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# IoT-Enabled Air Quality and Safety Monitor

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**Abstract:** *Air pollution has become a major environmental and health concern in modern cities. Continuous monitoring of air quality is important to detect harmful gases and maintain a safe environment. This project presents an IoT-based Air Quality Monitoring System that measures environmental parameters such as temperature, humidity, and air quality using sensors and transmits the data to a cloud platform for remote monitoring.*

*The system is built using an ESP32 microcontroller, which acts as the central processing unit. A DHT22 sensor is used to measure temperature and humidity, while an MQ-135 gas sensor detects harmful gases present in the air. The collected data is processed by the ESP32 and displayed locally on an OLED display. If poor air quality is detected, an alert system consisting of a buzzer and LED is activated to warn users about potential air pollution.*

*The ESP32 connects to the internet through its built-in Wi-Fi module and sends sensor data to the Blynk IoT cloud platform. Users can monitor temperature, humidity, and air quality levels in real time using the Blynk mobile application or web dashboard. This enables remote monitoring and instant alerts whenever air quality conditions become unsafe.*

*The proposed system is cost-effective, portable, and easy to implement. It demonstrates how Internet of Things (IoT) technology can be used for environmental monitoring and smart alert systems. Such systems can be deployed in homes, laboratories, classrooms, and industrial environments to improve safety and awareness of air pollution levels.*

**Keywords**: Internet of Things (IoT), Air Quality Monitoring, ESP32 Microcontroller, MQ-135 Gas Sensor, DHT22 Sensor, Blynk IoT Platform, Environmental Monitoring, Smart Alert System

## I. INTRODUCTION

Air pollution has become one of the most serious environmental problems affecting human health and the ecosystem. Rapid industrialization, urbanization, and the increasing number of vehicles have led to a rise in harmful gases and pollutants in the atmosphere. Continuous exposure to polluted air can cause respiratory diseases, allergies, and other health issues. Therefore, monitoring air quality is essential to ensure a safe and healthy environment.

Traditional air quality monitoring systems are often expensive and limited to large monitoring stations, which makes them unsuitable for personal or small-scale use. With the advancement of technology, the Internet of Things (IoT) has provided an efficient way to develop low-cost and smart environmental monitoring systems. IoT enables devices to collect data from sensors and transmit it over the internet for real-time monitoring and analysis.

In this project, an IoT-based Air Quality Monitoring System is designed using the ESP32 microcontroller. The ESP32 is a powerful microcontroller with built-in Wi-Fi capability, which allows the system to send sensor data to the internet. The system uses a DHT22 sensor to measure temperature and humidity and an MQ-135 gas sensor to detect harmful gases and air pollutants. The collected data is processed by the ESP32 and displayed on an OLED display for local monitoring.

To provide real-time remote monitoring, the system is integrated with the Blynk IoT platform. Sensor readings such as temperature, humidity, and air quality status are transmitted to the Blynk cloud through Wi-Fi and displayed on a

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mobile dashboard. If poor air quality is detected, the system activates an alert mechanism using a buzzer and LED, warning the user about unsafe environmental conditions.

The proposed system is simple, cost-effective, and easy to implement. It demonstrates how IoT technology can be applied to environmental monitoring and smart alert systems. Such systems can be used in homes, offices, laboratories, classrooms, and industrial areas to monitor air quality and maintain a healthier environment.

## II. LITERATURE SURVEY

Air quality monitoring has become an important research area due to increasing environmental pollution and its impact on human health. Many researchers have explored the use of sensor networks and Internet of Things (IoT) technology to develop smart environmental monitoring systems. These systems help in detecting harmful gases and monitoring environmental parameters in real time. According to several studies on IoT-based environmental monitoring, integrating sensors with microcontrollers and cloud platforms allows users to access environmental data remotely and take preventive actions when air pollution levels increase.

Researchers have proposed different approaches for monitoring air quality using low-cost sensors and microcontroller platforms. For example, several studies have used gas sensors such as MQ-135, MQ-7, and MQ-2 to detect pollutants including carbon dioxide, ammonia, and smoke in the environment. These sensors are often connected to microcontrollers like Arduino, Raspberry Pi, or ESP32 to process the collected data. The processed data can then be transmitted to cloud platforms for real-time monitoring and analysis.

