Air Quality Monitoring System

Dipali Sharnagat, Triveni Tembhurne, Samiksha Kuhite

Department of Electronics and Communication, Priyadarshini College of Engineering Nagpur,India

Abstract—The Air Quality Monitoring System is an innovative solution designed to detect and monitor hazardous gases such as methane, carbon monoxide, and other air pollutants in real-time using a range of sensors. This system integrates MQ-02, MQ-04, MQ-07, and M135 gas sensors, with an ESP32 microcontroller that processes the sensor data and transmits it to the Blynk IoT platform for remote monitoring. By continuously measuring gas concentrations, the system ensures the detection of potentially hazardous levels of pollutants, providing real-time alerts and enabling timely interventions. The ESP32 also triggers an audible alarm via a buzzer when dangerous gas concentrations exceed predefined thresholds, ensuring immediate attention in local environments. Through the integration of IoT technology, users can access live air quality data on their smartphones or web browsers, even when they are not physically near the system, providing flexibility and enhancing safety protocols. This project aims to improve safety in industrial and residential areas by offering continuous monitoring and the ability to respond proactively to potential gas leaks or pollution.

I. INTRODUCTION

Air pollution and the decline in air quality have become pressing global challenges, posing significant threats to public health, environmental sustainability, and overall quality of life. With rapid urbanization, industrial growth, and an increase in vehicular emissions, the concentration of harmful gases like methane (CH_4), carbon monoxide (CO), nitrogen dioxide (NO_2), and other pollutants has reached alarming levels in many regions worldwide. Methane, in particular, stands out as one of the most potent greenhouse gases, with a global warming potential significantly higher than that of carbon dioxide. Its presence in the atmosphere, primarily due to anthropogenic activities such as agriculture, landfills, and fossil fuel extraction, contributes not only to climate change but also to health hazards, as it often exists alongside other toxic compounds. The need for accurate, real-time monitoring of methane and other pollutants has never been more critical, as it forms the basis for informed decision-making, effective environmental policies, and public awareness.

Fig: Air Quality Monitoring System

II. PROPOSED SYSTEM

An IOT based air pollution monitoring system is proposed that uses an MQ135 gas sensor interfaced to node MCU; the system is connected through ESP32 wifi module to the thinks Speak cloud to analyze the sensor data.

A. HARDWARE

• MQ2:(Methane/Carbon Monoxide Sensor)
The sensor uses a semiconductor material that changes its resistance based on the concentration of gases in the air. When gases interact with the sensor's surface, the resistance of the sensor material changes, and this change is used to estimate the gas concentration.

• MQ4: (Methane Gas Sensor)
Similar to other MQ sensors, the MQ-04 works by changing its electrical resistance in the presence of methane gas. The sensor heating element inside is sensitive to methane molecules, and the change in resistance is proportional to the gas concentration.

• MQ7: (Ammonia Gas Sensor)
As with other MQ sensors, the MQ-07 utilizes a semiconductor material that undergoes a change in resistance when exposed to ammonia gas. This change in resistance is then converted to a voltage that can be measured to determine the ammonia concentration.

• MQ135: (General Air Quality Sensor)
The M135 sensor detects changes in the resistance of its sensing material, which varies depending on the concentration of VOCs in the surrounding air. The change in resistance is used to determine the level of pollutants.

• 16x2 LCD display
A 16x2 LCD display is an essential component in an air quality monitoring system, offering a simple and

effective way to provide real-time feedback to users. This display can showcase critical environmental parameters such as temperature, humidity, gas concentrations, and particulate matter levels. Its ability to deliver concise and immediate information makes it a valuable addition to both portable and stationary air quality devices. Compact, cost-effective, and energy-efficient, the 16x2 LCD is ideal for IoT-based air monitoring systems, especially in areas where simple, standalone operation is needed.

- ESP32 CONTROLLER

ESP32 controller is a versatile microcontroller unit known for its high performance and powerful features, making it the foundation of IoT (Internet of Things) and the world of technology. It is powered by the dual-core TenSi LX6 processor, which can provide computing power to solve difficult tasks while maintaining low power consumption. ESP32 comes with built-in Wi-Fi and Bluetooth capabilities for seamless connectivity to the internet and other devices, enabling easy data exchange and remote control. Their rich hardware, which includes GPIO pins, ADCs, DACs, and communication interfaces, gives researchers the flexibility to interact with a variety of sensors and actuators, making them ideal for everything from home automation to business monitoring. Known for its versatility and performance, the ESP32 controller is the brain of the body.

