Fire Detection system using Arduino

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ABSTRACT

Fire detection systems are the most critical element of any building design these days. These days, reports of fire occurrences are frequent. In many instances, this could be the result of people's carelessness. Take a look at a few locations, such as gas stations, snack stores, homes, and primarily offices, etc. Every year, there are believed to be around ten thousand fire incidents. In this study, an automatic fire detection system using a sensor is introduced, taking all of these factors into account. Our suggested solution works differently from the current one, which uses a fire sensor to detect the fire. The current systems have fire alarms that sound an alert when a fire is discovered inside a certain area. The proposed system contains the fire alarm, Bread Board, LCD screen, Arduino in addition to that it sends a notification to our mobile and mail can be sent to the attached mail id which will be having the information of the accident-prone area, and also the information needed to alert the fire station about the incident.

Keywords— *sensor, Bread Board, Arduino Alarmed, Fire accident, Gas Station.*

I.INTRODUCTION

A fire alarm system is a system that is designed to warn people when there is fire, smokes, or any other harmful gas appear on the premise. The alarms are activated automatically or manually turned on with manual fire alarm activation devices such as manual call points or pull stations. The manual activation exist is to help people warn of a fire or harmful gas leak quickly as it may take some time for the sensors to kick in. The alarms can either be motorized bells or wall mounted sounder or horns. They can also be a speaker strobe which sound an alarm, followed by a voice urging evacuation message which alarming people on the situation and warning them not to use elevators if there is any. The fire alarms sounders can be set to different frequencies and tones depending on the country and the manufacturer. Some place needs a higher frequency and tone such as shopping malls and high-levelled building.

Fire alarm system is crucial in every building as it can prevent any mishaps and can save lives. The system can sense heat and gas thus alarming people via buzzer, automated announcements, or alarming lights. It is faster than having to scream to alarm people of a fire or a gas leak. Basically, heat sensor will sense any temperature above the normal room temperature. The

Arduino will be used as micro-controller to control the whole system. Once the temperature rise is detected, the signal will be sent to the buzzer or LED to alarm people. Thus, the people will be alarmed, and everyone will be able to evacuate safely.

The fire alarm system is a safety system that warn people when the flame and flammable gas are detected. This system will automatically activate when the flame sensor and gas sensor detected the flame and gas. Then, the piezo buzzer will trigger and the LED will turn on to warn the people surrounding. In addition, the LCD also will display the status of this fire alarm system.

II. CIRCUIT DIAGRAM

The circuit diagram for the fire detection system using Arduino consists of several key components interconnected on a breadboard. The Arduino board is at the center, connected to a gas sensor, a piezo sensor, a micro servo motor, and an LCD display. The gas sensor detects smoke or combustion gases, while the piezo sensor listens for fire-related sounds. When either sensor detects a fire hazard, the Arduino processes the data and triggers the servo motor to actuate a safety mechanism, such as closing a vent or activating an alarm.

The LCD display provides real-time feedback by showing sensor readings and alert messages, ensuring occupants are informed about potential fire risks.

III.LIST OF ELEMENTS AND OVERVIEW

The list of elements that are required to develop Fire Detection system as shown in the below table[I]. some of the main components are Arduino, Micro servo motor, Bread Board.

TABLEI.LIST OF ELEMENTS THAT ARE REQUIRED

Component	Quantity
Arduino	1
Micro servo motor	1
Piezo sensor	1
Gas sensor	1
Bread Board	1
LCD screen	1
Connecting wires	As required

We will discuss briefly about the each and every component thatis listed in the above table[I].

1. Arduino:

In this fire alarm system, the Arduino uno R3 ATMEGA328P has been used. The Arduino environment has two platform which are a development board and the software environment. A development board has 8-bit microcontroller, programming hardware, USB programming interface and input/output pin. For software development which is Integrated Development Environment (IDE) has cross-compiler, debugger, simulator and programmer. To make the programming code of the system, the code is upload from Arduino IDE to microcontroller (ATMEGA328P) at Arduino uno.

