Module Code & Module Title

4CS016: Embedded Systems Programming

Mini Project: Fire alarm system

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Abstract

The innovations of embedded systems has proven to be aid humans' day to day life easier, work smarter and environment safer. This project can be taken as a prime example of how these innovation can be used for the betterment of every people and the society. Environmental circumstances and personal carelessness are the most common causes of fires in houses, which pose a menace to the neighborhood, resulting in human mortality and property destruction. Considering this, I have choose to make a fire alarm system, which uses the simple devices but could save lives. The most crucial issue in household fire detection systems is quick warning of a fire. As a result of sensor failure, wireless sensor networks based fire detection systems might fail to identify a fire. To mitigate and minimize this major issue we have developed a DIY Arduino fire alarm system from scratch using various tools. We have also used smoke sensor to detect smoke level, which will send a signal to Arduino, which then will pass on the signal to a buzzer that will buzz and alert the surrounding area as an output of the system. Alarm that will alert everyone in the vicinity of the fire. Additionally, a user-friendly LCD display provides real-time updates and relevant information corresponding to the detected smoke level.

This fire alarm system provides better accuracy and reliability while addressing the need for quick warnings, lowering the risk of fire-related damages and casualties in residential areas. This project showcases the potential of embedded systems in creating valuable safety solutions and contributes in creating safer living spaces in low-budget with high reliability. The report outlines the methodology, technical details, findings, and recommendations for future enhancements of the system.

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1. Introduction

Majority of houses, businesses and the entire environment are at risk of fire. A lack of safety precautions could result in substantial loss of life and properties. Fire is one of the most common causes of damage to structures, human lives and air pollution, particularly in Nepal. For every organization or household, fire detection systems are an extremely valuable fire-fighting equipment. Early detection is critical in ensuring the safety of firefighters. Losses can be considerably avoided when fire detection systems are used properly (Schroll, Dec 7, 2007).

The main objective of this project is to mitigate the risk of fire and its damages on human lives by alerting people on time. This project has leveraged the capabilities and the significant implementation of arduino undo, smoke sensor and various other such as LCD, LED, buzzer etc. to construct a cost-effective and reliable fire alarm system, which will detect the smoke and alert people if the smoke goes beyond the predefined threshold.

The arduino uno is a microcontroller board which provides the real-time detection of the environment by getting the information from the gas sensor. The gas-sensor detects and monitors the smoke level, red led glows and the buzzer buzzes if the smoke level exceeds the threshold.

1.1Current Scenario in Nepal

Forest and home fires are most common in Nepal during the spring season. The current hot and dry weather conditions increase the risk of flames across the country. According to government figures, 77 people die in Nepal each year due to fire-related incidents, including forest fires.

According to a recent assessment from the National Disaster Risk Reduction Management Authority (NDRRMA), fires have caused enormous damage over the last ten years, from 2014 to mid-March 2023. During this time, a total of 18,772 fire incidents were registered in Nepal, according to the NDRRMA. These incidents led to the loss of 769 lives and left 2,548 individuals injured. The financial cost of the damages amounted to over Rs. 22.23 billion during the same period. (Khatri, 2023).

There was massive rate of wildfires at 92 different places all over Nepal, according to the data of the Department of Forests and Soil Conservation. The online fire alert system provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) indicates that there are active fires in multiple locations. Specifically, Pyuthan has 15 fire incidents, Chitwan has 14, and Parsa has 10. Additionally, wildfires are occurring in seven places in Palpa, six in Dang, and five in Gorkha till april 2023. (Republica, 2023)

