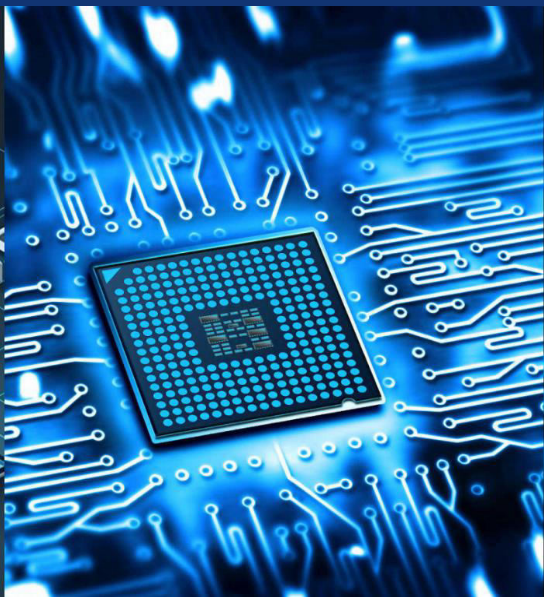
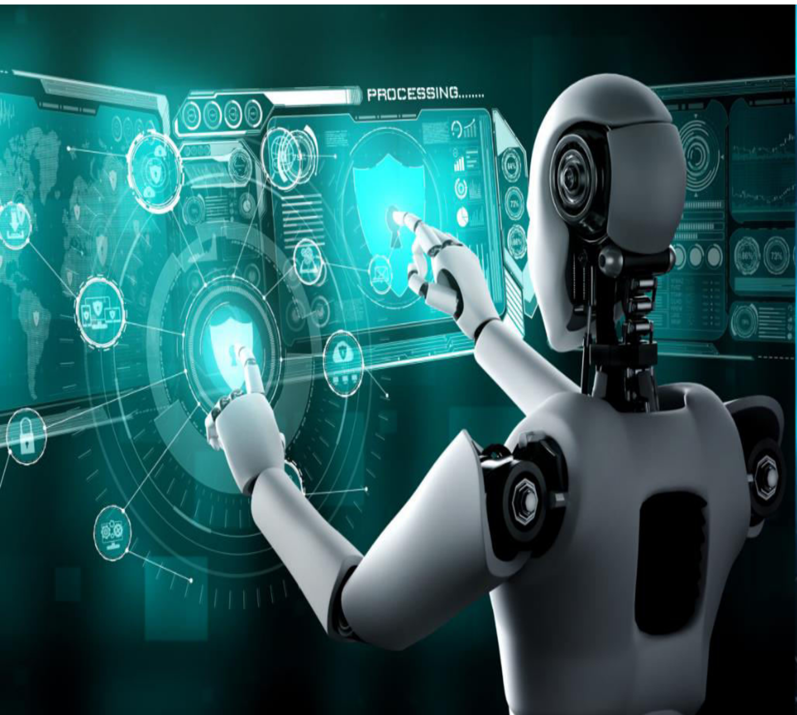
ISSN(O): 2320-9801

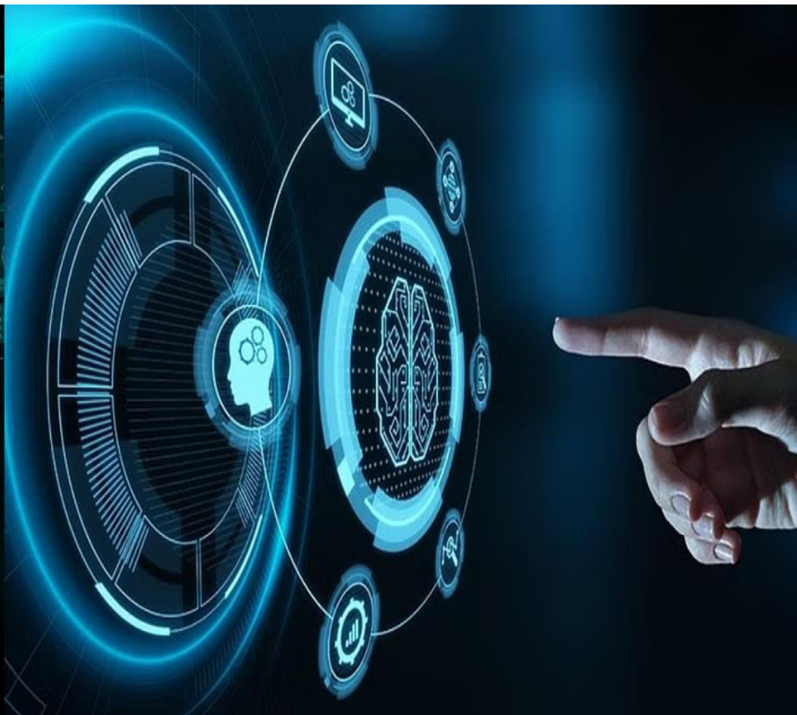
ISSN(P): 2320-9798



International Journal of Innovative Research in Computer and Communication Engineering