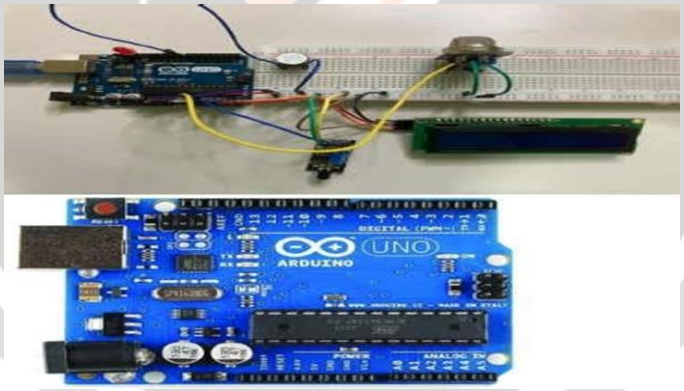


Fig2: Arduino diagram

2.**Micro servo motor:**

The working principle of a micro servo motor is based on the interaction between electrical signals and mechanical components, primarily involving a small DC motor, gears, a potentiometer, and control electronics.

Here's how it typically works:

1. **DC Motor**: At the core of a micro servo motor is a small DC motor. When electricity flows through the motor, it generates rotational motion.
2. **Gears**: The rotational motion from the DC motor is transferred to gears, which then amplify the torque and reduce the speed of rotation. Gears are crucial in servo motors as they provide the necessary mechanical advantage for precise control.
3. **Potentiometer (Position Feedback Device)**: Inside the servo motor, there is a potentiometer or a similar position feedback device. This component provides feedback to the control electronics regarding the current position of the motor shaft. The potentiometer is mechanically coupled to the output shaft of the motor so that its resistance changes as the shaft rotates.
4. **Control Electronics**: The control electronics receive input signals, typically in the form of PWM (Pulse Width Modulation) signals, from an external controller, such as a microcontroller or a servo motor driver.
   These control signals determine the desired position or angle that the servo motor should rotate to.

5. **Feedback Loop**: The control electronics compare the desired position with the actual position If there's a difference between the desired and actual positions, the control electronics adjust the voltage supplied to the motor to drive it in the required direction until the positions match.
6. **Closed-Loop Control**: Servo motors operate in a closed-loop control system. This means that they continuously monitor their own output and adjust their behaviour to achieve the desired output. The feedback mechanism provided by the potentiometer ensures accurate positioning and helps correct any deviations from the desired position.
7. **Mechanical Output**: The output shaft of the servo motor rotates to the desired position based on the control signals received by the control electronics. This rotational motion can be used to actuate various mechanisms, such as steering in RC vehicles, moving robot joints, or controlling camera gimbals.

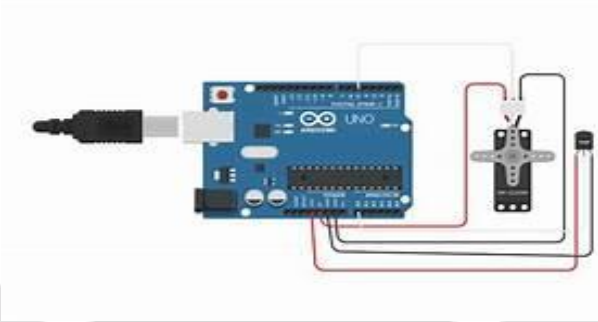


Fig3: Micro server motor

3.**Piezo Electric Sensor:**

Piezoelectric sensors are fascinating devices that convert mechanical stress or pressure into electrical signals. Here's how they work:

1. Piezoelectric Material: At the core of a piezoelectric sensor is a piezoelectric material, such as quartz, Rochelle salt, or certain ceramics. These materials exhibit the piezoelectric effect, which means they generate an electric charge in response to mechanical stress or pressure.
2. Crystalline Structure: Piezoelectric materials have a unique crystalline structure that allows them to generate electric charges when subjected to mechanical deformation. When pressure is applied to the material, it causes a slight distortion in the arrangement of atoms within the crystal lattice, resulting in the separation of positive and negative charges.
3. Generation of Electric Charge: When mechanical stress or pressure is applied to the piezoelectric material, it generates an electric charge across its surface. This charge is proportional to the amount of pressure applied and the sensitivity of the material.
4. Electrodes: To capture the electric charge generated by the piezoelectric material, electrodes are attached to its surface. These electrodes allow the electric charge to be conducted away from the material and used as an electrical signal.
5. Output Signal: The electric charge generated by the piezoelectric material is typically in the form of a voltage or current signal. This signal can be amplified and processed to measure the magnitude and duration of the applied pressure or mechanical stress.
6. Applications: Piezoelectric sensors find applications in various fields, including:
    - Pressure sensing: Piezoelectric sensors can measure changes in pressure, making them useful in applications such as pressure monitoring in industrial processes, automotive tire pressure monitoring systems, and medical devices.
    - Acceleration sensing: Piezoelectric sensors can detect changes in acceleration, allowing them to be used in devices like airbag deployment systems in automobiles and vibration monitoring systems.
    - Force sensing: Piezoelectric sensors can measure force or load, making them valuable in applications such as force-sensitive touch screens, load cells in weighing scales, and structural health monitoring of bridges and buildings.
7. High Sensitivity: Piezoelectric sensors are known for their high sensitivity and fast response times. They can detect very small changes in pressure or mechanical stress, making them suitable for precise measurements in various applications.

