21AIE114 Principles of Measurements & Sensors

FIRE ALARM SYSTEM

S2 CSE AIE B BATCH

GROUP 9

MEMBERS

Megha Mohan	AM.EN.U4AIE21176
Anushka Kaimal	AM.EN.U4AIE21116
Navami S K	AM.EN.U4AIE21146
Parvathy G Pillai	AM.EN.U4AIE21150
Aiswarya Shajil Kumar	AM.EN.U4AIE21107

AMRITA SCHOOL OF ENGINEERING

AMRITA VISHWA VIDYAPEETHAM

AMRITAPURI 690 525

July 2022

Contents

ABSTRACT

Fire Alarm System is a simple circuit that detects the fire and activates the Siren Sound or Buzzer. It has a number of devices working together to detect and warn people through visual and audio appliances when smoke, fire, carbon monoxide or other emergencies are present. Fire Alarm Circuits, Temperature Sensors and Smoke Sensors are a part of the security systems which help in detecting or preventing damage.

In this mini project we are mainly focusing on the sensors such as temperature and gas sensors that we use and interface it with Arduino using TinkerCad and LTspice.

Installing Fire Alarm Systems in commercial buildings like offices, movie theatres, shopping malls and other public places is compulsory. These alarms may be activated automatically from smoke detectors and heat detectors or may also be activated via manual fire alarm activation devices such as manual call points or pull stations. This is a very simple alarm circuit using Arduino Uno, Piezo, Gas sensor, Temperature sensor, resistors, LED, wire and breadboard. The primary purpose of fire alarm system is to provide an early warning of fire so that people can be evacuated & immediate action can be taken to stop or eliminate of the fire effect as soon as possible.

Sensors we used and its importance in real time

In this project we used 2 sensors to detect fire emergencies:

- Temperature Sensor
- Gas Sensor

1.Temperature Sensor

A simple temperature sensor is a device, to measure the temperature through an electrical signal it requires a thermocouple or RTD (Resistance Temperature Detectors). The thermocouple is prepared by two dissimilar metals which generate the electrical voltage indirectly proportional to change in the temperature. The RTD is a variable resistor, it will change the electrical resistance indirectly proportional to changes in the temperature in a precise, and nearly linear manner.

Temperature Sensor Working:

The measurement of the temperature sensor is about the hotness or coolness of an object. The working base of the sensors is the voltage that reads across the diode. If the voltage increases, then the temperature rises and there is a voltage drop between the transistor terminals of base & emitter, they are recorded by the sensors. If the difference in voltage is amplified, the analogue signal is generated by the device and it is directly proportional to the temperature.

Different Types of Sensors:

The different types of sensors include the following

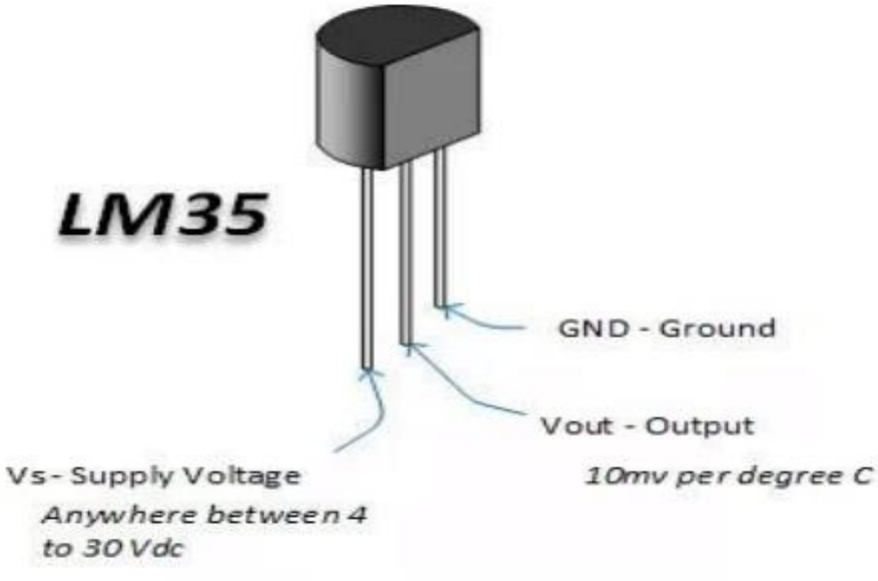
● Thermocouple Sensor

● Thermistor Sensor

● Resistance Temperature Detector

● Infrared Sensors

LM35 Temperature Sensor



The power supply of the LM35 temperature sensor requires 5.5V and it consists of three terminals of a material which perform the operation according to the temperature to vary resistance. When the voltage increases, then the temperature also rises. We can see this operation by using a diode.

Temperature sensors are directly connected to microprocessor input, therefore it is capable of direct and reliable communication with microprocessors. The sensor unit can communicate effectively with low-cost processors without the need of A/D converters. The features of LM35 temperature sensor are explained below.

Features of LM35 Temperature Sensor

- Low self-heating
- Operates from 4 to 30 volts
- Rated for full l −55˚ to +150˚C range
- Calibrated directly in ˚ Celsius (Centigrade)
- Suitable for remote applications
- Low cost due to wafer-level trimming

TMP36 sensor

TMP36 is a temperature sensor chip which generates an analog voltage at the output which is linearly proportional to the Celsius temperature. Then convert this voltage into temperature based on a 10 mV/°C scale factor. It has a shutdown capability which limits the output current to less than 0.5 µA. It provides a supply current of up to 50 µA.

Pin No:	Pin Name	Description
1	+Vs	Positive Supply Pin
2	Vout	Output Voltage Pin
3	Gnd	Ground Pin

Features

- Operate on low voltage
- 10 mV/°C scale factor
- ±2°C Temperature accuracy
- ±0.5°C linearity
- External Calibration not required
- Stable with large capacitive loads
- Specified −40°C to +125°C, operation to +150°C
- Less than 50 µA quiescent current
- Auto Shutdown current 0.5 µA max
- Low self-heating Qualified for automotive applications

Applications of temperatures Sensor

● The temperature sensors are used in the military/Defence

● It can be used in the home automation systems like air conditioners, refrigerators, microwave Oven.

● It can also be used in industries like warehouses, mushroom cultivation.

