# J.C BOSE UNIVERSITY OF SCIENCE AND TECHNOLOGY , YMCA, FARIDABAD

## WORKSHOP PROJECT

## Air Quality Monitoring System

*A mini project report submitted in the partial fulfilment of*

*Degree of Bachelor of Technology in*

*Electronics and Communication Engineering (ECE).*

*By*

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*Under the guidance of*

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# Contents

# CERTIFICATE

It is certified that the work contained in the thesis titled " Air Quality Monitoring System " by Ravi Jhajhriya (22001008047), Rudhraj (22001008052), Sahil Choudhary (22001008056), Siddharth Singh (22001008063) has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

Place:

Date:

| Head of the Department | Mini-project Coordinator | Project Supervisor |
|---|---|---|

# ACKNOWLEDGEMENT

We feel great pleasure to acknowledge all those involved in the process of our education and research. In the first place, we would like to record our deep and sincere gratitude towards our teacher in-charge, Ms. Kusum Arora for her supervision, advice, guidance, and crucial contribution, which made her a backbone of this project. Her understanding, encouraging nature and personal guidance have provided a good basis for this project. Her involvement with her originality has triggered and nourished our intellectual maturity that we will benefit from, for a long time to come.

We wish to express our gratitude towards our all teachers, who helped us throughout our course work. We extend our acknowledgement to our lab mates, lab staff, who are directly or indirectly involved in carrying out the project work.

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# ABSTRACT

Air pollution has become a critical concern globally, posing severe threats to human health and the environment. Monitoring air quality is essential to assess pollution levels, identify harmful pollutants, and enable timely corrective actions. This project presents the development of an **Air Quality Monitoring System** designed to measure and display real-time air quality data. The system incorporates various sensors, including the **GP2Y1010AU0F dust sensor** for particulate matter (PM2.5) measurement, the **MQ2 gas sensor** to detect harmful gases, and the **DHT11 sensor** for temperature and humidity readings.

The collected data is processed using a microcontroller, and air quality metrics are calculated, including the Air Quality Index (AQI). The results are displayed on a **16x2 LCD with I2C interface** for easy visualization. This system provides a cost-effective and portable solution for real-time air quality monitoring. It can be deployed in homes, workplaces, or public spaces to increase awareness and encourage actions toward reducing pollution levels.

The project emphasizes the importance of technology in promoting environmental sustainability and improving public health.

# INTRODUCTION

Air pollution is a pressing environmental issue that directly impacts human health, ecosystems, and climate. The increasing levels of pollutants, such as particulate matter (PM2.5), toxic gases, and harmful chemicals, necessitate the need for real-time monitoring to mitigate their adverse effects. The **Air Quality Monitoring System** is designed as an innovative and cost-effective solution to address this challenge.

This project aims to measure key air quality parameters, including particulate matter concentration, gas levels, temperature, and humidity. The system utilizes the **GP2Y1010AU0F dust sensor** to detect PM2.5 particles, the **MQ2 gas sensor** to identify the presence of harmful gases, and the **DHT11 sensor** to record ambient temperature and humidity. These sensors, integrated with a microcontroller, process data to calculate the **Air Quality Index (AQI)** and provide a comprehensive representation of air quality.

The data is displayed on a **16x2 LCD with I2C interface**, making it user-friendly and suitable for deployment in homes, offices, and public spaces. The system not only raises awareness about air quality but also aids in taking proactive measures to reduce pollution. By leveraging readily available components and straightforward design, this project provides an accessible solution for improving environmental monitoring and public health.

# BASIC PRINCIPLE

The **Air Quality Monitoring System** operates on the principle of **sensing and data analysis** to determine air quality. The project relies on a combination of sensors to measure environmental parameters, such as particulate matter, harmful gases, temperature, and humidity. Each sensor converts the physical quantity it measures into an electrical signal, which is processed to calculate the Air Quality Index (AQI).

1. **Dust Measurement**:
   The **GP2Y1010AU0F dust sensor** detects particulate matter (PM2.5) in the air using an optical sensing mechanism. It emits infrared light, which scatters when it encounters dust particles. The intensity of the scattered light is proportional to the concentration of particles, which is converted into a measurable voltage.
2. **Gas Detection**:
   The **MQ2 gas sensor** uses a sensitive semiconductor layer that reacts to combustible gases like carbon monoxide, methane, and LPG. Changes in resistance due to gas exposure are translated into an output voltage corresponding to the gas concentration.
3. **Temperature and Humidity Monitoring**:
   The **DHT11 sensor** uses a capacitive humidity sensor and a thermistor to measure ambient humidity and temperature, respectively. These environmental factors are critical in understanding how pollutants behave in different conditions.
4. **Data Processing and Display**:
   The microcontroller processes the sensor outputs and calculates the AQI based on predefined formulas. The processed data is then displayed on a **16x2 LCD** with an I2C interface for real-time monitoring.

