Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 205 (2025) 219-232 EISSN 2392-2192

Air Quality Monitoring and Alert System

Sancharika Banerjee[a*], Sukanta Seni[a], Tuhina Halder [b]

[a] Narula Institute of Technology, Nilgunj Road, Agarpara, Kolkata-700109,India.

[b] Narula Institute of Technology, Nilgunj Road, Agarpara, Kolkata-700109,India.

*Corresponding author: sancharikabanerjee5@gmail.com (S.Banerjee)

ABSTRACT

Air pollution is a pressing environmental challenge with significant implications for public health and ecosystems. This research presents a cost-effective and portable air quality monitoring system utilizing an Arduino Uno and an MQ-135 gas sensor. The system is designed to detect and measure the concentration of harmful gases, including CO2, NH3, benzene, and smoke, in real-time. Data is displayed on an I2C-compatible LCD or OLED screen, offering immediate insights into air quality levels.

When pollution levels exceed a predefined threshold, the system activates an alert mechanism using a buzzer to indicate hazardous conditions. The proposed system is versatile and can be deployed in various settings, including homes, schools, and offices, providing a practical solution for environmental monitoring.

Future enhancements include the integration of wireless communication modules such as ESP8266 to enable remote monitoring through mobile applications or web platforms. This project underscores the importance of air quality awareness and offers a scalable, user-friendly tool for promoting environmental sustainability and healthier living standards.

Keywords: Air Quality Monitoring, Arduino Uno, MQ-135, Gas Sensor, I2C Display, Pollution Detection, Environmental Sustainability, Alert System.

(Received 10 May 2025; Accepted 14 June 2025; Date of Publication 13 July 2025)

1. INTRODUCTION

Overview: The Air Quality Monitoring and Alert System is a cost-effective, real-time system designed to measure air quality and notify users when pollution levels are hazardous. By employing the MQ-135 gas sensor, the system detects the concentration of air pollutants and uses an Arduino microcontroller to process sensor data and generate alerts. This research explores the development of such a system, integrating Arduino technology with the MQ-135 sensor as a means to provide an efficient, affordable, and accurate solution for air quality monitoring. The study posits that this integration can facilitate timely alerts to mitigate health risks associated with poor air conditions.

Background: Air pollution is a significant environmental and public health concern, contributing to millions of premature deaths annually. The World Health Organization (WHO) has established guidelines for acceptable air quality levels, but many urban areas around the globe regularly exceed these standards, exposing their populations to serious health risks. To address this issue, there is a pressing need for low-cost, real-time air quality monitoring systems capable of alerting users to poor air conditions, especially in resource-constrained environments.

Objective: The primary objective of this research is to design and implement a low-cost air quality monitoring and alert system that employs the MQ-135 gas sensor and Arduino microcontroller. The system aims to:

- Measure real-time air pollutant concentrations.
- Provide visual and auditory alerts when air quality is poor.
- Offer a user-friendly interface for visualizing air quality data.

Technical Stack:

- **Hardware**: The system comprises an Arduino Uno, MQ-135 gas sensor, buzzer, 16×2 LCD display, resistors, a breadboard, jumper wires, and an I2C module.
- **Software:** The software stack includes the Arduino Integrated Development Environment (IDE) for programming in C++, along with libraries for interfacing the MQ-135 sensor and the LCD display.

2. METHODOLY

The proposed system will use IoT devices connected in series with each street light through one wire communication. This device will monitor the status of air and detect air quality.

Step1: Connect 16*2 LCD with I2C module

At first, we added I2C module with 16 pins of 16*2 LCD. And I2C module has four ports: GND, Vcc, SDA, SCL, respectively.

Step2: Connect 16*2 LCD (I2C MOD) with Arduino Uno

GND of I2C LCD is connected to the GND of Arduino Uno via jumper wires. SimilarlyVcc of I2C LCD is connected to the 5V od the Arduino Uno. Analog 4 (A4) is connected to SDof LCD and analog 5(A5) is connected to SCL of LCD.