● The temperature sensors are used to measure the temperature of the boilers in thermal power plants.

2.Gas Sensor

Gas sensors are devices that can detect the presence and concentration of various hazardous gases and vapors, such as toxic or explosive gases, volatile organic compounds (VOCs), humidity, and odors.

Different Types of Gas sensors are typically classified into various types based on the type of the sensing element it is built with. Below is the classification of the various types of gas sensors based on the sensing element that are generally used in various applications:

● Metal Oxide based gas Sensor.

● Optical gas Sensor.

● Electrochemical gas Sensor.

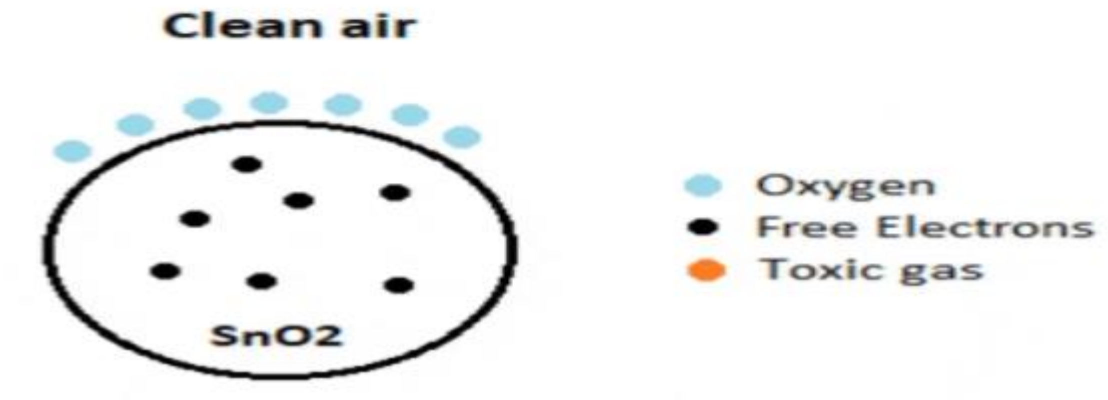
● Capacitance-based gas Sensor.

● Calorimetric gas Sensor.

● Acoustic based gas Sensor.

Gas Sensor Working:

The ability of a Gas sensor to detect gases depends on the chemiresistor to conduct current. The most commonly used chemiresistor is Tin Dioxide ($SnO2$) which is an n-type semiconductor that has free electrons (also called as donor). Normally the atmosphere will contain more oxygen than combustible gases. The oxygen particles attract the free electrons present in $SnO2$ which pushes them to the surface of the $SnO2$. As there are no free electrons available output current will be zero. The below figure shows the oxygen molecules (blue color) attracting the free electrons (black color) inside the $SnO2$ and preventing it from having free electrons to conduct current.



When the sensor is placed in the toxic or combustible gases environment, this reducing gas (orange color) reacts with the adsorbed oxygen particles and breaks the chemical bond between oxygen and free electrons thus releasing the free electrons. As the free electrons are back to their initial position they can now conduct current, this conduction will be proportional to the amount of free electrons available in SnO_2, if the gas is highly toxic more free electrons will be available.

Applications of Gas Sensors:

● Used in industries to monitor the concentration of the toxic gases.

● Used in households to detect emergency incidents.

● Used at oil rig locations to monitor the concentration of the gases that are released.

● Used at hotels to avoid customers from smoking.

● Used in air quality check at offices.

● Used in air conditioners to monitor the CO_2 levels.

● Used in detecting fire.

● Used to check concentration of gases in mines.

From above listed gas sensors and temperature sensors,

we took

1. MQ2 Gas sensor

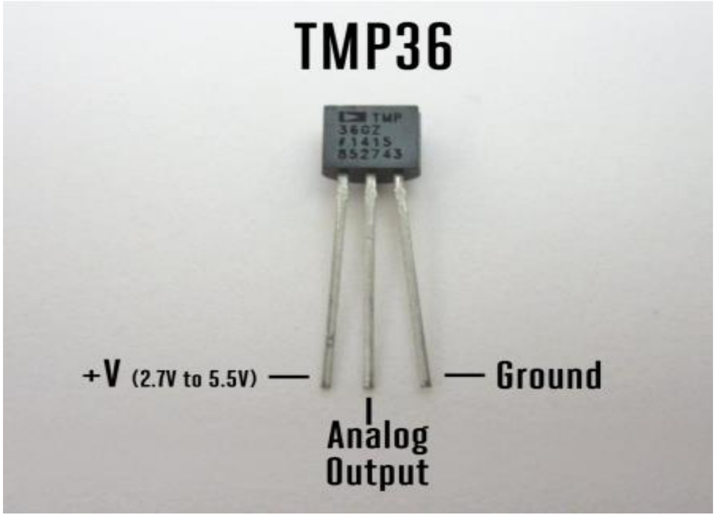
2. TMP36 Sensor (TINKERCAD)

3. LM35 Sensor (LTSPICE)

MQ2 Gas sensor

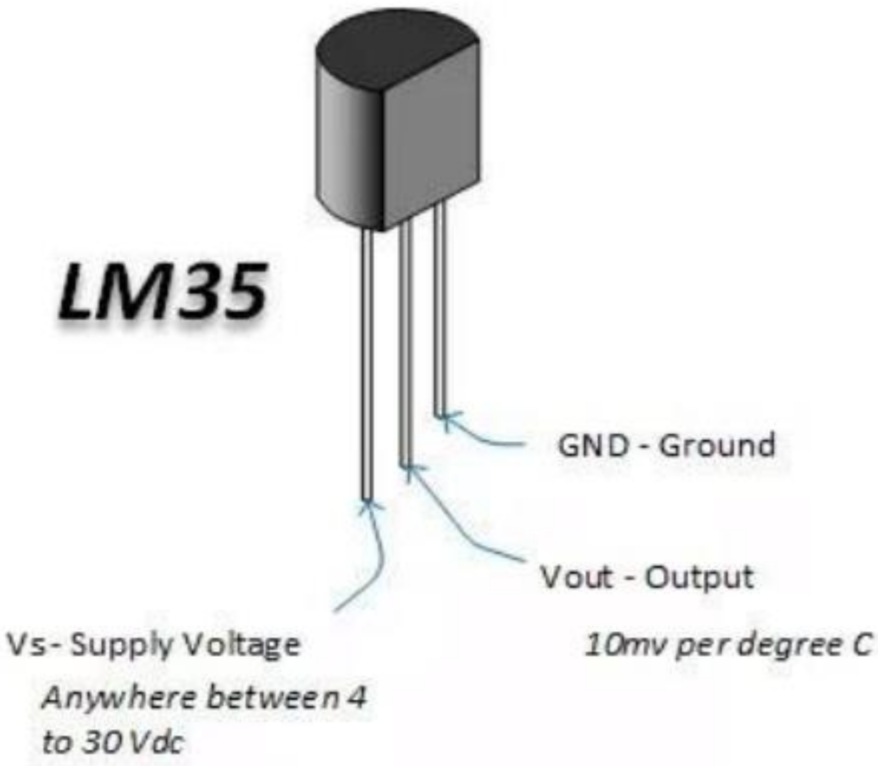
The gas sensor is used to measure the concentration or presence of gas in the atmosphere. It is also used to detect smoke in the air. Based on the gas, a potential difference is generated by changing the resistance of the material present inside the sensor. The output is measured in terms of Voltage.

