

IoT based Air Pollution Monitoring System Using NodeMCU

*Aaditya Mahajan¹, Aashutosh Kushwah², Ashwin Tomar³, Deepanshu Patidar⁴,
Dr. Aditya Mandloi⁵*

¹Electronics and Communication Engineering, Medicaps University, Indore, MP, 453331, India

²Electronics and Communication Engineering, Medicaps University, Indore, MP, 453331, India

³Electronics and Communication Engineering, Medicaps University, Indore, MP, 453331, India

⁴Electronics and Communication Engineering, Medicaps University, Indore, MP, 453331, India

⁵Assistant Professor, Electronics and Communication Engineering, Medi-Caps University, Indore

Abstract—Air pollution has become a significant concern in recent years due to its negative impact on human health and the environment. It is important to monitor air quality in real-time to reduce the causes which are caused by air pollution. Previously many IoT-based air quality monitoring devices have been made by using different microcontrollers such as Arduino UNO, and Raspberry Pi which are costly, and some of them require different hardware to connect to Wi-Fi. In this project we are using NodeMCU microcontroller. NodeMCU has built-in Wi-Fi capabilities and it is low cost.

The proposed IoT-based air pollution monitoring system offers several advantages, including scalability, cost-effectiveness, and accessibility. By using NodeMCU and cloud computing technologies we can easily monitor air quality in urban and industrial areas. Ultimately, we can reduce air pollution and improve public health.

Keywords—*NodeMCU, IOT, Wi-Fi, Air quality, Monitoring*

INTRODUCTION

In today's world, air pollution has become a critical issue which is affecting public health and the environment. Real-time air quality monitoring has become very important so that we can have control of it. By using Internet of Things (IoT) technology, air pollution monitoring is more convenient and efficient than ever.

In this project, we will develop an IoT-based air pollution monitoring system where we will monitor the air quality in a mobile way via the internet and trigger an alarm when the air quality falls below a certain level, which means when there is a sufficient amount of harmful gases such as CO₂, smoke, alcohol, benzene and NH₃ are present in the air. It displays the air quality in PPM on LCD and mobile devices so we can monitor it very easily.

As our project is based on IoT, we need to understand what IoT is.

The Internet of Things (IoT) is a collective network that is used to facilitate communication between connected devices and the cloud. This means with the help of IoT we can control devices by using the internet.

IoT devices are widely used for industrial as well as consumer use such as smart homes, healthcare, industrial automation, automotive, and wearable technology.

OBJECTIVE

- In this project, we will select a suitable air quality sensor and integrate it into the NodeMCU platform to accurately measure air quality parameters in real-time.
- Establish Wi-Fi connections, collect sensor data, and transmit data to remote servers or cloud platforms.

- Using the Blynk cloud platform for visualizing the sensor data by using gauge and getting alert notifications on mobile.

PROJECT RESOURCES

Hardware required:

- MQ-135 Air quality sensor
- 16x2 LCD display
- Potentiometer
- NodeMCU
- Buzzer

Software required:

- Arduino IDE
- Blynk.Console

Components description:

1. MQ-135 Air quality sensor:-

The MQ-135 Gas sensor is capable of detecting smoke, ammonia, sulfur, benzene, and CO₂ in the air. It contains an analog and digital output pin. The digital pin becomes elevated when the concentration of these gases in the air increases more than the predetermined threshold. The onboard potentiometer can be used to set this threshold value. An analog voltage that can be used to estimate the concentration of these gases in the atmosphere is produced by the analog output pin.



Fig. 1

The MQ135 air quality sensor module uses about 150mA and runs at 5V. Before providing precise findings, it needs to be preheated.

Detail of MQ-135 sensor:-

The MQ135 is one of the popular gas sensors from the MQ series of sensors that are commonly used in air quality control equipment. It has an analog and digital output and runs between 2.5 and 5.0 volts. The pinouts and key parts of an MQ135 module are indicated in Fig. 2.