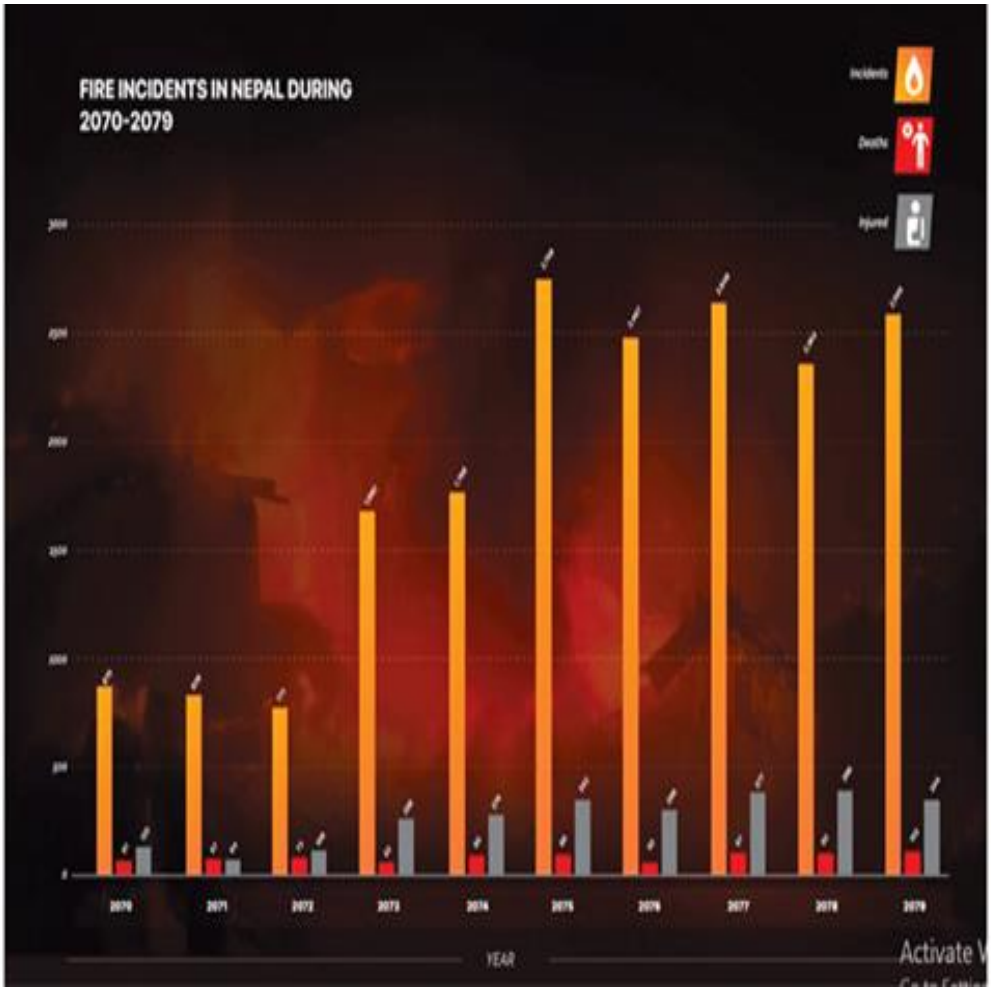

Figure 1 Bar graph of Fire incidents in Nepal from 2070 to 2079

1.2 Project as a Solution

After analyzing the current scenario and problems in our society I have come up with this project to give a solution to this major issue. As the concept of fire alarms in homes is still an evolving concept in our country I have researched and developed a DIY (Do it yourself) Fire alarm system which anyone can build with very minimum resources and some research in this field. No matter how careful we can be, sometimes all it takes is a simple scented candle or a gas leakage to cause havoc in your household or a business. To avoid it as much as possible, this system is a great way to protect ourselves and our property. Before the fire gets out of control, the system delivers an early warning of the threat, giving enough time to leave the building and alert the authorities. As we know the significance of time in internal or external fires, early detection with the help of our DIY fire alarm system can help many homes in our society to not only protect their property but most importantly protect themselves and other family members from it.

1.3 Aims and Objectives:

The main aim of this project is to build an easy and convenient fire alarm system with buzzer which will alert people about the fire on time. Our aim was also encouraging and create awareness about the importance of fire alarm systems. Some of the objectives are:

- To aware people about the importance of fire safety and alarm system at households, businesses, health and to environment.

- To provide an idea and concept of Do-it-yourself fire alarm system, which anyone can build at home with limited resources.

- To build a fire alarm system that will detect the fire as soon as possible and the alarm will go off.

- To help in avoiding major damage and loss to property of people using the fire alarm system.

2. Background

2.1. System Overview

Fire detection and alarm systems are meant to detect fires early in their progression, when it is still possible to take the required actions to protect the safety of occupants and infrastructure. Detectors offer data to the control panels, which raise the alarms in this system. The detection system and the alarm system are the two main components of a fire alarm and detection system. The development of a home fire alarm is based on the Arduino board as the main controller board that interacts with the smoke sensor for this project. A smoke sensor that is sensitive to different gases, is one of the easiest ways to detect smoke. Now, in the event of a fire, smoke level can be detected by our smoke sensor, which will notify Arduino that a fire has been detected. The 220ohm resistor is used to resist the amount of voltage. The output is digital and the working voltage is 5v DC. A logic high on the output indicates the existence of smoke which will glow the red led ands trigger the buzzer to buzz continuously. A low logic output indicates that there is no smoke. I have implemented the use of LCD to display the message to people according to the level of smoke.

2.2. Design and Diagrams

Frizting Diagram: This is the design of hardware Architecture of fire alarm system.

