



# Automated Fire Detection System Analysis for Fire Protection

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## ABSTRACT

This thesis focuses on elucidating the advantages of implementing fire protection systems and their significance in loss prevention strategies. Participants will gain firsthand knowledge of the principles and procedures involved in maintaining, inspecting, testing, and resolving issues with fire protection and detection equipment. This encompasses various systems, such as fire protection water distribution systems, sprinkler systems (including wet pipe, dry pipe, pre-action, and deluge systems), and alarm systems.

The program is tailored to address the specific concerns and challenges related to fire protection systems and troubleshooting encountered by attendees. Participants will have the opportunity to witness the operational functionality of sprinkler systems firsthand. Field demonstrations will encompass hands-on training sessions covering the inspection, testing, troubleshooting, and maintenance procedures of systems, providing attendees with practical experience and skill enhancement opportunities.

## INTRODUCTION

**1.1 History of the Organization:** In 1961, M/s TVS and M/s Lucas jointly began manufacturing automotive electrical systems. Today, Lucas-TVS leads the Indian auto electrical market with over 50 years of design and manufacturing experience. Their products are installed in 4 out of 5 vehicles daily, serving a wide range of renowned customers globally.

### 1.2 Overview

Fire, a foundational element of human civilization, continues to cause significant losses in modern architecture. To mitigate these risks, buildings are equipped with fire detection systems. However, these systems often suffer from false alarms, leading to damage of expensive machinery and equipment. Therefore, enhancing the reliability of fire detection systems is crucial to prevent such costly incidents and ensure effective fire suppression.

### 1.3 study objective

The objective of this project is,

- To design and fabricate separate fire detection system by using smoke detector, heat detector, flame detector.
- To design a reliable fire detection system by using combinations of sensors like smoke detector, temperature sensor and infrared detector.
- To prepare a working manual and maintenance manual for reliable operation.

### 1.4 importance of automatic detection and alarm systems

In IS 2189:1976 it is suggested that with the rapid growth of industries and expansion of cities, fire hazards have also increased. Though considerable attention is being paid by the authorities concerned towards fire prevention and protection, a possible outbreak of fire cannot be detected and forestalled without an automatic fire alarm system. In the absence of such a system, it is also not possible to ensure

- a) An immediate transmission of call to the fire brigade in the event of an outbreak of fire in any premises during the closed hours, and
- b) An effective control of a fire in the incipient stage with the help of first aid fire appliances.

An automatic fire alarm system function through detectors distributed in the premises to be protected, which causes the alarm to be actuated automatically whenever there is possibility of a fire breaking out or immediately upon the outbreak of fire. The system helps evacuation of the premises, and brings firefighting facilities into action as soon as possible. Installation of an automatic fire alarm system in public and important office buildings is necessary to ensure quick evacuation of the premises and prompt action for an effective control of fire in incipient stage with the help of first aid fire appliances provided in the premises. Provision of an automatic fire alarm system is all the more necessary in case fire protection and precautions are required when the premises are unoccupied as at night and during weekdays and holidays, or in particular parts of the premises which are at times unattended. The fire alarm systems is designed so as to provide, in the event of fire, an early alarm to prevent loss of life and property by warning occupants for evacuation of firefighting and salvage staff.

The design of a system shall be determined considering the desired speed of response to dangerous fire conditions and desired accuracy of indication of the origin of calls. The relative importance of these two facts shall depend on the number of type of occupancy of the premises, the nature of work performed, the value and the nature of this structure and its content, its size and number of storeys, staircases and exits to the street and its situation in relation to adjacent property and thoroughfare. In boarding schools, hospitals and institutions, the highest assessment possible, shall be placed on both factors.

### 1.4 fundamentals of automatic fire detection

Fire as a phenomenon has got four chronologically sequenced stages of development

- Incipient stage (non visible smoke) • Smoldering stage (visible smoke but no flame) • Flaming stage (radiation of heat and light) • Heating stage (dissipation of heat energy to surroundings)

The purpose of an automatic fire detector is to detect fire by sensing any one or combination of characteristic phenomena, depending on stage of fire and convert this happening of a particular phenomenon into electrical signals and thus provide the means of alarm. People or agencies can be alerted or alarmed to be ready to deal and fight with the consequences of a fire happening. In addition to this or alternatively the fire detector maybe utilized to automatically operate the fire extinguisher.

Above four phenomena's have been utilized to develop four different principles of operation of automatic detection system as detailed below:

Phenomena	Type of detector	Sensed by
Invisible smoke	Ionization smoke detector	Nose
Visible smoke	Optical smoke detector	Eye & Nose
Flame (visible radiations)	Radiation (flame detector)	Eye & Nose
Heat (temperature)	Heat (thermal) detector	Eye, Nose & Skin

Table 1.1 combustion products and detectors

The various detectors are designed as plug-in units which fit different bases, according to place and type of mounting. If conditions on the premises change, the various types of detectors can easily be exchanged.

### 1.5 fire detection methods

The fire can be detected at its earlier stages through four main characteristics:

1. Incipient stage
2. Aerosols (tiny particles) are always produced by a fire and they are the first byproduct of fire. An ionization chamber is used to detect these tiny particles. It responds even to the invisible particles produced in the clear burning fire provided that the density of particle is high enough.
3. Smoldering stage(visible)

Presence of smoke is an indication of fire. using the principle of light obscuration or light scattering on to smoke particles and a photosensitive device, it is possible to give an early warning.

4. Radiation (flame)

Certain fires produce flames, right from the start. Principles used are that of detecting the infra-red/ultra-violet radiation emitted by the radiation from fire sources and hence it is necessary to ensure that the response occurs only if the radiation is flickering in a manner characteristic of flame.

## 5. Heat

Fire which is produced will exhibit enormous heat. This increase in heat will increase the temperature of the room. So a heat sensor or thermistor is used to detect the heat. If the temperature in the room exceeds to a predetermined level, then this temperature sensor or heat detector will sense the heat and give an alarm signal.