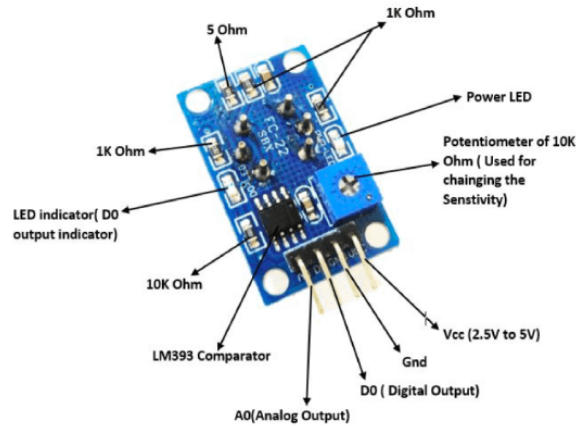


Fig. 2

Technical Specifications of MQ135 Gas Sensor:-

- Operating Voltage: 2.5V to 5.0V
- Power consumption: 150mA
- Typical operating Voltage: 5V
- Digital Output: 0V to 5V (TTL Logic)
- Analog Output: 0-5V

Measure PPM Value using Analog Pin:

The PPM value of the required gas can be determined using the sensor's analog output pin. To accomplish this we are using NodeMCU microcontroller. To determine the value of R_s/R_o , where R_s is the sensor resistance when gas is present and R_o is the sensor resistance in pure air, the microcontroller will measure the analog voltage and carry out some calculations. The graph below (Fig.3), which is taken from the datasheet of the MQ135 Sensor, can be used to compute the PPM value of necessary gas once we have determined this ratio of R_s/R_o .

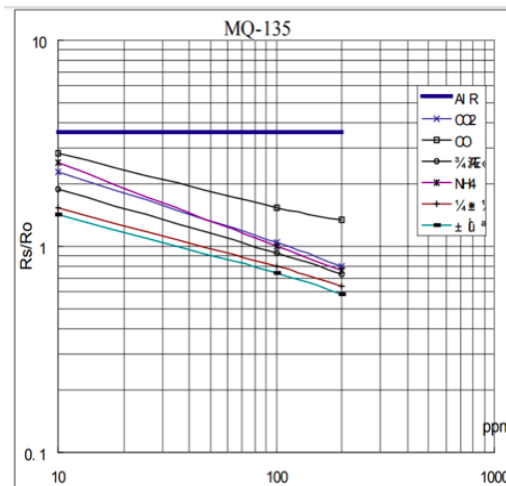


Fig. 3

2. NodeMCU:-

The NodeMCU (Node Microcontroller Unit) is an open-source software and hardware development environment built around ESP8266 module. The ESP8266 module is designed and manufactured by Espressif Systems and contains the crucial elements of a computer such as CPU, RAM, WiFi, and SDK. NodeMCU allows us to write scripts to interact with the GPIO pins, connect to Wi-Fi networks, and communicate with various sensors. NodeMCU is an easy-to-use development board so we can easily program it using Arduino IDE.

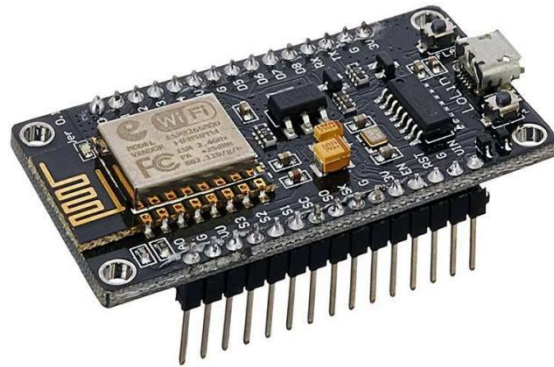


Fig. 4

Specifications:-

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz

Pin configuration:-

Pin Category	Name	Description
Power pins	Micro-USB, 3.3V, GND, Vin	Micro-USB: NodeMCU can be powered through the USB port 3.3V: Regulated 3.3V can be supplied to this pin to power the board GND: Ground pins Vin: External Power Supply
Control Pins	EN, RST	The pin and the button resets the microcontroller.
Analog Pin	A0	Used to measure analog voltage.
GPIO Pins	GPIO1 to GPIO16	NodeMCU has 16 general purpose input-output pins on its board.

SPI Pins	SD1, CMD, SD0, CLK	NodeMCU has four pins available for SPI communication.
UART Pins	TXD0, RXD0, TXD2, RXD2	NodeMCU has two UART interfaces, UART0 (RXD0 & TXD0) and UART1 (RXD1 & TXD1). UART1 is used to upload the firmware/program.
I2C Pins		NodeMCU has I2C functionality support but we have to find which pin is I2C due to the internal functionality of these pins.