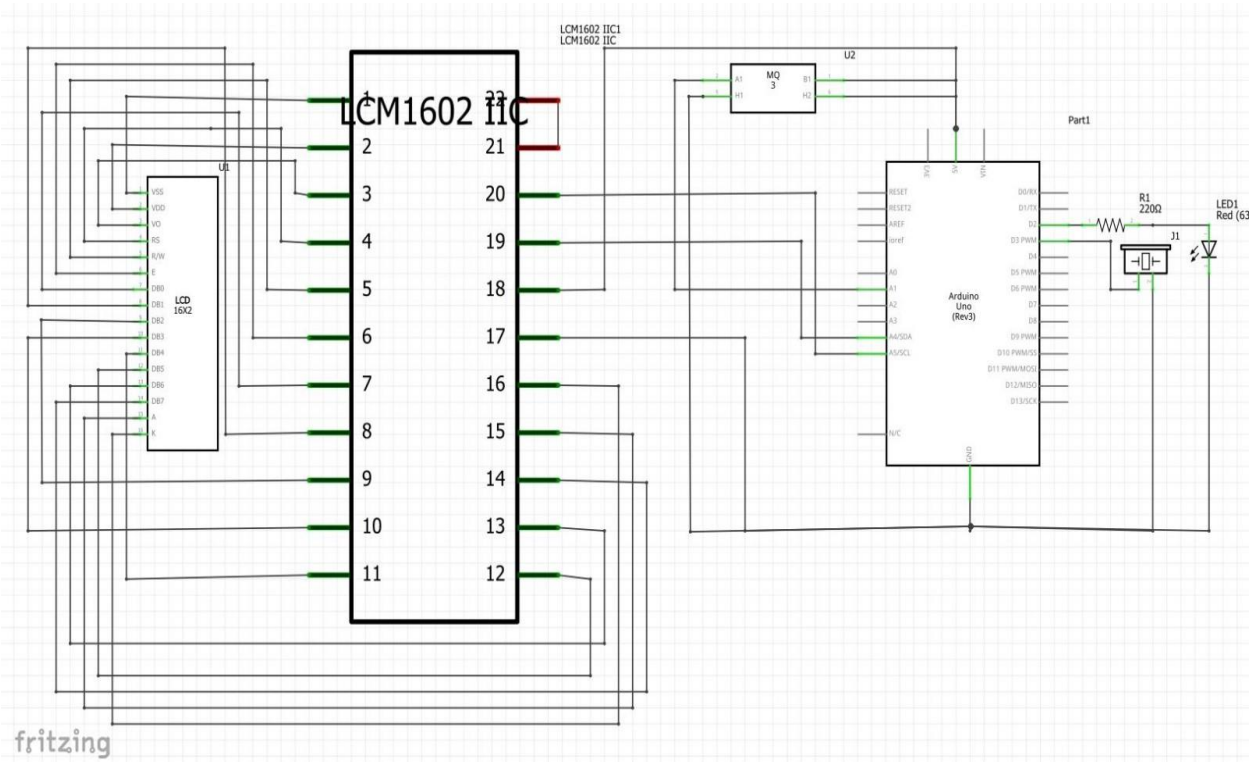

Figure 2 Fritzing Diagram

Circuit Diagram: This is the diagram of fire alarm circuit**.**

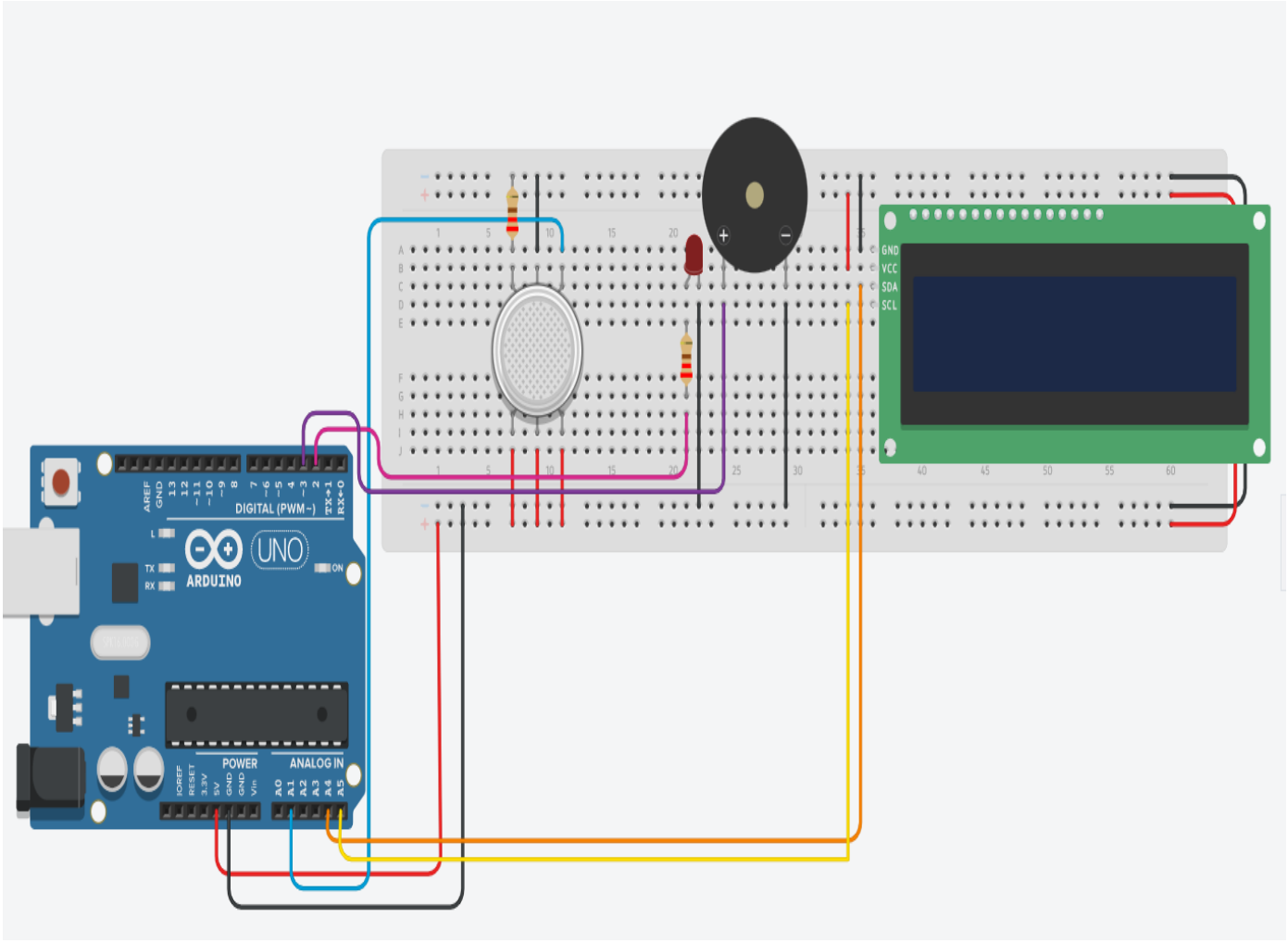