Step3: Connect MQ-135 gas sensor with Arduino and Breadboard

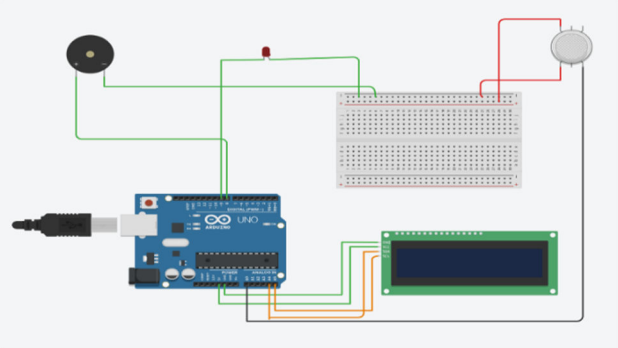
Vcc of the MQ-135 gas sensor is connected to 5V power supply of Arduino uno. GND of MQ sensor is connected to the ground of the Breadboard. A0 pin of the MQ is connected with the A0 pin of Arduino uno.

Step4: Connection of Buzzer and LED with Arduino uno

Pin number 8 and 9 of Arduino is connected to Buzzer and LED respectively. And the other side of buzzer and LED is connected to the GND of breadboard.

Step5: Software Implementation

The software code is written in Arduino IDE, combining sensor readings, data processing, and user alerts. The program reads the analog output from the MQ-135 sensor, converts the readings to a corresponding concentration level, and displays the data on the LCD.The buzzer is triggered when the air quality crossed the predefined threshold limits.



3. APPLICATIONS

Indoor and Outdoor Air Quality Monitoring: Monitoring air quality both in homes, offices, and other indoor spaces to ensure a healthy environment, and in outdoor spaces, like parks, streets, and industrial areas, to track pollution levels.

Monitoring Air Quality in Industrial Field: Air quality monitoring in industrial settings, like factories and warehouses, to ensure worker safety and compliance with regulations.

MnitoringLowCost Air Quality: Developing low-cost air quality monitoring systems using MQ135 and Arduino for widespread deployment in urban and rural areas.

Real-Time Air Quality Detect: Development of a real-time air quality monitoring system utilizing the MQ-135 gas sensor and Arduino to deliver instantaneous feedback on air quality levels.

Smart Cities and IoT: Integrating air quality monitoring systems with smart city infrastructure and IoT devices to create a more sustainable, efficient, and livable urban environment.

Air Quality Monitoring for Research and Development: Implementation of an air quality monitoring system using the MQ-135 gas sensor and Arduino for advancing research and development in environmental science and public health.

4. OVERVIEW OF COMPONENTS

4.1. MQ-135 Sensor

The MQ-135 sensor is a widely used air quality sensor capable of detecting and monitoring various gases, including ammonia (NH_3), alcohol, benzene, smoke, and carbon dioxide (CO_2). This sensor operates on a supply voltage of 2.5–5.0 V with a typical power consumption of 150 mA. To achieve accurate results, the sensor requires a preheating period of approximately 20 seconds before operation.

This sensor provides both analog and digital outputs, making it versatile for use in different applications, such as air quality control systems and environmental monitoring equipment. Key technical specifications of the MQ-135 sensor include:

Key Features:

- Operating Voltage: 2.5–5.0 V
- Typical Operating Voltage: 5.0 V
- Power Consumption: 150 mA
- Detectable Gases: NH_3, CO_2, Alcohol, Benzene, Smoke
- Digital Output Range: 0–5 V

4.2. Buzzer

A buzzer is an electromechanical or mechanical audio signaling device used to convert electrical signals into sound. It is widely utilized in applications such as timers, alarms, printers, and computers due to its ability to produce a variety of sound outputs, including alarms, music, sirens, and bells.