In summary, piezoelectric sensors convert mechanic stress or pressure into electrical signals through the piezoelectric effect, allowing for sensitive and accurate measurement of various physical parameters.

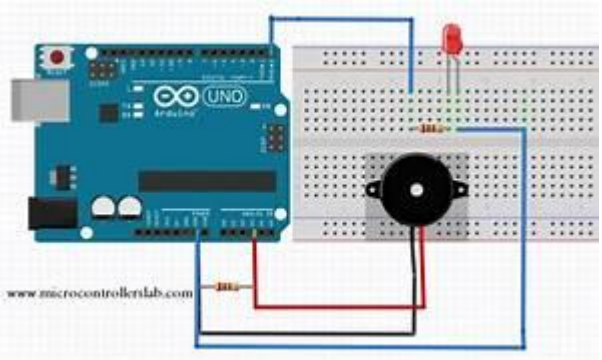


Fig4: Piezo Electric Sensor

4.Gas Sensor:

Gas sensors are vital components used to detect thepresence and concentration of gases in the air. Here an overview of their construction and working principle:

Construction:

1. **Gas-Sensitive Material**: The heart of a gas sensor is a gas-sensitive material. This material undergoes changes in its electrical properties (e.g., resistance, capacitance) when it comes into contact with specific gases. Common gas-sensitive materials include metal oxides (e.g., tin dioxide), semiconducting polymers, and catalytic metals.
2. **Substrate**: The gas-sensitive material is typically deposited or coated onto a substrate, which provides mechanical support and electrical connections. The substrate can be made of materials like ceramic, glass, or silicon.
3. **Electrodes**: Electrodes are attached to the gas-sensitive material to measure the changes in its electrical properties. These electrodes allow the sensor to interface with external circuitry for signal processing and analysis.
4. **Enclosure**: Gas sensors are often housed in protective enclosures to shield them from environmental factors such as humidity, temperature variations, and mechanical damage. The enclosure may have openings or pores to allow the gas to reach the sensing element.
5. **Heater Element (For Some Types)**: In certain gas sensor designs, especially those using metal oxide materials, a built-in heater element is included. The heater increases the operating temperature of the sensing element, promoting gas adsorption and enhancing sensor response.

Working Principle:

1. **Gas Adsorption**: When a gas comes into contact with the gas-sensitive material, it undergoes adsorption or absorption onto the surface of the material. This interaction changes the electrical conductivity or capacitance of the sensing element.
2. **Change in Electrical Properties**: The adsorption of gas molecules causes a change in the electrical properties of the gas-sensitive material. For example, in metal oxide-based sensors, the presence of reducing gases leads to a decrease in resistance, while oxidizing gases cause an increase in resistance.
3. **Measurement**: The electrodes connected to the gas-sensitive material detect the changes in electrical properties. By measuring parameters such as resistance, capacitance, or voltage, the sensor can determine the concentration of the target gas in the surrounding environment.
4. **Signal Processing**: The electrical signal from the sensor is often processed using additional circuitry, such as amplifiers, filters, and analog-to-digital converters. This processing may include calibration and compensation for environmental factors to improve the accuracy and reliability of the gas concentration measurement.
5. **Output**: Gas sensors typically provide an output signal proportional to the concentration of the target gas. This output can be displayed on a digital screen, transmitted to a control system for automated actions, or logged for further analysis.