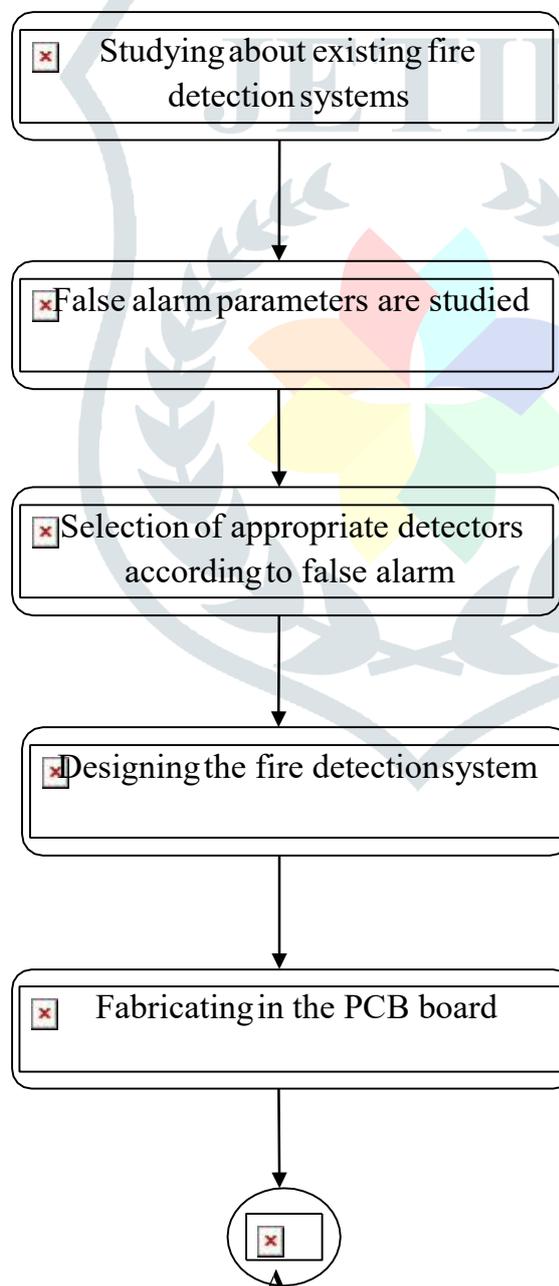
### 1.6 prompt detection

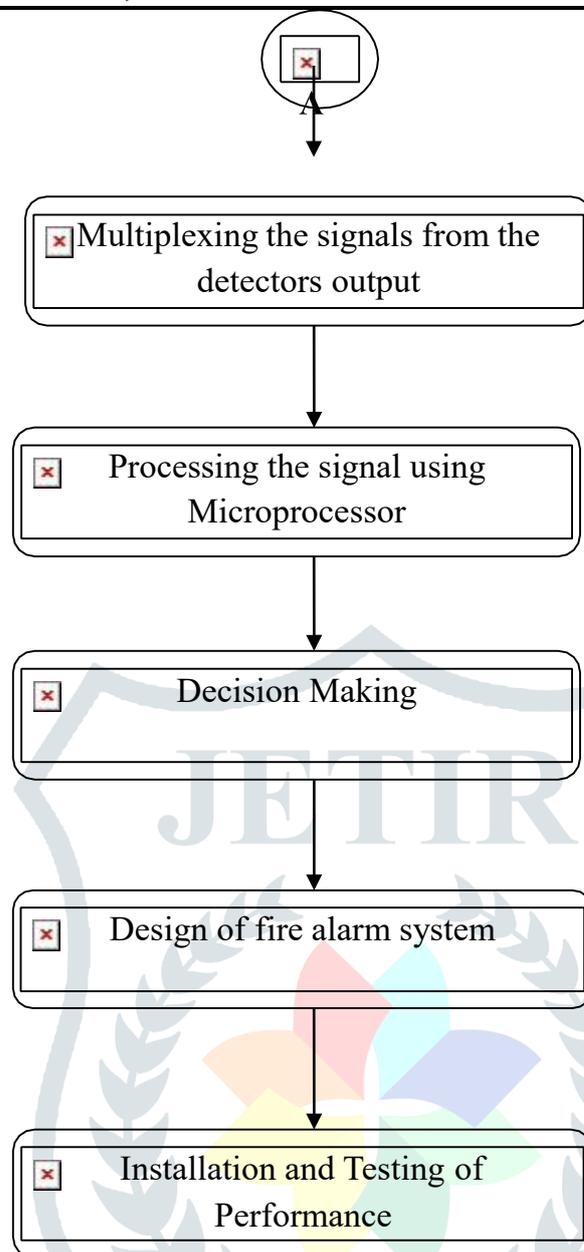
Early detection of a fire helps assure that a blaze is held in check in its incipient stage before it becomes a serious threat to life and property. The need then is to evolve a perfect detection system which is sensitive and reliable, and directly linked to ultra-fast means of alarm and extinguishment.

## 2.METHODOLOGY.

### 2.1 PROCESS DIAGRAM.

This is the following step by step procedure for the design and fabrication of reliable direction system





**Fig 3.1 PROCESS DIAGRAM**

### 3.2 3.2 General

- The aim of this project is to design a reliable fire detection system and simultaneously reducing the false alarm.
- Study of existing fire detection system from the literatures and by visiting the websites of various manufacturing industries.
- Study of false alarm parameters like unwanted smoke (smoke density), welding fumes, spark, light intensity, aerosols, temperature (heat).
- The scope includes design and fabrication of each component.
- Different types of detection systems will be designed and fabricated for the Products of combustion (IR, flame, heat and smoke).
- Combinations of these detection systems will also be tried out and comparison are made.
- For combining these detection systems any one of the multiplexing techniques like time division multiplexing (TDM) or frequency division multiplexing (FDM) or wavelength division multiplexing (WDM) can be used.

- The multiplexed data or combined data is given to the microprocessor.
- By using decision making method, we can clearly identify which detectors output has to be selected for reliable fire detection.
- The detected reliable output shall be given to the alarm system.
- Designing of fire alarm as per NFPA 72 for reliable fire detection system.
- Locating the fire detector in the room for reliable detection by conducting initiation test of detection system.
- Preparation of working manual and maintenance manual for reliable operation.
- Installation of detection system in a room and testing the performance of fire detection system and fire alarm system.

### **3.3 Designing of fire detection system**

#### **3.3.1 Smoke sensing technology**

It is an electronic device, which is used to detect the smoke from the various stages of fire. Commercial, industrial, and mass residential devices issue a signal to a fire alarm system, while household detectors, known as smoke alarms, generally issue a local audible and/or visual alarm from the detector itself. Smoke detectors are typically housed in a disk-shaped plastic enclosure about 150 millimetres (6 in) in diameter and 25 millimetres (1 in) thick, but the shape can vary by manufacturer or product line. Most smoke detectors work either by optical detection (photoelectric) or by physical process (ionization), while others use both detection methods to increase sensitivity to smoke. Sensitive alarms can be used to detect, and thus deter, smoking in areas where it is banned such as toilets and schools. Smoke detectors in large commercial, industrial, and residential buildings are usually powered by a central fire alarm system, which is powered by the building power with a battery backup. However, in many single families detached and smaller multiple family housings, a smoke alarm is often powered only by a single disposable battery.

##### **3.3.1.2 Principles of smoke sensing**

There are various principles used in smoke detectors to detect the smoke.

##### **3.3.1.3 Ionization smoke detection theory**

An ionization type smoke detector is generally cheaper to manufacture than an optical smoke detector; however, it is sometimes rejected because it is more prone to false (nuisance) alarms than photoelectric smoke detectors. It can detect particles of smoke that are too small to be visible. It consists of radioactive element americium<sup>241</sup> (<sup>241</sup>Am), corresponding to about 0.3 µg of the isotope. The radiation passes through an ionization chamber, an air-filled space between two electrodes, and permits a small, constant current between the electrodes. Any smoke that enters the chamber absorbs the alpha particles, which reduces the ionization and interrupts this current, setting off the alarm.

##### **3.3.1.4 Principle of light obscuration detection**

An optical detector is a light sensor. When used as a smoke detector, it includes a light source (incandescent bulb or infrared LED), a lens to collimate the light into a beam, and a photodiode or other

photoelectric sensor or a light dependent resistor (LDR) at an angle to the beam as a light detector. In the absence of smoke, the light passes in front of the detector in a straight line. When there is no smoke, the light from the bulb will be directly falling on the LDR. Now the resistance will be decreased and the corresponding voltage will be low.

So the alarm circuit is not triggered.