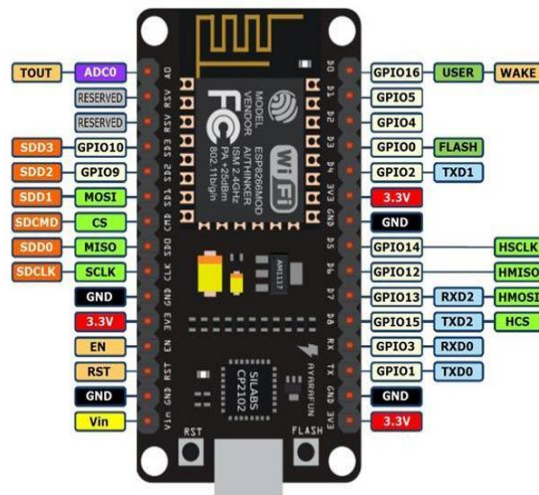


Fig. 5

3. 16x2 LCD Display:-

The term LCD stands for liquid crystal display. This particular type of electronic display module is used in a wide range of circuits and gadgets, including TV sets, computers, calculators, cell phones, and more. Seven segments and multi-segment light-emitting diodes are the major applications for these displays. The primary advantages of utilizing this module are its low cost and it is easily programmable.



Fig. 7

Pin configuration of 16x2 LCD Display:-

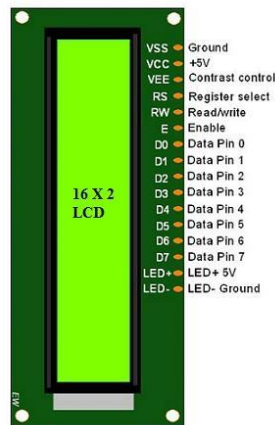


Fig. 8

- Pin1 (Ground/Source Pin): It is used to connect the GND terminal of the microcontroller unit or power source.
- Pin2 (VCC/Source Pin): It is used to connect the supply pin of the power source.
- Pin3 (V0/VEE/Control Pin): This pin regulates the difference of the display, used to connect a potentiometer that can supply 0 to 5V.
- Pin4 (Register Select/Control Pin): This pin toggles among command or data register, used to connect a microcontroller unit pin and obtains either 0 or 1 (0 = data mode, and 1 = command mode).
- Pin5 (Read/Write/Control Pin): This pin toggles the display among the read or writes operation, and it is connected to a microcontroller unit pin to get either 0 or 1 (0 = Write Operation, and 1 = Read Operation).
- Pin 6 (Enable/Control Pin): This pin should be held high to execute Read/Write process, and it is connected to the microcontroller unit & constantly held high.
- Pins 7-14 (Data Pins): These pins are used to send data to the display. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only four pins are connected to the microcontroller unit like 0 to 3, whereas in 8-wire mode, 8-pins are connected to microcontroller unit like 0 to 7.
- Pin15 (+ve pin of the LED): This pin is connected to +5V
- Pin 16 (-ve pin of the LED): This pin is connected to GND.

Features of 16x2 LCD Display:-

The features of this LCD mainly include the following.

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit

- These are obtainable in Blue & Green Backlight
- It displays a few custom generated characters

4. Potentiometer:-

A potentiometer is a three-terminal resistor that can be used to create an adjustable voltage divider. It has a sliding or revolving contact. It functions as a variable resistor or rheostat if only the wiper and one end of the terminal are used. Potentiometers are measuring devices that are simply voltage dividers used to measure electric potential or voltage; the name of the component comes from their use of this same principle.

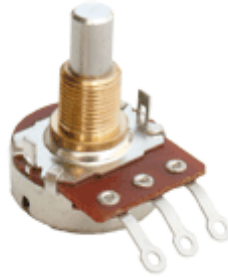


Fig. 9

A potentiometer is used to adjust the LCD driving voltage; where an increase can overcome the effects of temperature. More importantly, the potentiometer is used to accommodate the desires of the user in terms of screen brightness or screen contrast.