Typically powered by DC voltage, the buzzer features two terminals:

- **Positive (+)**: Marked with a '+' symbol or represented by a longer terminal, typically powered by 6V.
- **Negative (-)**: Marked with a '-' symbol or represented by a shorter terminal, connected to ground (GND).

Key Features: Color: Black

- Frequency Range: 3–300 Hz
- Operating Temperature: -20°C to +60°C
- Operating Voltage: 3V to 24V DC
- Sound Pressure Level: 85 dBA at 10 cm
- Supply Current: <15 mA

4.3. Ardiuno Uno

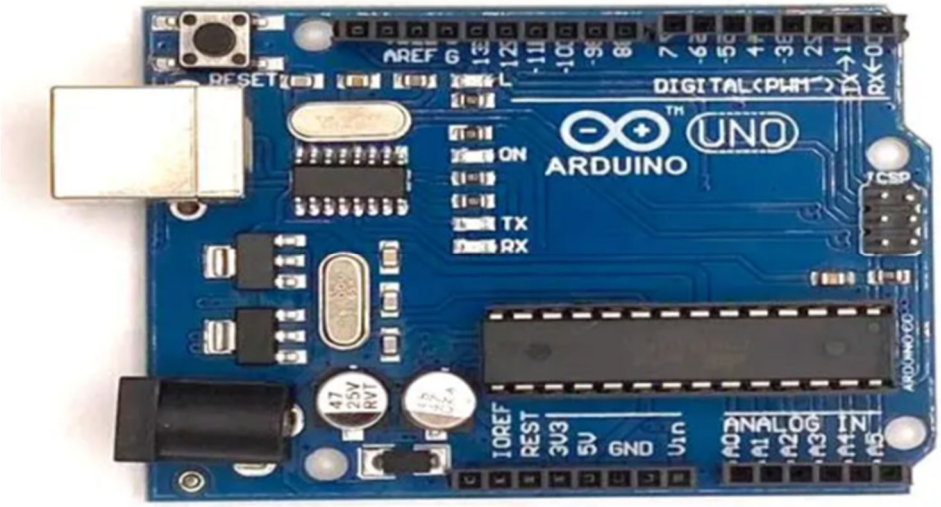
The Arduino Uno is a highly popular microcontroller board that bridges the gap between hardware and software, ideal for prototyping and educational applications. As an open-source platform, it encourages innovation and accessibility, making it a favorite choice among hobbyists and developers. The Arduino Uno R3 utilizes the ATmega328P microcontroller and has undergone three major revisions to enhance its functionality and design.

The board is equipped with 14 digital input/output pins, six of which support Pulse Width Modulation (PWM), enabling its use in diverse projects. It features a USB-B port for programming and communication, a power jack for external power supply, six analog input pins, a reset button, and 32 KB of flash memory for code storage.

Programming the Arduino Uno is facilitated by the Arduino Integrated Development Environment (IDE), which simplifies code development and uploading to the board.

Key Specifications:

- **Microcontroller:** ATmega328P
- **Operating Voltage:** 5V
- **Input Voltage:** 7–12V (recommended), 6–20V (limits)
- **Digital I/O Pins:** 14 (6 with PWM capability)
- **Analog Input Pins:** 6
- **Maximum Current per I/O Pin:** 40 mA
- **Maximum Current for 3.3V Pin:** 50 mA

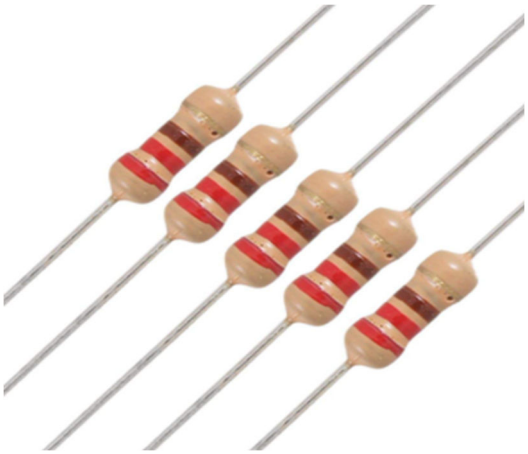


4.4. Resisitor

A resistor is a passive electrical component designed to impede the flow of electric current by introducing resistance into a circuit. It is an essential element in nearly all electrical networks and electronic systems. The resistance of a resistor is quantified in ohms (Ω), where one ohm corresponds to the resistance that allows a current of one ampere (A) to flow when a voltage of one volt (V) is applied across its terminals. This relationship is defined by Ohm's Law: V=IR or R=V/I

