alarm System

Sujal Gongale, Amardip Raipure, Saurabh Zade, Ujwal Ratnaparkhi, Prof. Deepali Vaidya mam.

Abstract- A fire alarm system using a flame sensor is an advanced safety system designed to detect fire at an early stage by sensing infrared (IR) radiation emitted by flames. Unlike traditional smoke or heat detectors, flame sensors provide faster detection, especially in open environments. This paper discusses the working principle, components, advantages, and applications of flame sensor-based fire alarm systems. A fire alarm system using a flame sensor is an advanced safety system designed to detect fire at an early stage by sensing infrared (IR) radiation emitted by flames. Unlike traditional smoke or heat detectors, flame sensors provide faster detection, especially in open environments. This paper discusses the working principle, components, advantages, and applications of flame sensor-based fire alarm systems.

Keywords: Alarm System, Detection, Heat Detector, Fire, Smoke Detector, etc.

I. INTRODUCTION

A fire alarm system is an essential safety device designed to detect fire at an early stage and alert people to prevent accidents, loss of life, and property damage. Fire can spread rapidly, so early detection and warning are crucial for taking immediate action. Traditional fire alarm systems use smoke or heat detectors, but in this project, a Flame Sensor (FEM Sensor) is used for faster and more accurate fire detection. Traditional fire alarm systems mainly depend on smoke detectors and heat sensors. Although these systems are widely used, they may take time to respond, especially in open areas or situations where smoke is not produced immediately.

To overcome these limitations, flame sensor-based fire alarm systems have been developed. A flame sensor can directly detect fire by sensing the infrared (IR) radiation emitted by flames, allowing faster and more accurate detection. This project focuses on designing a fire alarm system using a flame sensor and a microcontroller. The system continuously monitors the environment and triggers an alarm when a flame is detected. It includes components such as a flame sensor module, buzzer, LED indicators, and a control unit. Such systems are simple, cost-effective, and easy to install.

II. WORKING FIRE ALARM SYSTEM

The Fire Alarm System is an automatic electronic device designed to detect the presence of fire or flame and alert people immediately through audible and visual signals. This system continuously monitors the surrounding area and responds instantly when a flame is detected. The core component of this system is the Flame (FEM) Sensor, which operates based on the principle of infrared (IR) radiation detection.



Figure 1: FLEM SENSOR

1. Principle Of Operation

All flames emit infrared radiation in a specific wavelength range of approximately 760 nm to 1100 nm. The FEM sensor is highly sensitive to this range of IR light and can detect the presence of fire even at a distance. When infrared light from a flame strikes the sensor's photodiode, it generates an electrical signal proportional to the intensity of the flame. The Arduino interprets the sensor signal and decides whether a fire is present or not. If a fire is detected,

the system activates a buzzer and an LED indicator to warn the occupants of the area.

2. Functional Stage Operation

Stage 1 – Power Supply Initialization

When the system is switched ON, the 5V regulated power supply energizes the Arduino and the sensor module. All components enter standby mode. During this time, the Arduino initializes its input and output pins:

- Input pin: Connected to the flame sensor output.
- Output pins: Connected to the buzzer and LED.

Stage 2 – Continuous Monitoring

In normal conditions, when there is no fire, the flame sensor output remains HIGH (logic 1). The Arduino continuously reads this state and ensures that both the buzzer and LED are OFF, keeping the system silent and in observation mode. This stage represents the “safe” condition, where the system waits for any sign of fire.

Stage 3 – Flame Detection

When a fire or flame appears within the sensor’s detection range, the infrared light intensity increases. The flame sensor output drops to LOW (logic 0), signaling that a flame has been detected.

Stage 4 – Alarm Activation

- It turns ON the buzzer, producing a loud warning sound.
- It lights up the LED, providing a visual indication of the fire.

These two indicators alert nearby individuals or workers to take immediate safety action, such as extinguishing the fire or evacuating the area. The alarm continues until the flame is no longer detected.

Stage 5 – System Reset

After the flame source is removed or the fire is extinguished, the infrared radiation level returns to

normal. The flame sensor output goes back to HIGH (logic 1). The Arduino detects this signal change and automatically turns OFF the buzzer and LED, bringing the system back to the monitoring mode. This allows the fire alarm system to operate continuously without manual reset.

III. CIRCUIT OPERATION EXPLANATION

The circuit mainly consists of:

- Flame Sensor (FEM Sensor): Senses the flame and sends an electrical signal.
- Buzzer: Provides an audible alarm.
- LED: Provides a visual indication.
- Power Supply (5V): Powers all the components.

Connections are made as follows:

- Sensor output → Arduino digital pin D2.
- Buzzer → Arduino digital pin D8 through a resistor.
- LED → Arduino digital pin D13.
- VCC and GND → Power supply terminals.