Gas sensors are widely used in various applications, including environmental monitoring, industrial safety, indoor air quality monitoring, automotive exhaust monitoring, and detection of hazardous gases in confined spaces. They play a crucial role in ensuring safety and efficiency in diverse settings.

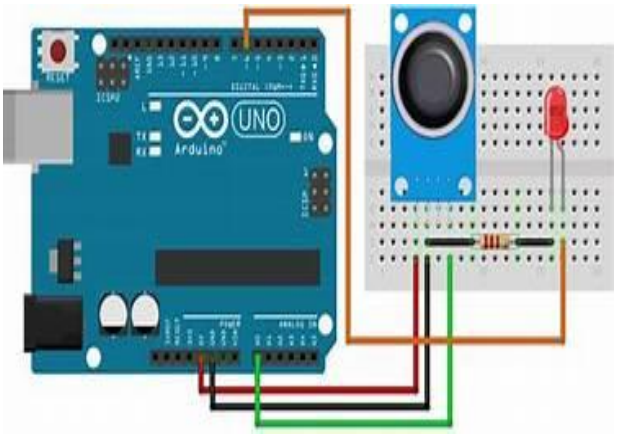


Fig5: Gas Sensor

5.Bread Board:

A breadboard, also known as a protoboard, is a fundamental tool used in electronics prototyping to create temporary circuits. Here's how it works:

Construction:

1. **Holes**: A breadboard consists of a plastic base with a grid of holes arranged in rows and columns. These holes are typically interconnected in a specific pattern underneath the plastic base.
2. **Rails**: Along the edges of the breadboard, there are usually two sets of metal strips called rails. These rails provide power distribution lines for the circuits built on the breadboard.
3. **Terminal Strips**: The rows of holes in the main body of the breadboard are divided into sections called terminal strips. Each terminal strip typically consists of several interconnected holes, usually five per row.

Working Principle:

1. **Inserting Components**: To create a circuit on a breadboard, electronic components such as resistors, capacitors, integrated circuits (ICs), and wires are inserted into the holes of the breadboard. The legs or leads of the components are inserted into the holes to make electrical connections.
2. **Interconnections**: The holes in each terminal strip are internally connected, usually in a linear manner. This means that inserting a component lead into any hole within a terminal strip will create an electrical connection with all other holes in that same strip.
3. **Connections across the Breadboard**: Components can be connected across the breadboard by inserting their leads into appropriate holes. For example, connecting a resistor between two adjacent holes in different terminal strips creates an electrical connection between those strips.
4. **Power Distribution**: The rails on the edges of the breadboard provide power distribution lines. Typically, one rail is used for connecting to the positive (+) supply voltage (usually labelled as VCC or +) while the other rail is used for connecting to the ground (GND or -) supply. Additional rails may be present for other voltages or common reference points.
5. **Building Circuits**: By inserting components and making connections on the breadboard, complex circuits can be built and tested without soldering. Components can be easily rearranged or replaced to experiment with different circuit configurations.
6. **Prototyping and Testing**: Breadboards are commonly used in electronics prototyping to quickly test circuit designs before finalizing them for soldering onto a printed circuit board (PCB). They allow engineers and hobbyists to experiment with circuits, troubleshoot problems, and iterate on designs rapidly.
7. **Reusable**: Breadboards are reusable, allowing components to be removed and circuits to be dismantled easily. This makes them a convenient tool for iterative design and experimentation.

Overall, breadboards provide a versatile and practical platform for electronics enthusiasts and professionals to create, test, and iterate on circuit designs without the need for soldering or permanent connections.

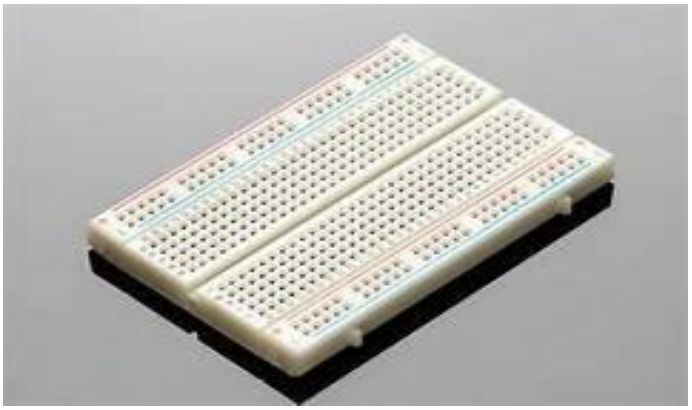


Fig6: Bread Board

6.Lcd Screen:

Liquid Crystal Display (LCD) screens are widely used in devices such as televisions, computer monitors, smartphones, and digital clocks. Here's an overview of how LCD screens work:

Construction:

1. **Liquid Crystal Layer**: The core component of an LCD screen is a layer of liquid crystal material sandwiched between two transparent electrodes. This layer is typically made up of long, rod-shaped molecules that can align themselves under an electric field.
2. **Polarizing Filters**: Two polarizing filters are placed on either side of the liquid crystal layer. These filters are oriented at right angles to each other, meaning that light can only pass through the combination when its polarization matches the alignment of both filters.
3. **Glass Substrates**: The electrodes and polarizing filters are typically attached to glass substrates, which provide mechanical support and protection for the delicate components.
4. **Backlight**: In most LCD screens, a backlight is placed behind the liquid crystal layer to provide illumination. This backlight can be fluorescent tubes, LEDs (Light Emitting Diodes), or other light sources.

Working Principle:

1. **Polarization of Light**: When unpolarized light from the backlight enters the LCD screen, it passes through the first polarizing filter. This filter polarizes the light waves in a specific orientation.
2. **Control of Light by Liquid Crystals**: The liquid crystal layer acts as a light valve. When an electric field is applied to specific areas of the liquid crystal layer by the transparent electrodes, the orientation of the liquid crystal molecules changes. Depending on the type of LCD (e.g., Twisted Nematic, In-Plane Switching), this change in orientation affects the polarization of light passing through the layer.
3. **Manipulating Light Transmission**: By varying the voltage applied to different areas of the liquid crystal layer, the amount of light transmitted through those areas can be controlled. This allows the LCD screen to display different shades of colour and brightness by selectively blocking or allowing light to pass through.
4. **Colour Filters**: In colour LCD screens, additional colour filters are placed over the pixels to produce a full range of colours. Each pixel typically consists of subpixels with red, green, and blue colour filters, allowing for the creation of a wide spectrum of colours when combined.
5. **Pixel Array**: The LCD screen is divided into an array of pixels, each containing liquid crystal cells corresponding to individual image elements (pixels) on the screen. By controlling the voltage applied to each pixel, the desired image can be displayed on the screen.
6. **Backlight Adjustment**: In some LCD screens, the intensity of the backlight can be adjusted dynamically to control overall brightness and power consumption.

Overall, the working principle of LCD screens involves manipulating the polarization of light using liquid crystals controlled by electric fields, resulting in the display of images and text on the screen.

