Weather Monitoring System

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Abstract:

The day-to-day conditions of the atmosphere at a place with respect to elements like humidity, temperature, wind speed, rainfall, etc. is called the weather of that place. Most weather phenomena occur in the troposphere, just below the stratosphere. Weather generally refers to day-to-day temperature and precipitation activity, whereas climate is the term for the average atmospheric conditions over longer periods of time. When used without knowing what weather is, we associate climate with weather and think both are the same. Monitoring the weather conditions manually is difficult. The idea is to develop an automated system which monitors the weather condition. The weather conditions are different from one place and another. These pressure and temperature differences can occur due to the sun angle at any particular spot. Through this system we can automatically collect the information about toxic gas present in atmosphere, temperature and to find weather conditions(rainy, cloudy or sunny). The objective is to formulate the weather and be able to forecast the weather with minimum error.

Introduction:

The measurements of temperature, toxic gas content and weather condition remotely by using the appropriate sensors is not only important in environmental or weather monitoring but also crucial for many industrial processes. The idea behind this project is to develop a device which monitors and displays the temperature, toxic gas content and weather condition of the atmosphere, using analogue components. The analogue outputs of the sensors are connected to a microcontroller through an ADC for digital signal conversion and data logging. An LCD display is also connected to the microcontroller to display the measurements. The device has many advantages as compared to other weather monitoring systems in terms of its smaller size, on-device display, lower cost, and greater portability.

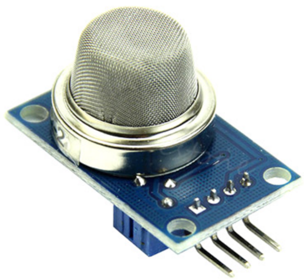
Components Required:

- Temperature sensor [TMP 36]
- Gas sensor
- Photoresistor
- LCD
- Piezo (buzzer)
- Arduino Uno R3

Description of the sensors:

Gas Sensor:

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

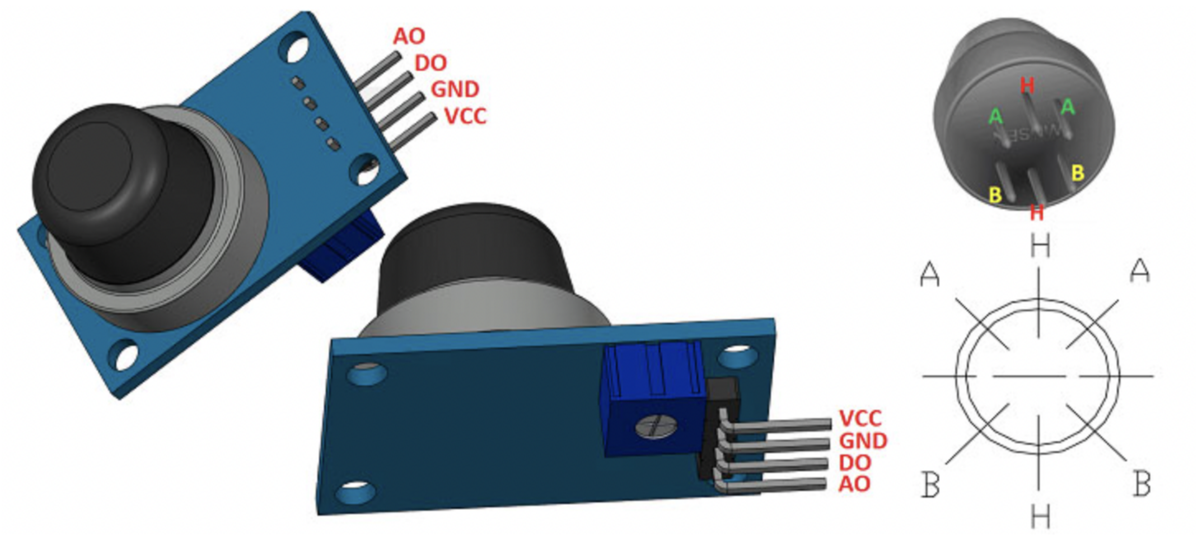


Working of gas sensor:

The ability of a Gas sensor to detect gases depends on the **chemiresistor** to conduct current. The most commonly used chemiresistor is Tin Dioxide (SnO_2) 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 SnO_2 which pushes them to the surface of the SnO_2. As there are **no free electrons** available output current will be zero.

When the sensor is placed in the toxic or combustible gases environment, this reducing gas reacts with the absorbed 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.

How to use a gas sensor:



A basic gas sensor has 6 terminals in which 4 terminals (A, A, B, B) act as input or output and the remaining 2 terminals (H, H) are for heating the coil. Of these 4 terminals, 2 terminals from each side can be used as either input or output (these terminals are reversible as shown in the circuit diagram) and vice versa.These sensors are normally available as modules (shown right), these modules consist of the gas sensor and a comparator IC. The gas sensor module basically consists of 4 terminals

- Vcc – Power supply
- GND – Power supply
- Digital output – This pin gives an output either in logical high or logical low (0 or 1) that means it displays the presence of any toxic or combustible gases near the sensor.
- Analog output – This pin gives an output continuous in voltage which varies based on the concentration of gas that is applied to the gas sensor.

The output of a gas sensor alone will be very small (in mV) so an external circuit has to be used in order to get a digital high low output from the sensor. For this purpose, a comparator (LM393), adjustable potentiometer, some resistors and capacitors are used. The purpose of LM393 is to get the output from the sensor, compare it with a reference voltage and display whether the output is logically high or not. Whereas the purpose of the potentiometer is to set the required threshold value of the gas above which the digital output pin should go high.

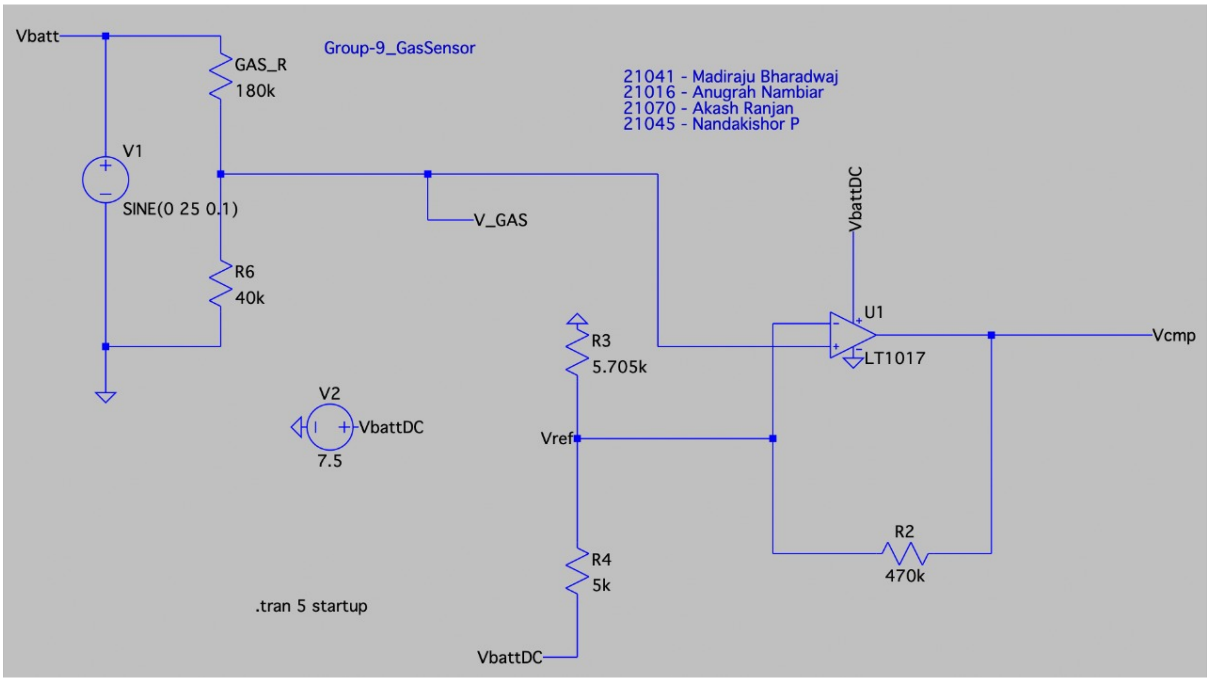
Properties of Gas Sensor:

Operating voltage	5V
Load resistance	20 KΩ
Heater resistance	33Ω ± 5%
Heating consumption	<800mw
Sensing Resistance	10 KΩ – 60 KΩ
Concentration Scope	200 – 10000ppm
Preheat Time	Over 24 hour