### 3.3.1.5 Schematic diagram

The smoke detector circuit is presented as Fig 3.2

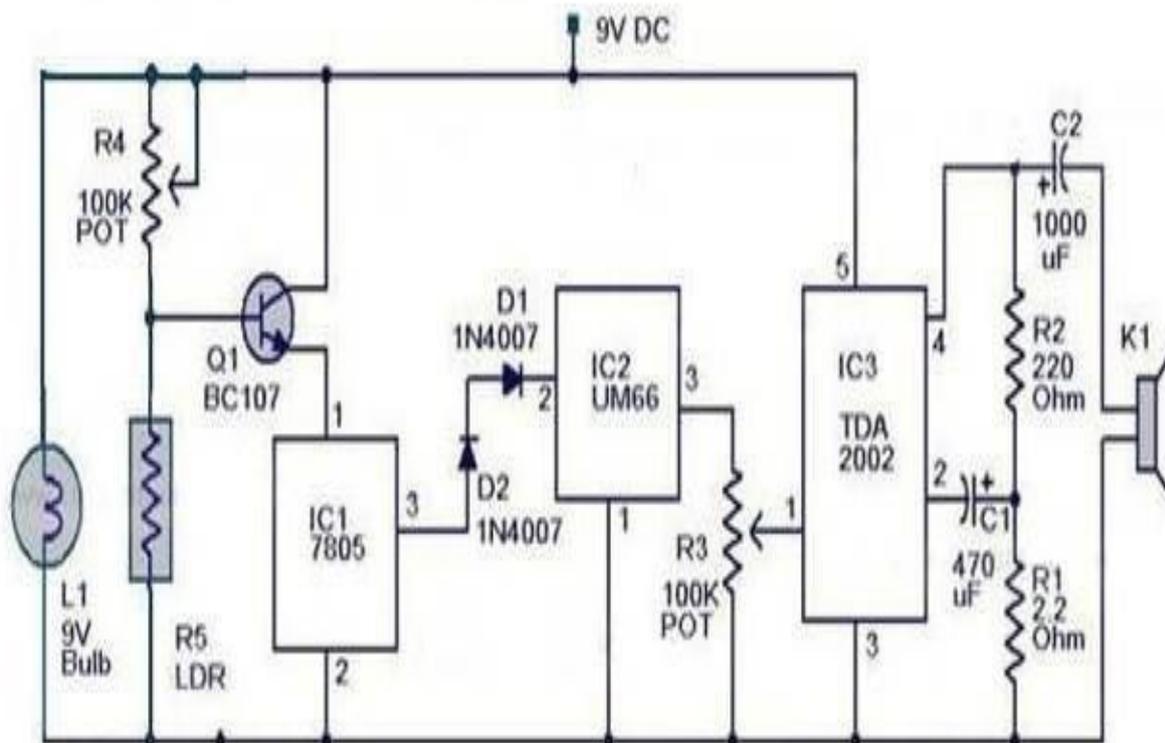


Fig 3.2 smoke detector

### 3.3.1.6 Explanation

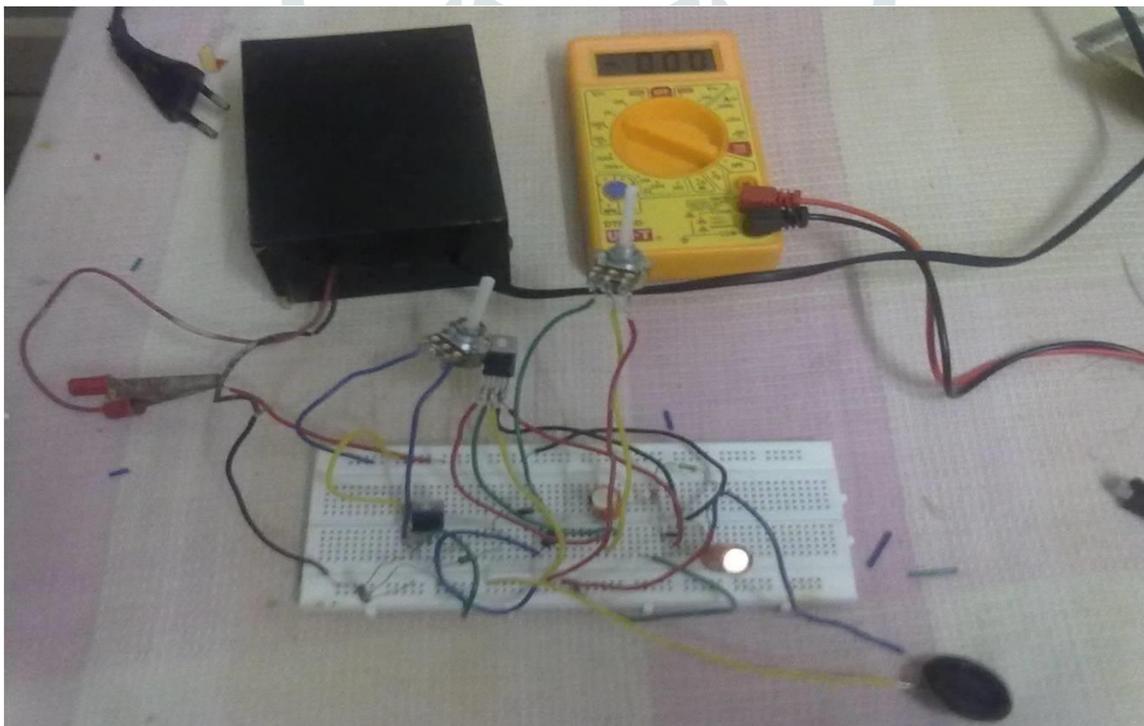
Here is a simple fire alarm circuit based on a LDR and lamp for sensing the fire. The alarm works by sensing the smoke produced during fire. The circuit produces an audible alarm when the fire breaks out with smoke. Here the 9V bulb and the LDR is faced each other to receive light from the bulb to LDR.

When there is no smoke the light from the bulb will be directly falling on the LDR. The LDR resistance will be low and so the voltage across it will be below 0.6V. The transistor will be in OFF condition and nothing happens. When there is sufficient smoke to mask the light from LDR, the LDR resistance increases and so do the voltage across it. Now the transistor will switch to ON. This gives power to IC1 and it outputs 5V. these powers the tone generator IC2 to play the sound. This sound will be amplified by IC3 to drive the speaker. Resistor R2 and R1 forms a feedback network for the TDA2002 and C1 couples the feedback signal from the junction of R1 and R2 to the inverting input of the same IC. The diode D1 and D2 in combination drops 1.4V to give the rated voltage (3.5V) to UM66. UM 66 cannot withstand more than 4V

### 3.3.1.7 Components inventory for smoke detector

- Potentiometer R4 can be used to adjust the sensitivity of the alarm.
- Potentiometer R3 can be used for varying the volume of the alarm.
- Any general purpose NPN transistor (like BC548, BC148, and 2N222) can be used for Q1.
- Light dependent resistor (LDR) □ A bulb which has a rating of 9V is used.
- IC 7805 is used as a voltage regulator.
- IC UM66 is a tone producer.
- IC TDA2002 is used as a power amplifier.
- A loud speaker is used to produce sound.
- The circuit can be powered from a 9V battery or a 9V DC power supply.
- Instead of a bulb we can use a bright LED with a 1K resistor series to it.

The bread board connection is presented as Fig 3.3



**Fig 3.3 Bread board connection**

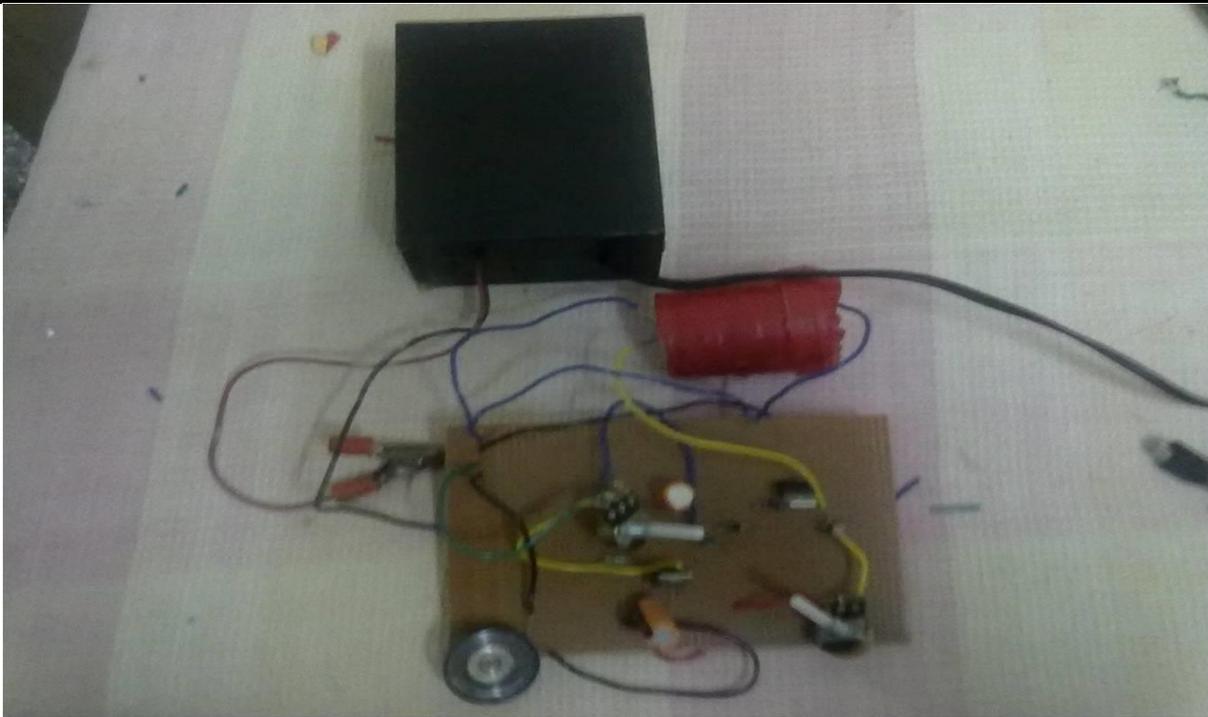


Fig 3.4 Dot board connection

### 3.3.1.7 Performance evaluation testing

The performance of the smoke detector is checked by installing each component in the bread board and simultaneously monitoring the voltage with the help of multimeters. At each stage the voltage will be varying according to the obstruction of smoke. If the smoke is detected, the switching circuit is activated and trigger the alarm circuit. Now the components from the bread board are transferred to the dot board.

### 3.3.2 Heat detector

A heat detector is a fire alarm device designed to respond when the convected thermal energy of a fire increases the temperature of a heat sensitive element. The thermal mass and conductivity of the element regulate the rate flow of heat into the element. All heat detectors have this thermal lag. Heat detectors have two main classifications of operation, "rate-of-rise" and "fixed temperature."

#### 3.3.2.1 Fixed temperature heat detection technology

This is the most common type of heat detector. Fixed temperature detectors operate when the heat sensitive eutectic alloy reaches the eutectic point changing state from a solid to a liquid. Thermal lag delays the accumulation of heat at the sensitive element so that a fixed-temperature device will reach its operating temperature sometime after the surrounding air temperature exceeds that temperature. The most common fixed temperature point for electrically connected heat detectors is 136.4°F (58°C). Technological developments have enabled the perfection of detectors that activate at a temperature of 117°F (47°C), increasing the available reaction time and margin of safety. This type of technology has been available for decades without the use of batteries or electricity as shown in the picture.

### 3.3.2.2. Rate-of-rise heat detection technology

Rate-of-rise (ROR) heat detectors function based on a swift elevation in element temperature, typically at a rate of 12° to 15°F (6.7° to 8.3°C) per minute, regardless of the initial temperature. This design allows the detector to activate in lower temperature fire scenarios than those with fixed thresholds. It incorporates two heat-sensitive components: one monitors convective or radiant heat transfer, while the other gauges ambient temperature. Activation occurs when the former's temperature surpasses the latter.

While effective in detecting rapid temperature increases, ROR detectors may overlook slowly developing fires with low energy release rates. To address this limitation, combination detectors integrate a fixed temperature element. This component triggers when the ambient temperature surpasses the designated threshold. Thus, the combination detector offers a comprehensive approach, responding promptly to rapid temperature spikes as well as to slower, progressively evolving fire situations.