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)





Impact Factor: 8.771

Volume 13, Issue 2, February 2025

www.ijircce.com ijircce@gmail.com +91-9940572462 +91 63819 07438

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Real-Time ThingSpeak Integration in an Internet of Things-based Air Quality Monitoring System

R. Srinivas[1] , Anapana Reetika[1], Niddana Pragna Preethi [1], Priya Bhoomika[1], Priya Bhoomika[1], Sasanapuri Vivek[1], Darapu Karishma [1]

Department of Computer Science and Engineering, Aditya Institute of Technology and Management, Tekkali, India

ABSTRACT: An Internet of Things (IoT)-based air quality monitoring system that measures and analyzes ambient air quality in real time is presented in this study. The system detects pollutants like carbon monoxide, alcohol, and flammable gasses by integrating gas sensors (MQ2, MQ3, and MQ7) with an ESP32 microprocessor. The data is analyzed, transformed into percentages, and shown on a 16x2 LCD for local monitoring. Through interactive graphs, users can remotely monitor trends in air quality, thanks to the system's usage of ThingSpeak for real-time data presentation and storage. The system offers precise and dependable monitoring, making it an affordable and expandable solution for environmental health management. Its threshold value of 4095 indicates 100% gas concentration.

KEYWORDS: ESP32, IoT, real-time data, integration of ThingSpeak, environmental monitoring, LCD, Arduino IDE, MQ2 Sensor, MQ3 Sensor, MQ7 Sensor

I. INTRODUCTION

The health and well-being of people and communities are greatly influenced by the quality of the air. There are serious threats to both human health and the environment from poor air quality, which is brought on by pollutants like carbon monoxide, alcohol vapors, and flammable gasses. Conventional air quality monitoring methods frequently depend on costly, stationary equipment that can be difficult to implement widely. The emergence of the Internet of Things (IoT) has created a rising opportunity to create scalable and affordable technologies that offer real-time air quality monitoring.

To detect and analyze air quality in real time, this project suggests an Internet of Things-based Air Quality Monitoring System that combines gas sensors, an ESP32 microcontroller, and ThingSpeak cloud services. Three different kinds of sensors—MQ2, MQ3, and MQ7—are used by the system to identify different contaminants, such as carbon monoxide, alcohol vapors, and flammable gasses. The data is wirelessly sent to the ThingSpeak platform after sensor readings are processed and shown locally on a 16x2 LCD screen. This allows users to remotely assess pollution levels and see patterns. To provide precise and trustworthy monitoring, the threshold value for sensor readings is set at 4095, which corresponds to 100% pollution concentration.

The system is appropriate for a variety of applications, including industrial settings and urban air quality monitoring, due to its low cost and lightweight design, as well as its real-time data display capabilities. The suggested solution overcomes the drawbacks of conventional monitoring systems by utilizing IoT technology, offering a user-friendly instrument for people and enterprises to evaluate and control air quality efficiently. To illustrate the system's potential for improving environmental health monitoring, this paper describes its architecture, installation procedure, and experimental findings.

II. LITERATURE SURVEY

With numerous research concentrating on using the Internet of Things (IoT) for real-time data collection and analysis, air quality monitoring has become a crucial component of maintaining public health. A low-cost air quality monitoring

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

system that uses Arduino and ThingSpeak to provide real-time monitoring of pollutants was developed in a study by Kelechi et al. [15]. The system gives customers easy-to-use visualization tools and incorporates sensors to detect air pollution levels. Similar to this, Murad et al. [17] suggested an Internet of Things-based pollution monitoring system that integrates cloud platforms for data management. It uses ThingSpeak and the Blynk application to track air quality in real time. These studies show how IoT is increasingly being used to monitor air quality, particularly in urban settings.

Several sensor technologies have been used to further investigate the adoption of inexpensive air quality monitoring systems. In Dhaka, Khan [16] concentrated on an Internet of Things (IoT)- based air quality index assessment system that uses sensors to track particle matter and other contaminants. This method demonstrated the value of cloud platforms in data management and visualization while enabling effective data gathering in an urban environment. A Raspberry Pi- based IoT-enabled air quality monitoring system was also presented by Balasubramaniyan and Manivannan [4], who showed how to track different pollutants in real time and transfer the data to a cloud server for analysis. These studies demonstrate how well IoT devices and inexpensive sensors may be combined to create scalable, real-time air quality monitoring systems.