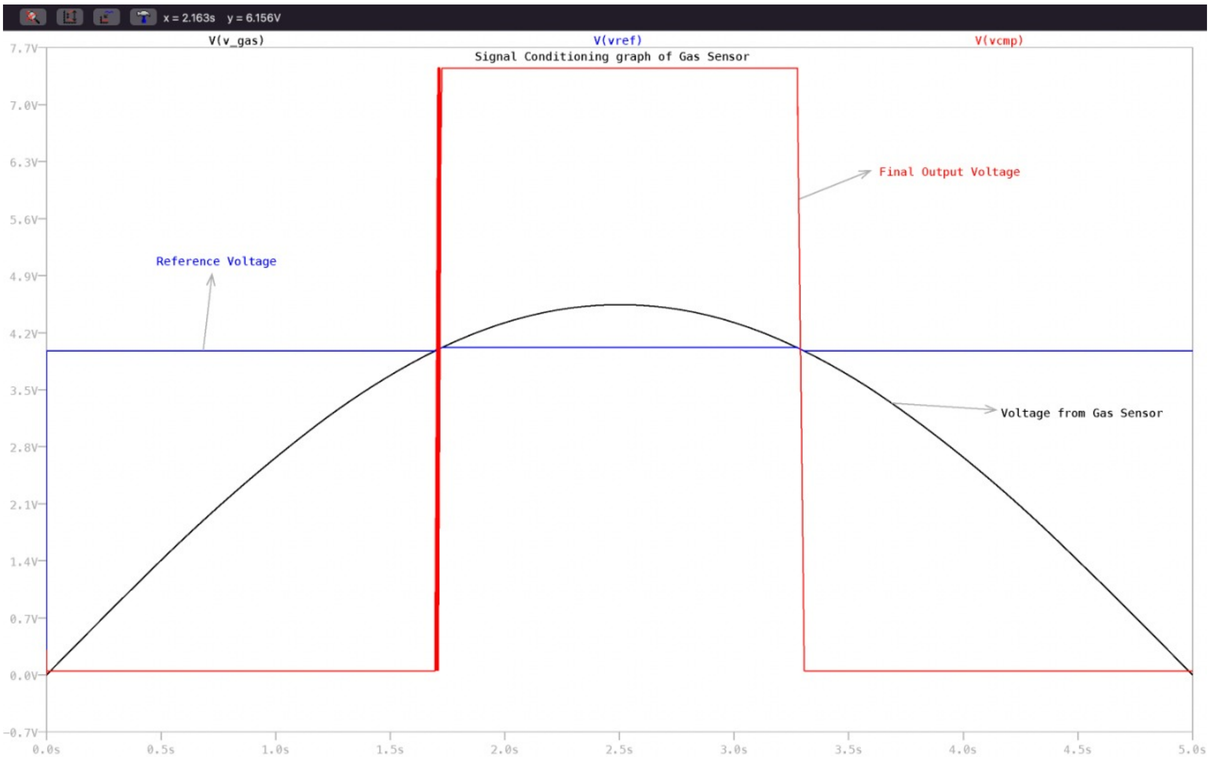
Applications of Gas Sensor:

- 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 CO2 levels.
- Used in detecting fire.
- Used to check concentration of gases in mines.
- Breath analyzer.

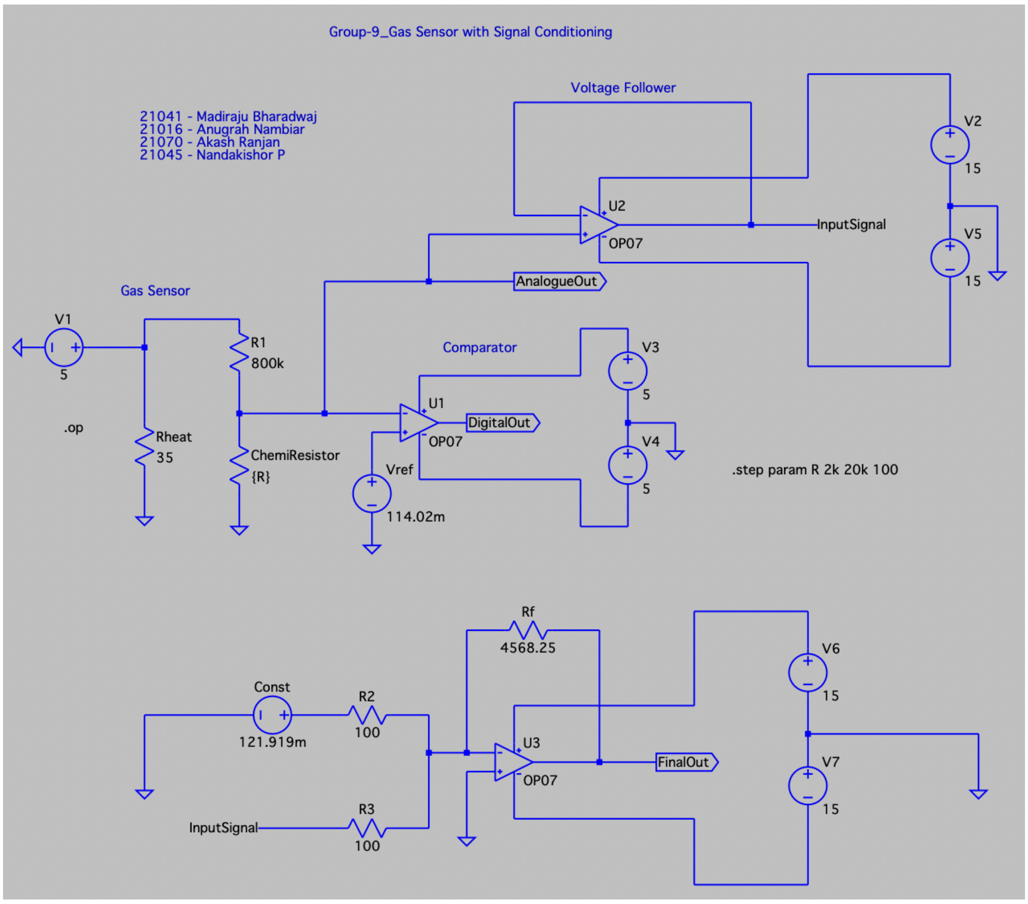
LtSpice of Gas Sensor:



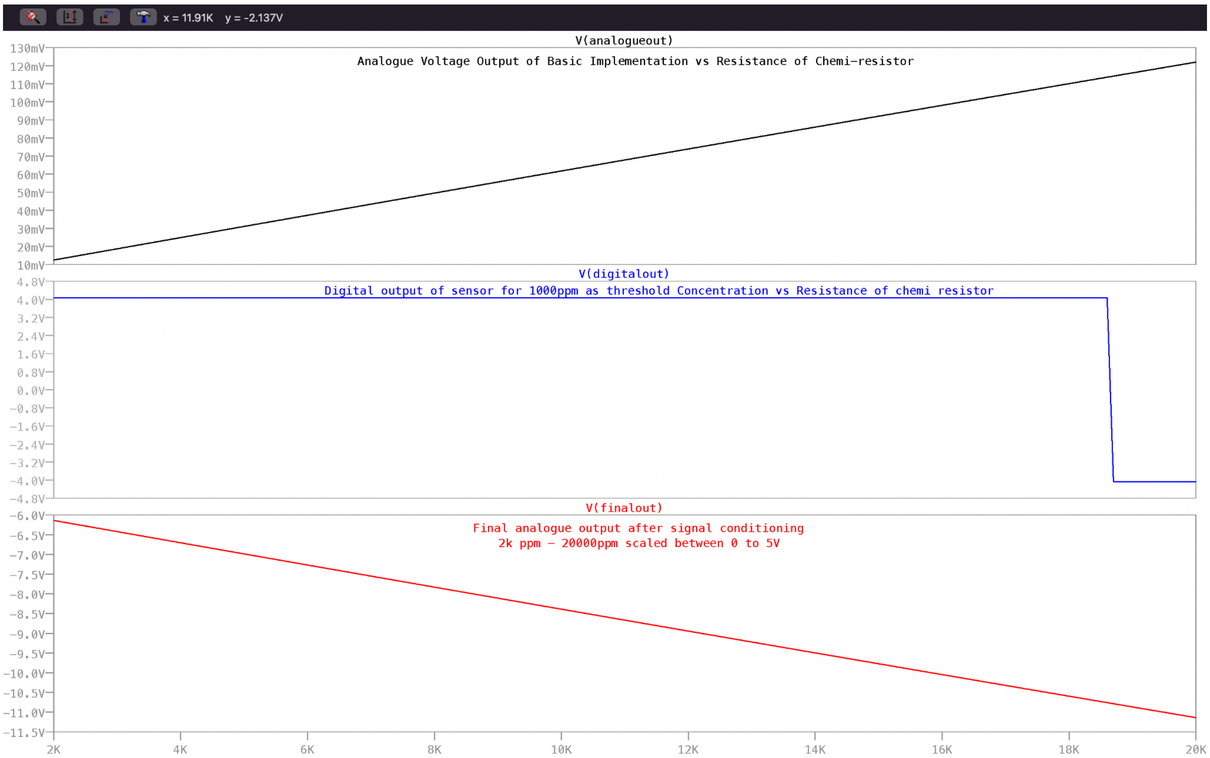
Graph of Gas Sensor Simulation:



Gas sensor with Signal Conditioning:



Graph:



Temperature Sensor:

Temperature sensor is a device used to measure the temperature using an electrical signal. It requires a thermocouple or RTD (Resistance temperature Detector).

