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JSS SCIENCE AND TECHNOLOGY UNIVERSITY

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING

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Table Of Contents

INTRODUCTION

Introduction to Fire Safety

Fire safety is a critical aspect of building and maintaining a secure environment in homes, workplaces, and public spaces. It encompasses a range of measures and practices designed to prevent fires, minimize their impact, and ensure the safety of individuals and property.

Importance of Fire Safety: The importance of fire safety cannot be overstated. Fires can start unexpectedly and spread rapidly, posing significant risks to human life, property, and the environment. Effective fire safety measures are essential to mitigate these risks, protect lives, and reduce economic losses.

Key Elements of Fire Safety: Fire safety involves several key elements:

1. **Prevention:** Proactive measures such as proper storage of flammable materials, regular maintenance of electrical systems, and adherence to fire codes and regulations help prevent fires from starting.
2. **Detection:** Early detection of fires is crucial for prompt response. Smoke detectors, heat sensors, and flame sensors are examples of devices that provide early warning, allowing occupants to evacuate safely and emergency responders to intervene swiftly.
3. **Notification:** Alert systems, including sirens, alarms, and visual indicators like flashing lights or LED displays, notify occupants of the presence of a fire. Clear and timely alerts are essential for ensuring that individuals can take immediate action.
4. **Evacuation:** Well-defined evacuation plans and routes, coupled with regular drills and training, ensure that occupants can evacuate quickly and efficiently in the event of a fire. Designated meeting points outside the building further enhance safety and accountability.
5. **Suppression:** Fire suppression systems such as sprinklers, fire extinguishers, and automated suppression systems (e.g., gas-based suppression) help contain and extinguish fires before they can cause extensive damage.
6. **Education and Training:** Educating occupants about fire hazards, safety procedures, and the proper use of fire safety equipment empowers individuals to respond effectively during emergencies. Training programs for fire safety personnel and first responders further enhance preparedness and response capabilities.

WORKING PRINCIPLE

The working principle of a flame sensor system utilizing a buzzer, LED, and relay involves detecting the presence of flames through infrared (IR) radiation, and using this detection to trigger both visual and auditory alerts, as well as potentially control external devices like alarms or automated systems. Here's how such a system typically operates:

1. **Flame Detection**: The flame sensor module contains a photodiode or phototransistor that is sensitive to the IR radiation emitted by flames. Flames emit characteristic wavelengths of IR light, which the sensor can distinguish from background IR radiation (such as sunlight or artificial lighting).
2. **Sensor Output**: When the flame sensor detects IR radiation within its detection range (usually between 700 nm to 1100 nm), it generates an electrical signal. This signal indicates the presence of a flame to the control circuitry
3. **Control Circuit Activation**: The signal from the flame sensor is processed by a microcontroller or dedicated control circuit. This control circuit is programmed to respond to the flame detection signal in specific ways
4. **Buzzer Activation**: Upon detecting a flame, the microcontroller or control circuit activates a buzzer. The buzzer emits a loud, audible sound to alert individuals nearby about the detected flame. This auditory alert is crucial for immediate response, especially in noisy environments where visual cues might be less effective.
5. **LED Indicator Activation**: Simultaneously, the control circuit also activates an LED indicator. The LED lights up to provide a visual indication that a flame has been detected. This visual alert helps individuals quickly locate the source of the alert and verify the presence of a fire hazard.