# → Components

## GP2Y1010AU0F Dust Sensor

The **GP2Y1010AU0F** is an optical dust sensor manufactured by Sharp. It is designed to detect fine particles such as cigarette smoke or house dust in the air. The sensor is widely used in air quality monitoring systems, purifiers, and HVAC systems. Below is a breakdown of its details and working principle:

**Working Principle:**

1. **Infrared Light Scattering**:
   - The sensor uses an **infrared LED** and a **photo-detector** placed at an angle inside the device.
   - When particles (dust) pass through the detection chamber, they scatter the infrared light.
2. **Photo-detection**:
   - The scattered light is detected by the photo-detector, and the intensity of the scattered light is converted into an electrical signal.
3. **Analog Voltage Output**:
   - The sensor outputs a voltage that corresponds to the dust concentration in the air. The relationship between the output voltage and dust concentration is defined in the sensor's datasheet.
4. **Sampling**:
   - To get an accurate reading, the LED inside the sensor is turned on for a short duration (e.g., 280 µs). This minimizes noise and ensures precise measurements.

## 2. LCD

An LCD (Liquid Crystal Display) is used in the tachometer to display the motor's real-time rotational speed (RPM) in a clear and user-friendly manner. The LCD provides a visual interface for monitoring speed data, making it easier for users to track motor performance. It is interfaced with a microcontroller, which processes the tachometer signals and updates the display dynamically. The use of an LCD enhances the functionality of the tachometer by offering accurate and instant feedback. This ensures efficient motor operation and simplifies troubleshooting in various applications.

## 3. DHT11 Temperature and Humidity Sensor

The **DHT11** is a commonly used temperature and humidity sensor that provides calibrated digital outputs. It is widely used in weather monitoring systems, home automation projects, and other applications requiring environmental data collection.

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**Basic Details:**

1. **Operating Voltage**: 3.3V to 5.5V.
2. **Output**: Digital signal via a single-wire communication protocol.
3. **Temperature Range**: 0°C to 50°C with an accuracy of ±2°C.

4. **Humidity Range**: 20% to 90% Relative Humidity (RH) with an accuracy of ±5%.
5. **Power Consumption**: Low (max current 2.5 mA during data transmission).

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**Working Principle:**

The **DHT11** sensor combines a resistive humidity sensing component and a thermistor for temperature measurement, both connected to a microcontroller inside the sensor for signal processing.

**Humidity Measurement:**

- The sensor uses a **resistive humidity sensing element** where the resistance changes based on the relative humidity of the surrounding air.
- This change in resistance is converted to a digital signal.

**Temperature Measurement:**

- The sensor contains a **thermistor** (a temperature-sensitive resistor) whose resistance changes with temperature.
- This change is measured and processed into a digital signal.

## 4. Jumper Wires

Jumper wires are essential components in electronics and prototyping, commonly used in conjunction with breadboards and microcontroller platforms like Arduino. These wires, often with male-to-male connectors, female to female, male to female , facilitate easy and temporary connections between different points on a circuit.

## 5. MQ2 Gas Sensor

The **MQ2 gas sensor** is a versatile sensor used to detect gases like LPG, methane, propane, hydrogen, alcohol, and smoke. It is widely used in gas leak detection systems, air quality monitors, and safety applications.

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**Basic Details:**

1. **Operating Voltage**: 5V.
2. **Output**:

- **Analog**: A varying voltage proportional to gas concentration.
- **Digital**: High/Low signal based on a user-set threshold (via potentiometer).

3. **Sensing Range**:
   - LPG: 200 to 10000 ppm.
   - Methane: 500 to 10000 ppm.
   - Smoke: 300 to 10000 ppm.
4. **Preheat Time**: 20 seconds for stable output.
5. **Power Consumption**: Approximately 800mW.

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**Working Principle:**

The MQ2 sensor uses a **heating element** inside a sensing layer made of tin dioxide (**$SnO_2$**). This layer interacts with gases and changes its resistance depending on the concentration of the gas in the air.

1. **Gas Detection**:
   - In clean air, the tin dioxide layer has high resistance.
   - When target gases are present, the gas molecules interact with the surface and reduce the resistance.
   - This resistance change is converted into an electrical signal.
2. **Output Signal**:
   - The sensor provides an **analog voltage** that is proportional to the gas concentration.
   - A **digital output** is also available when the gas level crosses the user-defined threshold (set via an onboard).