Working of a temperature sensor:

The TMP36 uses a solid-state technique to measure the temperature. It makes use of the fact that the voltage drop between the base and emitter (forward voltage – V_{be}) of the Diode-connected transistor decreases at a known rate as the temperature increases. By precisely amplifying this voltage change, it is easy to generate an analog signal that is directly proportional to temperature.

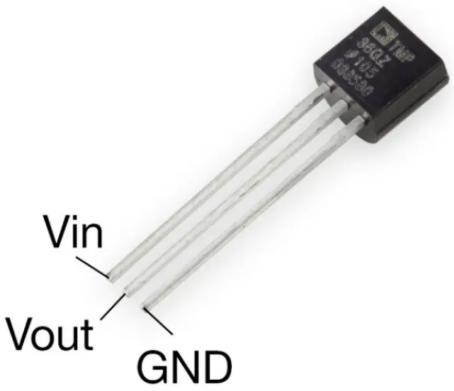
This linear relationship between forward voltage and temperature is the reason why diode-connected transistors are used as temperature measurement devices. Essentially this is how temperature is measured, although there have been some improvements in this technique over the years. The good news is that all these complex calculations are done inside the TMP36. It just outputs a voltage that is linearly proportional to temperature.

The TMP36 is easy to use, just connect the left pin to power (2.7-5.5V) and the right pin to ground (assuming the flat side of the sensor is facing you). Then the middle pin will have an analog voltage that is directly proportional (linear) to the temperature in °C. This can be easily seen in the output voltage vs temperature characteristic. Note that the analog output voltage is independent of the power supply.

To convert the voltage to temperature, simply use the basic formula:

$$\text{Temp } (°C) = (V_{out} – 0.5) * 100$$

How to use a temperature sensor:



Testing the TMP36 is pretty easy, just connect the left pin to the 2.7-5.5V power supply and the right pin to ground. Now connect your multimeter in DC voltage mode to ground and the middle pin. At room temperature (25°C), the voltage should be about 0.75V.

Vin - The power supply for the sensor which can be anywhere between 2.7V to 5.5V.

Vout - Pin produces an analog voltage that is directly proportional (linear) to the temperature. It should be connected to an Analog input.

GND - Is a ground pin.

Properties of Temperature Sensor:

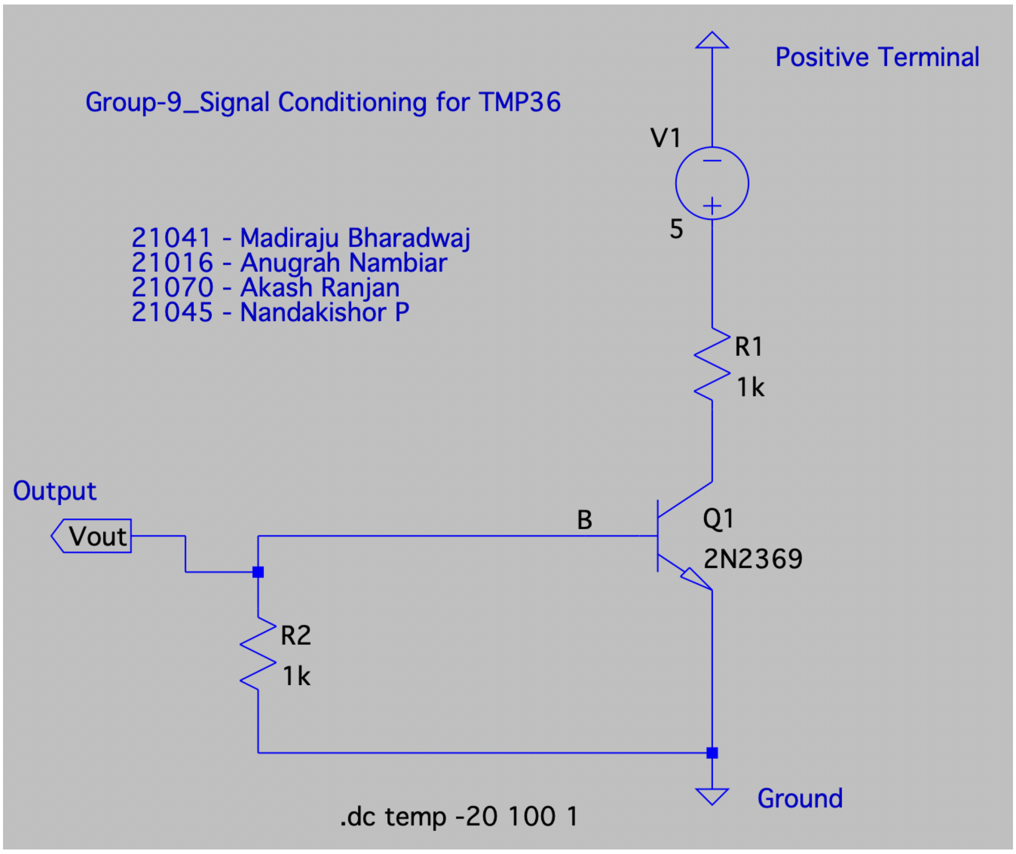
Power supply	2.7V to 5.5V
Current draw	50μA
Temperature range	-40°C to 125°C
Accuracy	±2°C
Output scale factor	10mV/°C
Output range	0.1V (-40°C) to 1.75V (125°C)
Output at 25°C	750mV

Applications of temperature sensor:

- There are many different aspects of motors and most of these require temperature measurement to ensure the motor itself does not overheat.
- Ring terminal temperature sensors are often used on surface plates as they can be mounted onto a flat surface and measure temperature effectively.
- Kettles, toasters, washing machines, dishwashers and coffee machines will all contain temperature sensors.
- Within computers there are temperature sensors to ensure the system does not overheat.
- Motorsport temperature sensors need to be highly reliable and durable to ensure performance is not compromised in this harsh environment.
- Temperature sensors are used to monitor the temperature of the melted chocolate for 3D printing.
- These are used in the heating control systems such as in buildings where temperature controls for the switch on or off the heating or cooling system.
- These are frequently used in humidity and air control conditioning equipment.

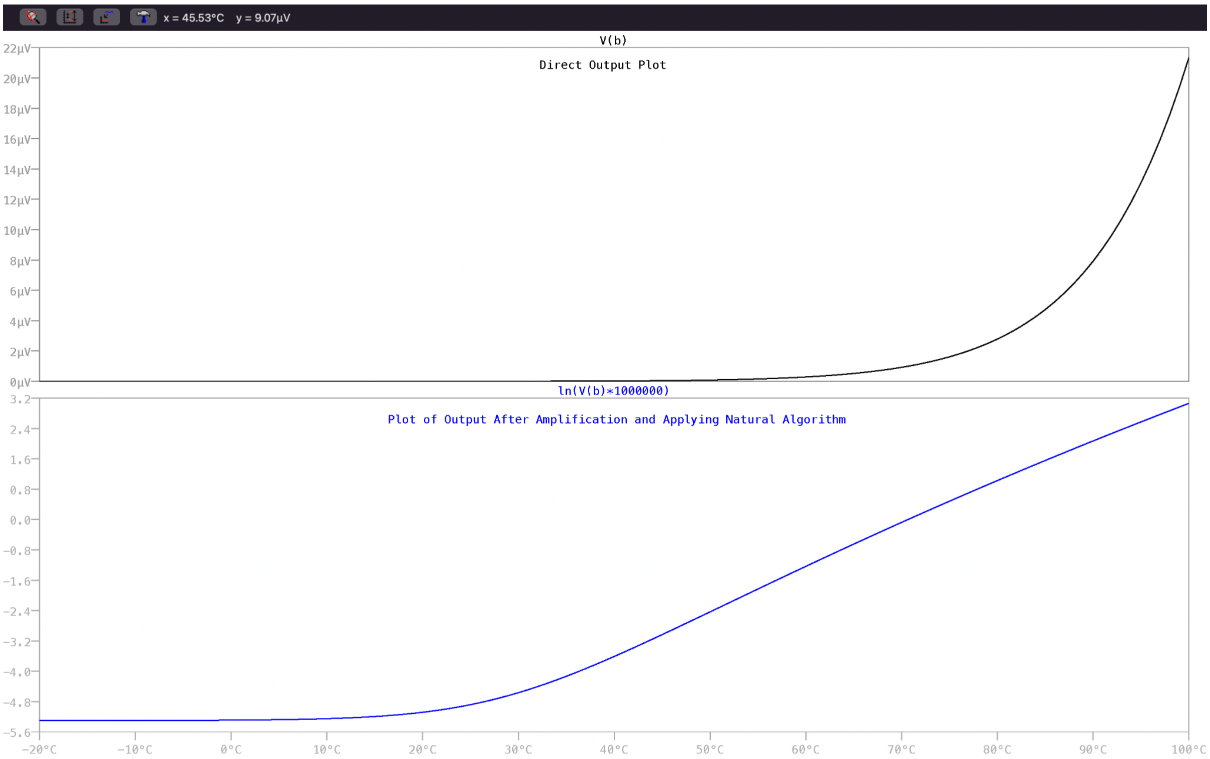
Signal Conditioning for Temperature Sensor:

TMP36:



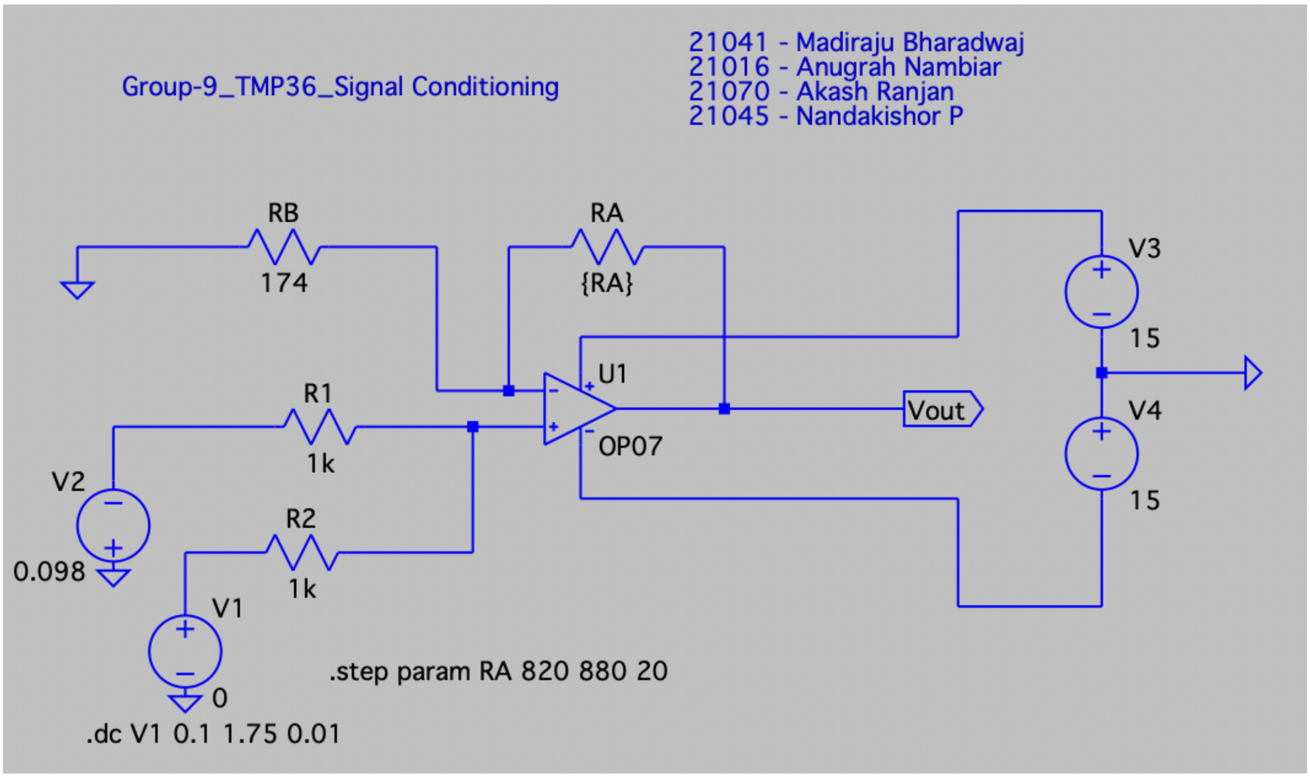
Positive Terminal
Group-9_Signal Conditioning for TMP36
V1
5
21041 - Madiraju Bharadwaj
21016 - Anugrah Nambiar
21070 - Akash Ranjan
21045 - Nandakishor P
R1
1k
Output
Vout
B
Q1
2N2369
R2
1k
Ground
.dc temp -20 100 1

Graph:



x = 45.53°C y = 9.07µV
V(b)
Direct Output Plot
22µV
20µV
18µV
16µV
14µV
12µV
10µV
8µV
6µV
4µV
2µV
0µV
ln(V(b)*1000000)
Plot of Output After Amplification and Applying Natural Algorithm
3.2
2.4
1.6
0.8
0.0
-0.8
-1.6
-2.4
-3.2
-4.0
-4.8
-5.6
-20°C
-10°C
0°C
10°C
20°C
30°C
40°C
50°C
60°C
70°C
80°C
90°C
100°C

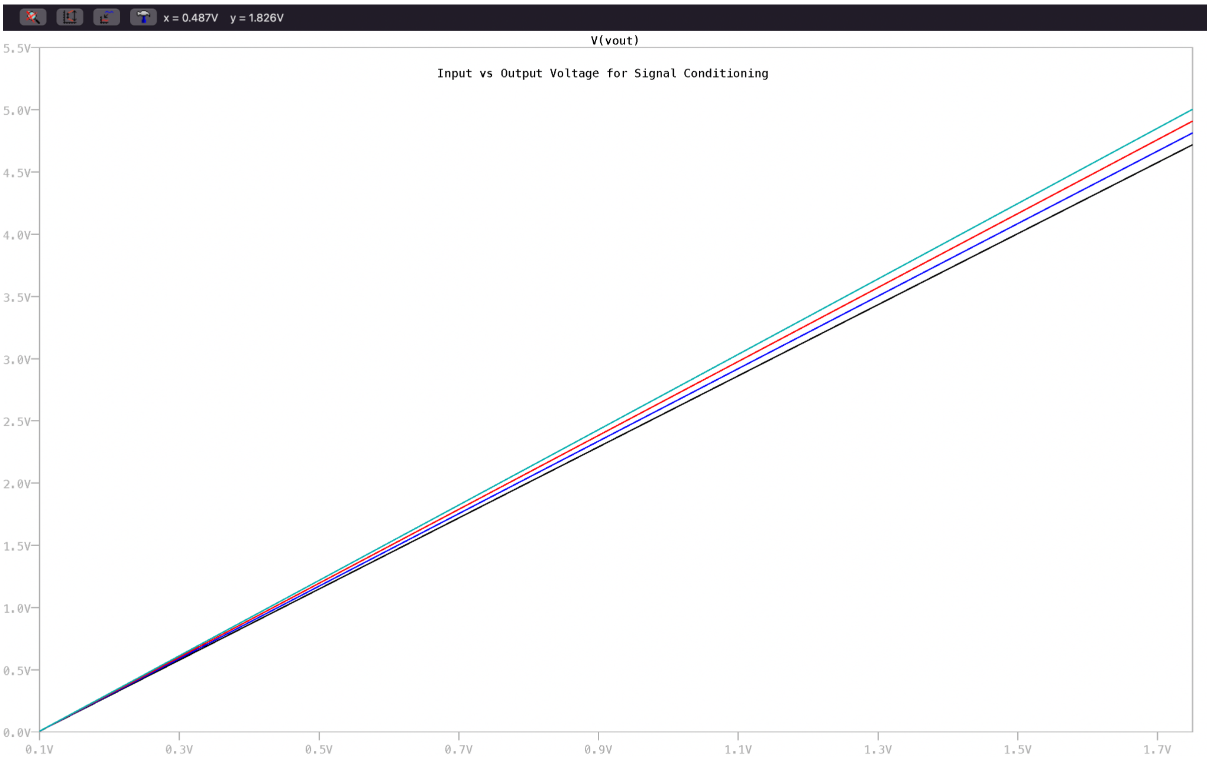
After observing the direct output of the sensor, we observed that the plot of Temperature vs voltage is similar to that of an exponential function. For making an exponential function linear the output should be passed through a logarithmic function. But as the output is in micro-volts the output should be amplified a lot before other signal processing.Testing this hypothesis resulted in a positive result giving a linear output plot for the input range of 40 degree Celsius to 100 degrees Celsius. The application of logarithmic function to the output can be done using an Op-Amp logarithmic amplifier.