Resistors are versatile components with numerous applications in electrical and electronic systems, including:

- Limiting the flow of electric current
- Dividing voltage within a circuit
- Generating heat as a byproduct of resistance
- Matching and loading circuits for optimal performance
- Controlling gain in amplifier circuits
- Establishing time constants in RC (resistor-capacitor) circuits
- Acting as electric brakes in specific industrial and automotive applications



4.5. Led

A Light-Emitting Diode (LED) is a semiconductor device that emits light when an electric current flows through it. This emission occurs due to the recombination of electrons and holes within the semiconductor material, releasing energy in the form of photons. LEDs are designed to allow current to flow inthe forward direction while blocking current in the reverse direction, making them highly efficient and reliable light sources.

Key Characteristics:

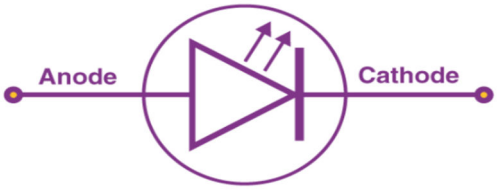
- Emits light in a specific wavelength range, depending on the material composition.
- Operates at low voltages and currents, resulting in energy efficiency.
- Long lifespan compared to traditional light sources.

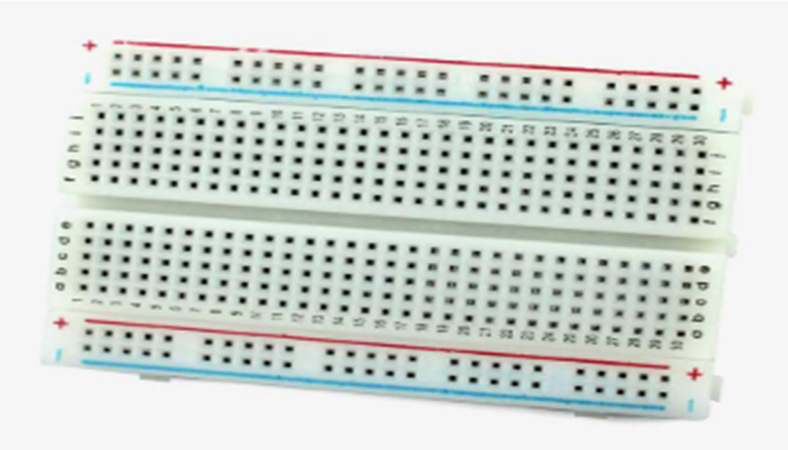
4.6. Breadboard

A breadboard is a reusable platform used to build and test electronic circuits. It's a temporary solution for prototyping and experimenting with different circuit designs.

Key Features:

- Grid Pattern: A breadboard has a grid pattern of holes, typically with a spacing of 0.1 inches (2.54 mm).
- Rows and Columns: The grid is divided into rows and columns, with each row and column connected by a metal strip.
- Power Rails: Most breadboards have two power rails, one for positive voltage (VCC) and one for ground (GND).
- Jumper Wires: Breadboards use jumper wires to connect components and create circuits.





4.7. 16*2 Lcd

A 16x2 LCD (Liquid Crystal Display) is a type of display screen that can show 2 rows of text, with each row containing up to 16 characters. It is commonly used in embedded systems, such as robots, automation systems, and IoT devices, and is often used to display status information, such as temperature, humidity, or sensor readings.