A cloud-based platform called ThingSpeak is frequently used in air quality monitoring systems because of its ease of use and integration potential. Emphasizing the value of cloud-based data management, Corral-Plaza et al. [6] created an Internet of Things platform for smart air station monitoring and remote sensing. To create a comprehensive air quality monitoring system, their team investigated how sensor data could be sent to the cloud for processing. Additionally, ThingSpeak is a flexible and dependable platform for such applications, according to the study by Grace and Manju [9], which examined a variety of wireless sensor network-based air pollution monitoring systems. These systems' integration of ThingSpeak improves data accessibility and visualization, facilitating users' remote air quality monitoring. The integration of cloud platforms and IoT sensors to control dynamic indoor air pollution has been the subject of numerous research projects. To solve problems with fluctuating pollution levels in real time and enable efficient decision-making based on sensor data, Edupuganti et al. [8] investigated a dynamic air pollution monitoring system deployed using IoT. In a related work, Rana et al. [19] used cutting-edge technology like blockchain and node authentication to guarantee the accuracy of air quality data sent by Internet of Things sensors. By enhancing the security and precision of air quality monitoring systems, these developments hope to advance the creation of increasingly complex and dependable indoor and urban air quality management solutions.

INFERENCES FROM LITERATURE SURVEY.

The literature review emphasizes the growing usage of Internet of Things (IoT) technology in air quality monitoring systems, emphasizing the use of inexpensive sensors, cloud-based data management, and real-time data collecting. Research shows how well platforms like ThingSpeak work to manage and visualize air quality data, allowing for remote monitoring and analysis. In urban and residential settings, low-cost sensor-based systems—like those that use Arduino—have been effectively used to track a variety of contaminants, offering important information for environmental management and public health. Additionally, new research highlights how crucial it is to improve data security and accuracy using cutting-edge technology like blockchain and node authentication. All of these studies show that IoT-based air quality monitoring systems provide dependable, scalable, and effective real-time environmental monitoring solutions.

III. PROPOSED METHODOLOGY

A. Problem Statement

The absence of affordable, easily accessible, and real-time air quality monitoring technologies for identifying and controlling environmental contaminants is the issue this research attempts to solve. Conventional techniques for monitoring air quality are frequently costly, have a restricted coverage area, and do not give the public continuous or publicly available data. With the use of inexpensive sensors connected to the ThingSpeak platform, this project seeks to create an Internet of Things-based air quality monitoring system that will enable real-time tracking and visualization of air pollution levels. The system aims to enhance air quality monitoring and support well-informed decision-making for environmental health management by offering an easily accessible, scalable, and effective solution.

© 2025 IJIRCCE | Volume 13, Issue 2, February 2025| DOI: 10.15680/IJIRCCE.2025.1302043

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

B. Objectives

I. REAL-TIME AIR QUALITY MONITORING:

The main objective of this project is to develop and put into place a system that offers ongoing, real-time monitoring of a Several air quality measures, such as carbon monoxide concentration, alcohol content, and gas levels. When evaluating the effects of air pollution on the ecosystem and human health, several factors are crucial. The system gathers data at regular intervals using sensors like MQ2 (for gas detection), MQ3 (for alcohol vapor detection), and MQ7 (for carbon monoxide detection). By facilitating wireless connectivity, the ESP32 Wi-Fi module is essential in enabling the sensors to send their data to an internet platform. The precise measurement of air quality, which can be used to evaluate pollution levels in various environments, is the main goal of this mission.

II. Integration with Cloud Platform:

This air quality monitoring system's integration with the ThingSpeak cloud platform is one of its key features. Through this connectivity, real-time sensor data may be transferred to the cloud and made available for remote monitoring. Viewable from any internet-connected device, ThingSpeak provides an intuitive interface for displaying sensor data as graphs and charts. Analyzing historical trends over time is made feasible by cloud integration, which also guarantees that the data is stored securely. The technology can notify users of possible pollution spikes or long-term environmental changes by using the cloud to deliver actionable insights on air quality patterns. Additionally, additional capabilities like data logging and pattern detection are made possible by cloud-based analysis.

III Cost-Effective Solution

Creating an affordable air quality monitoring system that can be extensively implemented without the financial burden of conventional, pricey air quality monitoring stations is one of the project's main goals. The entire system is kept below a reasonable budget by utilizing dependable but reasonably priced sensors, like the MQ series, and an inexpensive microcontroller (ESP32). Small enterprises, households, and educational institutions can all use this system because it uses free cloud platforms like ThingSpeak and minimizes the expense of hardware. This goal also emphasizes how crucial it is to develop a solution that is affordable for areas or communities that might lack the funds to install sophisticated air quality monitoring devices.

IV User-Friendly Display:

The local, real-time display of air quality data is a crucial component of this project, in addition to the cloud-based monitoring. A 16x2 LCD with an I2C module is incorporated into the system to give users instant information on the

Quality of the air in their surroundings. Without requiring an internet connection or additional devices, this display will provide real-time information about the quality of the air by displaying vital sensor data, including gas levels, alcohol concentrations, and carbon monoxide concentrations. This goal guarantees that users can still engage directly with the system and get crucial information about their surroundings, particularly in places without convenient internet connectivity.