Figure 3 Tinkercad Circuit diagram of fire alarm system

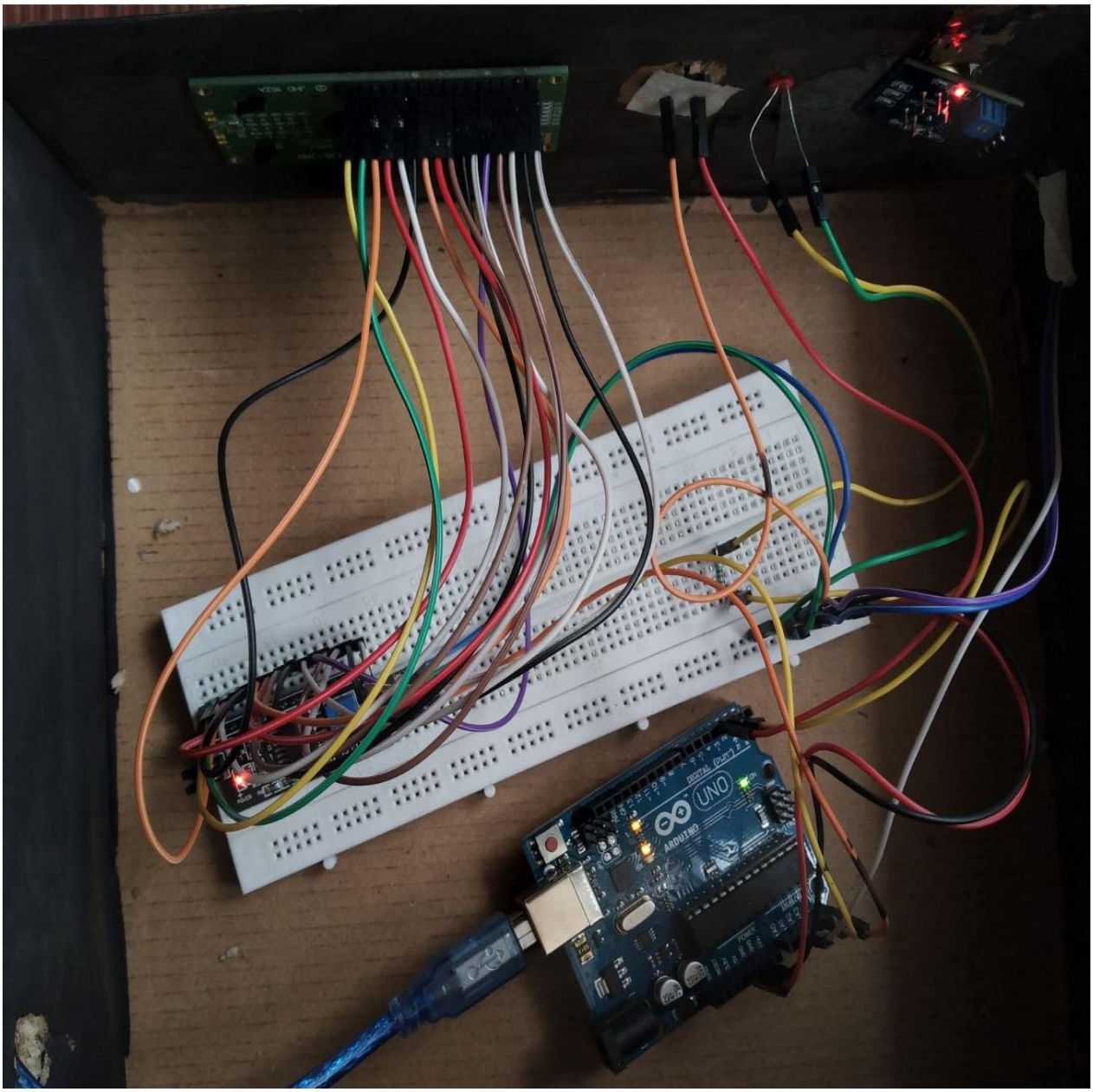

Figure 4 Circuit connection diagram

Flowchart: This the flowchart of fire alarm system.