From the output plot obtained the required feedback resistance for best results is 880 kΩ.

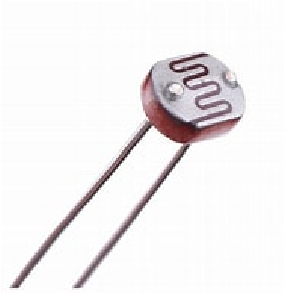
Now with the proper signal conditioning we mapped the output of the TMP36 sensor to the 0V-5V input range of the Arduino UNO.

Graph:



Photoresistor:

A photoresistor is a type of resistor whose resistance decreases when the intensity of light increases. In other words, the flow of electric current through the photoresistor increases when the intensity of light increases.

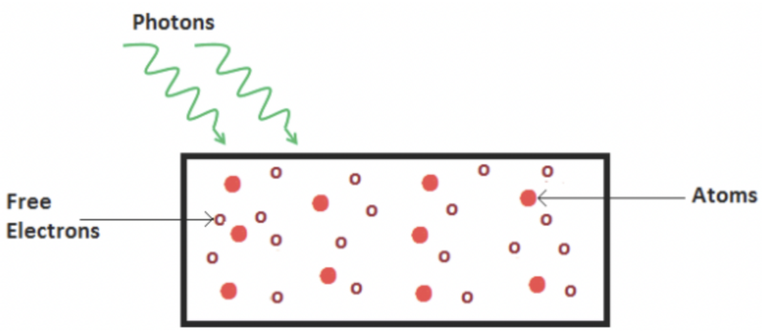


Working of Photoresistor:

As we know valence electrons are those found in the outermost shell of an atom. Hence, these are loosely attached to the nucleus of the atom. This means that only some small amount of energy is needed to pull it out from the outer orbit.

Free electrons on the other hand are those which are not attached to the nucleus and hence free to move when an external energy like an electric field is applied. Thus when some energy makes the valence electron pull out from the outer orbit, it acts as a free electron; ready to move whenever an electric field is applied. The light energy is used to make valence electrons a free electron.

This very basic principle is used in the Photoresistor. The light that falls on a photoconductive material is absorbed by it which in turn makes lots of free electrons from the valence electrons.



As the light energy falling on the photoconductive material increases, the number of valence electrons that gain energy and leave the bonding with the nucleus increases. This leads to a large number of valence electrons jumping to the conduction band, ready to move with an application of any external force like an electric field.

Thus, as the light intensity increases, the number of free electrons increases. This means the photoconductivity increases that imply a decrease in photo resistivity of the material.

How to use Photoresistor:

The active semiconductor region is normally deposited onto a semi-insulating substrate and the active region is normally lightly doped.

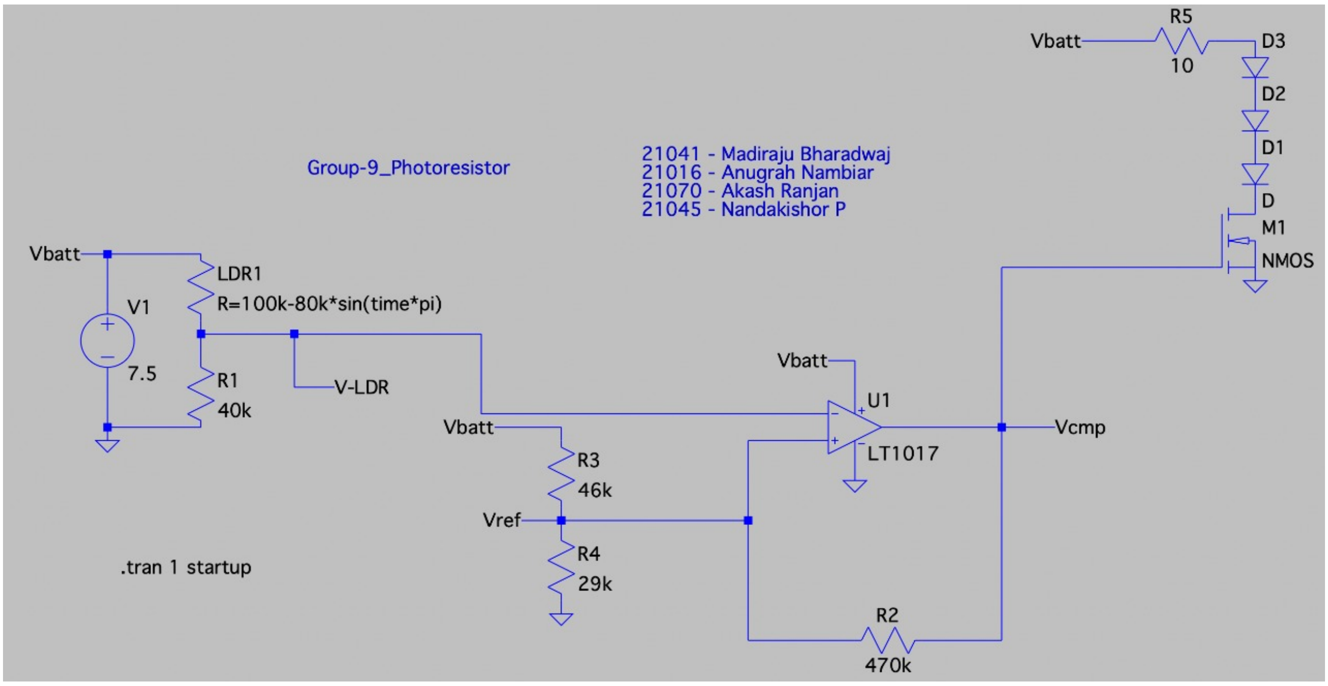
Ohmic contacts are made on the either side of the area of doping and the two terminals are connected to pass current when light falls on them ,depending on the intensity of light it would produce a certain amount of current.The photo-sensitive plate should face towards the light source.

A built in 10k resistor on the module can be used to build a divider circuit for measuring changes in light intensity from the photoresistor. A device such as an Arduino can be used to read the light intensity using an analog input pin.

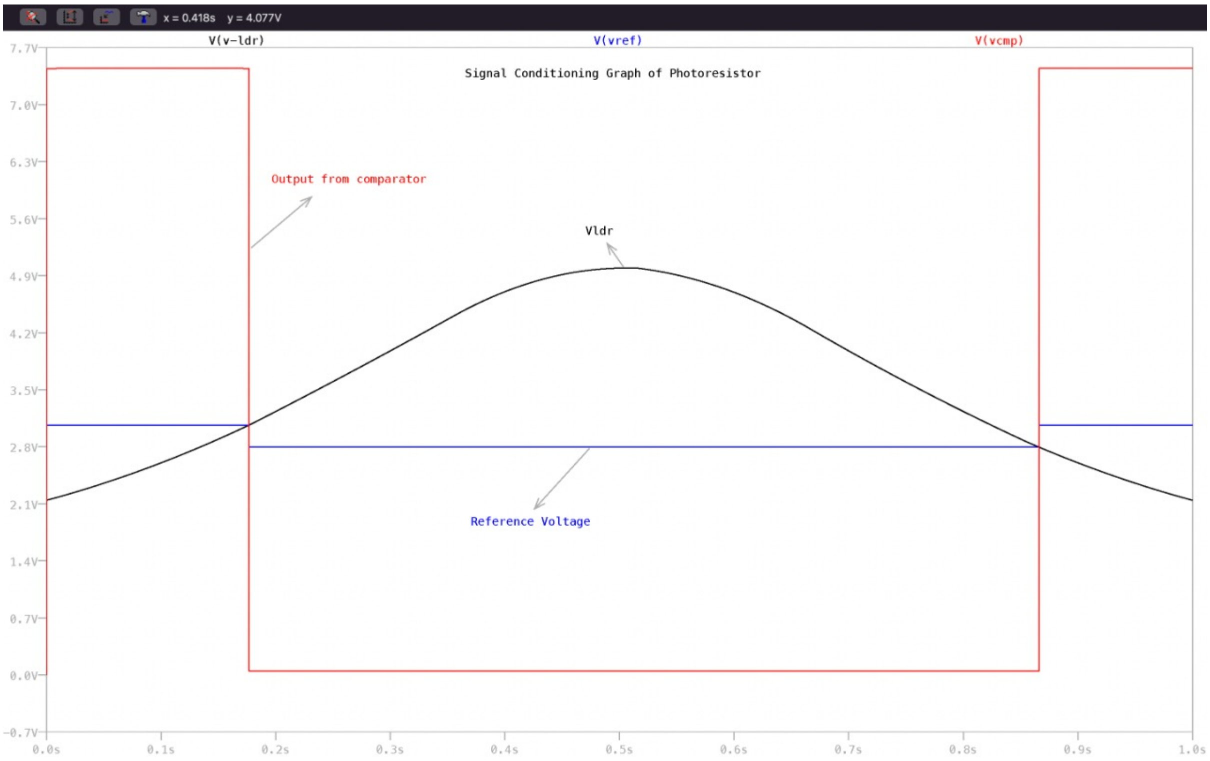
Properties of Photoresistor:

Power Supply	Around 5V
Input Voltage	0V - 1.8V
Output Voltage in Darkness	3V
Output Voltage in Brightness	0.1V
Resistance in Dark	200 kΩ
Resistance in Bright Light	1 kΩ or 2 kΩ

Ltspice of Photoresistor:



Graph of Photoresistor Simulation:

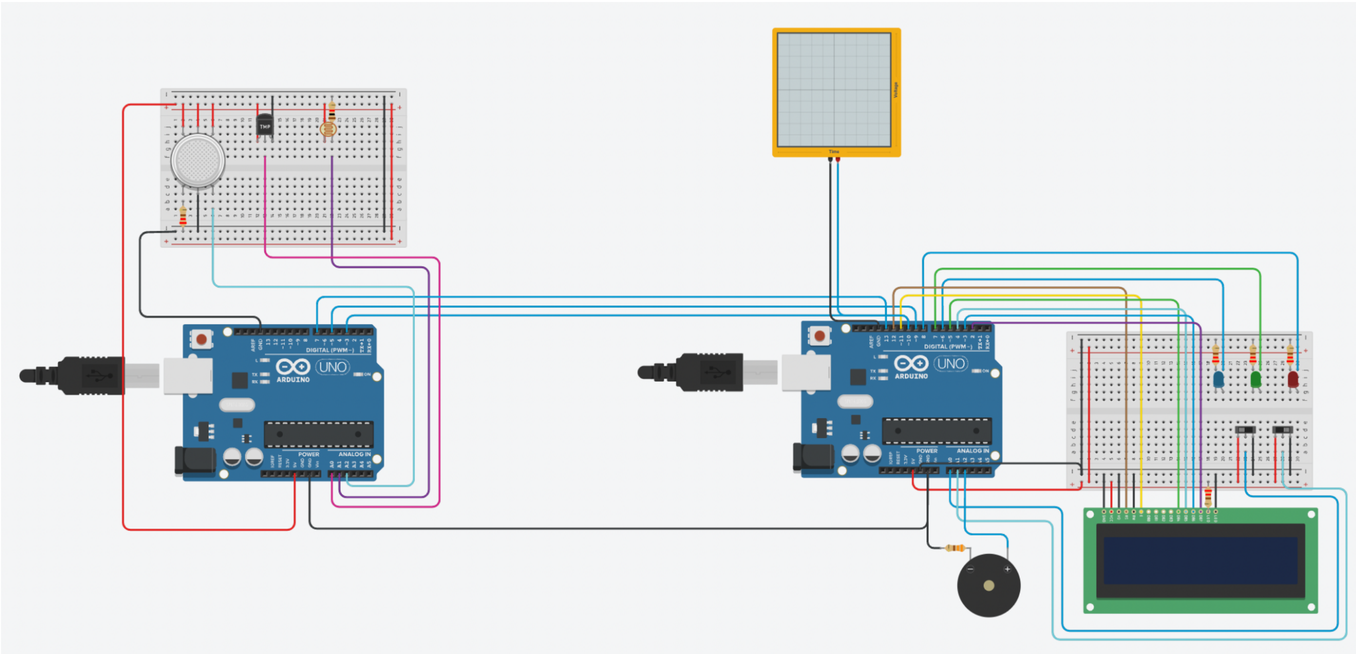


Applications of Photoresistor:

- These are used as light sensors.
- These are used to measure the intensity of light.
- Night light and photography light metres use photoresistors.
- Their latency property is used in audio compressors and outside sensing.
- Photoresistors can also be found in Alarm clocks, outdoor clocks, solar street lamps, etc…
- Infrared astronomy and Infrared Spectroscopy also use photoresistors for measuring mid-infrared spectral regions.

Weather Monitoring System:

Tinkercad Circuit:



The working of the system is starting with all the switches turned off. The leds are all turned off and the LCD is also turned off.

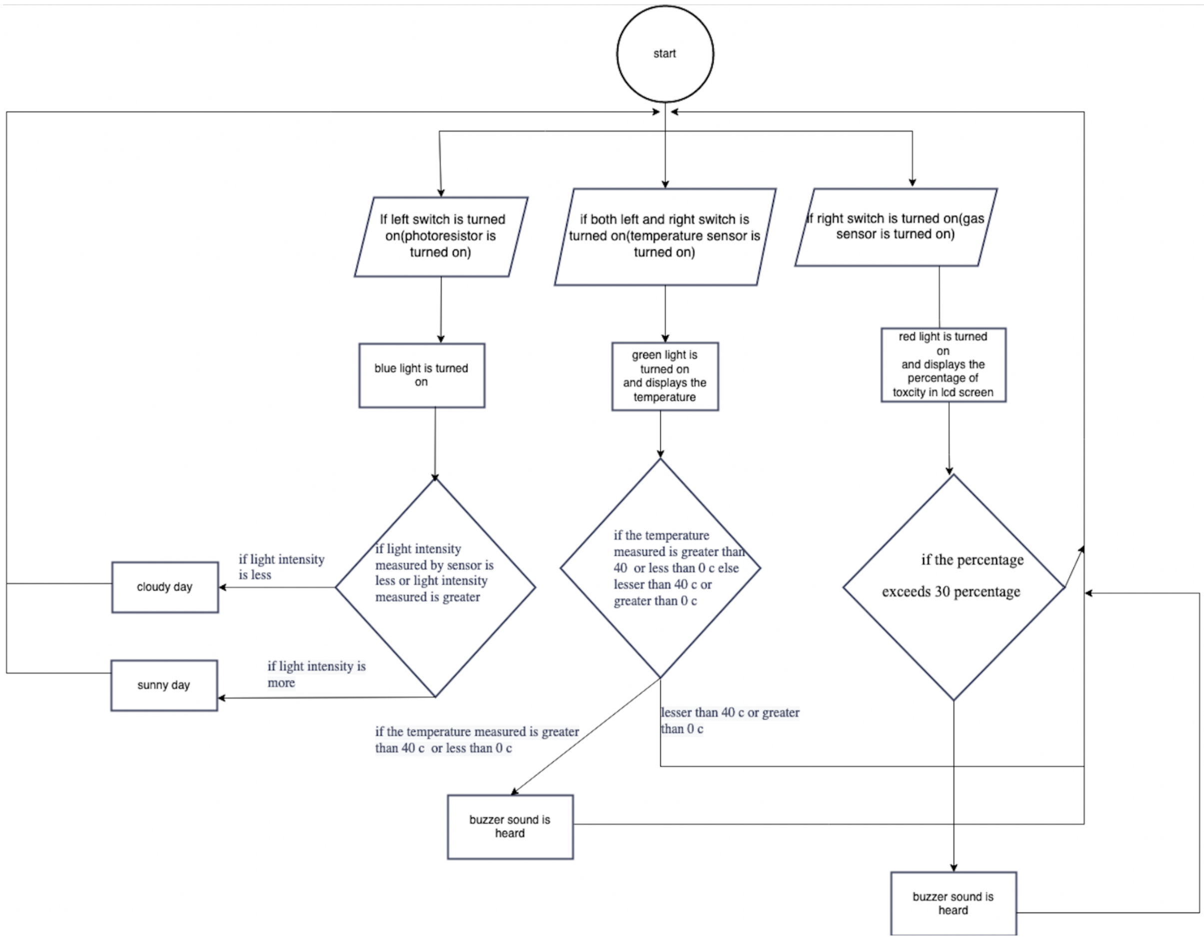
As soon as we start the simulation we are supposed to keep both the switches closed and that means for that point of time we are not measuring anything and none of the sensors are working.