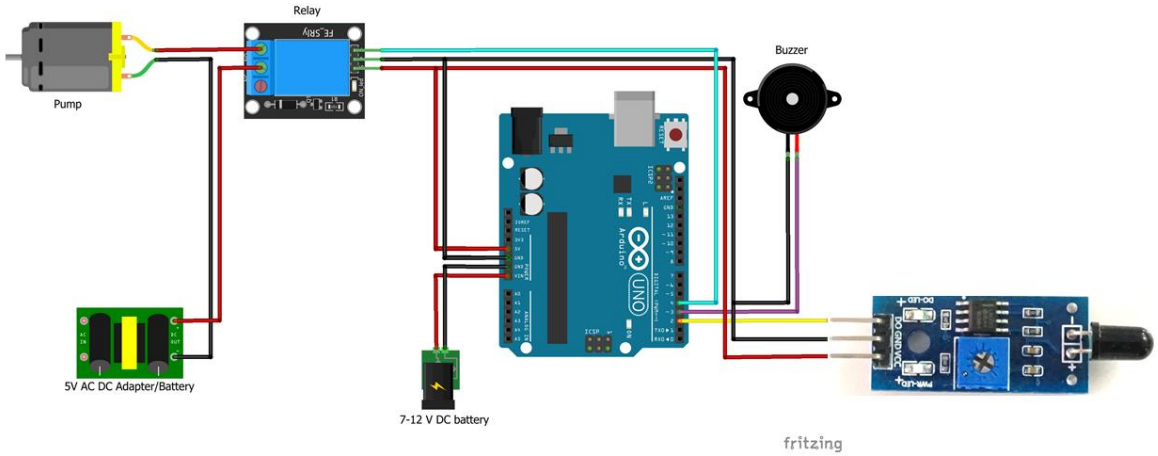
6. **Relay Control**: In many flame sensor systems, especially those used in industrial or complex environments, a relay is used to control external devices. The microcontroller or control circuit can activate a relay based on the flame detection signal. The relay can switch on/off other equipment such as fire alarms, sprinkler systems, or ventilation fans. This allows the flame sensor system to not only alert occupants but also trigger automated fire suppression or evacuation measures.

7. **Alert Continuation and Reset**: The buzzer continues to sound and the LED remains illuminated as long as the flame sensor detects the presence of flames. Once the fire hazard is resolved or the system is manually reset, the buzzer stops, and the LED turns off. Some systems may include automatic reset functions after a certain period of time without detecting flames.

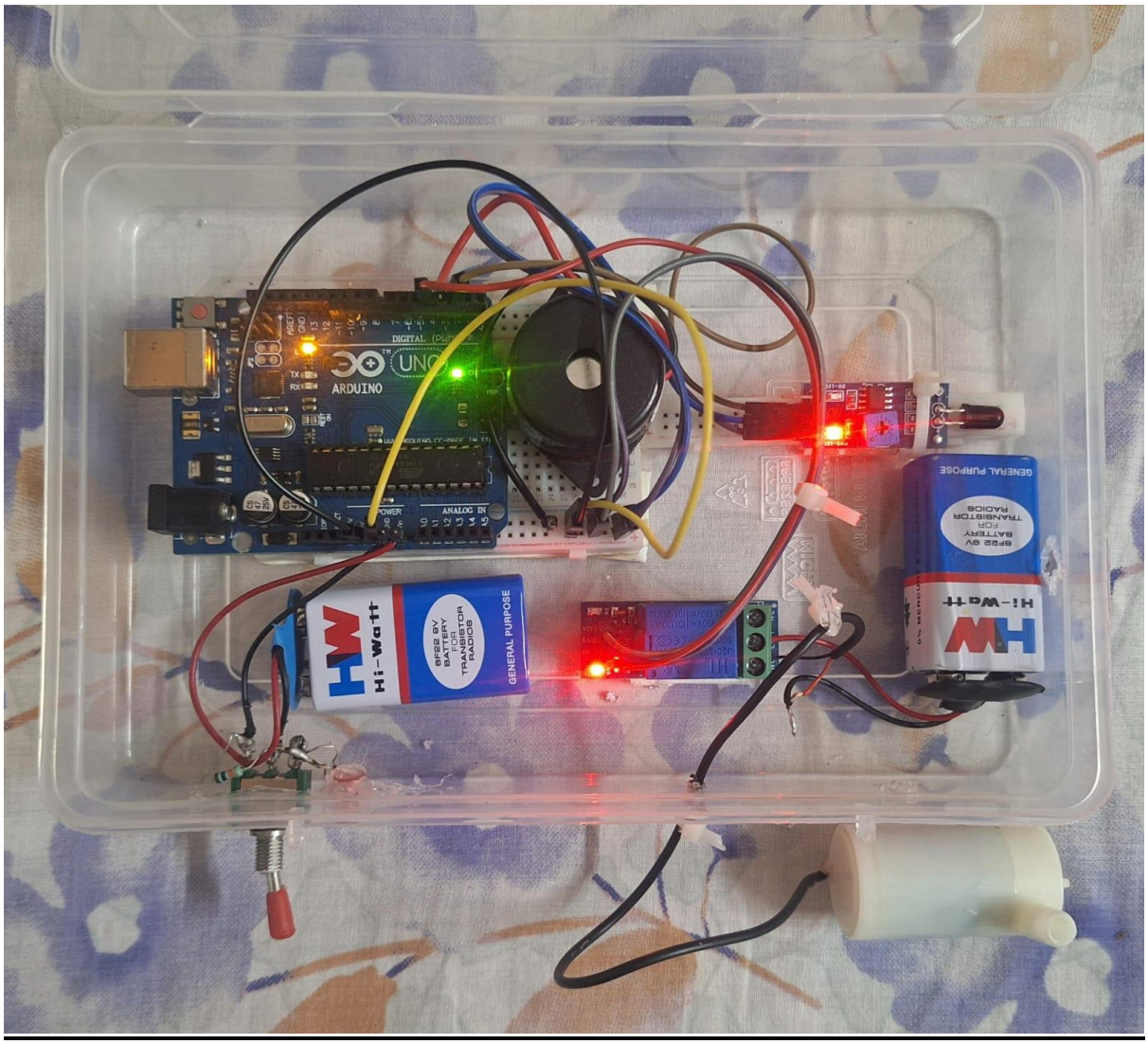
Key Components:

- **Flame Sensor**: Detects IR radiation from flames.
- **Microcontroller/Control Circuit**: Processes signals from the flame sensor and controls the activation of the buzzer, LED, and relay.
- **Buzzer**: Emits auditory alerts.
- **LED Indicator**: Provides visual indication of flame detection.
- **Relay**: Controls external devices or systems based on flame detection signals

VIRTUAL CIRCUIT IMAGE



REAL CIRCUIT IMAGE



COMPONENTS

1. FLAME SENSOR

A flame sensor is a specialized electronic device designed to detect the presence of flames or fires based on their optical characteristics. Here's an overview of how flame sensors work, their types, and typical applications:

Working Principle

Flame sensors typically work on the principle of detecting infrared (IR) radiation emitted by flames. Flames emit characteristic wavelengths of IR light, which can be distinguished from background IR radiation (such as sunlight or artificial lighting) by the sensor.

Detection Mechanism:

- **IR Detection**: Flame sensors use a photodiode or phototransistor sensitive to IR radiation. When a flame is present, it emits IR light in specific wavelengths (typically between 700 nm to 1100 nm).
- **Signal Processing**: The sensor detects the IR radiation and generates an electrical signal proportional to the intensity of IR light detected.

Response:

- When the sensor detects the presence of a flame, it outputs a signal to indicate flame presence. This signal can be used to trigger various actions such as activating alarms, initiating shutdown procedures, or triggering fire suppression systems.

Types of Flame Sensors

Flame sensors can be categorized based on their sensing technology and application:

1. **Infrared (IR) Flame Sensors**: These sensors detect IR radiation emitted by flames. They are sensitive to specific wavelengths associated with combustion processes.
2. **Ultraviolet (UV) Flame Sensors**: UV flame sensors detect the UV radiation emitted by flames. They are particularly sensitive to the short wavelengths of UV light produced by flames.
3. **Combination IR/UV Flame Sensors**: Some sensors combine IR and UV detection capabilities for enhanced reliability and sensitivity across different types of fires and lighting conditions.

Flame sensor

2. BUZZER

The BUZZER is a sounding device that can convert audio signals into sound signals. It is usually powered by DC voltage. It is widely used in alarms, computers, printers and other electronic products as sound devices. It is mainly divided into piezoelectric buzzer and electromagnetic buzzer, represented by the letter "H" or "HA" in the circuit. According to different designs and uses, the buzzer can emit various sounds such as music, siren, buzzer, alarm, and electric bell.