Key Features:

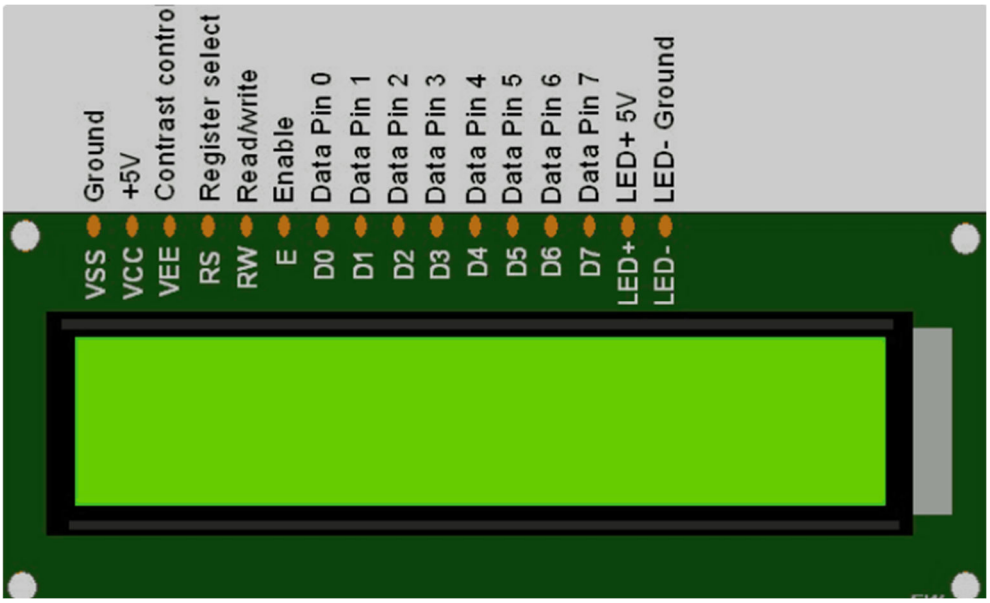
1. Display Size: 16 characters x 2 rows

2. Display Type: LCD (Liquid Crystal Display)

3. Interface: Typically uses a 4-bit or 8-bit parallel interface

4. Backlight: Usually has a built-in backlight for visibility

5. Power Consumption: Typically low power consumption, around 2-5V



4.8. I2c Module

An I2C (Inter-Integrated Circuit) module isa smallelectronicmodule thatallowsmultipledevices tocommunicatewitheachotherusingtheI2Cprotocol.

Key Features:

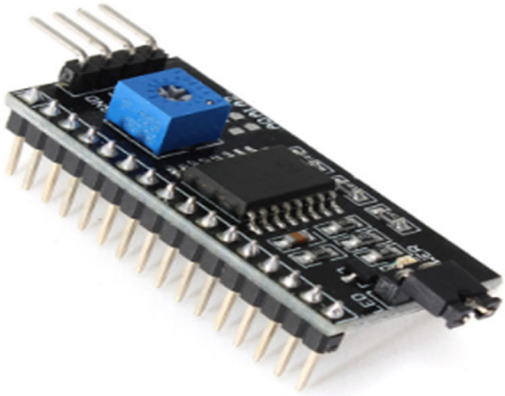
1. I2C Protocol: Uses the I2C protocol for communication.