### 3.3.2.3 Selecting the ideal heat detector

Heat detectors are explicitly designated as "Not a life safety device" due to their distinct purpose from smoke detectors, especially in areas like bedrooms or adjacent hallways. However, they fulfil a crucial function in spaces such as kitchens, utility areas (e.g., laundry rooms, garages, or attics), where installing smoke detectors might not be appropriate. In these settings, heat detectors offer early fire detection, allowing for additional time for evacuation or firefighting endeavours.

Unlike interconnected smoke detectors commonly found in homes, mechanical heat detectors operate independently as fire alarm systems. They are adaptable for installation in various home areas, offering portability and easy setup. Despite their autonomy, they provide dependable performance and contribute significantly to residential fire safety when used alongside mandated smoke detectors. Their lack of interconnection means that when a heat detector is activated, it precisely identifies the fire's location, aiding in the safe evacuation of occupants.

To summarize, while heat detectors are not replacements for smoke detectors in specific locations, they serve as valuable complements to fire safety measures in areas prone to heat-related fire risks, bolstering overall protection for occupants and property.

### 3.3.2.4 Circuit diagram

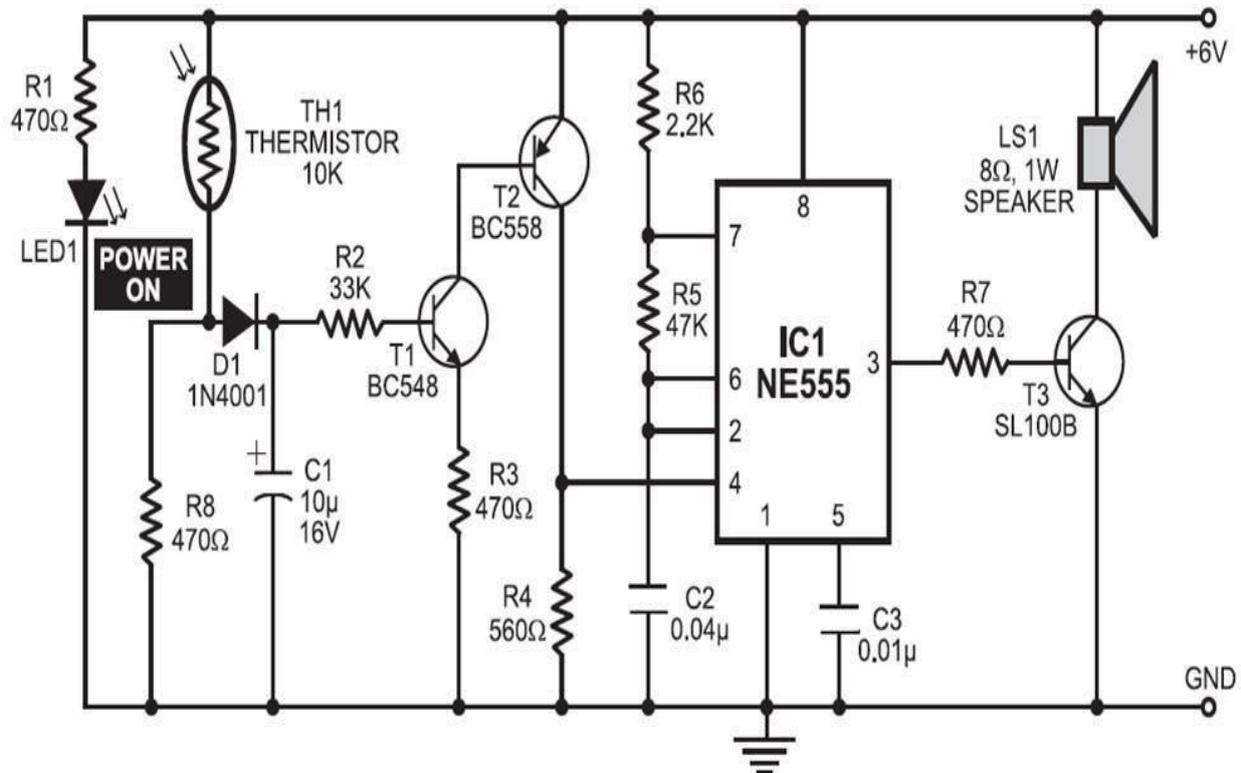


Fig 3.5 Heat detector

### 3.3.2.5 List of components used for heat detector

- 3.3.2.5.1 NE555-timer IC.
- Thermistor (resistance value varies according to the heat).
- 3.3.2.5.3 Resistors and capacitors.
- 3.3.2.5.4 Switching transistors.
- 3.3.2.5.5 Light emitting diode (LED).
- 3.3.2.5.6 A 6V power supply.
- 3.3.2.5.7 8ohm, 1W loud speaker.

### 3.3.2.6 Exploring the functionality of heat detectors

This fire alarm system utilizes a thermistor as its heat sensor, with its resistance diminishing as the temperature rises. Functioning in the audio frequency range, the NE555 timer IC (IC1) acts as an astable multivibrator, generating sound via a loudspeaker (LS1) upon activation. Transistors T1 and T2 drive IC1, and the oscillation frequency is governed by R5, R6, and C2. When the temperature surpasses a certain threshold, the thermistor establishes a low-resistance path, triggering transistor T1 and extending the alarm duration through capacitor C1. Transistor T2 resets IC1 once the temperature normalizes. Diode D1 prevents capacitor discharge during cooldown phases. To shield the thermistor from harm, it is advisable to encase it in mica tape. The system operates on a 6V-12V power supply, with LED1 serving as an indicator for power status. With readily available components and a standard PCB, this system offers a simple assembly process for efficient heat detection in fire alarm systems.

### 3.3.2.7 Testing of performance

First the heat detector circuit is installed in the bread board.

3.3.2.7.1 When the thermistor is hot, the voltage across it will be above 0.8V which is measured using multimeter.

3.3.2.7.2 This voltage is enough to switch on the transistor.

3.3.2.7.3 When the thermistor is cold, the resistance will be high and more voltage drop occurs (below 0.5V) across the thermistor and this voltage is not sufficient to switch on the transistor.

3.3.2.7.4 After testing the performance in bread board it is transferred to dot board.

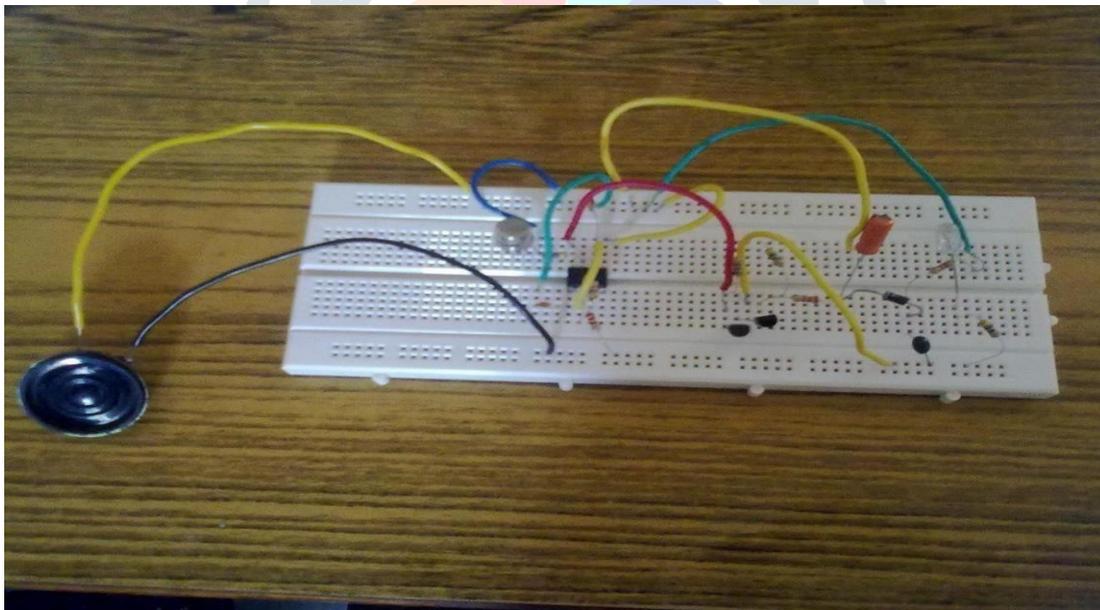


Fig 3.6 Bread board connection of heat detector

## 3.3.3 Advancements in Flame Detection Technology

Various types of flame detectors exist, including optical flame detectors utilizing optical sensors for flame detection, ionization flame detectors relying on current flow within flames to detect their presence, and thermocouple flame detectors.

### 3.3.3.1 Swift-Acting Electromagnetic Radiation Detector

Traditional fire detectors, such as heat and combustion detectors, rely on specific environmental changes like temperature increases or the production of visible aerosols to identify fires. Heat detectors

respond to gradual temperature rises from low-energy fires, while combustion detectors depend on convection currents to carry combustion products to the detector. However, they activate only when fires generate sufficient energy to propel combustion products through the surrounding warm air layer, resulting in a delay between the fire event and detection, typically ranging from 40 to 300 seconds depending on factors like fire distance and materials involved.