In recent years, IoT platforms such as Blynk, ThingSpeak, and Firebase have been widely used in air quality monitoring systems. These platforms allow sensor data to be stored, visualized, and monitored remotely through mobile applications or web dashboards. Many systems also include alert mechanisms such as LEDs, buzzers, or notifications to warn users when the pollution level exceeds a safe threshold.

Previous research also highlights the importance of developing cost-effective and portable monitoring systems that can be easily deployed in homes, laboratories, classrooms, and industrial environments. Using compact sensors and wireless communication technologies makes it possible to build affordable monitoring solutions without requiring large and expensive monitoring stations.

Therefore, the proposed IoT-based Air Quality Monitoring System focuses on providing a simple and efficient solution for monitoring environmental conditions. By combining sensors, a microcontroller, cloud connectivity, and alert mechanisms, the system demonstrates how IoT technology can help improve environmental awareness and support healthier living environments.

## III. SCOPE OF THE PROJECT

The scope of the IoT-Based Air Quality Monitoring System is to design and develop a smart environmental monitoring system that measures air quality parameters and provides realtime alerts using IoT technology. The system aims to monitor environmental conditions such as air pollution, temperature, and humidity using sensors and display the information both locally and remotely through an IoT platform. The platform helps users monitor environmental conditions and take preventive actions when air quality becomes unsafe.

• Functional Scope:

The functional scope of the IoT-Based Air Quality Monitoring System defines the main operations and services provided by the system. The system is designed to monitor environmental parameters and notify users when air quality conditions become unsafe.

One of the primary functions of the system is air quality detection, where the MQ-135 gas sensor detects harmful gases present in the surrounding environment. The sensor continuously monitors air conditions and sends data to the microcontroller for processing.

Another important function of the system is temperature and humidity monitoring using the DHT22 sensor. This sensor measures environmental temperature and humidity levels, allowing users to observe climate conditions along with air quality data.

The system also includes a real-time display module, where the collected data is displayed on an OLED screen. This allows users to view temperature, humidity, and air quality status directly from the device without needing internet access.

The project also provides an alert mechanism, where a buzzer and LED are activated when the air quality becomes poor. This immediate alert helps users identify hazardous environmental conditions and take necessary actions.

Additionally, the system supports remote monitoring through the Blynk IoT platform. The ESP32 microcontroller sends sensor data to the cloud through Wi-Fi, allowing users to monitor environmental conditions using a mobile application or web dashboard. • Non-Functional Scope:

The non-functional scope of the IoT-Based Air Quality Monitoring System describes the quality attributes that ensure the system operates efficiently and reliably.

One of the important non-functional aspects is usability. The system is designed with a simple interface so that users can easily understand environmental data through the OLED display and IoT dashboard.

Another important requirement is performance and reliability. The system must continuously monitor environmental parameters and provide accurate readings in real time without delays.

Security and data protection are also important considerations. The IoT platform should ensure that sensor data transmitted through Wi-Fi is safely stored and accessible only to authorized users.

The system must also ensure scalability, meaning additional sensors or monitoring modules can be added in the future, such as dust sensors, $CO_2$ sensors, or environmental monitoring networks.

Finally, maintainability and flexibility are important requirements. The system should allow easy updates to the software, improvements in sensor accuracy, and integration with additional IoT platforms or mobile applications in future versions.

## IV. METHODOLOGY/APPROACH

The development of the IoT-Based Air Quality Monitoring System follows a structured implementation approach to ensure that each stage of the system design and development is completed systematically. This methodology ensures that the system operates efficiently, provides accurate environmental data, and delivers reliable real-time monitoring through IoT technology.

Step 1: Problem Analysis & Requirement Identification The first phase of the project involves identifying the environmental monitoring problem and determining the system requirements. Increasing air pollution and lack of real-time monitoring tools highlight the need for a low-cost air quality monitoring solution.

The system requirements include detecting harmful gases, measuring temperature and humidity, displaying environmental data locally, and transmitting sensor readings to an IoT cloud platform for remote monitoring. The project aims to provide users with immediate alerts whenever air quality conditions become unsafe.