- Buzzer

The buzzer is a critical component in the Air Quality Monitoring System, designed to alert users in real-time when methane (CH_4) levels exceed safe thresholds. It serves as an audible warning system, ensuring immediate attention to potential hazards, especially in scenarios where visual monitoring (like checking an LCD or mobile app) might not be possible.

B. SOFTWARE

The system software is primarily divided into two key parts: the local control software running on the ESP32 microcontroller and the remote monitoring interface provided by the Blynk IoT platform.

- ESP32 Microcontroller Software

The software on the ESP32 is responsible for controlling the sensors, processing the data, and managing the alerts. It continuously reads the gas sensor outputs and checks if any gas concentration exceeds the predefined threshold. o In case of an exceedance, the system triggers the buzzer for local

alerts and sends real-time data to the Blynk IoT platform via Wi-Fi. o The software also manages the continuous monitoring and periodic recalibration of the sensors to ensure accurate readings over time.

- Blynk IoT Platform

The Blynk platform is used for remote monitoring and control. It provides a mobile app or web interface where users can view realtime gas concentrations, receive push notifications, and set custom thresholds for alerts. o The Blynk app offers a user-friendly interface with live data visualizations (such as graphs and gauges), allowing users to monitor air quality from any location with internet access.

III. LITERATURE SURVEY

The Internet of Things (IoT) is a transformative paradigm that connects physical devices, embedded systems, and digital technologies to enable seamless communication, data exchange, and intelligent decision-making. In their seminal work, Bandyopadhyay and Sen (2011) highlighted the profound impact of IoT on modern society, its diverse applications across industries, and the technical and standardization challenges it faces. IoT extends the internet's capability beyond traditional computing devices to include everyday objects such as appliances, sensors, vehicles, and industrial equipment, thus creating a web of interconnected entities.

This interconnectedness facilitates a variety of innovative applications. For instance, in smart homes, IoT-enabled devices like thermostats, lighting systems, and security cameras enhance convenience, energy efficiency, and safety. Similarly, in healthcare, IoT supports remote patient monitoring, real-time diagnostics, and telemedicine, transforming patient care and enabling proactive health management. The industrial sectoroften referred to as Industry 4.0, leverages IoT for predictive maintenance, process optimization, and supply chain automation. Smart cities are another critical application area, where IoT systems monitor traffic, optimize energy usage, and manage waste efficiently, leading to improved urban living standards. Despite these advancements, IoT presents several challenges that must be addressed to realize its full potential.
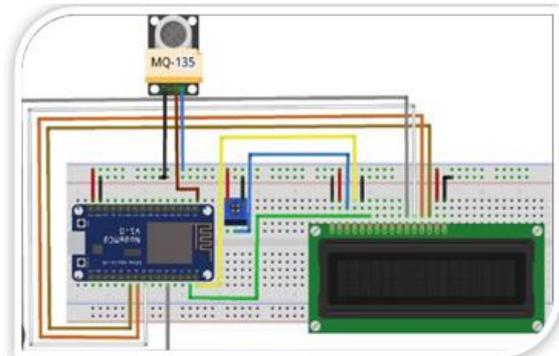
Fig: Circuit Diagram

IV. PROPOSED METHOLOGY

The proposed methodology for the Air Quality Monitoring System leverages the MQ-4 sensor to detect methane gas concentrations in the air. This system is built around the ESP32 microcontroller, which serves as the core processing and communication unit. The MQ-4 sensor continuously monitors the methane levels in the environment, providing analog outputs that are processed to determine the gas concentration. A predefined threshold is established based on normal methane levels, and if the sensor detects concentrations exceeding this threshold, the system triggers an alert. The alert is generated via a connected buzzer, providing immediate auditory feedback to ensure timely action. Additionally, the system is integrated with the Blynk IoT platform, enabling real-time data transmission to a mobile or web-based application for remote monitoring.

This ensures that users can track methane levels from anywhere, enhancing safety and preventive measures.To ensure accurate readings, the MQ-4 sensor undergoes a calibration process during the initialization phase. The baseline methane levels are determined over multiple readings, and this data is used to set the alert threshold dynamically. The ESP32 microcontroller processes the analog data from the sensor and converts it into digital signals for further analysis. The data is also sent to the Blynk application using Wi-Fi connectivity. This cloud-based platform allows users to visualize the methane concentration in real-time through a user-friendly interface. Customizable alerts, such as push notifications or email alerts, can also be configured on the Blynk app to notify users of hazardous gas levels. The system design is compact, energy-efficient, and capable of continuous operation, making it suitable for industrial, residential, or agricultural use cases.