In contrast, electromagnetic radiation detectors, including infrared and ultraviolet types, employ photocells sensitive to radiation emitted by fires. Unlike traditional detectors, they respond swiftly, within microseconds, to flames emitting infrared and ultraviolet radiation. This radiation travels at the speed of light and remains unaffected by air currents, allowing for rapid detection. Photocell currents indicating flicker frequencies in the UV and IR spectra confirm flame presence. To prevent false alarms from non-flame radiation sources like sunlight or heaters, the detector's integrator-timer circuit activates only after detecting a consistent signal for 2 to 10 seconds.

### **Ultraviolet Flame Detection Technologies.**

Ultraviolet radiation typically spans wavelengths ranging from 100 angstroms to 3800 angstroms. Ultraviolet flame detectors utilize ultraviolet-sensitive cells or gas-filled tubes as their primary components, responding to the transmission of UV radiation emitted by flames. Similar to infrared detectors, these UV detectors necessitate direct exposure of the flame or spark to the detector for proper functioning. Fundamentally, the detector comprises a gas-filled tube or a photoelectric cell. The operational principle of a UV detector employing a photocell resembles that of an IR detector, with the primary distinction being the frequency response, typically ranging from 1850 angstroms to 2450 angstroms. In the case of a gas-filled tube, UV radiation ionizes the gas within, generating a small current between its electrodes, which is then amplified. When the current induced by the UV radiation from the fire surpasses the predetermined threshold in the amplifier, the alarm relay promptly closes, indicating a fire. To introduce a delay before alarm activation, an integrator/timer is commonly integrated into the system.

### **Infrared Flame Sensing Technologies**

Before delving into the specifics of how IR detectors operate, it's important to understand infrared radiation. In the electromagnetic spectrum, infrared radiation spans wavelengths from 7600 angstroms to 1000000 angstroms. Within this range, the region from 7600 angstroms to 20000 angstroms is termed near infrared, while wavelengths above 20000 angstroms belong to the far infrared category. It's the far infrared radiation, emitted by fires, that infrared detectors detect.

An IR detector typically comprises components such as a lens with an optical filter, a photoelectric cell, a waveform amplifier, and a timer circuit. The photoelectric cell converts light energy into electrical energy and can be categorized into photoconductive and photocells. These cells are commonly fabricated from materials like thallos sulphide, lead telluride, lead selenide, selenium, and silicon.

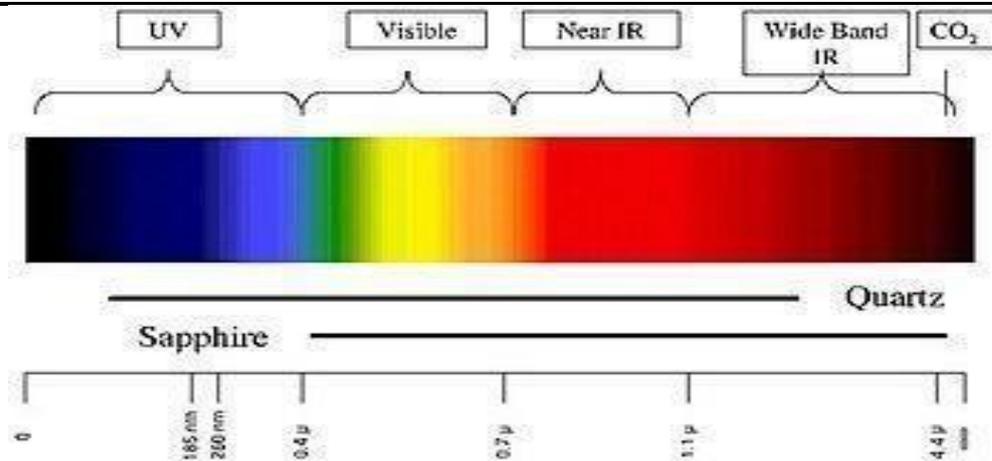


Fig 3.7 Flame detection region

**Circuit diagram**

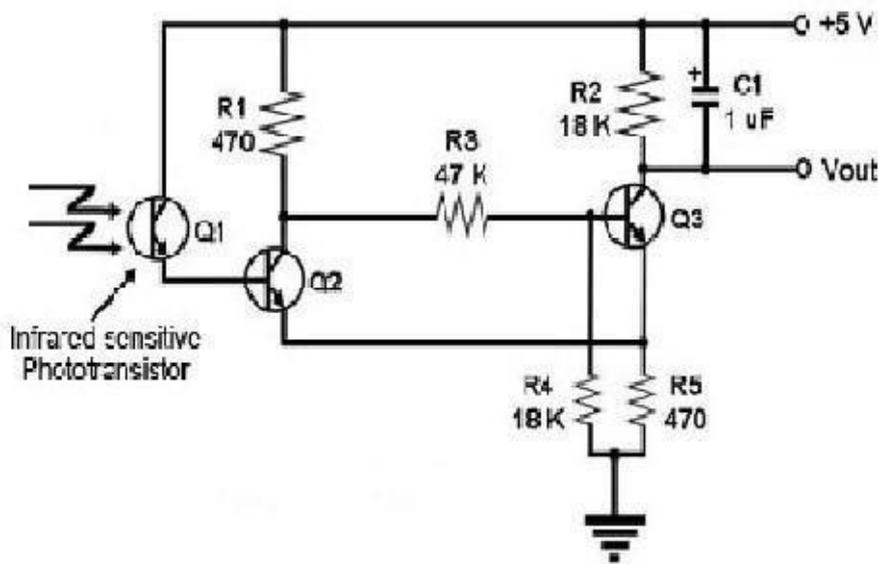


Fig 3.8 flame detector

**3.3.4.4 Infrared Radiation Overview**

This circuit is designed to detect the presence of fire by utilizing the infrared-sensitive phototransistor Q1. Unlike standard transistors, Q1's base is stimulated by infrared rays rather than input current. As infrared rays intensify on Q1, its conductivity increases. When a flame or fire is nearby, Q1 conducts, delivering current to the base of Q2. Once this current surpasses a certain threshold, Q2 activates, subsequently pulling down the base of Q3. This action deactivates Q3, causing Vout to rise. Vout can then activate a light-emitting diode or an alarm circuit. In the absence of nearby IR sources, both Q1 and Q2 remain inactive, allowing the base of Q3 to remain high, keeping Q3 on and Vout low. Proper sensitivity requires optimization of sensor positioning and experimentation with R1 and R3 values. Additionally, an infrared filter may be necessary for the phototransistor if it's affected by excessive ambient light.