2. Two-Wire Interface: Uses only two wires (SCL and SDA) for communication.

3. Multi-Device Support: Allows multiple devices to be connected to the same bus.

4. Low Speed: Typically operates at a low speed of 100 kHz or 400 kHz.

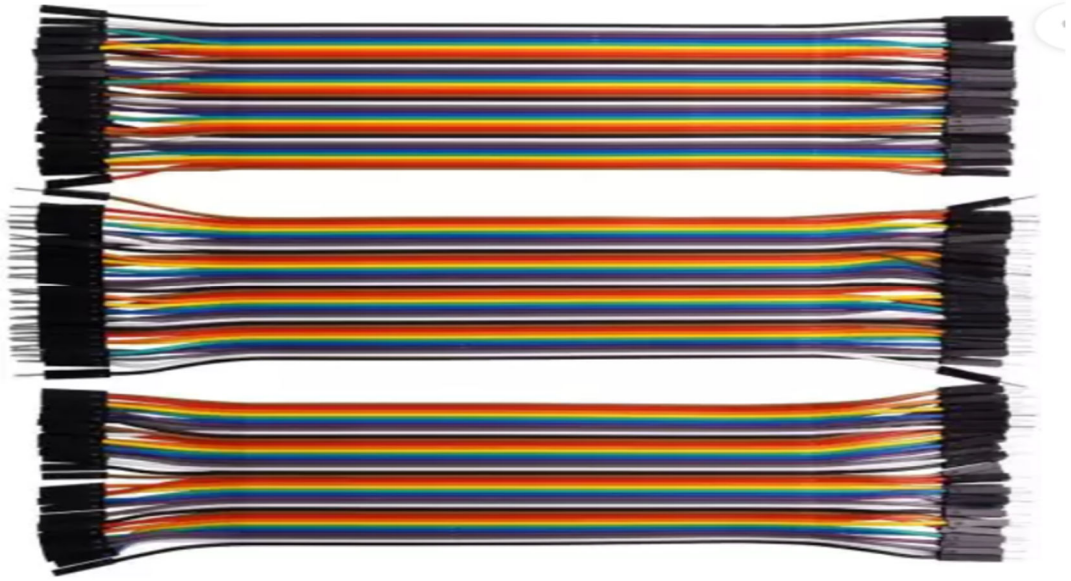
5. Short Distance: Designed for short-distance communication, typically up to 1 meter.



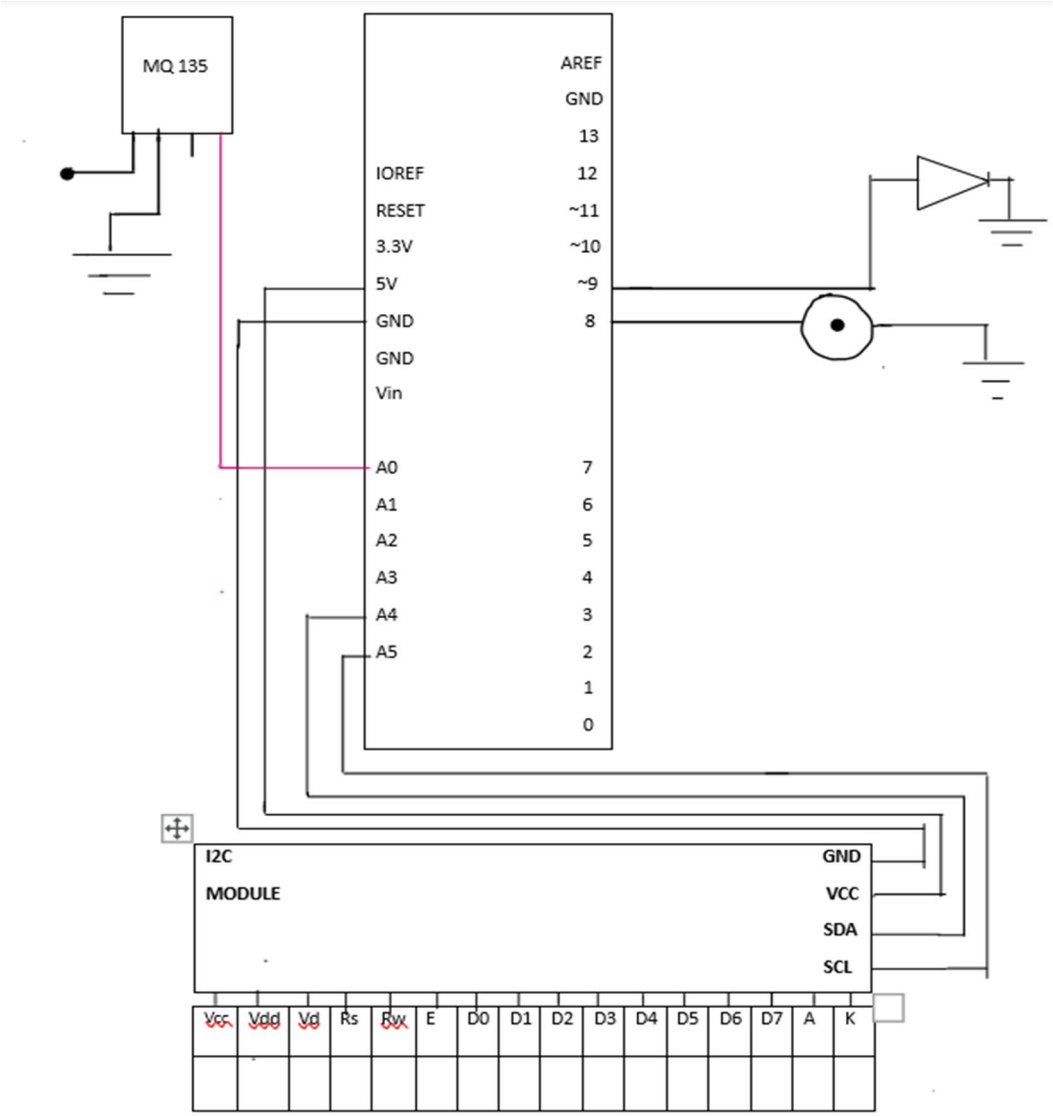
4.9. Jumper Wires: Jumper wires, also known as jumpers, jumper cables, or simply cables, are electrical wires or groups of wires often terminated with connectors, pins, or “tinned” bare ends. These wires are primarily used to interconnect components in breadboards, prototype circuits, or test setups without the need for soldering. Jumper wires facilitate rapid assembly and modification of circuits during the prototyping and testing phases.