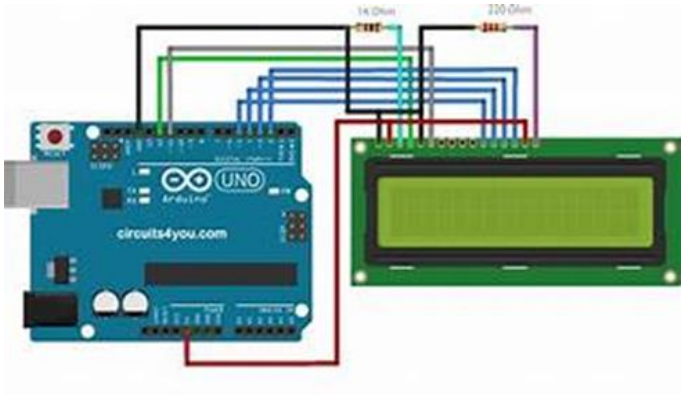


Fig7: Lcd Screen

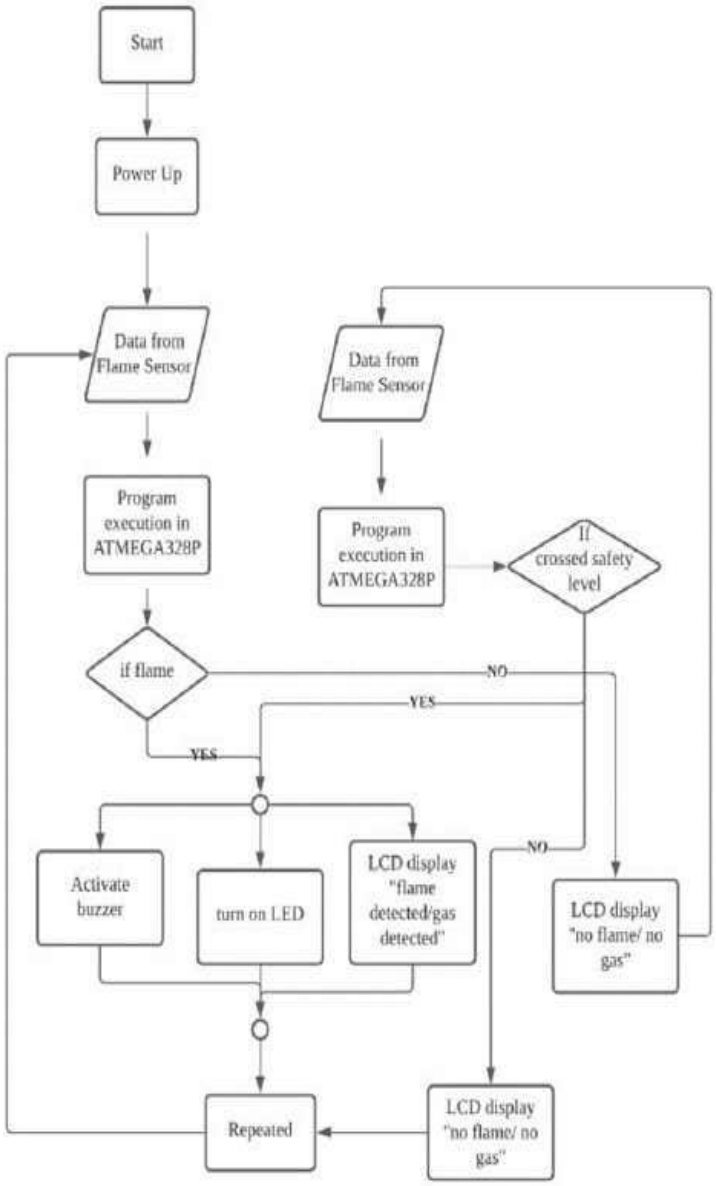
8.Connecting Wires:

Connecting wires, also known simply as wires or jumper wires, are essential components in electronics and electrical engineering. They are used to establish electrical connections between various components such as microcontrollers, sensors, actuators, and other electronic devices. Here are some key points about connecting wires:

1. **Purpose:** The main purpose of connecting wires is to transmit electrical signals, power, or data between different components in a circuit or system.
2. **Types:** Connecting wires come in various types, including solid core wires and stranded wires. Solid core wires have a single, solid conductor inside, making them suitable for breadboarding and creating stable connections. Stranded wires have multiple thin strands of wire twisted together, providing flexibility and durability, which is useful for projects that involve movement or frequent adjustments.
3. **Gauge:** Wires are available in different gauges (thicknesses), typically measured in American Wire Gauge (AWG) or millimetres squared (mm^2). The gauge of the wire determines its current-carrying capacity and resistance. Thicker wires (lower AWG number or larger mm^2) can carry more current without overheating.
4. **Colours:** Connecting wires often come in different colours, such as red, black, blue, green, yellow, and white. These colours are used to visually distinguish between different connections, power rails, ground connections, data lines, and so on, which helps in organizing and troubleshooting complex circuits.
5. **Termination:** Wires may have various types of terminations or connectors at their ends, such as male or female header pins, alligator clips, spade connectors, banana plugs, or bare ends for soldering. The type of termination depends on the application and how the wire will be connected to other components.
6. **Usage:** Connecting wires are widely used in prototyping, circuit building, testing, and repair work. They are commonly used with breadboards, where components can be easily plugged in and interconnected without soldering.
7. **Safety:** When working with connecting wires, it's important to observe proper safety practices, such as using wires with appropriate gauges for the current being carried, avoiding sharp bends that can damage the wire, and ensuring secure connections to prevent short circuits or intermittent connections.

Fig8: Connecting Wires

7.Flow Chart:



1.For flame sensor and gas sensor, the program will execute in microcontrollerATMEGA328P which pin A2 and A0 as input, respectively.2.