TMP36 sensor



TMP36 IC is mainly used in thermostats and temperature measuring applications. It has low output impedance and produces a linear output. It does not require external calibration and therefore you don't need external components. These devices can handle temperature ranges of -40°C to 150°C. All these features make this chip suitable for use in a variety of temperature measuring applications. These devices provide stable operation along with capacitive loads and drive 10,000 pF load without creating any oscillations.

LM35 Sensor



The LM35 sensor is a precision integrated-circuit temperature device with an output voltage linearly proportional to the Centigrade temperature. This sensor has an advantage over sensors that are calibrated in kelvin as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling because this sensor is calibrated in centigrade temperature. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. The low-output impedance, linear output and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. These are used in Power Supplies and Battery Management and some electrical appliances.

This sensor has 10mV/°C as the scaling factor taking 0°C as reference temperature and 0V as Reference Voltage. The rise in each degree of 1°C scales the 10mV output voltage.

Signal Conditioning circuit(s) and requirements:

To design a Fire Alarm circuit using a few electrical components like Temperature and Gas sensors using TinkerCad and interface it with Arduino.

Components:

1.Arduino UNO Board

2.Temperature Sensor

3.Gas Sensor

4.Resistors

5.BreadBoard

6.LED

7.Piezo Buzzer

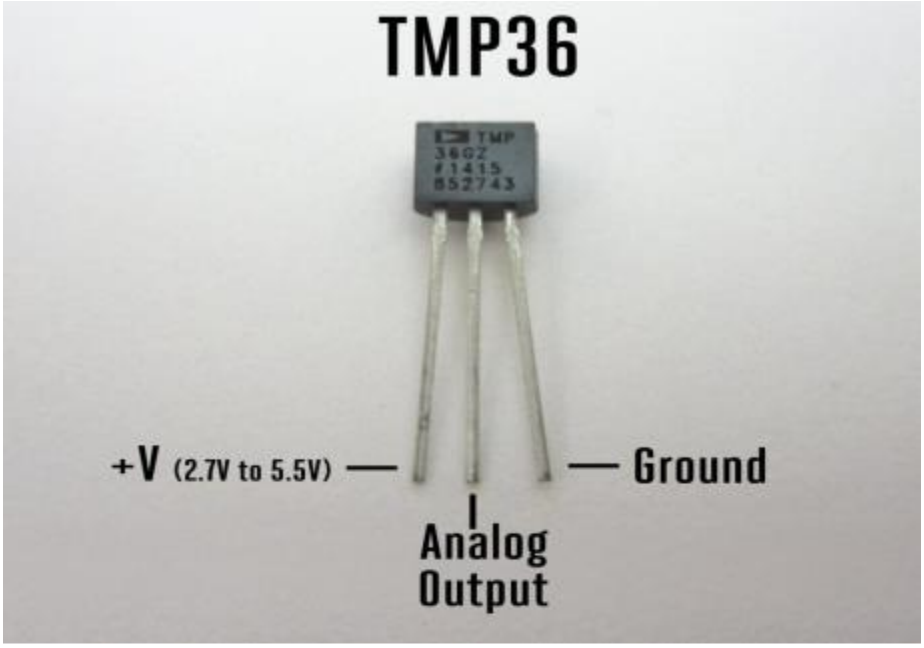
8.Wires

1. Arduino UNO Board

Arduino board is a microcontroller that is used to accept inputs from sensors connected and provide an output action on the desired device connected to it. The sensor inputs can be from light-detecting sensors, motion sensors

(Ultrasonic or IR), temperature sensors, etc. The output from this device can be received through other output devices such as LED, Buzzer, Serial monitor, etc.

2. TMP36 Temperature Sensor



TMP36 is a temperature sensor chip which generates an analog voltage at the output which is linearly proportional to the Celsius temperature. Then convert this voltage into temperature based on a 10 mV/°C scale factor. It has a shutdown capability which limits the output current to less than 0.5 µA. It provides a supply current of up to 50 µA.

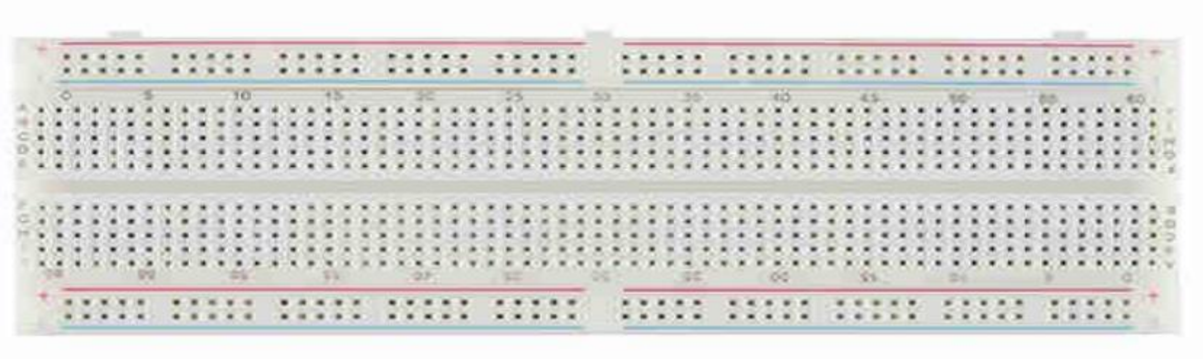
3. Gas sensor

The gas sensor is used to measure the concentration or presence of gas in the atmosphere. It is also used to detect smoke in the air. Based on the gas, a potential difference is generated by changing the resistance of the material present inside the sensor. The output is measured in terms of Voltage.