From this system we are able to measure weather using the measurement of the different parameters of the weather using the different sensors in this system. When we turn on the left switch we are sensing the condition of the clouds and the present condition of the sky using a photoresistor and the result will be displayed on the LCD screen. The mode of measurement of the parameter can be understood using the LED, in this case the blue Led will be glowing.

Similarly, for the involvement of the next sensor we are using the next switch and turning off the first switch as we do this the LED depicting the involvement of the gas sensor will glow (Red LED) and the measurement of the toxicity present in the gas will be displayed on the LCD screen. If the toxicity is found to be more than 30 percent in the gas then the buzzer goes on and the alarm sound is made.

If both the switches are turned on at the same time then it means that the temperature is being measured and the temperature sensor is active and the temperature is being displayed on the LCD and the green led will be turned on to make the user aware of the choice of parameter he/she has opted for measurement of temperature.

FlowChart:



start
If left switch is turned on(photoresistor is turned on)
if both left and right switch is turned on(temperature sensor is turned on)
if right switch is turned on(gas sensor is turned on)
blue light is turned on
green light is turned on and displays the temperature
red light is turned on and displays the percentage of toxcity in lcd screen
if light intensity measured by sensor is less or light intensity measured is greater
if the temperature measured is greater than 40 or less than 0 c else lesser than 40 c or greater than 0 c
if the percentage exceeds 30 percentage
if light intensity is less
cloudy day
if light intensity is more
sunny day
if the temperature measured is greater than 40 c or less than 0 c
lesser than 40 c or greater than 0 c
buzzer sound is heard
buzzer sound is heard

Code:

Arduino 1:

```
// Receiver

#include <SoftwareSerial.h>
#include <LiquidCrystal.h>

#define rxPin 10
#define txPin A5
SoftwareSerial mySerial =  SoftwareSerial(rxPin, txPin);

#define rxPin1 9
#define txPin1 A4
SoftwareSerial mySerial1 =  SoftwareSerial(rxPin1, txPin1);

#define rxPin2 13
#define txPin2 A3
SoftwareSerial mySerial2 =  SoftwareSerial(rxPin2, txPin2);

#define LedGreen 7
#define LedBlue 6
#define LedRed 8

LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

int Temp = 0;
int val = 0;
int gas = 0;

void setup() {

  pinMode(rxPin, INPUT);
  pinMode(txPin, OUTPUT);
  mySerial.begin(9600);

  pinMode(rxPin1, INPUT);
  pinMode(txPin1, OUTPUT);
  mySerial1.begin(9600);

  pinMode(rxPin2, INPUT);
  pinMode(txPin2, OUTPUT);
  mySerial2.begin(9600);

  pinMode(LedGreen, OUTPUT);
  pinMode(LedBlue, OUTPUT);
  pinMode(LedRed, OUTPUT);

  Serial.begin(9600);
  pinMode(A0, INPUT);
  pinMode(A1, INPUT);
  pinMode(A2, OUTPUT);


  lcd.begin(16, 2);
}

void loop() {
  if ( digitalRead(A0) == HIGH && digitalRead(A1) == HIGH)
  {
    mySerial.listen();
    if (mySerial.available() > 0)
    {
      Temp = mySerial.read();
      Temp = map(Temp, 4, 89, -40, 125);

      if (Temp <= 125 && Temp >= -40)
      {
        //Serial.println(Temp);
        lcd.print("Temperature:  ");
        lcd.setCursor(12, 0);
        lcd.print(Temp);
        lcd.setCursor(15, 0);
        lcd.print("C");

```

Text | 1 (Arduino Uno R3)

```
        if ( Temp >= -40 && Temp <= 0)
        {
          digitalWrite(LedBlue, HIGH);
          digitalWrite(LedGreen, LOW);
          digitalWrite(LedRed, LOW);
          tone(A2,1000,20000);
        }
        else if ( Temp > 0 && Temp <= 40)
        {
          digitalWrite(LedBlue, LOW);
          digitalWrite(LedGreen, HIGH);
          digitalWrite(LedRed, LOW);
        }
        else
        {
          digitalWrite(LedBlue, LOW);
          digitalWrite(LedGreen, LOW);
          digitalWrite(LedRed, HIGH);
          tone(A2,1000,200);
        }
        if (Temp > 100) tone(A2, 100, 100);
        delay(3);
        lcd.clear();
        noTone(A2);
      }
    }
  }
  else if ( digitalRead(A0) == HIGH && digitalRead(A1) == LOW)
  {
    digitalWrite(LedBlue, LOW);
    digitalWrite(LedGreen, LOW);
    digitalWrite(LedRed, LOW);

    mySerial1.listen();
```

Text | 1 (Arduino Uno R3)

```
    if (mySerial1.available() > 0)
    {
      val = mySerial1.read();
      digitalWrite(LedBlue, HIGH);
      //Serial.println(val);

      if ( val > 0 && val < 149)
      {
        lcd.print("Weather Type : ");
        lcd.setCursor(0, 1);
        lcd.print("Overcast");
        delay(3);
      }
      else if ( val > 149 && val < 218)
      {
        lcd.print("Weather Type : ");
        lcd.setCursor(0, 1);
        lcd.print("Partially Cloudy");
        delay(3);
      }
      else
      {
        lcd.print("Weather Type : ");
        lcd.setCursor(0, 1);
        lcd.print("Sunny/Clear");
        delay(3);
      }
      lcd.clear();
    }
  }

```

Text 1 (Arduino Uno R3)

```
      lcd.clear();
    }
  }

  else if ( digitalRead(A0) == LOW && digitalRead(A1) == HIGH)
  {
    digitalWrite(LedBlue, LOW);
    digitalWrite(LedGreen, LOW);
    digitalWrite(LedRed, LOW);

    mySerial2.listen();
    if (mySerial2.available() > 0)
    {
      gas = mySerial2.read();
      if ((gas <= 100) && (gas >= 0))
      {
        Serial.println(gas);
        //gas = map(gas, 0, 255, 0, 100);
        lcd.print("Toxic Gas !");
        lcd.setCursor(0, 1);
        lcd.print("Percentage = ");
        lcd.setCursor(13, 1);
        lcd.print(gas);
        if (gas > 30) tone(A2, 1000, 50);
        digitalWrite(LedRed, HIGH);
        delay(3);
        lcd.clear();
      }
    }
  }
  else
  {
    digitalWrite(LedBlue, LOW);
    digitalWrite(LedGreen, LOW);
    digitalWrite(LedRed, LOW);
    noTone(A2);
  }
}
```

Arduino 2:

Text 2 (Arduino Uno R3)

```
// Transmitter

#include <SoftwareSerial.h>

#define rxPin 2
#define txPin 3
SoftwareSerial mySerial =  SoftwareSerial(rxPin, txPin);

#define rxPin1 4
#define txPin1 5
SoftwareSerial mySerial1 =  SoftwareSerial(rxPin1, txPin1);

#define rxPin2 6
#define txPin2 7
SoftwareSerial mySerial2 =  SoftwareSerial(rxPin2, txPin2);

int Temp;
int val;
int gas;

void setup()
{

  pinMode(rxPin, INPUT);
  pinMode(txPin, OUTPUT);
  mySerial.begin(9600);

  pinMode(rxPin1, INPUT);
  pinMode(txPin1, OUTPUT);
  mySerial1.begin(9600);

  pinMode(rxPin2, INPUT);
  pinMode(txPin2, OUTPUT);
  mySerial2.begin(9600);

  Serial.begin(9600);

}
```