Step 2: System Architecture & Design

In this phase, the system requirements are converted into a technical architecture that defines how different hardware and software components interact with each other.

The system architecture includes the following layers:

• Sensor Layer: Consists of sensors such as MQ-135 for air quality detection and DHT22 for temperature and humidity monitoring.

• Processing Layer: Uses the ESP32 microcontroller to collect sensor data, process the information, and control the alert mechanisms.

• Communication Layer: Utilizes the built-in Wi-Fi capability of the ESP32 to transmit environmental data to the Blynk IoT cloud platform.

• Application Layer: Displays sensor readings through the Blynk mobile dashboard and the OLED display module.

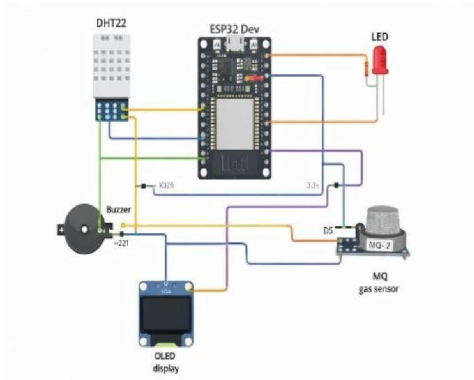


Fig. Circuit Diagram

Step 3: Hardware Integration & System Development During this stage, the physical components of the system are assembled and integrated with the microcontroller.

The MQ-135 gas sensor and DHT22 sensor are connected to the ESP32 microcontroller to collect environmental data. An OLED display is used to show real-time sensor readings locally, while an LED and buzzer are connected to act as an alert system when poor air quality is detected. The system software is developed using the Arduino IDE, where the ESP32 is programmed using C++-based embedded code to read sensor values, process environmental data, and send the information to the IoT platform.

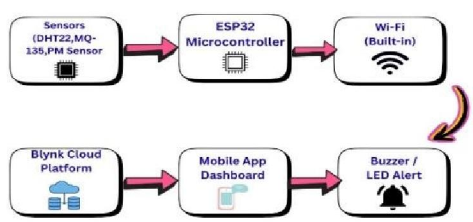


Fig. Block Diagram

Step 4: Testing & System Validation

Once the system is developed, various tests are conducted to ensure the system operates correctly.

• Sensor Testing: Verifying that the MQ-135 sensor accurately detects air pollution and the DHT22 sensor correctly measures temperature and humidity.

• System Integration Testing: Ensuring that the ESP32 successfully processes sensor data and communicates with the Blynk IoT platform.

• Alert System Testing: Confirming that the LED and buzzer activate whenever the air quality level crosses the defined threshold.

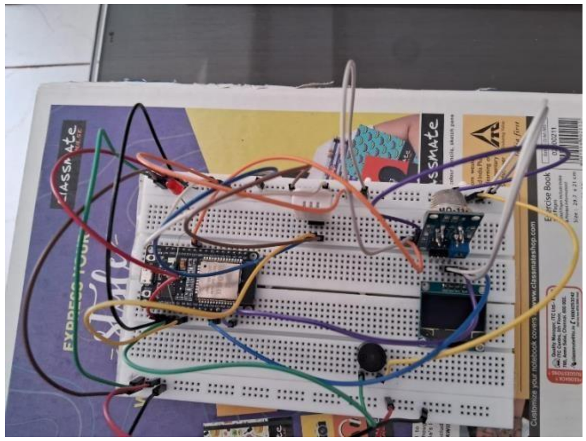

Fig. Working Model

Step 5: Implementation & Monitoring

The final stage involves implementing the system for realtime monitoring.

The ESP32 connects to the internet using Wi-Fi and continuously transmits sensor readings to the Blynk IoT platform, where users can monitor environmental conditions through a mobile application or web dashboard. The system also displays real-time values on the OLED screen, allowing users to observe environmental conditions locally. Through this approach, the system provides a cost-effective and efficient IoT-based environmental monitoring solution That helps users detect air pollution and maintain a safer environment.