Jumper wires come in various types based on the connectors at their ends:

- **Male-to-Male**: For connecting components with female headers.
- **Female-to-Female**: For linking male pins or headers.
- **Male-to-Female**: For versatile connections between male and female terminals.



CIRCUIT DIAGRAM



5. SYSTEM BENEFIT

5.1. Environmental Benefits:

- **Improved Air Quality:** Real-time monitoring of air quality helps identify pollution sources and takes corrective action to improve air quality.
- **Reduced Pollution:** By monitoring air quality, industries and governments can take steps to reduce pollution, resulting in a cleaner environment.
- **Protection of Ecosystems:** Air quality monitoring helps protect ecosystems, including forests, water bodies, and wildlife habitats.

5.2. Health Benefits

- **Improved Public Health:** Air quality monitoring helps to identify areas with poor air quality, enabling authorities to take action to protect public health.
- **Reduced Respiratory Problems:** By monitoring air quality, people can take precautions to avoid exposure to poor air quality, reducing respiratory problems.
- **Early Warning Systems:** Air quality monitoring systems can provide early warnings for poor air quality, enabling people to take necessary precautions.

5.3. Economic Benefits

- **Cost Savings**: Air quality monitoring can help industries reduce costs by optimizing processes and reducing energy consumption.
- **Increased Productivity**: By monitoring air quality, industries can take steps to improve indoor air quality, leading to increased productivity and employee well-being.
- **Compliance with Regulations**: Air quality monitoring helps industries comply with environmental regulations, reducing the risk of fines and penalties.

5.4. Technological Benefits

- **Real-Time Data**: Air quality monitoring provides real-time data, enabling quick decision-making and action.
- **Data Analysis**: Air quality monitoring systems can analyze data, providing insights into air quality trends and patterns.