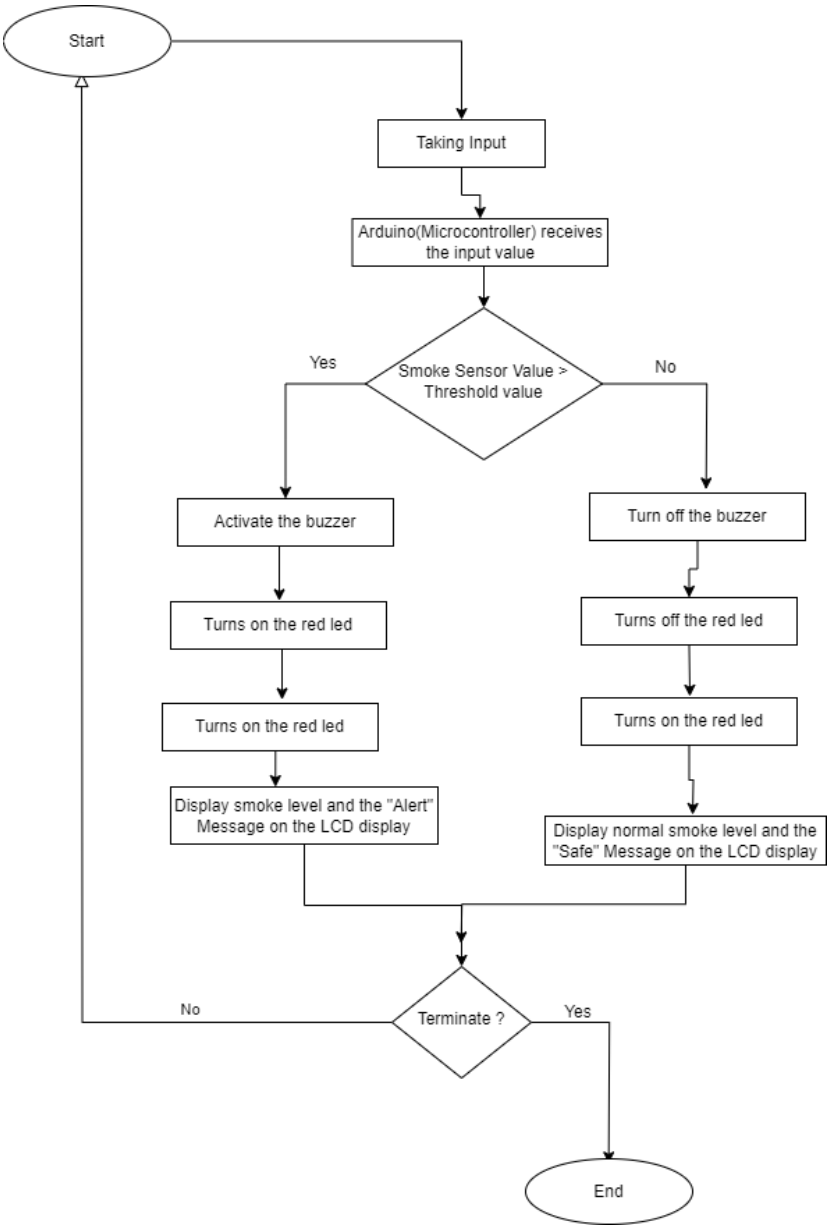

Figure 5 Flowchart of Fire Alarm System

2.3. Components used:

Following components are used while developing the fire alarm system as a project.

- **Arduino Uno**: Because Arduino is the main board, the ATmega328 microcontroller on it is employed as the circuit's main controller, it detects and monitors real-time detection of the objects in the environment. It's a well-known open-source microcontroller-based kit introduced in Italy in 2004 by Massimo Banzi for building wide range of projects. It interacts with array of outputs the LEDs, motors and displays in response to the inputs and the sensor. It has a set of analog and digital pins that may be used in a range of other boards and circuits to do a variety of tasks. The Arduino board has a USB serial communication interface for loading codes from a computer. (Makerspaces, 2022)

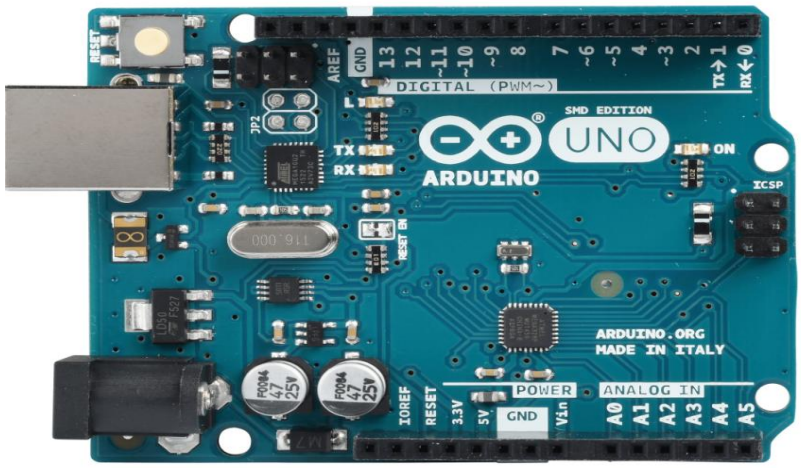

Figure 6 Arduino Uno

- **16*2 LCD Display**: LCD stands for Liquid Crystal Display, and used in various devices such as calculator, mobile phone etc. 16*2 LCD display has 16 pin outs. The main features of LCD display are:

- The LCD operates within a voltage range of 4.7V to 5.3V.
- The LCD consists of two rows, with each row capable of displaying up to 16 characters.
- The LCD has a low current consumption of 1mA when the backlight is not activated. (elprocus, 2023)

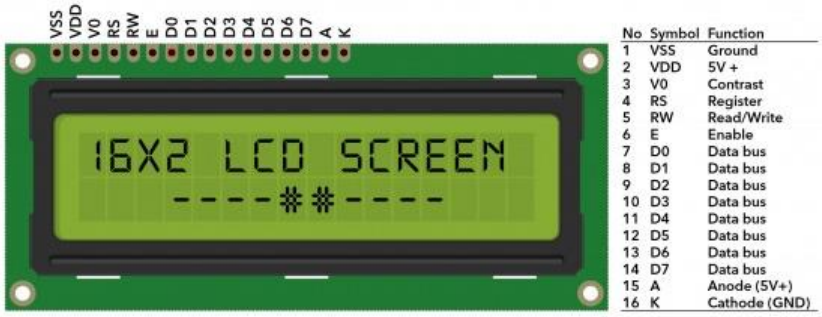

*Figure 7 16 * 2 LCD Display*

- **I2c serial interface adapter Module:** I2C serial interface adapter module with the PCF8574 chip is used to control LCD panel so as to provide easier pin configuration. This module makes the work much simpler by requiring only four pins. Two signal output pins (SDA and SCL) are made available when a 16x2 LCD is connected to the serial interface adaptor and other two pins VCC and GND simply connected to 5V and GND of arduino. (Components101, 2021)

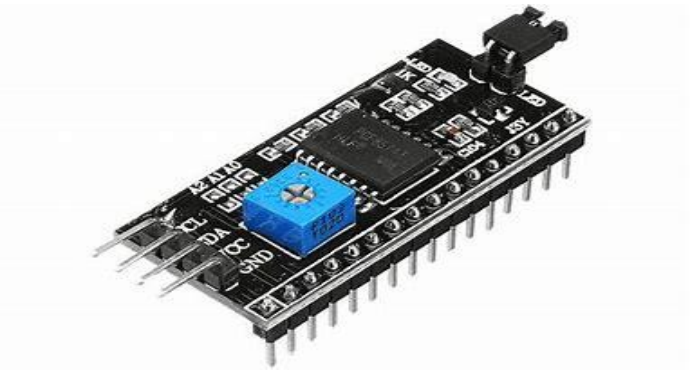

Figure 8 I2c serial interface adapter Module:

- **LED:** LEDs, short for light-emitting diodes, are electronic devices that emit visible or infrared light when an electric current is applied. They are widely used in various electronic devices as indicator lamps, such as in appliances, electronics, and automotive applications. Moreover, LEDs are utilized in signage and billboards as alphanumeric displays or even for creating full-color posters. Their versatility makes LEDs a popular choice for efficient and durable lighting solutions in many different industries. (britannica, 2023)

Figure 9 led

- **Smoke Sensor:** MQ2 sensor is widely used MOS sensor which can detect different gases by analyzing the resistance. It consumes approximately 800mW and 5V DC power. It is capable of detecting range of gases which includes LPG smoke, alcohol, propane, hydrogen, methane, and carbon monoxide. It is commonly used in the applications such as LPG gas detection, fire alarm, air quality monitoring systems etc. IT has 3 pins, which connects to ground, 5V and analog pin. It is easy to use and has two different outputs. In addition to a binary signal of their presence, it offers an analog representation of the quantity of combustible gasses in air. (lastminuteengineers, 2018)

Figure 10 Smoke Sensor

- **Buzzer:** A buzzer is a mechanical or electromechanical audio signaling device which converts a signal from audio to sound. Buzzer has two terminal namely positive and negative terminal. DC power (ranges from 3V – 24V) is passed through positive terminal, whereas the negative pin is connected to GND terminal. It is mostly used in alarms, timer, printers, etc. (elprocus, 2023)

Figure 11 Buzzer

- **Jumper Wires:** The wires having the connector pins which acts as a connecting wire transferring the electric signals between two points of the circuit is known as jumper wires. It is of two kind, male and female wire. It is wide range of colorful wires and is the most fundamental of all electronic component which establish connection between different devices to micro controller. (Writer, 2020)

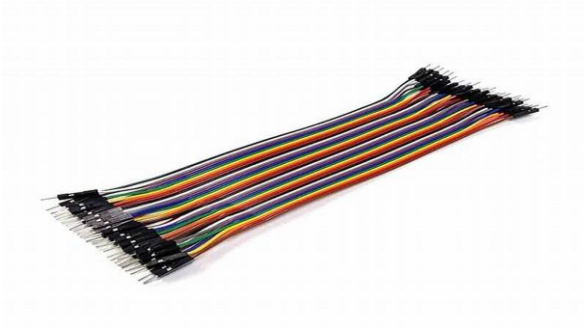

Figure 12 Jumper Wire

3. Development:

3.1. Phase 1 Planning and Design

In this phase, all the planning were done on designs and diagrams of a fire alarm system. Research on hardware and software resources were done that will be required for it. After doing a lot of research and generating the idea about the designs and diagrams, the layout of my project on how the system will work was created.