## Program

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>

#include <DHT.h>

#define DHTPIN 7           // DHT11 sensor connected to pin 7

#define DHTTYPE DHT11      // Define sensor type (DHT11)

#define MQ2_PIN A2         // MQ2 gas sensor connected to analog pin A2

#define DUST_SENSOR_PIN A0 // GP2Y1010AU0F dust sensor connected to
A0

#define LED_CONTROL_PIN 3  // LED control pin of GP2Y1010AU0F
connected to PWM pin 3

DHT dht(DHTPIN, DHTTYPE);   // Initialize DHT11 sensor

LiquidCrystal_I2C lcd(0x27, 16, 2); // Initialize LCD

void setup() {

  Serial.begin(9600);         // Start serial communication

  dht.begin();                // Initialize DHT11 sensor

  lcd.begin(16, 2);           // Initialize LCD display

  lcd.backlight();            // Turn on the backlight

pinMode(LED_CONTROL_PIN, OUTPUT);

  digitalWrite(LED_CONTROL_PIN, LOW); // Turn on dust sensor LED for
operation

lcd.setCursor(0, 0);

  lcd.print("When Started:");
```

```
  lcd.setCursor(0, 1);

  lcd.print("Project by: Ravi, Rudraj, Sahil, Siddharth");

  delay(3000); // Display message for 3 seconds

}

void loop() {

  // Read temperature and humidity

  float temperature = dht.readTemperature();

  float humidity = dht.readHumidity()

 int mq2_value = analogRead(MQ2_PIN);  // Reading analog value from MQ2

  float mq2_concentration = map(mq2_value, 0, 1023, 0, 500); // Example
conversion (calibration needed)

 int aqi_dust = getAQIFromDust(dust_concentration);

  int aqi_gas = getAQIFromGas(mq2_concentration);


 int final_aqi = max(aqi_dust, aqi_gas);

lcd.clear();

  lcd.setCursor(0, 0);

  lcd.print("AQI: " + String(final_aqi));


  // Display AQI status on LCD

  lcd.setCursor(0, 1);

  lcd.print(getAQIStatus(final_aqi));
```

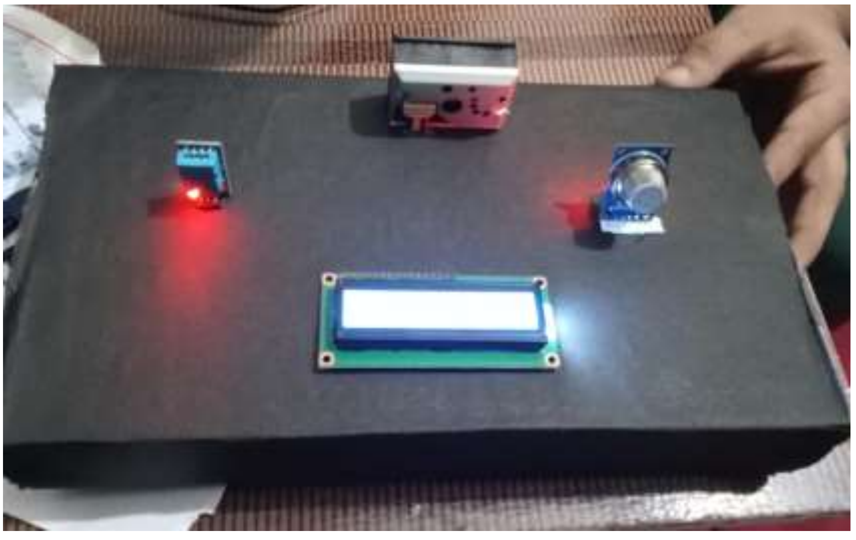
```
  // Display temperature and humidity if space allows
  if (final_aqi < 150) { // Ensure there's space for all info
    lcd.setCursor(0, 1);
    lcd.print("Temp: " + String(temperature) + "C");
    lcd.setCursor(0, 2);
    lcd.print("Humidity: " + String(humidity) + "%");
  }
// Display all sensor data on Serial Monitor
  Serial.print("Temperature: " + String(temperature) + "C, ");
  Serial.print("Humidity: " + String(humidity) + "%, ");
  Serial.print("MQ2 Concentration: " + String(mq2_concentration) + " ppm, ");
  Serial.print("Dust Concentration: " + String(dust_concentration) + " µg/m³, ");
  Serial.println("Final AQI: " + String(final_aqi));

  delay(1000); // Wait for 1 second before updating
}

int getAQIFromDust(float dust_concentration) {
  // Example mapping for dust concentration to AQI (calibration needed)
  if (dust_concentration <= 50) {
    return map(dust_concentration, 0, 50, 0, 50); // Very good
  } else if (dust_concentration <= 100) {
```