Piezo buzzer

The piezoelectric buzzer uses the piezoelectric effect of the piezoelectric ceramics and uses the pulse current to drive the vibration of the metal plate to generate sound. Piezoelectric buzzer is mainly composed of multi-resonator, piezoelectric plate, impedance matcher, resonance box, housing, etc. Some of the piezoelectric buzzers are also equipped with light-emitting diodes. The multi-resonator consists of transistors or integrated circuits. When the power supply is switched on (1.5~15V DC operating voltage), the multi-resonator oscillates and outputs 1.5~2.5kHz audio signal. The impedance matcher pushes the piezoelectric plate to generate sound. The piezoelectric plate is made of lead zirconate titanate or lead magnesium niobate

piezoelectric ceramic, and silver electrodes are plated on both sides of the ceramic sheet. After being polarized and aged, the silver electrodes are bonded together with brass or stainless-steel sheets.

Buzzer

3. RELAY

The relay is the device that open or closes the contacts to cause the operation of the other electric control. It detects the intolerable or undesirable condition with an assigned area and gives the commands to the circuit breaker to disconnect the affected area. Thus protects the system from damage.

It works on the principle of an electromagnetic attraction. When the circuit of the relay senses the fault current, it energises the electromagnetic field which produces the temporary magnetic fieldd.

This magnetic field moves the relay armature for opening or closing the connections. The small power relay has only one contacts, and the high-power relay has two contacts for opening the switch. It has an iron core which is wound by a control coil. The power supply is given to the coil through the contacts of the load and the control switch. The current flows through the coil produces the magnetic field around it.

Due to this magnetic field, the upper arm of the magnet attracts the lower arm. Hence close the circuit, which makes the current flow through the load. If the contact is already closed, then it moves oppositely and hence open the contacts.

Relay

4. LED

The Light-emitting diode is a two-lead semiconductor light source. In 1962, Nick Holonyak has come up with the idea of a light-emitting diode, and he was working for the General Electric company. The LED is a special type of diode and they have similar electrical characteristics to a PN junction diode. Hence the LED allows the flow of current in the forward direction and blocks the current in the reverse direction. The LED occupies a small area which is less than **1 mm^2**.

The LED function is very simple. Simply, a diode is a light-emitting diode. When the diode is forward biassed, the electrons and holes move quickly across the junction, constantly combining and removing one another. The electrons merge with the holes as they transition from n-type to p-type silicon, then vanish. As a result, it stabilizes the entire atom and provides a small burst of energy in a tiny packet of photons or light.

The quantum theory underpins the operation of the light-emitting diode. According to quantum theory, energy is emitted from the photon when the electron descends from a higher energy level to a lower energy level. The energy difference between these two energy levels is equal to the photon energy. The current passes through the diode if the PN-junction diode is forward biassed.

The passage of holes in the opposite direction of current and the flow of electrons in the current direction cause current flow in semiconductors. As a result of the movement of these charge carriers, recombination will occur.

The electrons in the conduction band jump down to the valence band during recombination. Electrons emit electromagnetic energy in the form of photons when they leap from one band to the next, and the photon energy is equal to the forbidden energy gap. This is how LED functions.

LED

5. WATER PUMP

Brushless Mini DC water Pump refers to a machine that uses DC 4.5V ~ 24V to drive a brushless motor to run, and the brushless motor rotation drives the impeller to rotate, thereby increasing the pressure of the liquid to achieve the effect of transferring liquid. The water pump is generally composed of pump body, motor stator, shaft, bearing, rotor (magnets and impellers) and so on. There are one inlet and one outlet on the pump body, water enters from the water inlet, and exits through the outlet. Any water pump that adopts this form and in small size is called brushless DC mini water pump.
With the development of all walks of life and the progress of science and technology, some customers want to make the pump smaller and lower power consumption, even portable and can be powered by DC. Therefore, miniaturization of water pumps has become an inevitable trend.
The main components of a small water pump include the motor, pump body, impeller, seals, and water outlet. The motor is the power source of the small water pump, and it drives the impeller to rotate through the electrical energy provided by the power supply.

The working principle of a small water pump is based on centrifugal force. When the motor starts, the impeller begins to rotate and generate centrifugal force. The centrifugal force sucks water into the pump body and then discharges it through the outlet. Throughout the entire process, the seal played a crucial role in preventing water leakage from the pump and ensuring its normal operation.