3.2. Phase 2 Collection of required hardware:

After planning the development and functionality, all the required resources for the fire alarm system was listed.

- Arduino Uno
- Smoke Sensor
- Resistor
- Buzzer
- LED
- Breadboard
- Jumper wires
- 16*2 LCD display
- I2C Module

3.3. Phase 3 Development And Working Mechanism:

In the first step, the smoke sensor is placed into a breadboard which is then connected to the Arduino using the configurations below:

VCC ---> +5V

GND ---> GND

A0 ---> Analog pin A1of Arduino

The Jump wires are used to make connections between the hardware devices and the breadboard**.** In the next step, we connect a piezo Buzzer to make an alarm sound when the smoke sensor detects high smoke level, with the following pin configuration:

(+) ---> Digital pin3

(-) ---> GND

In the next step, the red led was connected to the arduino with the following pin configuration:

(+) ---> (220ohm) Resistor---> Digital pin3

(-) ---> GND

The resistor is used to resist the voltage and to prevent any damages to the equipments. The red led starts glowing, when the smoke level exceeds the pre-defined threshold. This indicates danger or fire.

Then LCD display is put in the breadboard along with the I2C module. Meaning, I2C module is connected to the LCD display by connecting 16 pins of LCD to the 16 pins of 12C module. We

have used I2C module for the easier pin installment. Now, we have connected LCD Display with I2C module. The pin configuration of 12C module is shown below:

VCC ---> +5V

GND ---> GND

SDA ---> Analog pin A4

SCL ---> Analog pin A5

The SDA and SCL pins connected with analong pins A4 and A5 allows arduino to send and receive data to and from the device.

The final step would be to develop a code that executes our system. Initially when sensor reads the normal smoke value from the environment and LCD display displays the value accordingly along with the “Normal Smoke lev:” Message. When the smoke sensor detects smoke beyond the pre-defined threshold, it triggers the buzzer to buzz so as to alert the people, the red LED light on the breadboard flashes, and the relevant message on the LCD is displayed (i.e. Fire Alert!!) along with the value of the smoke level. When it detects smoke below the predefined smoke level, LED turns off, and display “Normal Smoke lev:” message on the LCD along with the value of the smoke level. We run the Arduino IDE in our desktop and run the code developed for the system.

4. Code

```
#Priya_Shrestha_2329818

#This program is built for the fire alarm system using smoke sensor, the buzzer and the led activates when the sensor value exceeds the pre-defined threshold else, they remain inactive.

//include the libraries

#include <Wire.h>  //for I2C communication

#include <LiquidCrystal_I2C.h>  // to control LCD display

LiquidCrystal_I2C lcd(0x27, 16, 2); // Adjust the address (0x27) if necessary

//define the pin configuration for led, buzzer and sensor analog pin

#define LED 2

#define Buzzer 3

#define Sensor A1



void setup() {

  Serial.begin(9600); //initializing the serial baud rate of 9600

  lcd.begin(); //prepare LCD module to communicate with microcontroller

  lcd.backlight(); //to ensure the display is visible.
```

```
  pinMode(LED, OUTPUT); //setting output pin mode for the LED
  pinMode(Buzzer, OUTPUT); // setting output pin mode for the LED
}
void loop() {
  int value = analogRead(Sensor); //read analog value from analog pin on arduino
  Serial.print("Sensor value: "); //print the sensor value
  Serial.println(value);
  lcd.setCursor(0, 0); //top left position
  lcd.print("Smoke Level: "); //print the value of the smoke level in lcd display
  lcd.print(value);
//setting the threshold smoke level as 200 and applying if-else condition
if (value > 200) {
   digitalWrite(LED, HIGH); //Led turn on when sensor value is greater than 200
    digitalWrite(Buzzer, HIGH);//The buzzer buzzes for the sensor value more than 200
    lcd.setCursor(0, 1); // bottom left position on the LCD display
```

```
lcd.print("Fire Alert!"); //display “Fire Alert” message on the LCD display

  }

else

 {

   digitalWrite(LED, LOW); //Led turn off when sensor value is less than 200

   digitalWrite(Buzzer, LOW);//Buzzer makes no sound for the sensor value less than 200

   lcd.setCursor(0, 1); //bottom left position on the LCD display

   lcd.print("Normal Smoke Lev:"); //display message  on the LCD display

  }

  delay(1000); //setting time delay of 1 seconds

}
```

5. Results and Findings

Following results and findings were observed, during the development phase of this project:

All the necessary hardware were properly and successfully integrated with the fire alarm system and the arduino code run perfectly.