```
    return map(dust_concentration, 51, 100, 51, 100); // Good
  } else if (dust_concentration <= 150) {
    return map(dust_concentration, 101, 150, 101, 150); // Moderate
  } else if (dust_concentration <= 200) {
    return map(dust_concentration, 151, 200, 151, 200); // Unhealthy for
sensitive groups
  } else {
    return map(dust_concentration, 201, 500, 201, 500); // Hazardous
  }
}
int getAQIFromGas(float gas_concentration) {
  // Example mapping for gas concentration to AQI (calibration needed)
  if (gas_concentration <= 50) {
    return map(gas_concentration, 0, 50, 0, 50); // Very good
  } else if (gas_concentration <= 100) {
    return map(gas_concentration, 51, 100, 51, 100); // Good
  } else if (gas_concentration <= 150) {
    return map(gas_concentration, 101, 150, 101, 150); // Moderate
  } else if (gas_concentration <= 200) {
    return map(gas_concentration, 151, 200, 151, 200); // Unhealthy for sensitive
groups
  } else {
    return map(gas_concentration, 201, 500, 201, 500); // Hazardous}
```

```
}String getAQIStatus(int aqi) {
  if (aqi <= 50) {
    return "Very Good";
  } else if (aqi <= 100) {
    return "Good";
  } else if (aqi <= 150) {
    return "Moderate";
  } else if (aqi <= 200) {
    return "Unhealthy for Sensitive Groups";
  } else if (aqi <= 300) {
    return "Unhealthy";
  } else {
    return "Hazardous";
  }
}
```



# Working

**Working of Air Quality Monitoring System Proje**

The Air Quality Monitoring System is designed to measure and display the levels of particulate matter (PM2.5), hazardous gases, temperature, and humidity in the environment using the following sensors:

1. **GP2Y1010AU0F PM2.5 Sensor**:
   - This sensor measures particulate matter (dust and smoke) in the air.
   - It outputs an analog voltage corresponding to the PM2.5 concentration.
   - The microcontroller reads this value, converts it to a digital format, and calculates the PM2.5 level.
2. **MQ135 Gas Sensor**:
   - This sensor detects hazardous gases such as CO2, NH3, and benzene in the air.
   - It outputs an analog signal based on the concentration of gases.
   - The microcontroller processes this signal and estimates air quality based on gas concentration levels.
3. **DHT11 Temperature and Humidity Sensor**:
   - This sensor provides the current temperature and humidity of the environment.
   - It outputs data digitally, which is read directly by the microcontroller.

**Process Flow**

1. Sensors collect real-time environmental data:
   - **PM2.5 levels** from GP2Y1010AU0F.
   - **Gas concentration** from MQ135.
   - **Temperature and humidity** from DHT11.
2. The microcontroller (e.g., Arduino) processes the sensor data:
   - Converts analog signals to digital values using an ADC.
   - Applies calibration equations to convert raw sensor data into meaningful units (e.g., $\mu g/m^3$ for PM2.5, ppm for gases).
3. Alerts
   - If any air quality parameter crosses a hazardous threshold, the system triggers an alert

# Application

1. **Indoor Air Quality Monitoring**:
    - Use the system to monitor air quality inside homes, offices, or classrooms.
    - Helps ensure a safe and healthy environment by identifying high levels of particulate matter or harmful gases.
2. **Pollution Monitoring in Specific Areas**:
    - Deploy the system in industrial areas, factories, or near construction sites to measure air pollution locally.
    - Provides immediate feedback on environmental conditions.
3. **Personal Health Safety**:
    - Ideal for individuals with respiratory issues like asthma or allergies to monitor air quality around them and take preventive measures.
4. **Educational Tool**:
    - Demonstrate air quality concepts in schools or colleges for environmental studies and electronics workshops.
    - Helps students understand sensor-based monitoring and its importance.
5. **Small-Scale Environmental Research**:
    - Useful for basic environmental data collection and analysis in areas without internet connectivity.
6. **Indoor Climate Control**:
    - Integrate with HVAC systems or air purifiers to monitor temperature, humidity, and air quality to optimize performance.

# Conclusion

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The Air Quality Monitoring System successfully demonstrates the ability to measure and display real-time environmental parameters, including PM2.5 levels, gas concentrations, temperature, and humidity. By leveraging sensors like the GP2Y1010AU0F, MQ135, and DHT11, the system provides a cost-effective and reliable solution for monitoring air quality in localized environments.

This project emphasizes the importance of understanding air pollution and its impact on health, making it highly relevant for personal use, educational purposes, and small-scale environmental monitoring. Without the use of a Wi-Fi module, the system remains standalone, portable, and easy to deploy in areas with limited connectivity.

The implementation showcases the practical application of sensor integration and microcontroller-based data processing, providing a foundation for further enhancements such as data logging or remote access. This project contributes to raising awareness about air quality and encourages proactive measures to maintain a healthier environment.