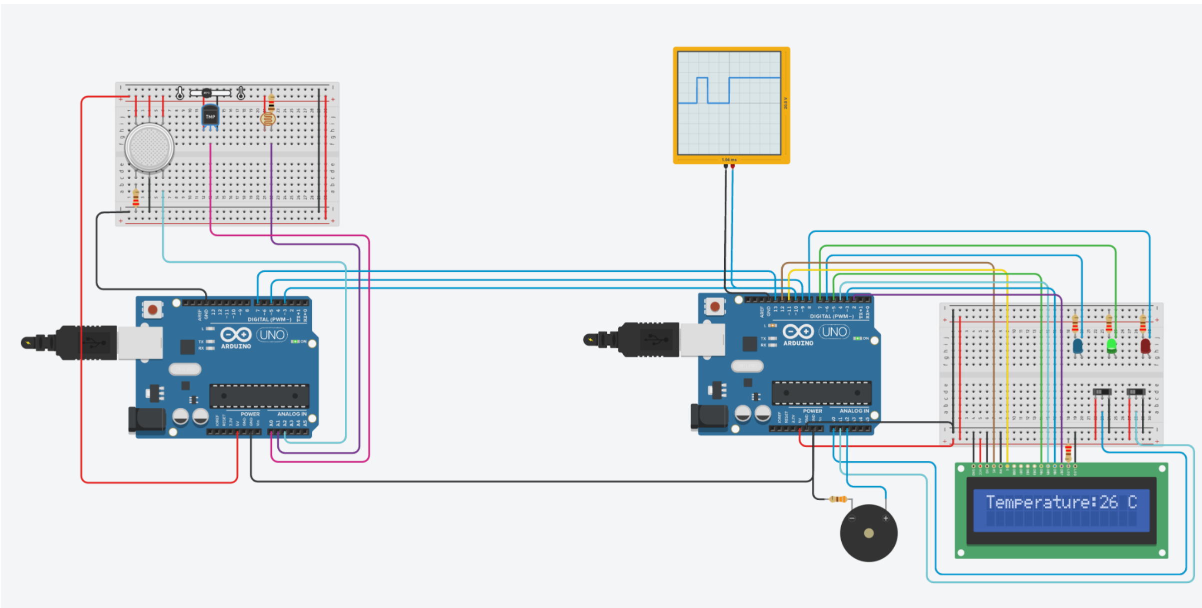
```
void loop()
{
  Temp = analogRead(A0);
  Temp = map(Temp, 0, 1024, 0, 255);
  //Serial.println(Temp);
  mySerial.write(Temp);
  delay(1);

  val = analogRead(A1);
  val = map(val, 1, 700, 0, 255);
  mySerial1.write(val);
  //Serial.println(val);
  delay(1);

  gas = analogRead(A2);
  //Serial.println(gas);
  gas = map(gas, 20, 120, 0, 100);
  mySerial2.write(gas);
  //Serial.println(gas);
  delay(1);
}
```

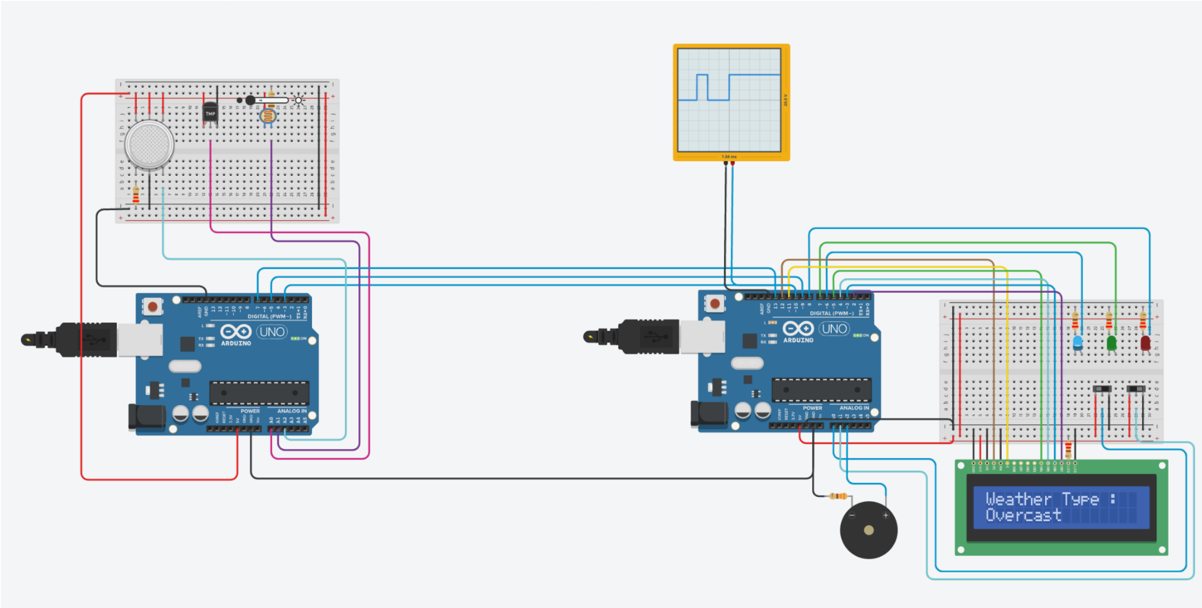
Working of Weather Monitoring System:

When Measuring Temperature:



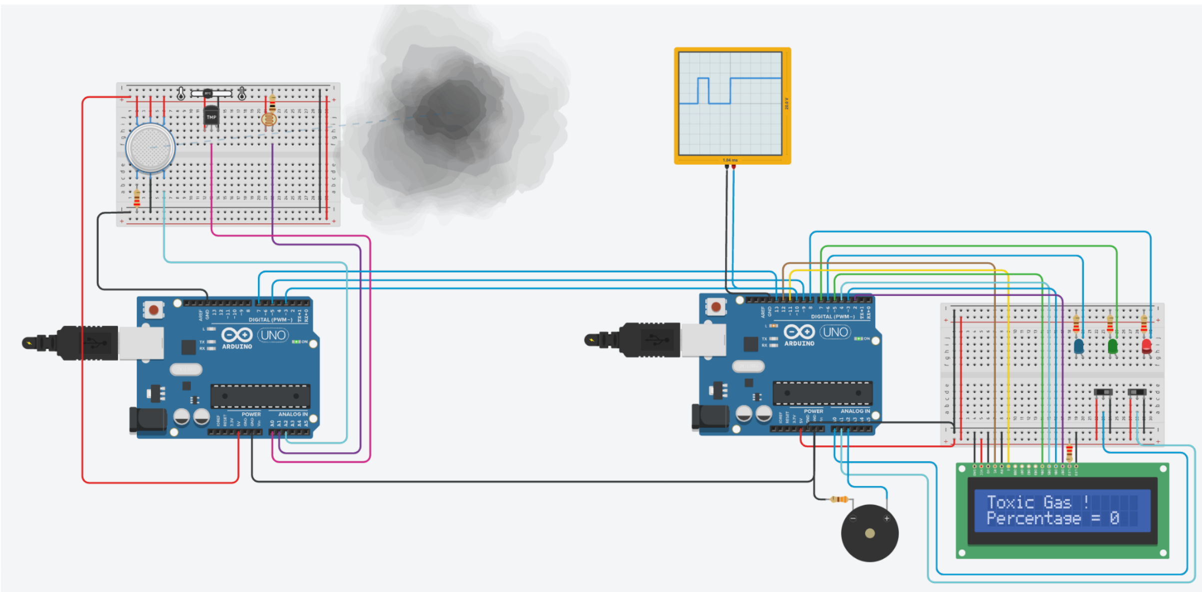
When we switch on both switches, we can observe that green led light glows which indicates that we are measuring the temperature. If the temperature sensor(TMP36) observes that temperature exceeds 40°C or below 0°C, a buzzer sound is heard . Buzzer sound is designed for the purpose to tell when the highest temperature or lowest temperature is crossed .

When Forecasting Weather:



When we switch on only the left switch ,we can observe that a blue light is turned on indicating the factor that the photoresistor is turned on and measuring the changes based on light intensity.If the light intensity is less ,LCD shows that it is cloudy ,else it is a sunny day.

When Measuring Toxic Gas:



When we switch on only the right switch ,we can observe that a red light is turned on indicating the factor that the gas sensor is turned on and measuring the changes based on concentration of the toxicity in air .The toxic gas intensity is shown in-terms of percentage in the LCD screen, if the percentage exceeds 30 percentage, a buzzer sound is heard.

Conclusion:

In the conclusion of this project we can conclude that the weather monitoring system developed with the idea of forecasting the weather of various places have been accomplished successfully and through this project we get to know about the various sensors which are having different specifications along with that different mode of operations are also present for each of them as all have different purpose and different parameters of measurements.

We can conclude that the system developed is having higher accuracy as it can be deployed directly to the various locations where the weather needs to be monitored and not only this it can also be used for monitoring the weather of different places while travelling. In that case the accuracy may vary by small margins.

At the end we can say that we have successfully accomplished the objective of developing a weather monitoring system.

References:

https://lastminuteengineers.com/mq2-gas-senser-arduino-tutorial/

https://lastminuteengineers.com/lm35-temperature-sensor-arduino-tutorial/

https://www.electronics-notes.com/articles/electronic_components/resistors/light-dependent-resistor-ldr.php

https://lastminuteengineers.com/tmp36-temperature-sensor-arduino-tutorial/

https://www.circuitstoday.com/photoresistor

https://components101.com/articles/introduction-to-gas-sensors-types-working-and-applications

https://www.elprocus.com/photoresistor-working-types-and-applications/

https://www.youtube.com/watch?v=bmeww8SGySc&t=908s

https://pianalytix.com/weather-monitoring-system-using-tinkercad/

https://devpost.com/software/whatdoesahamed-study

https://startingelectronics.org/pinout/photo-resistor/