4. Resistors

Resistors are passive devices that restrict the flow of current or divide the voltage through the circuit. The input power passes through these resistors and then to the sensors to avoid damage.

5. Breadboard



The breadboard is the basic component of any circuit building process. All components, be it input sensors or output display devices are connected to the power supply, microcontroller using wired connections through a breadboard. The holes in the breadboard are in series. There are various sizes like full-sized, half-sized, and mini breadboards.

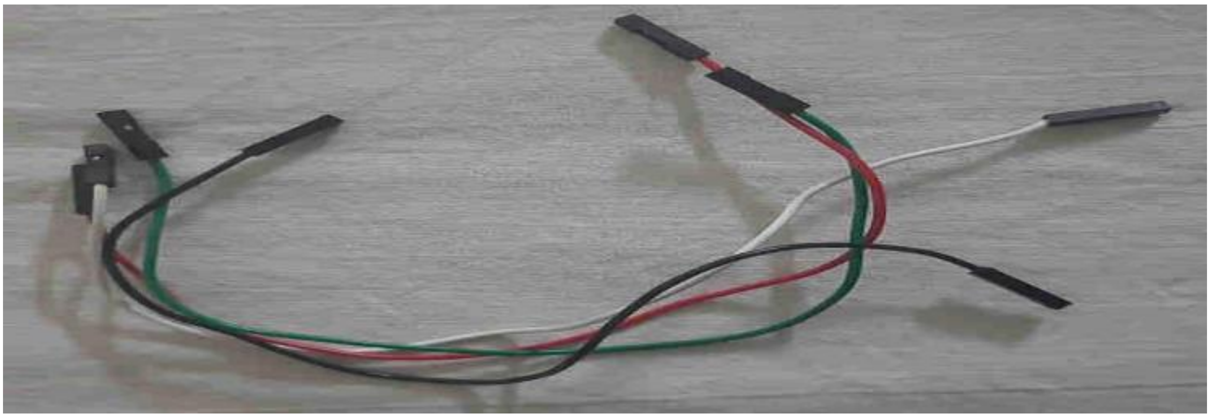
6. LED

Light Emitting Diode is a commonly used light source. It is a semiconductor that emits light when current flows through it.

7. Piezo Buzzer

It is an electrical component that generates a beep sound on receiving an input. It works on the principle of piezo crystal.

8. Jumper Wires



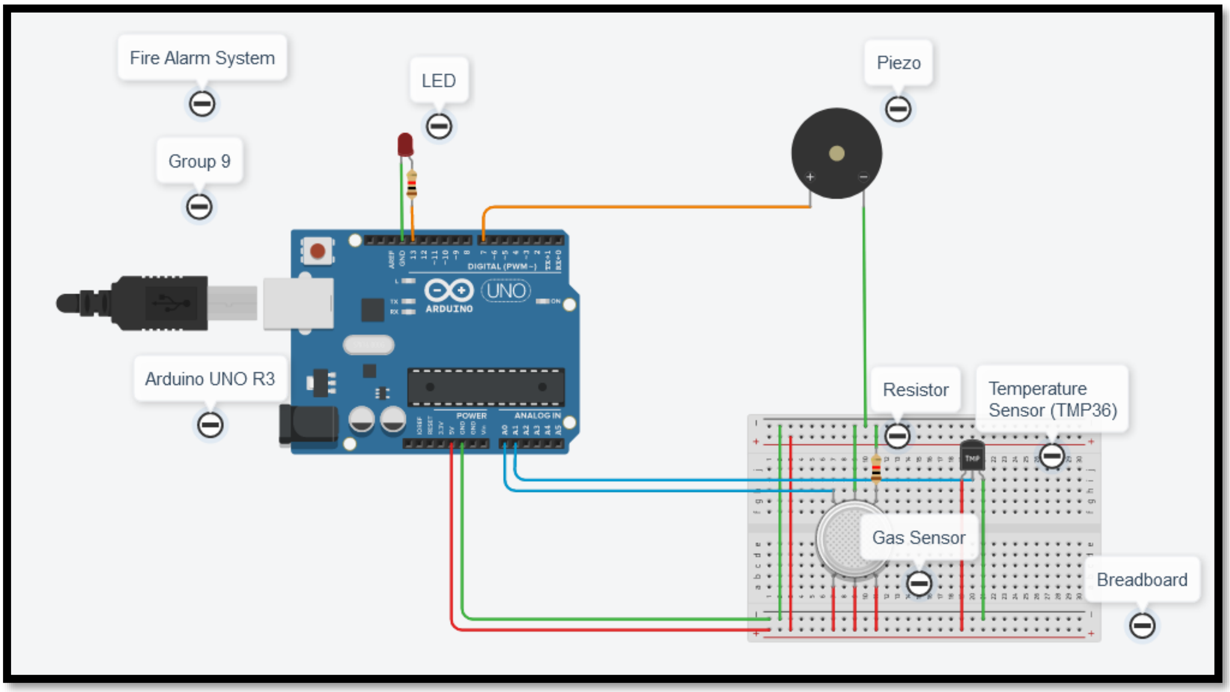
These are the main components that are used to establish the connections between different devices of the circuit.

Software used:

1. **TinkerCad**

2. **LT Spice**

Circuit Connections using Tinkercad:



Brief explanation of Circuit Connection:

Firstly, we need to connect one line of the breadboard to the ground and the other to the power supply. This is done by connecting the 5V pin of the Arduino Board to one line of connection pins on the breadboard. The other line of the breadboard is connected to the ground terminal of the Arduino Board. These lines will be connected to other devices.

The Temperature sensor has three pins. Ground, Vout, and Vs (Supply). The Vs pin that has a range of 4-20V is connected to the power supply line of the breadboard. The Ground terminal of the sensor is connected to the ground line of the breadboard. The Vout terminal of the temperature sensor is connected to one of the Analog pins of the Arduino Board, A1.