Mini water pump

6. 9V BATTERY

The 9V battery is an extremely common battery that was first used in transistor radios. It features a rectangular prism shape that utilizes a pair of snap connectors which are located at the top of the battery. A wide array of both large and small battery manufacturers produces versions of the 9V battery. Possible chemistries of primary (non-rechargeable) 9V batteries include Alkaline, Carbon-Zinc (Heavy Duty), Lithium. Possible chemistries of secondary (rechargeable) 9V batteries include nickel-cadmium (NiCd), nickel-metal hydride (NiMH), and lithium ion. The performance and application of the battery can vary greatly between different chemistries, meaning that some chemistries are better suited for some applications over others.

9V BATTERY

7. ARDUINO UNO

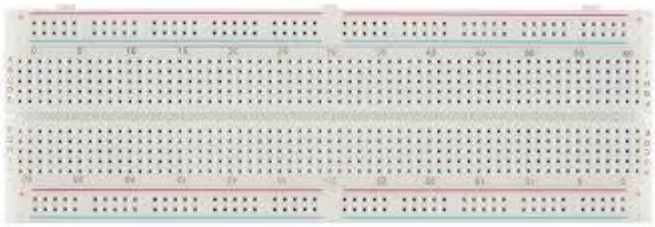
Arduino UNO is a microcontroller board based on the **ATmega328P**. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic

resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst-case scenario you can replace the chip for a few dollars and start over again.

The Arduino UNO includes 6 analog pin inputs, 14 digital pins, a USB connector, a power jack, and an ICSP (In-Circuit Serial Programming) header. It is programmed based on IDE, which stands for Integrated Development Environment. It can run on both online and offline platforms.

- **ATmega328 Microcontroller**- It is a single chip Microcontroller of the ATmel family. The processor code inside it is of 8-bit. It combines **Memory (SRAM, EEPROM, and Flash), Analog to Digital Converter, SPI serial ports, I/O lines, registers, timer, external and internal interrupts, and oscillator.**
- **ICSP pin** - The In-Circuit Serial Programming pin allows the user to program using the firmware of the Arduino board.
- **Power LED Indicator**- The ON status of LED shows the power is activated. When the power is OFF, the LED will not light up.
- **Digital I/O pins**- The digital pins have the value HIGH or LOW. The pins numbered from D0 to D13 are digital pins.
- **TX and RX LED's**- The successful flow of data is represented by the lighting of these LED's.
- **AREF-** The Analog Reference (AREF) pin is used to feed a reference voltage to the Arduino UNO board from the external power supply.
- **Reset button**- It is used to add a Reset button to the connection.
- **USB**- It allows the board to connect to the computer. It is essential for the programming of the Arduino UNO board.
- **Crystal Oscillator**- The Crystal oscillator has a frequency of 16MHz, which makes the Arduino UNO a powerful board.
- **Voltage Regulator**- The voltage regulator converts the input voltage to 5V.
- **GND**- Ground pins. The ground pin acts as a pin with zero voltage.
- **Vin**- It is the input voltage.
- **Analog Pins**- The pins numbered from A0 to A5 are analog pins. The function of Analog pins is to read the analog sensor used in the connection. It can also act as GPIO (General Purpose Input Output) pins.

8. BREADBOARD

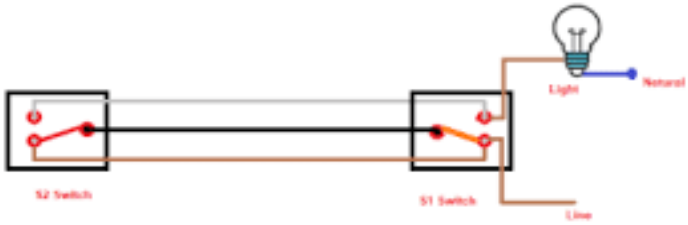


A Breadboard is simply a board for prototyping or building circuits on. It allows you to place components and connections on the board to make circuits without soldering. The holes in the breadboard take care of your connections by physically holding onto parts or wires where you put them and electrically connecting them inside the board. The ease of use and speed are great for learning and quick prototyping of simple circuits. More complex circuits and high frequency circuits are less suited to breadboarding. Breadboard circuits are also not ideal for long term use like circuits built on perfboard (protoboard) or PCB (printed circuit board), but they also don't have the soldering (protoboard), or design and manufacturing costs (PCBs).