5. Buzzer:-

A buzzer is an audio signalling device, which is commonly used in alarm systems, timers, and training systems, and as a means of verifying user input.



Fig. 10

Software description:-

1. Arduino IDE:-

The Arduino Integrated Development Environment - or Arduino Software (IDE) – It is the software that is used to connect to the Arduino hardware to upload programs and communicate with them.

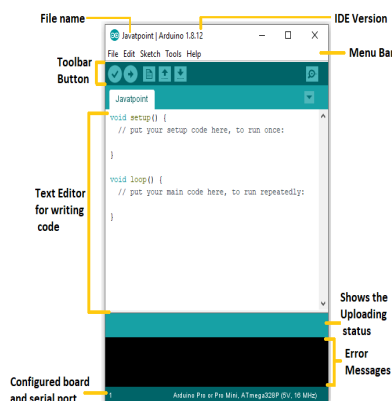


Fig. 11

2. Blynk.Console:-

Blynk is an IoT platform for iOS or Android Smartphone that is used to control Arduino, Raspberry Pi and NodeMCU via the Internet. It is used to create a graphical interface by compiling and providing the appropriate address on the available widgets.

Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, and it can store data, and visualize it.

There are three major components in the platform:-

- Blynk App: – It allows us to create amazing interfaces for our project using various widgets that are provided in the app.
- Blynk Server: – It is used to establish communication between Smartphone's and hardware.
- Blynk Libraries: – It enables communication, for all the popular hardware platforms, with the server and processes all commands.



Fig. 12

CONNECTIONS AND CIRCUIT DIAGRAM

MQ135's voltage and ground are connected to +5V and 0V and the analog output pin are connected to analog pin A0 of NodeMCU.

The connections of LCD are as follow:-

- Pin 1 (VEE) to the ground.
- Pin 2 (VDD or VCC) to the 5V.
- Pin 3 (V0) to the middle pin of the 10K potentiometer and connect the other two ends of the potentiometer to the VCC and the GND.
- Pin 9 (D2) to the D0 pin of NodeMCU.
- Pin 10 (D3) to the D1 pin of NodeMCU.
- Pin 11 (D4) to the D2 pin of NodeMCU.
- Pin 12 (D5) to the D3 pin of NodeMCU.
- Pin 13 (D6) to the D4 pin of NodeMCU.
- Pin 14 (D7) to the D5 pin of NodeMCU.
- Connect pin 15 to the VCC.
- Connect pin 16 to the Ground.

Positive terminal of Buzzer is connected to D6 of NodeMCU and the negative terminal to Ground.

Circuit Diagram:-

Fig. 13 shows the circuit made on the Breadboard.

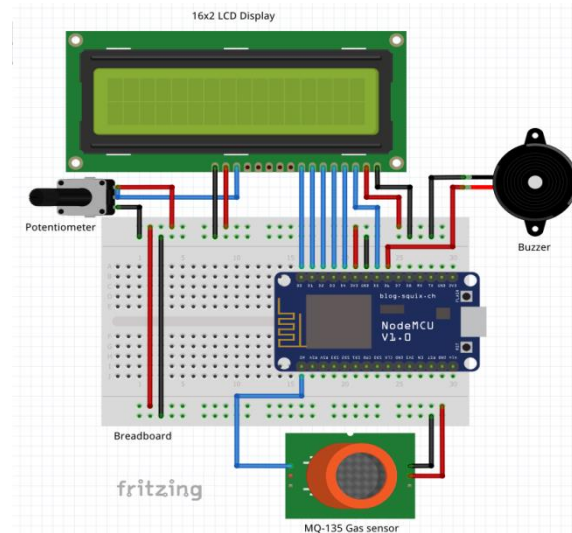


Fig. 13

Working explanation:-

The MQ135 sensor can sense CO₂, smoke, alcohol, benzene and NH₃, and some other gases, so it is the perfect gas sensor for our Air Quality Monitoring Project. When we will connect it to NodeMCU then it will sense the gases, and we will get the Pollution level in PPM (parts per million). MQ135 gas sensor gives the output in form of voltage levels and we need to convert it into PPM. So for converting the output in PPM, we have to use a library for MQ135 sensor.