Now let us learn how the connections are done with the Gas sensor. This sensor has 6 pins. 3 pins of the gas sensor are directly connected to the power supply line of the breadboard. Amongst the other 3 pins of the sensor, one pin is connected to one of the Analog pins of the Arduino Board, A0. The pin in the middle is connected to the ground line of the breadboard. The third pin of the sensor is connected to a resistor and then connected to the ground line.

The piezo buzzer is externally connected to the circuit. The ground pin of the buzzer is connected to the ground line of the breadboard. Another pin of the buzzer is connected to the digital pin, PIN 7 of the Arduino Board.

Lastly, the LED is connected to the Arduino directly. The cathode of the LED is connected to the GND pin of Arduino and the anode of the LED is connected through a resistor to the digital pin 13 of the Arduino.

Code:

```
// C++ code

float temp;

float vout;

float vout1;

int LED = 13;

int gasSensor;

int piezo = 7;

void setup()
```

```
{
pinMode(A0,INPUT);
pinMode(A1, INPUT);
pinMode(LED,OUTPUT);
pinMode(piezo,OUTPUT);
Serial.begin(9400);
}
void loop()
{
vout=analogRead(A1);
vout1=(vout/1023)*5000;
temp=(vout1-500)/10;
gasSensor=analogRead(A0);
if (temp>=80)
{
digitalWrite(LED,HIGH);
}
else
{
digitalWrite(LED,LOW);
}
if (gasSensor>=100)
{
digitalWrite(piezo,HIGH);
}
else
{ digitalWrite(piezo,LOW); }
```

```
Serial.print("in DegreeC= ");
Serial.print(" ");
Serial.print(temp);
Serial.print("\t");
Serial.print("GasSensor= ");
Serial.print(" ");
Serial.print(gasSensor);
Serial.println();
delay(1000); }
```

Every program code starts with the declaration of the variables we require for the execution of the program. A floating-point variable "temp" is declared for the temperature value that is going to be taken as input from the temperature sensor.

Another floating-point variable "out" is declared to store the value of the output from the temperature sensor. The variable "vout1" is going to store the value of the output from the gas sensor. The value of the pin to which the LED is connected is store in the variable "LED". Integer variables for Gas-sensor and Piezo buzzer are declared. The setup( ) function uses pinMode functions to assign the Mode for the pins declared. A0 pin is going the take the input from the Gas sensor, so it's assigned as input mode. The PIN A1 is going to take input from the Temperature sensor, so it is assigned as an input pin.

The LED is going to be the output indicator for the Gas sensor hence declared as Output. The piezo buzzer indicates the output of the Temperature sensor, hence it is declared as output. The baud rate for serial transmission, 9600 is given to begin the execution of the code.

The variable "vout" will hold the value read from the analog pin A0 which is the input from the Gas sensor. analogRead( ) function is used to take the input. The vout1 holds the value based on "vout". The above expression in the code shows the same. A set of if-else statements are used to assign values that could give the output. The first "if" condition checks if the input temperature is Greater than 80 C. If the temperature goes above 80, the LED is HIGH and it glows. Otherwise, the LED remains OFF (LOW). This function is done using the digitalWrite( ) function. The next set of "if" conditions check the input from the gas sensor. If the input value goes above 100, the Piezo Buzzer buzzes (HIGH) and if the value is less than 100, the value sent to the buzzer remains LOW.

This series of print statements will print the output received from the sensor. The temperature is printed first in terms of degree Celsius. The gas sensor output is printed consecutively. A delay of one second is given for every output. This happens in a loop until the circuit is plugged off.

Modelling of sensors in LTSpice:

1) **LM 35:**

   The LM35 is a common semiconductor temperature sensor. It produces an output voltage between -0.55 to 1.5 Volts, proportional to its temperature. This LM35 can be simulated using a LTSPICE model, which can be configured for a fixed temperature, or swept over a range of temperatures. The LM35 is an integrated circuit that provides a linear output proportional to temperature, with a sensitivity of 10mV per degree Celsius. It does not require any external calibration or trimming and provides typical accuracies of +/- 0.25 degrees at room temperature, and +/- 0.75 degrees over a full -55 to +150 degrees C temperature range. It is available in a number of different packages, e.g., TO-46, TO-92, 8-lead surface mount SO, and TO-220.
   To simulate this device in SPICE, such that it produces the normally expected voltage output at any given temperature, we require a linear temperature-controlled element. There is an option for the resistor model to specify a temperature coefficient, or a polynomial series of temperature coefficients. For a linear dependence, we only need one coefficient and the others may be omitted (defaulting to zero).
   A current source and a resistor can be used to create a voltage source that has a linear temperature coefficient. The resistor has a value:
   $R = R0 * (1. + dt * tc1)$
   where R0 is the resistance at the nominal temperature (TNOM), dt is the difference between the resistor's temperature and the nominal temperature, and tc1 is the temperature coefficient in ohms per degree.
   We need an output voltage that goes to zero at the temperature that the TC35 is calibrated to give zero output for, so a second current source and resistor are used to generate a voltage corresponding to a fixed temperature at zero C.

A voltage-controlled current source G1 is used to subtract the reference voltage from the temperature dependent voltage to obtain a temperature dependent output that is zero at the reference temperature for the LM35. The gain of G1 and its shunt resistor are chosen to give a voltage gain of 1 and an output impedance of 0.1 ohms to match the dynamic impedance of the LM35 for a 1mA load.
This simulation uses the built-in global temperature value of SPICE that is typically used to either specify the operating temperature of a circuit, or is swept to measure circuit characteristics over a temperature range.
The LM35 model is packaged as a subcircuit, and invoked as "X1 1 LM35" which simply gives us one node where the output voltage appears. Note that there is no simulation of the LM35 power supply, or any detail of the internal circuit; this is purely a behavioural model.