9. JUMPER WIRES

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with BREADBOARDS and other prototyping tools in order to make it easy to change a circuit as needed. Fairly simple. In fact, it doesn't get much more basic than jumper wires.

10. 2-WAY SWITCH



A switch is an electrical device that controls the flow of current in a circuit. Every electronic and electrical application uses at least one switch to perform on and off operation of the device. The switches are further classified into two types they are electrical switches and mechanical switches. The one-way (single-pole), two-way (double-pole) are the two types of an electrical switch. The two-way switch is used to on/off the light, fan from two different locations.

The two-way (double-pole) switch is used to ON and OFF the light from two different locations and the switch is mostly used in the case of stairs, in rooms that have two entries. This type of switch is generally used in some home wiring systems and industrial applications.

CODE USED FOR THE PROJECT USING ARDUINO IDE

```
#define SENSOR_PIN 2
#define BUZZER_PIN 3
#define RELAY_PIN 4
#define SPRINKLER_START_DELAY 5000  //5 seconds
#define SPRINKLER_ON_TIME 3000      //3 seconds Sprinkler on time

unsigned long previousTime = millis();

void setup()
{
  pinMode(RELAY_PIN, OUTPUT);
  pinMode(SENSOR_PIN, INPUT);
}

void loop()
{
  //If there is fire then the sensor value will be LOW else the value will be HIGH
  int sensorValue = digitalRead(SENSOR_PIN);

  //There is fire
  if (sensorValue == LOW)
  {
    analogWrite(BUZZER_PIN, 50);                    //Turn on buzzer

    if (millis() - previousTime > SPRINKLER_START_DELAY)  //We will wait for few seconds before sprinkler can be started once fire is detected.
    {
```

```
      digitalWrite(RELAY_PIN, LOW);                    //Relay is low level triggered relay so
we need to write LOW to switch on the light
      delay(SPRINKLER_ON_TIME);                        //Keep sprinkler on for sometime.
    }
  }
  else
  {
    analogWrite(BUZZER_PIN, 0);
    digitalWrite(RELAY_PIN, HIGH);
    previousTime = millis();
  }
}
```

APPLICATIONS

The integration of a flame sensor with a buzzer and LED makes it suitable for various applications, including:

- **Home Safety:** Providing early warning of fires in residential settings, ensuring prompt evacuation and minimizing property damage. **Home Safety:** Providing early warning of fires in residential settings, ensuring prompt evacuation and minimizing property damage.
- **Industrial Environments:** Monitoring for potential fires in factories, warehouses, and manufacturing plants where early detection is crucial for worker safety and asset protection. **Industrial Environments:** Monitoring for potential fires in factories, warehouses, and manufacturing plants where early detection is crucial for worker safety and asset protection.
- **Commercial Buildings:** Installing fire detection systems in offices, hotels, and public spaces to comply with safety regulations and protect occupants. **Commercial Buildings:** Installing fire detection systems in offices, hotels, and public spaces to comply with safety regulations and protect occupants.

Benefits of Fire Sensors:

- **Early Detection**: Provides early warning of fire hazards, allowing for prompt evacuation and fire suppression. **Early Detection**: Provides early warning of fire hazards, allowing for prompt evacuation and fire suppression.
- **Enhanced Safety**: Improves safety for occupants, workers, and valuable assets by detecting fires before they escalate. **Enhanced Safety**: Improves safety for occupants, workers, and valuable assets by detecting fires before they escalate.
- **Reduced Losses**: Minimizes property damage and financial losses associated with fire incidents. **Reduced Losses**: Minimizes property damage and financial losses associated with fire incidents.
- **Compliance**: Helps organizations comply with fire safety regulations and standards by implementing effective fire detection and prevention measures. **Compliance**: Helps organizations comply with fire safety regulations and standards by implementing effective fire detection and prevention measures.

CONCLUSION

In conclusion, the combination of a flame sensor with a buzzer and LED creates a reliable and effective fire detection system. By promptly alerting users through both auditory and visual signals, this system enhances safety measures and facilitates quick responses to potential fire emergencies.

As technology advances, these integrated systems continue to evolve, offering enhanced reliability and functionality to meet the ever-growing demands for fire safety in diverse environments.

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