The MQ2 Smoke Sensor was properly configured and connected to the arduino to detect the presence smoke-level. VCC, GND and A1 were connected to the 5V, GND and analog pin A0 of arduino-UNO board. The buzzer that was utilized satisfied and fulfilled the role of an audio signaling device which it was intended to do. Before finalizing any circuit design, breadboard and the circuit were tested to ensure the functionality. The resistor was used to resist the amount of current flowing through it into the LED to a level which the Arduino can deliver. LCD display was integrated into the system using I2C module for the serial communication.

First, we put the smoke sensor through its paces. We created a smoke and brought it close to the equipment during the test. It quickly detected the smoke-level and responded in a timely manner according to the pre-defined threshold as arduino reads the sensor data. Later, we tested the buzzers, arduino perfectly coordinates with buzzer and created a loud sound that notified the individuals in the vicinity about the danger.

Finally, red led kept glowing and display the alert message on the LCD display as soon as it detected smoke or flame. As a result, the system's operation is completed successfully.

The system has been tested several times. When the system was tested, it produced nearly no false alarms and runs effectively.

5.1. Test Cases and expected result.

5.1.0 Test Case 1

Objective	To show the device condition before the fire outbreak.
Action	The system was left idle.
Expected Result	Red led light turns off, Buzzer turns off.
Action Result	No sound of the buzzer, no indication from the red led and displays normal sensor value and ‘’Normal Smoke lev: ’’ message on LCD
Test Result	Successful.
Proof	Shown in the figure below.

Table 1: Test Case 1

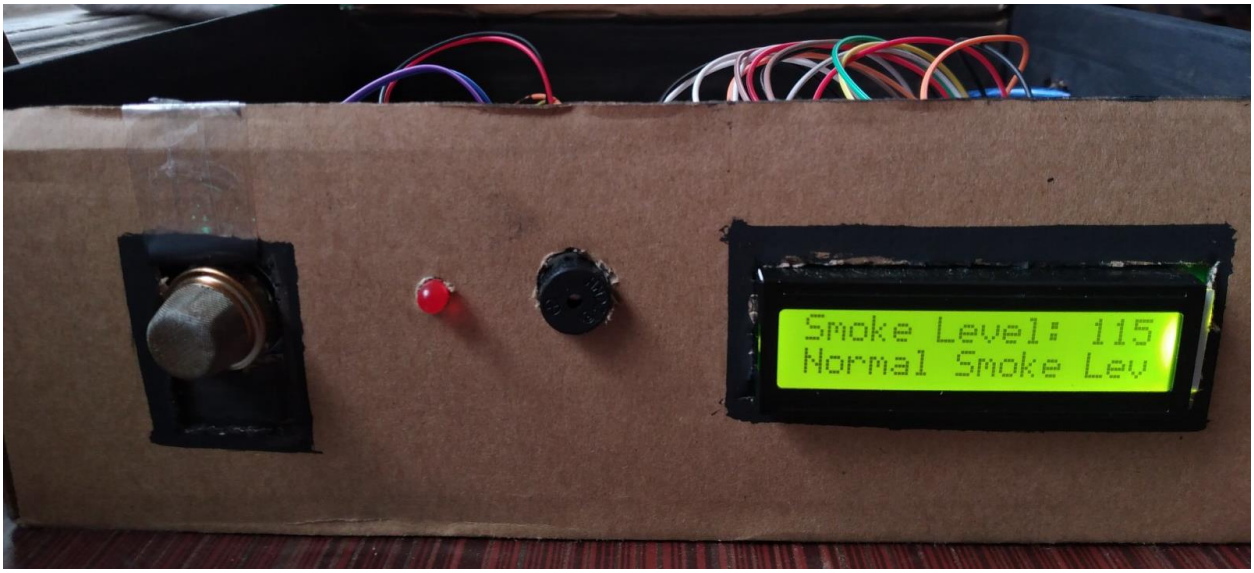

Figure 13 Test 1

5.1.1 Test case 2

Objective	To show the device response after detecting high smoke.
Action	Heavy smoke was introduced to the sensor.
Expected Result	Red led light is on, Buzzer is on and displays detected smoke level and ‘’Fire Alert!’’ message on LCD.
Action Result	Buzzer starts buzzing, Red led light turns on, detected smoke level and ‘’Fire Alert!’’ message was displayed on LCD.
Test Result	Successful.
Proof	Shown in the figure below.

Table 2:Test case 2

Figure 14 Test 2

6. Conclusion

This project has provided an invaluable insights on technologies which can be built in low cost using simple devices and embedded system but with high accuracy. Considering the real-world disaster such as fire in the residential area, this project was constructed to mitigate this problem and to minimize the loss.

I have encountered with several challenges during the development of this project, which required innovative ideas and technical expertise. The performance of the system was impressively increased as I found different solutions to overcome the challenges. This ensures the better functionality, its effectiveness in real-world scenario.

This project showcases the implementation of different devices and the insights of embedded system programming. As smoke is the primary suspect for the detection of the fire, smoke sensor is used which detects the smoke level immediately and alert the occupants as soon as smoke level exceeds the predefined smoke level and triggers the alerting equipment such as the buzzer and led.

Hence, with the better implementation of advanced equipment, this project can be further developed, modified and used as a great system to mitigate the risk of fire and the losses which comes along with it.

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