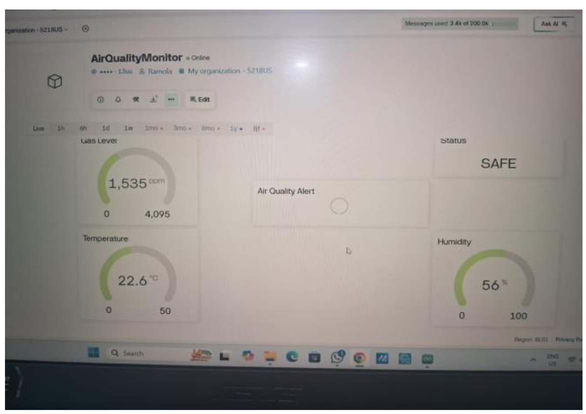


Fig. Dashboard

## V. ADVANTAGES

1. Real-Time Air Quality Monitoring: The system continuously monitors environmental conditions and detects harmful gases present in the air using sensors, providing real-time information about air quality levels.
2. Early Pollution Detection: The system immediately identifies poor air quality and activates an alert system using a buzzer and LED, helping users take preventive actions to avoid exposure to harmful gases.
3. Remote Monitoring through IoT: By connecting the ESP32 microcontroller to the internet, users can monitor environmental data remotely through the Blynk IoT mobile application or web dashboard.
4. Low-Cost and Affordable Solution: The system uses inexpensive sensors and microcontrollers, making it a cost-effective alternative to large and expensive environmental monitoring stations.

5. Local Display of Environmental Data: The OLED display provides instant information about temperature, humidity, and air quality directly on the device, allowing users to monitor conditions even without internet access.
6. Improved Environmental Awareness: The system helps users understand the impact of air pollution by continuously displaying environmental parameters and alerting them when pollution levels increase.
7. Portable and Easy to Install: The device is compact and portable, making it suitable for use in homes, laboratories, classrooms, offices, and small industrial environments for environmental monitoring.

## VI. APPLICATIONS

1. Indoor Air Quality Monitoring: The system can be used in homes, classrooms, and offices to monitor indoor air quality. It helps detect harmful gases or smoke in the environment and alerts users when pollution levels become unsafe.
2. Laboratory Safety Monitoring: In laboratories where chemicals and gases are used, the system can continuously monitor air conditions. If harmful gas levels increase, the buzzer and LED alert mechanism can warn users to take safety precautions.
3. Industrial Environment Monitoring: The system can be applied in small industrial units or workshops to detect gas leakage and air pollution. Continuous monitoring helps maintain a safer working environment for employees.
4. Smart Home and IoT Automation Systems: The air quality monitoring system can be integrated with smart home systems to automatically activate ventilation systems, air purifiers, or exhaust fans when poor air quality is detected.
5. Educational and Research Applications: The project can be used in educational institutions for learning purposes in fields such as IoT, environmental monitoring, and embedded systems. It helps students understand how sensors, microcontrollers, and cloud platforms work together in real-time applications.
6. Public Health Awareness: The system can be deployed in public places to monitor environmental conditions and raise awareness about air pollution. It helps people understand the importance of maintaining clean and safe air environments.

## VII. CONCLUSION

In today's era of smart technologies and connected devices, the IoT-Based Air Quality Monitoring System demonstrates how modern technology can be used to monitor environmental conditions effectively. By integrating sensors, microcontrollers, and IoT platforms, the system provides real-time information about temperature, humidity, and air quality levels. This allows users to easily monitor environmental conditions and take preventive actions when pollution levels become unsafe.

The project highlights the importance of using Internet of Things technology for environmental monitoring and public safety. With features such as real-time data display on the OLED screen, remote monitoring through the Blynk IoT platform, and alert mechanisms using LED and buzzer, the system offers a simple yet effective solution for detecting harmful gases and poor air quality conditions.

The proposed system is cost-effective, easy to implement, and suitable for use in homes, laboratories, classrooms, and small industrial environments. By increasing environmental awareness and providing instant alerts, the system helps users maintain a safer and healthier living environment.

Thus, the IoT-Based Air Quality Monitoring System demonstrates how smart technologies can contribute to building safer environments through continuous monitoring, real-time alerts, and efficient data communication using IoT platforms.

## VIII. ACKNOWLEDGMENT

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