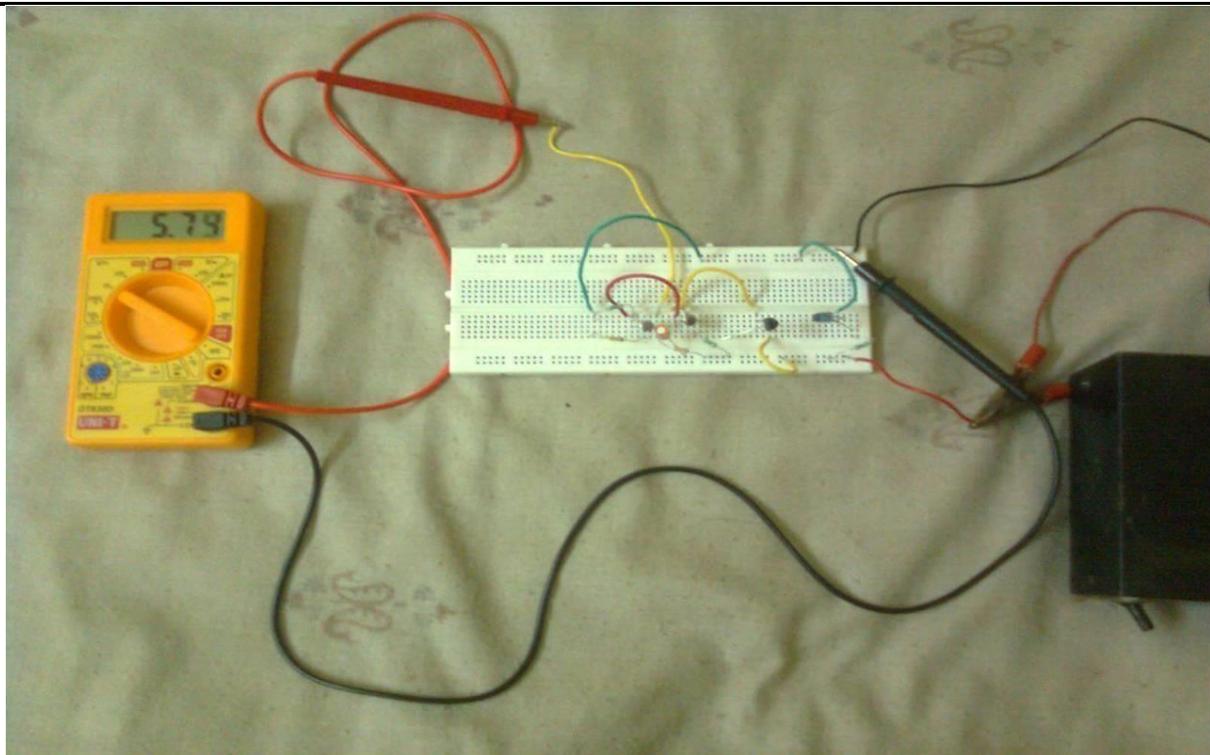
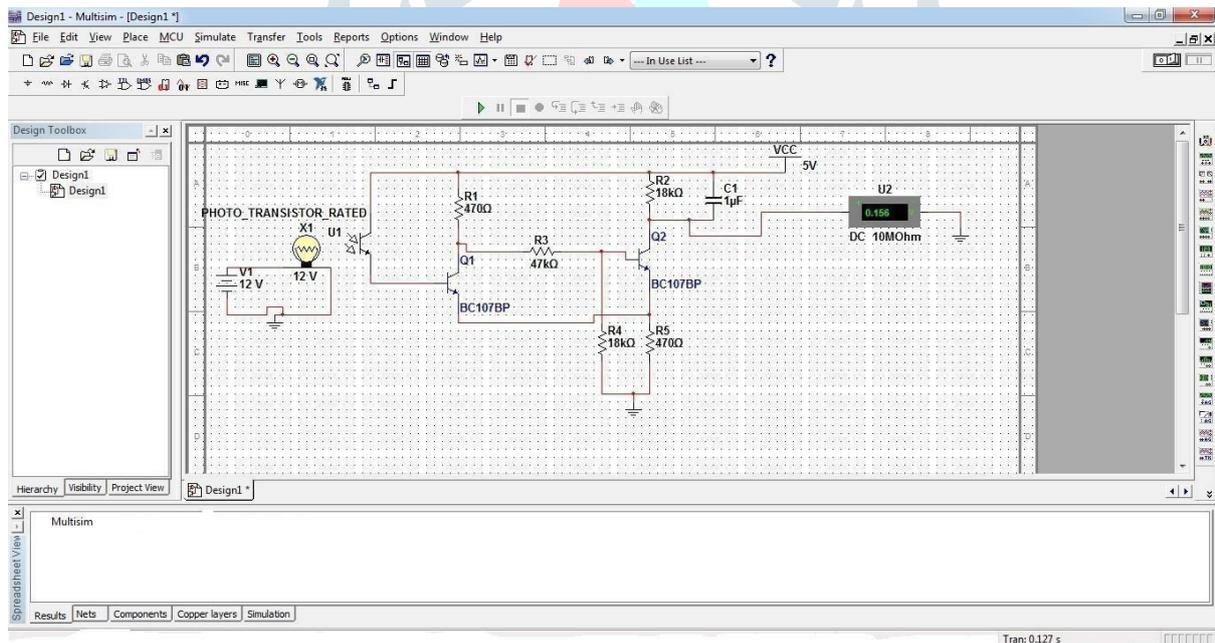
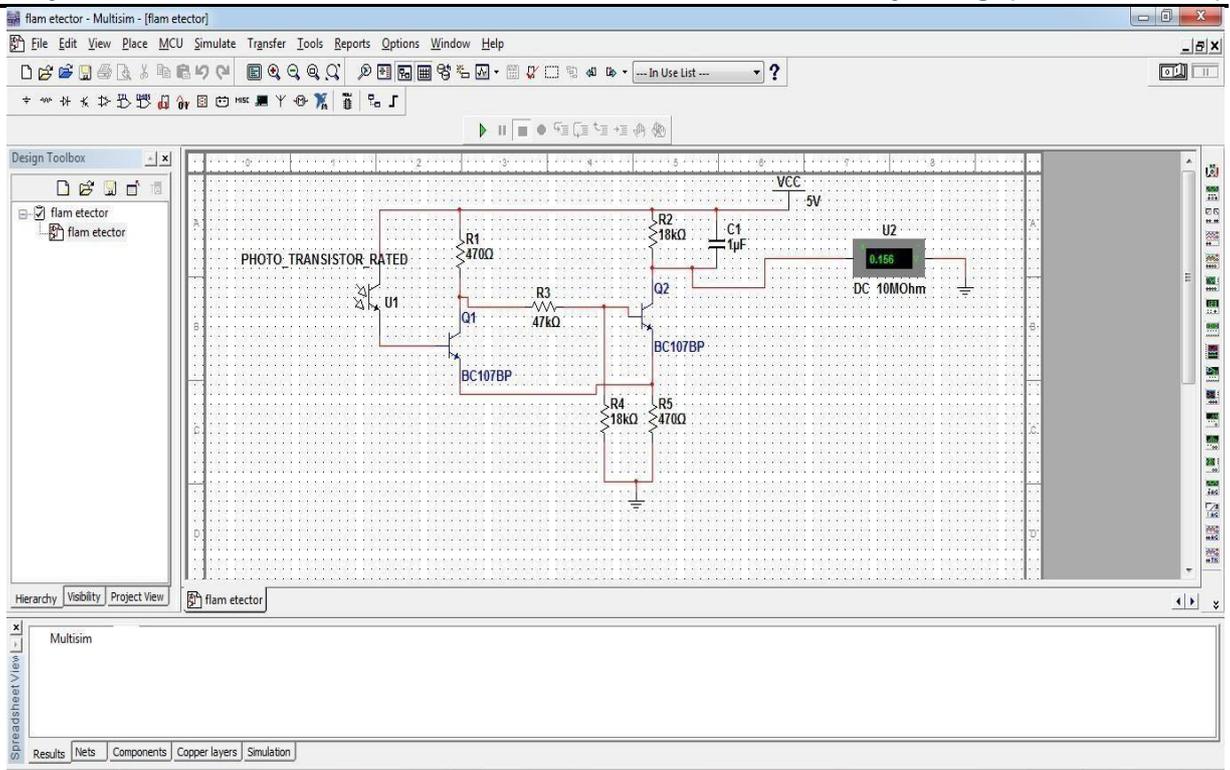


Fig 3.9 Bread board connection of flame detector





### 3.11 Flame detector output when IR light not falling on phototransistor

#### 3.3.4.6 Evaluating Performance.

The circuit is simulated using Multisim software. In the setup, the phototransistor and photodiode are positioned facing each other to receive IR radiation from the photodiode. When the diode is disconnected, the phototransistor remains non-conductive, keeping transistor Q1 in the ON state. Consequently, the 5V input is grounded through Q1, resulting in a minimal voltage output of approximately 0.158V, insufficient to trigger the alarm circuit. However, when the photodiode emits IR light, the phototransistor becomes conductive, causing transistor Q2 to switch OFF, resulting in a 5V output.

#### 3.3.4.7 Comparing Different Types of Detectors

Sensitivity:

Sensitivity in detection devices is primarily determined by their physical design, except for adjustable combustion units. Flame detectors typically exhibit inherently high sensitivity, making it less of a significant factor.

Reliability:

Reliability refers to the system's and individual components' capability to consistently function properly, ensuring readiness to perform their intended tasks.

Maintainability:

Maintainability of detection units is directly influenced by the complexity of their design.

Stability:

Stability pertains to a detector's ability to consistently detect fires over prolonged periods without a change in sensitivity. Periodic assessment of all units with electronic components is crucial due to the reduced stability inherent in some detectors.

### 3.4.5 Supplying Electrical Power

Power supply is an important thing in any of the circuit. The reliability of the circuit depends on the power supply too. So, we have to design a proper regulated DC power supply for the successful operation of the circuit.

#### 1. Components of power supply

- 230V transformer
- Diode-IN4007
- Voltage regulator IC-7805
- Resistance
- Capacitance

#### 2. Block diagram of power supply

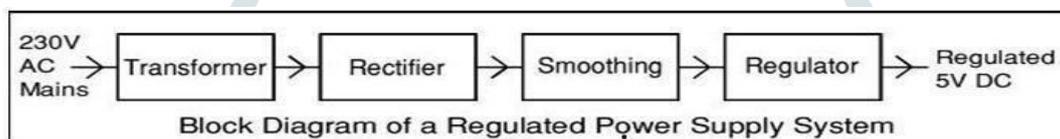


Fig 3.11 Power supply

#### 3. Transformer

- In this setup, step-down transformers are employed.
- The purpose of using a step-down transformer is to lower the high mains voltage (230V) to a safer, lower voltage.

#### 4. Rectifier

- A rectifier transforms AC (alternating current) into DC (direct current).
- A bridge rectifier is utilized due to its superior efficiency compared to half-wave and full-wave rectifiers.
- This is attributed to the fact that the output polarity remains consistent regardless of the input polarity

#### 5. Smoothing

- Smoothing involves reducing the fluctuation in DC voltage to a minimal ripple.
- This task is accomplished by connecting a large-value electrolytic capacitor across the DC power source.