2) **Gas Sensors:**

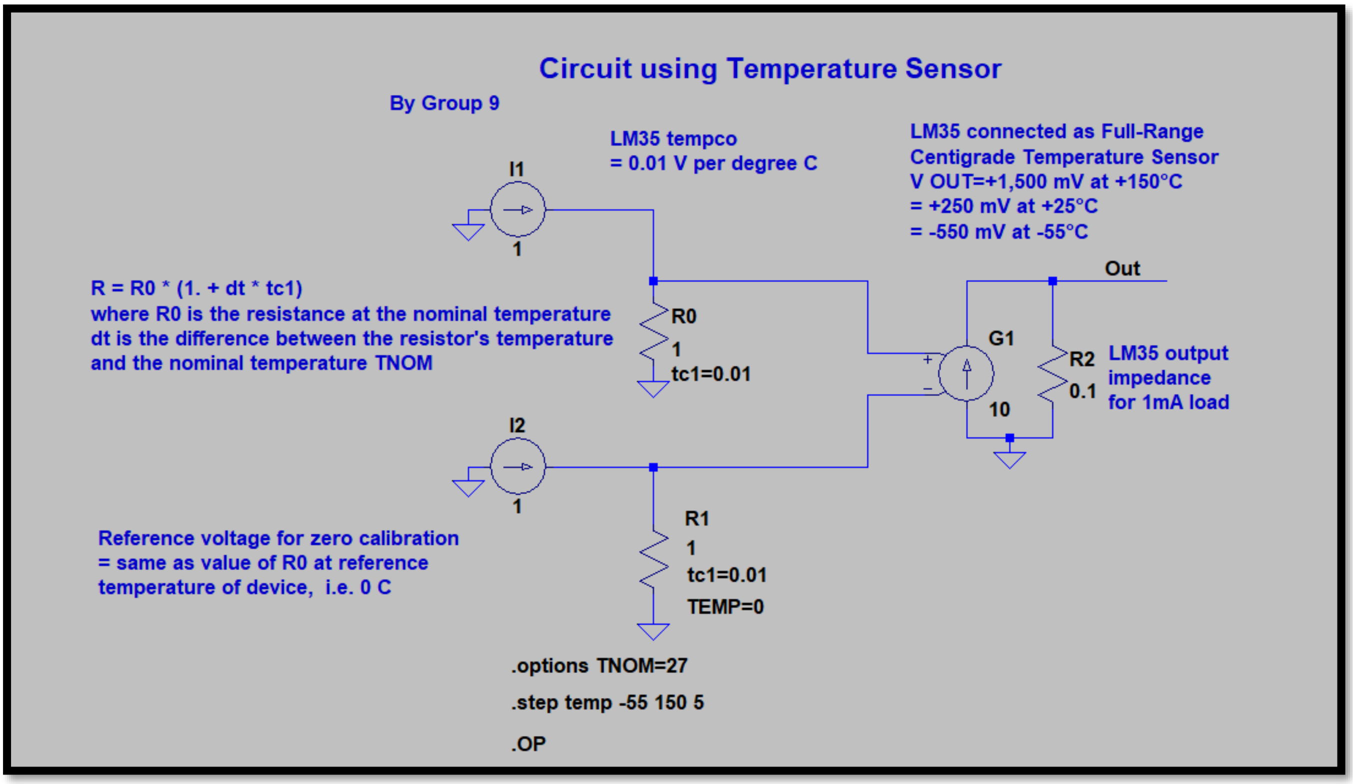
• The ADA4528-1/ADA4528-2 are ultralow noise, zero-drift operational amplifiers featuring rail-to-rail input and output swing. A zero drift amplifier is an operational amplifier that minimizes input offset voltage and input offset voltage drift (≒0).Selecting a zero-drift operational amplifier is a highly effective solution for applications that demand high-accuracy signal amplification

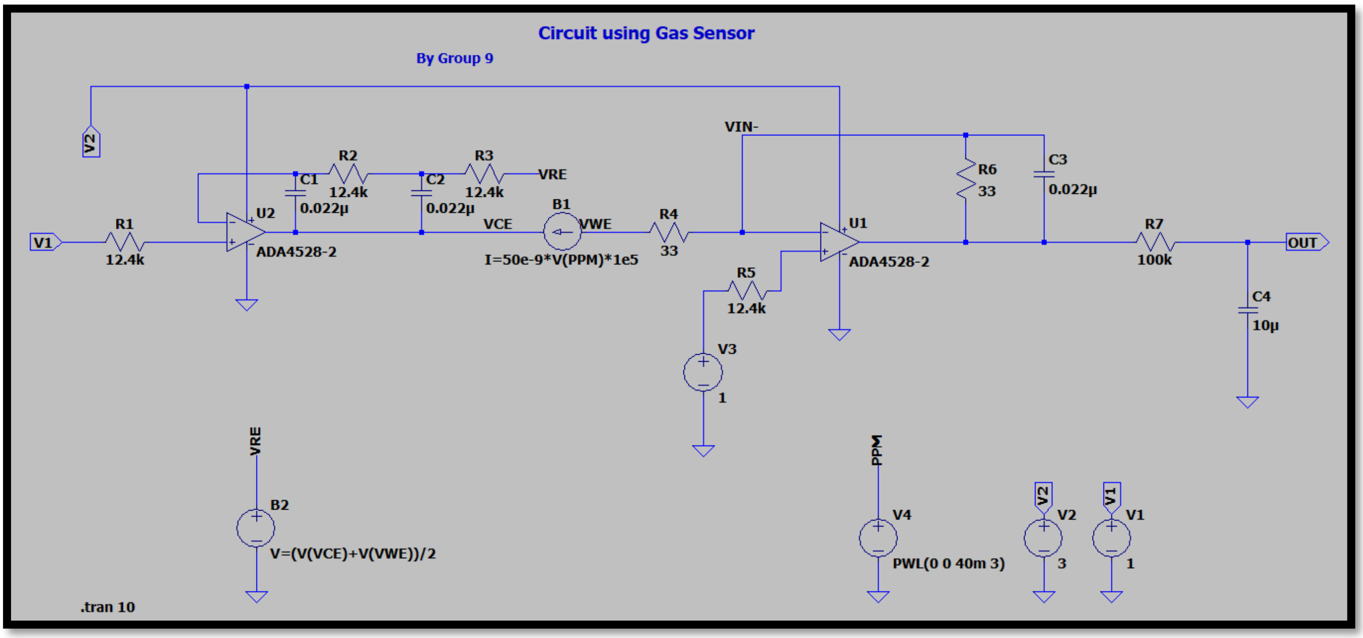
• B1 = Arbitrary behavioural voltage or current sources. A behavioural voltage source outputs a voltage according to any number of circuit parameters and it can be used to unleash the real mathematical power of LTspice

• Ppm: This is a way of expressing very dilute concentrations of substances. Just as per cent means out of a hundred, so parts per million or ppm means out of a million. Usually describes the concentration of something in water or soil. One ppm is equivalent to 1 milligram of something per litre of water (mg/l) or 1 milligram of something per kilogram of soil (mg/kg).