V. RESULT ANALYSIS

He Air Quality Monitoring System with the integration of MQ-02, MQ-04, MQ-07, and M135 sensors coupled with the ESP32 microcontroller and the Blynk IoT platform is designed to offer real-time monitoring of hazardous gases like methane, carbon monoxide, and other volatile organic compounds (VOCs). This system ensures environmental safety by detecting the presence of harmful gases in the air and providing immediate alerts to users through both local and remote mechanisms.

The working of the system begins with the initialization and calibration of the gas sensors. Each sensor (MQ-02, MQ-04, MQ-07, and M135) is designed to detect specific gases, with each having varying sensitivity levels. The MQ-02 sensor is sensitive to methane and LPG, while the MQ-04 and MQ-07 are optimized for detecting methane and carbon monoxide, with MQ-07 additionally capable of sensing LPG. The M135 sensor provides a more generalized detection capacity, identifying methane, carbon monoxide, and acetone, making it versatile for various industrial and residential applications. At startup, the system calibrates each sensor, taking baseline readings in a safe, clean environment to determine the average gas concentrations. This calibration ensures the sensors provide accurate data during real-time operation.

Simultaneously, the ESP32 sends the detected gas concentration data to the Blynk IoT platform via Wi-Fi. This integration allows users to monitor the gas concentrations remotely in real-time through a smartphone or web application. The Blynk platform provides a visual interface with live data feeds, graphs, and alerts, allowing users to view the current levels of methane, carbon monoxide, and other gases. This remote monitoring capability ensures that users can stay informed about the air quality in environments where they may not be physically present, such as factories, laboratories, or even home settings.
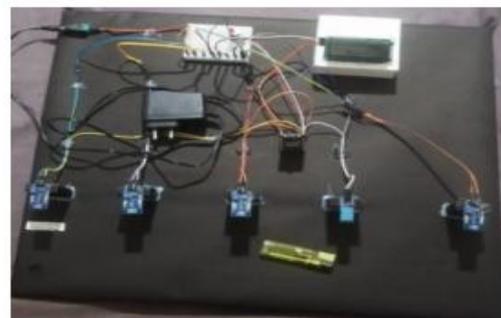

Fig: Hardware model

VI. FUTURE SCOPE

The Air Quality Monitoring System represents a significant step toward enhancing safety and improving environmental health through real-time monitoring and IoT integration. However, as technology continues to evolve and the need for more comprehensive and accurate environmental monitoring grows, there are numerous avenues for future development and expansion. Below are several potential areas for improvement and future scope of this project

1. Integration of Additional Sensors

While the current system utilizes MQ-02, MQ-04, MQ-07, and M135 sensors to monitor gases like methane and carbon monoxide, there is an opportunity to expand the range of detected gases and environmental factors. The addition of sensors for gases such as carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulate matter ($PM2.5$ and $PM10$) could provide a more comprehensive understanding of air quality. These sensors would be valuable in applications such as indoor air quality monitoring, industrial safety, and environmental research, where multiple pollutants need to be monitored simultaneously.

2. Enhanced Data Analytics and Machine Learning Integration

The current system focuses on real-time monitoring and alerting based on predefined thresholds. However, as the system collects more data over time, there is an opportunity to leverage data analytics and machine learning (ML) techniques to provide deeper insights into air quality trends. By applying ML algorithms, the system could analyze historical data to identify patterns and predict potential air quality hazards before they occur. This predictive approach would allow the system to provide proactive warnings and preventive measures based on environmental conditions. Additionally, anomaly detection algorithms could be used to identify irregularities in sensor data, such as malfunctioning sensors or sudden gas leaks, improving the system's overall reliability and performance.

3. Cloud-Based Integration and Advanced Visualization

While the Blynk IoT platform currently provides basic data visualization and real-time monitoring, integrating the system with more sophisticated cloudbased platforms like AWS, Google Cloud, or Microsoft Azure could significantly enhance its capabilities. These platforms offer powerful tools for storing, analyzing, and visualizing large datasets in real time. By utilizing advanced cloud services, the system could incorporate real-time dashboards, interactive graphs, and heat maps to provide a more intuitive and user-friendly interface for monitoring air quality across multiple locations. Furthermore, cloud integration could enable data sharing with other IoT devices or external systems, allowing for cross-platform communication and broader networked environments. This would be particularly useful in applications such as smart cities, where multiple monitoring devices could be connected to a central system, providing a holistic view of urban air quality.