#### 6. Regulator

- The regulator ensures a steady DC output by removing any remaining ripple and setting it to a fixed voltage.
- Voltage regulator integrated circuits (ICs) come in fixed options such as 5V, 12V, and 15V, or variable output voltages.
- Many regulators are equipped with automatic safeguards against overheating.

- A heat sink is necessary for proper heat dissipation, and the regulator typically features a mounting hole for attaching it.

#### 7. Detector Operating Voltage Specifications.

- The smoke detector operates at a voltage of 9V.
- The heat detector operates within a voltage range of 6V to 9V.
- The flame detector operates at a voltage of 5V.

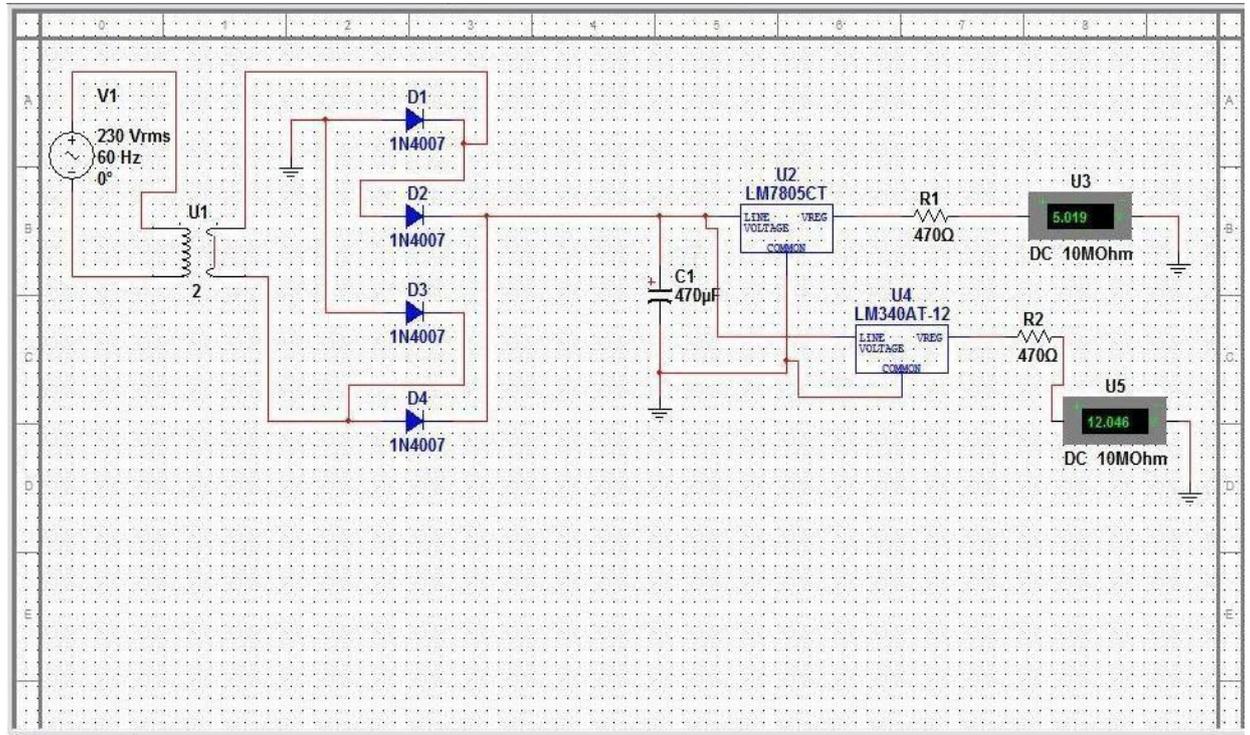


Fig 3.12 Power supply output using Multisim

### 3.5 Enhancing the System's Reliability.

#### 3.5.1 Smoke detector

- The positioning of the sensor arrangement significantly impacts the effectiveness of the smoke detector.
- Variations in smoke intensity also affect performance.
- Employing multiple photosensitive devices can enhance reliability.
- In case of detector failure to detect smoke, implementing an additional alarm circuit is recommended, further bolstering system reliability.

#### 3.5.2 Heat detector

- The effectiveness of the smoke detector is heavily influenced by the placement of the sensor arrangement.
- Changes in smoke density can impact its performance.
- Increasing reliability can be achieved by using multiple photosensitive devices.
- To address instances where the detector fails to detect smoke, adding an extra alarm circuit is advised to enhance overall system reliability.

### 3.5.3 Flame detector

- To prevent false light detection from sources like sunlight or room lamps, an integrator or timer circuit is implemented.
- A filter circuit is incorporated to eliminate unwanted ambient light and noise that may interfere with the detector.

### 3.6. Microcontroller-Based Multiplexing Techniques.

Multiplexing involves combining signals from multiple devices into a single output line. In this project, I've utilized a microcontroller as a multiplexer. The microcontroller integrates three inputs: the outputs from the smoke detector, heat detector, and flame detector. Using embedded C programming, the microcontroller combines these three inputs. Ultimately, it produces a single output that is directed to the relay.

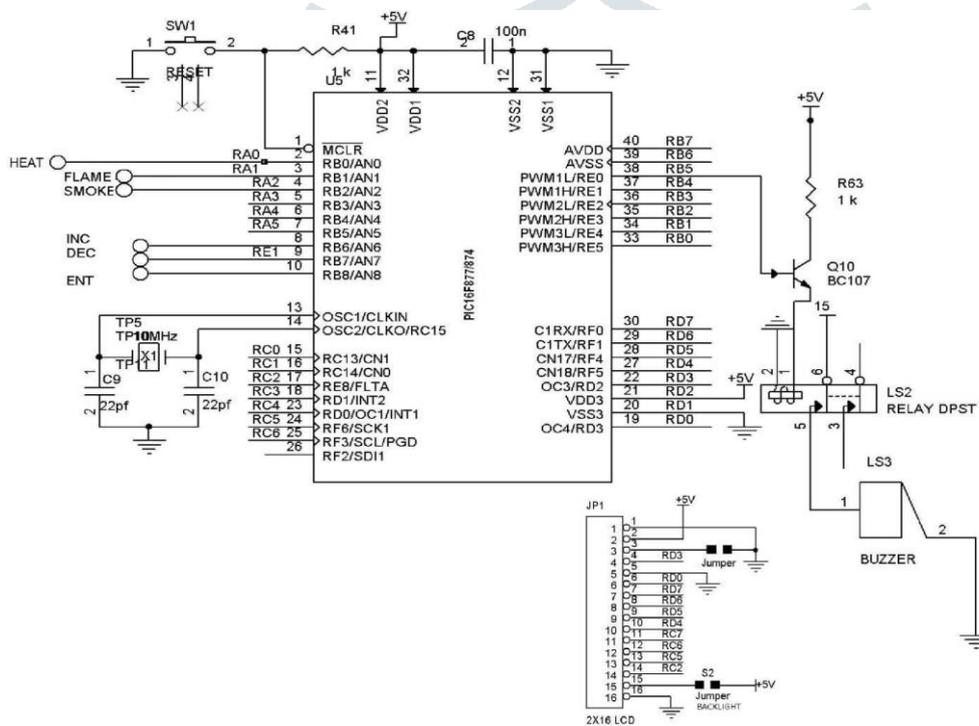


Fig 3.14 Multiplexing using microcontroller circuit diagram

#### 3.6.1. Microcontroller.

A microcontroller is a compact computing device integrated onto a single chip, comprising a processor core, memory, and programmable input/output peripherals. Typically, it includes program memory, such as NOR flash or OTP ROM, along with a limited amount of RAM. Unlike microprocessors found in personal computers, microcontrollers are tailored for embedded applications. They are extensively employed in automated products and systems, ranging from automobile engine controls to medical implants, remote controls, office equipment, household appliances, and toys. By consolidating processing, memory, and I/O functions onto a single chip, microcontrollers offer size and cost advantages, making digital control feasible for various devices and processes. Many microcontrollers feature mixed-signal capabilities, integrating analog components essential for controlling non-digital electronic systems. They exhibit diverse performance characteristics, with some operating on 4-bit words and clock frequencies as low as 4 kHz for minimal power consumption, ideal for battery-powered applications. Others fulfil performance-critical

roles, operating at higher clock speeds and consuming more power, akin to digital signal processors, for demanding