• Piecewise linear (PWL) functions are used to construct a waveform from a series of straight line segments connecting points defined by the user in LTspice. Since PWL functions are useful in creating custom waveforms, they are typically used in defining voltage or current sources.

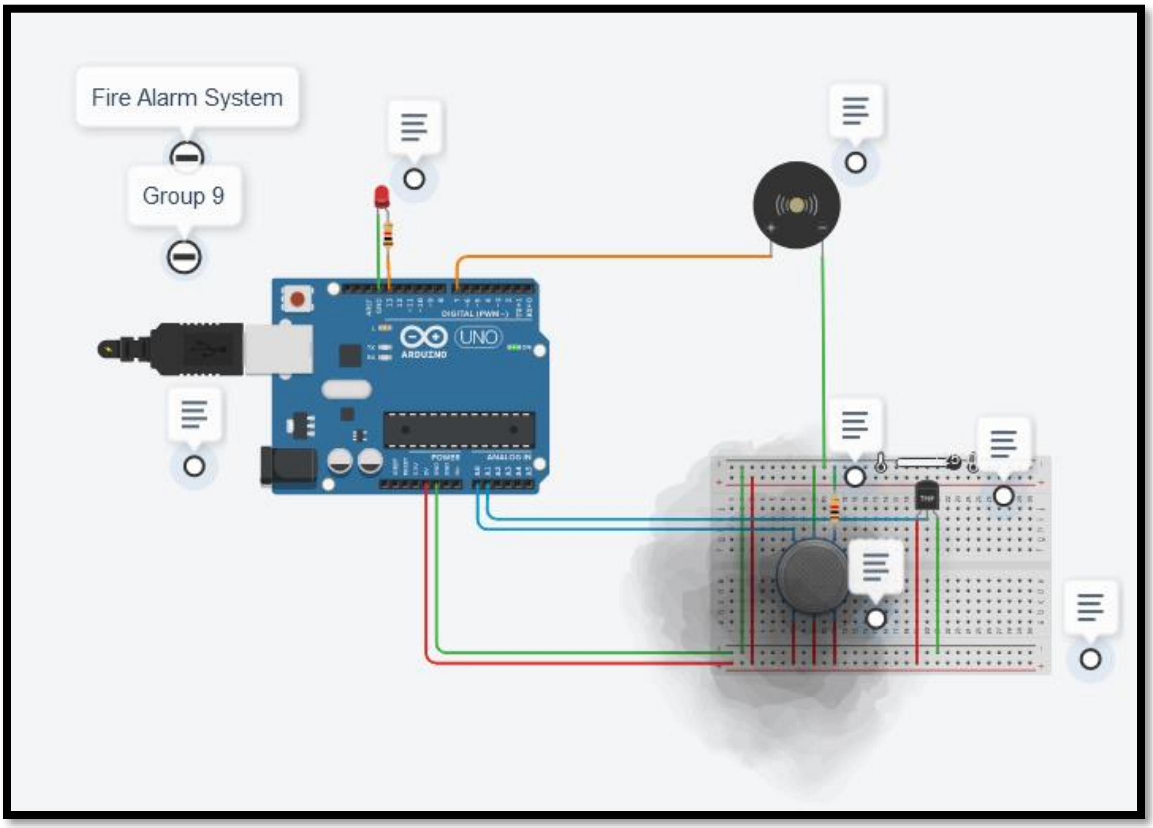
Circuit Connections using LTSpice:





Simulation outputs and analysis:

Simulation output using Tinkercad:



The working of the circuit, we can understand it in two parts.

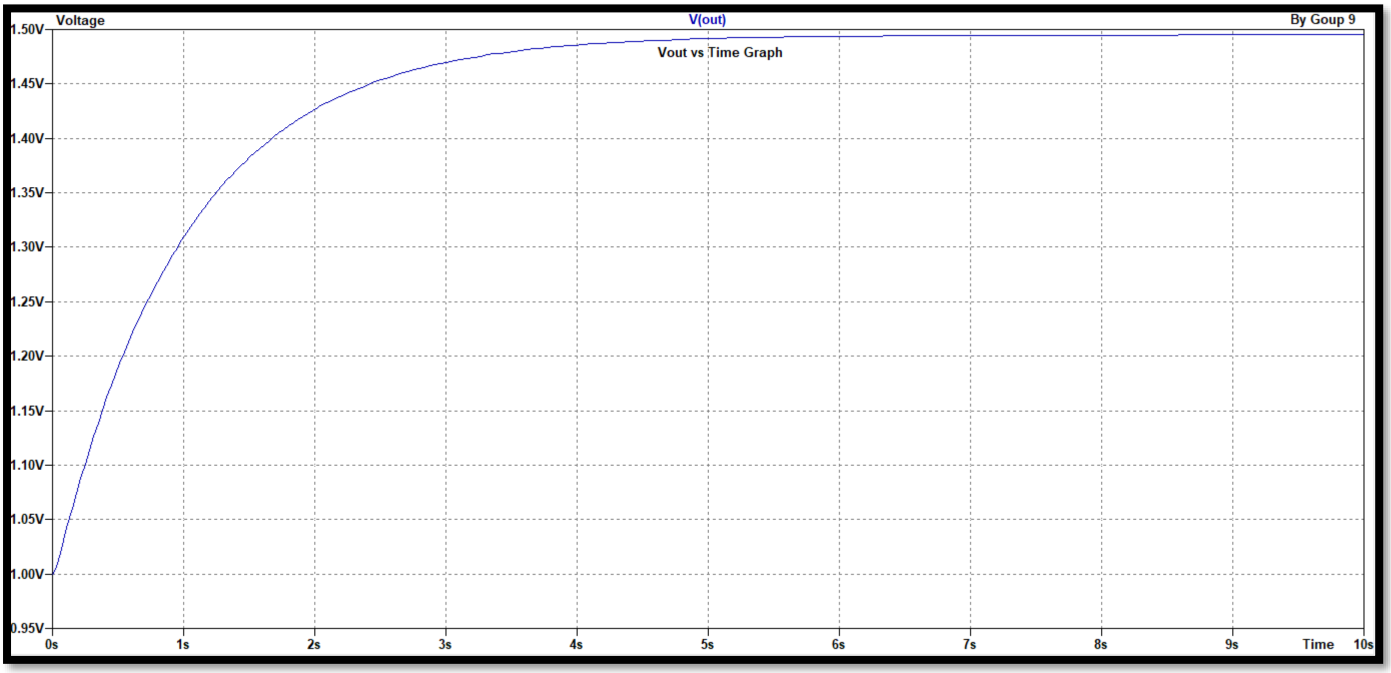
Part 1: Temperature sensor and its output