Figure 2: Fire Alarm System

IV. OBSERVATION AND PERFORMANCE

using testing, the system successfully detected small flames from matchsticks, candles, and lighters within a distance of 80–100 cm. The buzzer and LED responded within milliseconds of flame detection. The response time is very fast, and the accuracy is high for direct flame visibility. However, the detection may reduce under bright sunlight or if the flame is hidden by obstacles.

V. ADVANTAGES OF THE WORKING SYSTEM

- Quick response to open flames.
- Simple, low-cost, and reliable operation.
- Continuous automatic monitoring without manual control.
- Low power consumption and easy installation.
- Can be upgraded to include GSM or IoT-based alerts.

VI. DISADVANTAGES OF THE WORKING SYSTEM

1. Limited Detection Range:

The flame sensor can only detect fire within a short distance (usually up to 80–100 cm). It cannot sense flames that are far away or behind obstacles.

2. Cannot Detect Smoke or Heat:

The FEM sensor is designed only to detect infrared radiation from visible flames. It cannot detect smoldering fires that produce only smoke or heat without visible flames.

3. Affected by Ambient Light:

Strong sources of light such as sunlight, halogen lamps, or reflections may cause false triggering of the sensor, leading to unwanted alarms.

4. Direction-Sensitive:

The flame sensor is directional, meaning it can only detect flames that are directly in front of its sensor surface. Fire at other angles may go undetected.

5. Limited Area Coverage:

Since one sensor can cover only a small area, multiple sensors are needed to monitor large spaces, which increases the overall cost and wiring complexity.

6. No Automatic Fire Control:

The system only provides an alarm indication; it does not include any automatic extinguishing mechanism such as sprinklers or CO₂ release.

7. Environmental Sensitivity:

Environmental factors like dust, humidity, and high temperature can affect the performance and sensitivity of the flame sensor, reducing its reliability over time.

8. Maintenance Required:

The sensor needs to be kept clean and free from dust for accurate detection. Without regular maintenance, false alarms or detection failures may occur.

VII. FUTURE SCOPE

The Fire Alarm System using Flame (FEM) Sensor can be further improved and expanded to make it more advanced, intelligent, and reliable. While the current system efficiently detects flames and alerts users through a buzzer and LED, future developments can enhance its functionality and real-world usability.

- Integration with IoT (Internet of Things)
- GSM or SMS Alert System
- Automatic Fire Extinguishing System
- Multi-Sensor Integration
- Wireless Communication
- Battery Backup and Solar Power
- Data Logging and Fire Analysis
- AI and Machine Learning Integration

VIII. CONCLUSION

The Fire Alarm System using Flame (FEM) Sensor is an efficient, reliable, and low-cost solution for the early detection of fire. The system operates automatically and provides both audible (buzzer) and visual (LED) alerts whenever a flame is detected. By using a flame sensor that responds to infrared radiation emitted by fire, the system ensures rapid detection and quick response, minimizing possible damage to life and property. This project successfully demonstrates how sensor technology and microcontroller-based automation can enhance safety in residential, commercial, and industrial environments. The results show that the system reacts immediately to the presence of open flames within its detection range and returns to monitoring mode once the fire is removed. Although the system

has certain limitations—such as its inability to detect smoke or heat—it can be further improved by integrating smoke sensors, temperature sensors, GSM modules, or IoT connectivity for remote fire alerts and advanced control features. In conclusion, the proposed fire alarm system provides a practical and effective approach to fire safety. It offers a foundation for developing smart, scalable, and automated fire detection systems capable of saving lives and protecting property in modern applications. Acknowledgements I would like to express my sincere gratitude to all those who have supported and guided me in completing this project on “Fire Alarm System Using Flame Sensor.”

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Author's details

1. Sujal Bhimrao Gongale, Electrical Engineering, Rajiv Gandhi Clg of engineering reaserch & Technology chandrapur, gongalesujal@gmail.com

2. Amardip Bandu Raipure, Electrical Engineering, Rajiv Gandhi clg Of engineering reaserch & technology chandrapur, amardipraipure@gmail.com
3. Saurabh Vithoba Zade, Electrical Engineering, Rajiv Gandhi clg Of engineering reaserch & technology chandrapur, zadesaurabh2003@gmail.com
4. Ujwal Ramesh Ratnaparkhi, Electrical Engineering, Rajiv Gandhi clg Of engineering reaserch & technology chandrapur, ujwalratnaparkhi80@gmail.com
5. Prof. Deepali Vaidya, Department of Electrical Engineering, Rajiv Gandhi clg Of engineering reaserch & technology chandrapur, deepalivaidyabonde@gmail.com