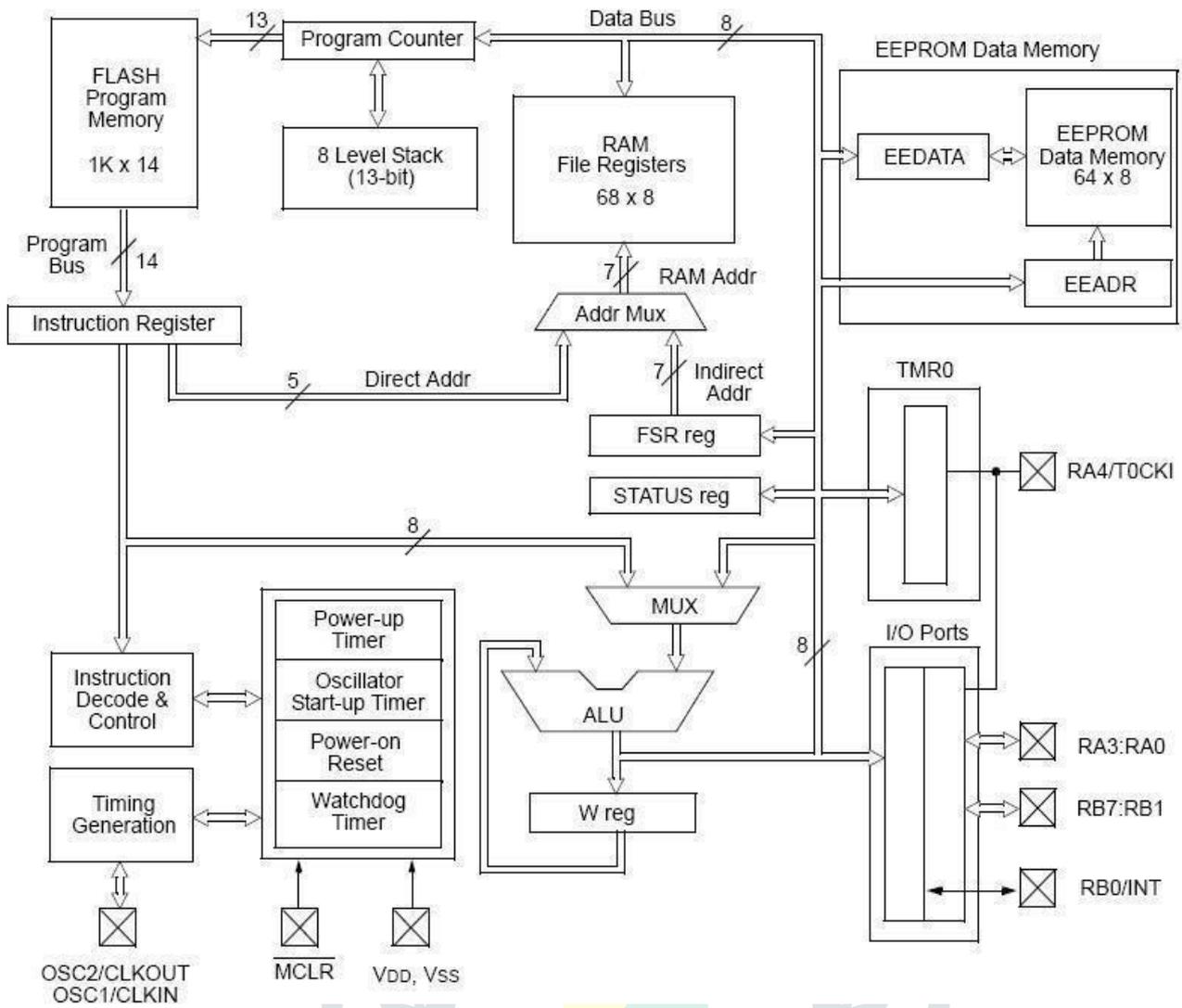


Fig 3.14 Microcontroller block diagram

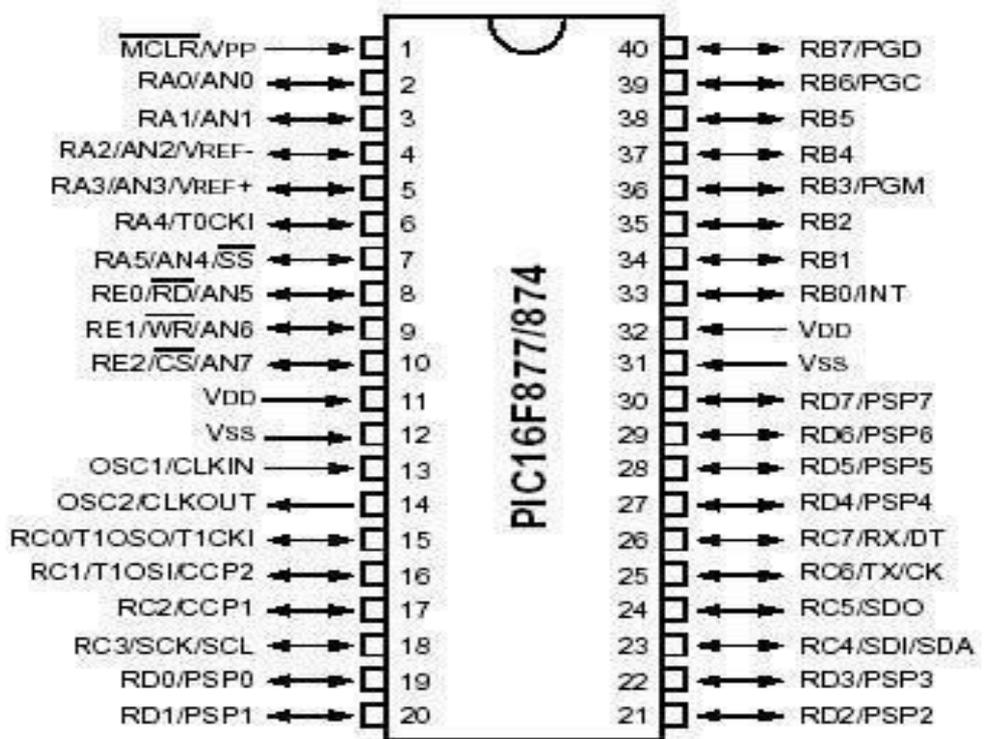


Fig 3.15 Microcontroller pin diagram

### 3.6.2. Coding for Embedded Systems in C.

Embedded C refers to a set of language enhancements for the C Programming language introduced by the C Standards committee to address common issues encountered in various embedded systems. Traditionally, embedded C programming has relied on nonstandard C language extensions to accommodate unique features like fixed-point arithmetic, multiple memory banks, and fundamental Input/Output operations. However, in 2008, the C Standards Committee extended the C language to address these challenges by establishing a unified standard for all implementations to follow. This standard incorporates several features not found in regular C, including fixed-point arithmetic, named address spaces, and hardware addressing for basic I/O operations. Embedded C largely retains the syntax and semantics of standard C, encompassing familiar elements like the main () function, variable declaration, conditional and loop statements, functions, arrays, structures, bit operations, macros, and unions.

### CONCLUSION

In essence, the amalgamation of smoke, heat, and flame detectors integrated into a microcontroller forms the foundation of a highly reliable fire detection system. This intricate network of sensors operates synergistically, constantly monitoring the environment for any signs of fire. Through the collective analysis of input data from these detectors, the microcontroller effectively discerns the presence of fire with exceptional accuracy. This holistic approach ensures that no aspect of a potential fire goes unnoticed, as each sensor is specialized in detecting specific elements associated with fire hazards.

Upon detection of any indication of fire, whether from one, two, or all three detectors, the microcontroller swiftly processes this information. Its rapid analysis triggers the immediate activation of the CO<sub>2</sub> flooding system. This automated response mechanism serves as a crucial line of defence, rapidly alerting workers and swiftly initiating fire suppression measures. By promptly flooding the affected area with CO<sub>2</sub>, the system aims to swiftly extinguish the fire, mitigating the potential for extensive property damage and, more importantly, safeguarding human life.

One of the paramount advantages of this integrated fire detection system is its ability to minimize the occurrence of false alarms. By employing a comprehensive array of sensors and a sophisticated microcontroller, the system can accurately differentiate between genuine fire threats and false alarms triggered by benign environmental factors. This not only enhances the system's reliability but also ensures that emergency response resources are utilized efficiently, reducing unnecessary disruptions and costs associated with false alarms.

In summary, this comprehensive approach to fire detection and suppression represents a significant advancement in fire safety technology. By seamlessly integrating multiple sensors with intelligent microcontroller processing, the system offers unparalleled accuracy, efficiency, and reliability in detecting and responding to fire emergencies, thereby safeguarding both property and human life with utmost effectiveness.

### REFERENCE

1. “Research on the Technology of Fire Detection Based on Image Processing in Unmanned Substation”- Zhou Jun-zhe, Song Ge (2010) “Fire Detection - the Least of Our Problems” - Andrew Morgan (1997)
2. “Vision-Based Flame Detection: Motion Detection & Fire Analysis”- Suzilawati Mohd Razmi, Nordin Saad, and Vijanth Sagayan Asirvadam (2010)
3. “Flame Recognition in Video” - Walter Phillips 111, Mubarak Shah, Niels da Vitoria Lobo
4. “Early-Stage Fire Detection Using Reliable Metal Oxide Gas Sensors and Artificial Neural Networks” -Bancha Charumpom, Michifumi Yoshioka, Tom Fujinaka, and Sigeru Omatu (2003)
5. “About automatic fire alarm systems research”- Huide Liu, Lili Gao, Suweiss Li, Tao Wu (2010)