Sensor was giving us value of 90 when there was no gas near it and the safe level of air quality is 350 PPM and it should not exceed 1000 PPM. When it exceeds the limit of 1000 PPM, then it starts cause Headaches, sleepiness and stagnant, stale, stuffy air and if exceeds beyond 2000 PPM then it can cause increased heart rate and many other diseases.

LCD will show the value given by the sensor and the value will also show on the Blynk app by using Gauge. When the value will be less than 1000 PPM, then the LCD will display “Fresh Air”. Whenever the value increase 1000 PPM, then the buzzer will start beeping and the LCD will display “Pollutant air” and the Blynk app will send an alert notification on mobile.

EXPECTED OUTCOMES

- By using this device we can have real-time monitoring of multiple air contaminants, including particulate matter.
- We can collect accurate and reliable data on air quality parameters over time to identify trends, hotspots, and potential sources of pollution by using this device.
- We can set the system to deliver warnings and alarms when air pollution levels rise above predefined threshold levels. This makes it possible to respond quickly to declining air quality by modifying industrial operations or issuing health alerts.

CONCLUSION

IoT-based air pollution monitors using NodeMCU provide a cost-effective and scalable solution for real-time air quality monitoring. The system leverages IoT technology to facilitate data-driven decision-making, enabling individuals and communities to combat air pollution and safeguard public health and the environment. Further improvements and enhancements can be made to increase the accuracy, reliability and usability of the system.

ACKNOWLEDGMENT

We would like to express our special thanks of gratitude to our in-charge professor Dr. Juned A Siddiqui, who gave us the golden opportunity to do this wonderful project on topic “IoT based Air Pollution Monitoring system using NodeMCU.”

We would also like to thank our professor Dr. Aditya Mandloi, for guiding us and enriching our project through his reservoir experience. He was extremely helpful in ensuring that our project progressed on the right track.

Also, this project would not have been completed without the help of readers including us, and various websites on the internet have helped me a lot in writing and understanding this project.

Finally, we would like to acknowledge our parents and our friends, who encouraged us and contributed their ideas and perspectives, which greatly enriched the project

REFERENCES

- [1] <https://www.unep.org/interactives/air-pollution-note/>
- [2] <https://www.airnow.gov/aqi/aqi-basics/>
- [3] <https://components101.com/wireless/esp8266-pinout-configuration-features-datasheet>
- [4] <https://www.electronicwings.com/nodemcu/introduction-to-nodemcu>
- [5] <https://www.arduino.cc/>
- [6] <https://docs.blynk.io/en>
- [7] <https://blynk.io/>
- [8] <https://docs.arduino.cc/retired/boards/arduino-uno/>
- [9] Prathamesh Barik . “Arduino Air Quality Monitoring System” . Retrieved from <https://circuitdigest.com/microcontroller-projects/arduino-based-air-quality-monitoring-system>
- [10] Muhammad Aqib . “IoT based Air Pollution Monitoring System using Arduino” . Retrieved from <https://circuitdigest.com/microcontroller-projects/iot-air-pollution-monitoring-using-arduino>
- [11] Poonam Pal, Ritik Gupta, Sanjana Tiwari and Ashutosh Sharma . “IoT based Air Pollution Monitoring System using Arduino”. *International Research Journal of Engineering and Technology* : Volume: 04, Issue: 10, Oct-2017
- [12] Piyush Devidas Potbhare, Ketan Bhange, Gaurav Tembhare, Rahul Agrawal, Swati Sorte and Prasad Lokulwar . “IoT based Smart Air Pollution Monitoring System” . *International Conference on Applied Artificial Intelligence and Computing 2022* doi: 10.1109/ICAAIC53929.2022.9792743
- [13] Agniva Banerjee, Bonny Sikdar and Sourav Roy . “IoT based Air Pollution Monitoring System” . Retrived from https://www.rccit.org/students_projects/projects/ee/2022/GR3.pdf
- [14] Shazia Afroze, Md. Istiak Hossain Paran and Rakibul Hasan Roki . “IoT based Air Quality Monitoring System using Arduino” . *International Journal for Multidisciplinary Research* : Volume: 5, Issue:2, March-April 2023
- [15] Hai Prasaath k . “Arduino based Air Quality Monitoring IoT project” . Retrieved from <https://www.engineersgarage.com/arduino-based-air-quality-monitoring-iot-project/>