VII. CONCLUSION

Conclusion of the Air Quality Monitoring System Project

The Air Quality Monitoring System is a highly effective solution for detecting and monitoring hazardous gases such as methane in the environment. By combining cutting-edge sensor technology with the power of IoT, this system offers a robust and reliable way to ensure the safety of individuals and environments where the risk of gas leakage or contamination exists. Through its seamless integration of MQ series

sensors, the ESP32 microcontroller, and the Blynk IoT platform, the system provides real-time monitoring, alerts, and data visualization that enhance situational awareness and enable timely intervention.

One of the key strengths of the Air Quality Monitoring System is its ability to continuously monitor and process environmental data, ensuring that hazardous conditions, such as high levels of methane, are detected and addressed before they pose a significant risk. The use of the MQ-02, MQ-04, MQ-07, and M135 sensors allows for accurate detection of various gases, and the system's calibration ensures that the readings are reliable. These sensors measure the concentration of gases in parts per million (PPM), providing precise data that can help identify leaks, pollution, or dangerous gas buildups. The ESP32 microcontroller serves as the heart of the system, processing the sensor data, comparing it against preset threshold values, and triggering local alerts when necessary. The buzzer activation provides an immediate audible warning to individuals in the area, ensuring that they are aware of potential danger.

The integration of Blynk not only allows for remote monitoring but also enables users to visualize data in real-time through intuitive graphical displays. This

functionality includes gauges, graphs, and LED indicators that provide clear and accessible feedback on the current air quality. The real-time data allows users to make informed decisions quickly, and the push notifications keep users alerted to any critical changes in the gas concentrations. This remote access feature ensures that users are always in control of the system, regardless of their physical location, making it especially valuable for monitoring multiple environments, such as factories, warehouses, and outdoor settings.

modern society, its diverse applications across industries, and the technical and standardization challenges it faces. IoT extends the internet's capability beyond traditional computing devices to include everyday objects such as appliances, sensors, vehicles, and industrial equipment, thus creating a web of interconnected entities. This interconnectedness facilitates a variety of innovative applications. For instance, in smart homes, IoT-enabled devices like thermostats, lighting systems, and security cameras enhance convenience, energy efficiency, and safety. Similarly, in healthcare, IoT supports remote patient monitoring, real-time diagnostics, and telemedicine, transforming patient care and enabling proactive health management. The industrial sector,

REFERENCES

[1] Kennedy Okokpujie, Etinosa Noma-Osaghae, Odusami Modupe, Samuel John and Oluga Oluwatosin, A Smart Air Pollution Monitoring System, International Journal of Civil Engineering and Technology, 9(9), 2018, pp. 799–809.

[2] Rawal R. Air Quality Monitoring System. International Journal of Computational Science and Engineering. 2019;9(1):1-9.

[3] Ali, Hassan & Soe, J. & Weller, Steven. (2015). A real-time ambient air quality monitoring wireless sensor network for schools in smart cities. 1-6. 10.1109/ISC2.2015.7366163.

[4] Kumar S, Jasuja A. Air quality monitoring system based on IoT using Raspberry Pi. In2017 International Conference on Computing, Communication and Automation (ICCCA) 2017 May 5 (pp. 1341-1346). IEEE.

[5] Gupta, Harsh & Bhardwaj, Dhananjay & Agrawal, Himanshu & Tikkiwal, Vinay & Kumar, Arun. (2019). An IoT Based Air Pollution Monitoring System for Smart Cities. 173-177. 10.1109/ICSETS.2019.8744949

[6] Kumar A, Kumari M, Gupta H. Design and Analysis of IoT based Air Quality Monitoring System. In2020 International Conference on Power Electronics & IoT Applications in Renewable Energy and its Control (PARC) 2020 Feb 28 (pp. 242- 245). IEEE.

[7] Asra Noorain F, Raju J, Varsha V, Nanditha HG. An IoT Based Approach To Minimize And Monitor Air Pollution Using ESP32 and Blynk Platform.

[8] Jayaratne R, Liu X, Ahn KH, Asumadu-Sakyi A, Fisher G, Gao J, Mabon A, Mazaheri M, Mullins B, Nyaku M, Ristovski Z. Low-cost PM2. 5