6. CODING

Arduino Uno

sketch_dec5a.ino

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// set the LCD number of columns and rows
int lcdColumns = 16;
int lcdRows = 2;
LiquidCrystal_I2C lcd(0x27, lcdColumns, lcdRows);
int buz = 8;  //buzzer connected to pin 8
int led = 9;  //led connected to pin 9

const int aqsensor = A0;  //output of mq135 connected to A0 pin of Arduino
int threshold = 250;      //Threshold level for Air Quality
void setup() {

  pinMode (buz,OUTPUT);     // buzzer is connected as Output from Arduino
  pinMode (led,OUTPUT);     // led is connected as output from Arduino
  pinMode (aqsensor,INPUT); // MQ135 is connected as INPUT to arduino

  Serial.begin (9600);      //begin serial communication with baud rate of 9600

  lcd.clear();              // clear lcd
  lcd.begin (16,2);         // consider 16,2 lcd
}
void loop() {

  int ppm = analogRead(aqsensor); //read MQ135 analog outputs at A0 and store it in ppm

  Serial.print("Air Quality: ");  //print message in serail monitor
  Serial.println(ppm);            //print value of ppm in serial monitor

  lcd.setCursor(0,0);             // set cursor of lcd to 1st row and 1st column
  lcd.print("Air Qualit: ");      // print message on lcd
  lcd.print(ppm);                 // print value of MQ135

  if (ppm > threshold)            // check is ppm is greater than threshold or not
    {
      lcd.setCursor(1,1);         //jump here if ppm is greater than threshold
      lcd.print("AQ Level HIGH");
      Serial.println("AQ Level HIGH");
      tone(led,1000,200);         //blink led with turn on time 1000mS, turn off time 200mS
      digitalWrite(buz,HIGH);     //Turn ON Buzzer
    }
  else
    {
      digitalWrite(led,LOW);   //jump here if ppm is not greater than threshold and turn off LED
      digitalWrite(buz,LOW);   //Turn off Buzzer
      lcd.setCursor(1,1);
      lcd.print ("AQ Level Good");
      Serial.println("AQ Level Good");
    }
  delay (500);
}
```

7. RESULT AND DISCUSSION

System Performance: The air quality monitoring system will display real-time data on the LCD, including gas concentration levels. Thisdevice was tested under various conditions – both indoors and outdoors. The readings from the MQ-135 varied with environmental changes, providing clear indications of air quality.

Alert Mechanism: This alert device effectively notified users when pollutant levels exceeded set limits. For example, the alarm was triggered when ppm>threshold.

```
AQ Level HIGH
Air Quality: 250
AQ Level Good
Air Quality: 240
AQ Level Good
```

8. CONCLUSION

The Air Quality Monitoring and Alert System utilizing Arduino and the MQ-135 sensor offers a reliable and economical approach to real-time air quality analysis. This device is adaptable for both personal and industrial purposes, empowering individuals and organizations to monitor environmental conditions and make informed decisions.

Future advancements could include the integration of IoT-enabled devices for remote monitoring and real-time data logging, further enhancing the system's capabilities and user interaction.

References

Here are some scientific sources and references related to Air Quality Monitoring System devices:

[1] Kumar & Saha, S. K. (2020). “Air quality monitoring and management: Challenges and opportunities.” Environmental Pollution.

This paper discusses various air quality monitoring systems, their design, and the challenges faced in implementing efficient air quality management. It includes technical insights on sensors, data collection, and the integration of these devices in urban and industrial areas

[2] Kalagotla Chenchireddy, D Sandhya, M Praveen, G Karthik, & G maruthi (2021). "Air Quality Monitoring and Alert System Using MQ135 Gas Sensor with Arduino Controller."

This paper discuss about gas sensors and their features, gives a brief information about Arduino board, and a potential circuit diagram of Air Quality monitoring system using MQ135 gas sensor with Arduino controller.

[3] Deepshikha, Vikram, Ganesh, Deva Kalyan. "Real-Time Air Quality Monitoring System."

This report work focus on the development of a low-cost device for real-time monitoring of air pollutants such as particulate matter (PM2.5), nitrogen dioxide (NO2), and carbon dioxide (CO2).