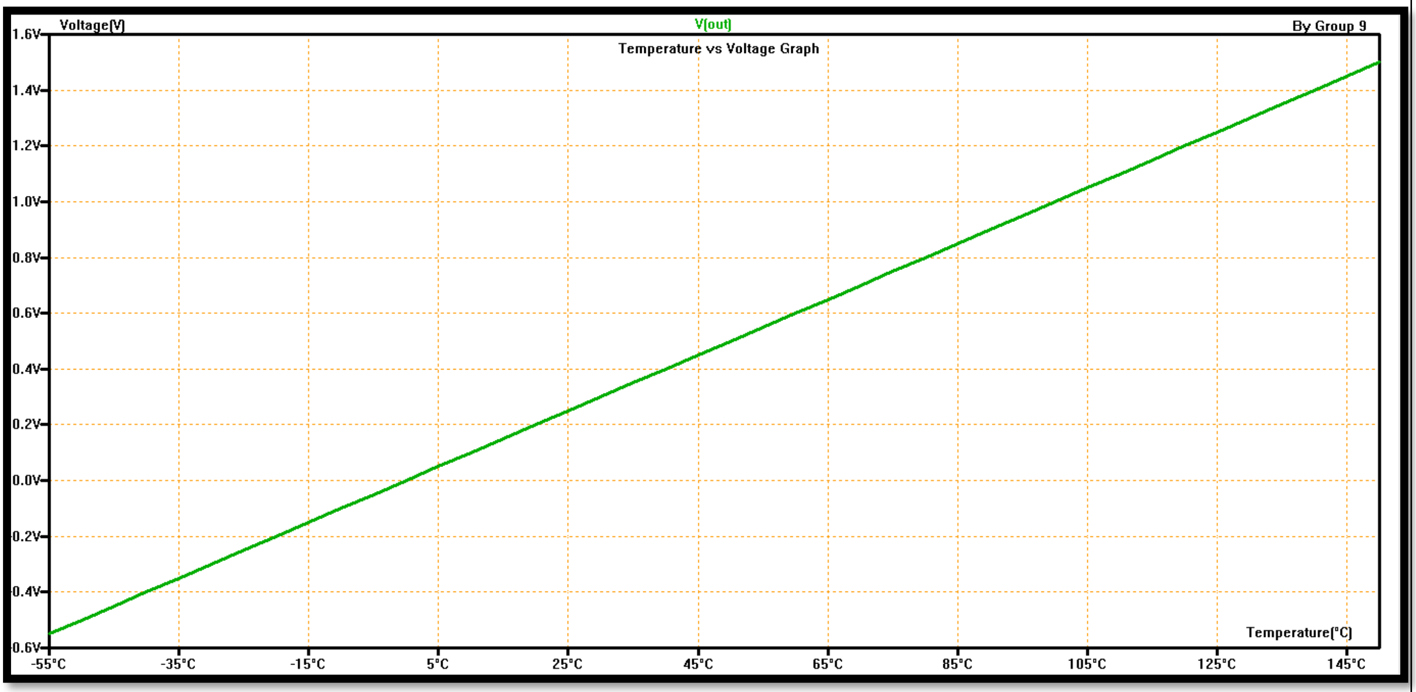
The Temperature sensor takes in input and when the temperature increases, the voltage increases, and hence the output initiates the functioning of the Buzzer. For every one degree increase in temperature, there is a 10mV increase in the voltage. The threshold value given for temp is ≥80. When the temp is ≥80 the LED glows else it won't glow.

Part2: Gas sensor and its output

A gas sensor is also used to detect smoke along with the concentration of gases. Based on the type of gas present in the atmosphere, a potential difference is developed by changing the Resistance of the material present inside the sensor and the same is measured as output. The Concentration of the gas is measured in ppm. The threshold value given for gas sensor is ≥100. When the concentration of gas is ≥100 the piezo starts to buzz else it won't buzz.

Simulation output using LTSpice:





CONCLUSION

Simulation software plays a major role in the building of large circuits as they help analyze the working of the circuit before it can be built practically. It helps us create a virtual design of the circuit we want to build and avoid damages to the circuit if in case we don't know, beforehand about the correct circuit connections.

The main aim of this mini project is to make a fire alarm that detects the fire by using a gas sensor and temperature sensor.

The Fire Alarm System helps early detection of fire and the concentration of gases in atmosphere so that we can take precaution to prevent accidents caused by fire and gas leakage.

Thus, we conclude from this fire alarm is used for safety and emergency purpose.

Reference

● https://www.news18.com/news/india/20-year-old-woman-diesanother-critically-injured-after-fire-breaks-out-mumbai-flat2542485.html/

● https://components101.com/articles/introduction-to-gas-senso rs-types-working-and-application/

● https://components101.com/sensors/tmp36-temperature-sensor/

● https://microcontrollerslab.com/tmp36-temperature-sensor/

● https://colinjs.com/elec/tempsens/tempsens.htm/

● https://realpars.com/fire-alarm-system/

● https://store.createlabz.com/blogs/createlabz-tutorials/home -fire-alarm-system-using-flame-sensor-and-lm35/

● https://create.arduino.cc/projecthub/nealpatel/gas-sensor-87 6a58/

● https://instrumentationtools.com/types-of-fire-and-gas-detec tors/

● https://www.youtube.com/watch?v=fwwI4R_97DI/

Temperature Sensor types, Working and their Applications (efxkits.co.uk)