2.For buzzer, LED and LCD as output. LCD is connected to analog pin A4 and A5 while buzzer and LED is connected to digital pin 8 and pin 13 respectively.

3.Threshold is set at value 500.

4.If the flame sensor detects the flame (flame value<500), buzzer and LED will activate, and LCD will display “FLAME: FLAME IS DETECTED”. While if the flame sensor does not detect the flame (flame value>500), buzzer and LED will not activate, and the LCD will display “FLAME: NO FLAME”.

5.If gas sensor detects the flammable gas or smoke (>500), buzzer and LED will activate and LED will display “GAS: GAS IS DETECTED”. While if the gas sensor does not detect the flammable gas or smoke (<500), buzzer and LED will not activate, and LCD will display “GAS: NO GAS”.

6.This program will repeat and loop.

8.Assembly Method:

1.Prepared all components that used to make fire alarm system.

2.Put the piezo buzzer and gas sensor at breadboard.

3.For piezo buzzer, connect the positive pin to digital pin while negative to ground pin using jumping wire.

4.For gas sensor, connect the pin A0 to pin analog A0 at Arduino UNO.

5.Connect to analog pin A2 for flame sensor.

6.The LED is connected to pin 137. The LCD is connected to analog pin A4 and A58. Power up the Arduino with connect to laptop/PC.9 Open software Arduino IDE and upload the sketch or program code to Arduino uno10. Then, light on the flame at flame sensor to see the output happen11 Then, turn on the flammable gas at gas sensor to see the output

Piezo buzzer

Positive pin (+) = pin 8 Negative pin (-) = ground

LED

Anode = pin 13Cathode = ground

Flame sensor

A0 = pin A2GND = ground VCC = power 5 V

Gas sensor

A0 = pin A0GND = ground VCC = power 5 V

Liquid crystal (LCD)

GND = ground VCC = power 5 VSDA = pin A4SCL = pin A5

9.Coding:

```
#include <Servo.h>
#include <LiquidCrystal.h>

LiquidCrystal lcd (5,6,8,9,10,11);
int buzzer = 4;
int sensor = A0;
int sensorThresh = 400;
int sensor2 = A1;
int sensor2Thresh = A1;
Servo myServo;
```

```
 void setup()
 {   pinMode(buzzer, OUTPUT);
 pinMode(sensor, INPUT);
 myServo. Attach(7);
 Serial.begin(9600);
 lcd.begin(16,2);
}
 void loop() {
 int val = analogRead(sensor);
 Serial.println(val);
 if (val > sensorThresh)
 {
  tone(buzzer, 1000, 500);
  lcd.clear();
  lcd.setCursor(0,1);
  lcd.print("MUST EVACUATE");
  delay(1000);
  lcd.clear();
  lcd.setCursor(0,1);
  lcd.print("ALARM ON!");
  myServo.write(180);
  delay(1000);
          }
          else
          {
     noTone(buzzer);
     lcd.clear();
     lcd.setCursor(0,0);
     lcd.print("ALARM OFF");
     delay(1000);
 }

}
```

IV. Result and Conclusion:

After several tests have been done towards our project, The Fire Alarm System has been able to be conducted according to the desired system. The system consists of two inputs, which are flame sensor and gas sensor. Starting off with the flame sensor, it detects the presence of the fire and it will send a signal to its output. In this case, the outputs are LED, Piezo Buzzer and the LCD Panel. The LED will light up and the buzzer will produce the sound after obtain the signal to aware the users about the presence of fire. The LCD Panel will display the information about the presence of fire. The second input, which is the gas sensor is a component that measures presences of the gas, which is smoke in this case. The type of gas sensor we use for this project is MQ-2. This type of gas sensor able to detects butane, methane, LPG and smoke. This gas sensor is placed at this fire alarm system to enhance to safety when there are fires. When the situation occurs, it will send a signal to its output, which is the buzzer. This buzzer acts as an alarm that reminds the users to be aware of the situation. Certain tests, improvements and changes were done to achieve the results mentioned above. The sensors have been tested and it work well as intended. This project certainly can be a huge helping to the society to prevent the unwanted situation. This alarm system can implement Fire Alarm requirement to maintain the safety and eliminate hazard.

V.ACKNOWLEDGMENT

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