C. Data Acquisition

1. Sensor Selection: To identify different air quality metrics, the system makes use of a collection of sensors. The following are these sensors: MQ2 Gas Sensor: Determines the concentrations of gases like methane, smoke, and LPG. The MQ3 Alcohol Sensor measures the amount of alcohol vapor present. The MQ7 Carbon Monoxide Sensor keeps track of the amount of carbon monoxide (CO) in the atmosphere. These sensors are perfect for an Internet of Things-based air quality monitoring system because they were chosen for their sensitivity, range, and affordability.

2. Sensor Interfacing: The ESP32 microcontroller's analog input pins are used to interface with each sensor. The ESP32 transforms the analog signals from the sensors into digital signals and then analyzes the data to extract useful information like the gas concentration in parts per million (ppm). Data is acquired at regular intervals, usually every few seconds or minutes, depending on the arrangement, and the sensors are powered by the ESP32's 3.3V output.

3. Data Processing and Calibration: The ESP32's integrated analog-to-digital converter (ADC) is used to process the raw data obtained from the sensors. The conversion of the signals to digital form for additional analysis is guaranteed by

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

this procedure. To guarantee precise measurements, the raw sensor data usually has to be calibrated. For instance, environmental variables like temperature and humidity must be taken into consideration when calibrating the MQ sensors because they can have an impact on sensor readings. Accurate figures that represent the actual concentration of gases are guaranteed by calibration.

Wi-Fi Integration: To ensure that it has an internet connection, the ESP32 joins a Wi-Fi network. This makes it possible for data to be transmitted continuously to the cloud, where it is stored and made accessible for additional analysis.

ThingSpeak Platform: This cloud-based platform was created specifically for gathering data from the Internet of Things. Users may monitor real-time data from their devices with its user-friendly UI. Depending on the settings, the air quality data is transferred to ThingSpeak at regular intervals, usually once or twice per minute. To provide consumers with a clear picture of the trends in air quality over time, ThingSpeak automatically processes the data and presents it in graphical formats like bar charts or line graphs.

4. User Interface and Real-Time Display

The system has a local display to give the user real-time feedback in addition to cloud-based monitoring. Air quality parameters, including gas concentrations (in parts per million)

Each of the detected gases is continuously displayed on the LCD panel that is attached to the ESP32. This enables users to get instant visual input regarding the air quality in their surroundings, which is crucial in circumstances where prompt action could be required.

Features of Local Displays: The concentration levels of gases identified by the sensors are shown on the LCD screen, together with any thresholds that could have been crossed. Without requiring a connection to the cloud platform, it offers an easy-to-use interface for rapid air quality inspection.

Summary of Data Acquisition

To sum up, sensors that monitor important air contaminants, an ESP32 microcontroller for signal processing and transmission, and cloud-based platforms for data storage and display make up the data acquisition system. After processing real-time sensor data to eliminate noise and guarantee accuracy, the system transmits the data to ThingSpeak for additional analysis. The system is an effective instrument for guaranteeing air quality safety because it provides both immediate and long-term monitoring choices, triggers threshold-based alarms, and has local display capabilities.

IV. PROPOSED SYSTEMS WORKING PRINCIPLE

Sensors like MQ2, MQ3, and MQ7 are used in the planned Air Quality Monitoring System to identify contaminants like carbon monoxide, alcohol vapors, and gases. The ESP32 microcontroller reads and processes the electrical signals that these sensors translate into when dangerous substances are present. To guarantee that the readings are precise and trustworthy, the microcontroller applies thresholds and calibrates data. An LCD (16x2) with I2C connectivity is used to display the real-time data locally, providing on-site visibility of the air quality.

Along with local monitoring, the system uses the ESP32's Wi-Fi capabilities to send the processed data to ThingSpeak, a cloud-based platform. Through graphs and charts, ThingSpeak offers real-time data visualization that is accessible from a distance using online or mobile interfaces. With the help of this connection, users may check pollution levels more accurately and take preventative action when thresholds are crossed by recording and analyzing changes in air quality over time. The technology provides an efficient and user-friendly way to monitor air quality by fusing local data gathering with cloud-based analysis.

To gather, process, and display air quality data, the Air Quality Monitoring System's system design combines several physical elements with cloud-based services. Three important gas sensors (MQ2, MQ3, and MQ7) are part of the architecture; they measure gas, alcohol, and carbon monoxide, respectively. An ESP32 microcontroller, which acts as the main processing unit for communication and data collection, is coupled to these sensors.

© 2025 IJIRCCE | Volume 13, Issue 2, February 2025| DOI: 10.15680/IJIRCCE.2025.1302043

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

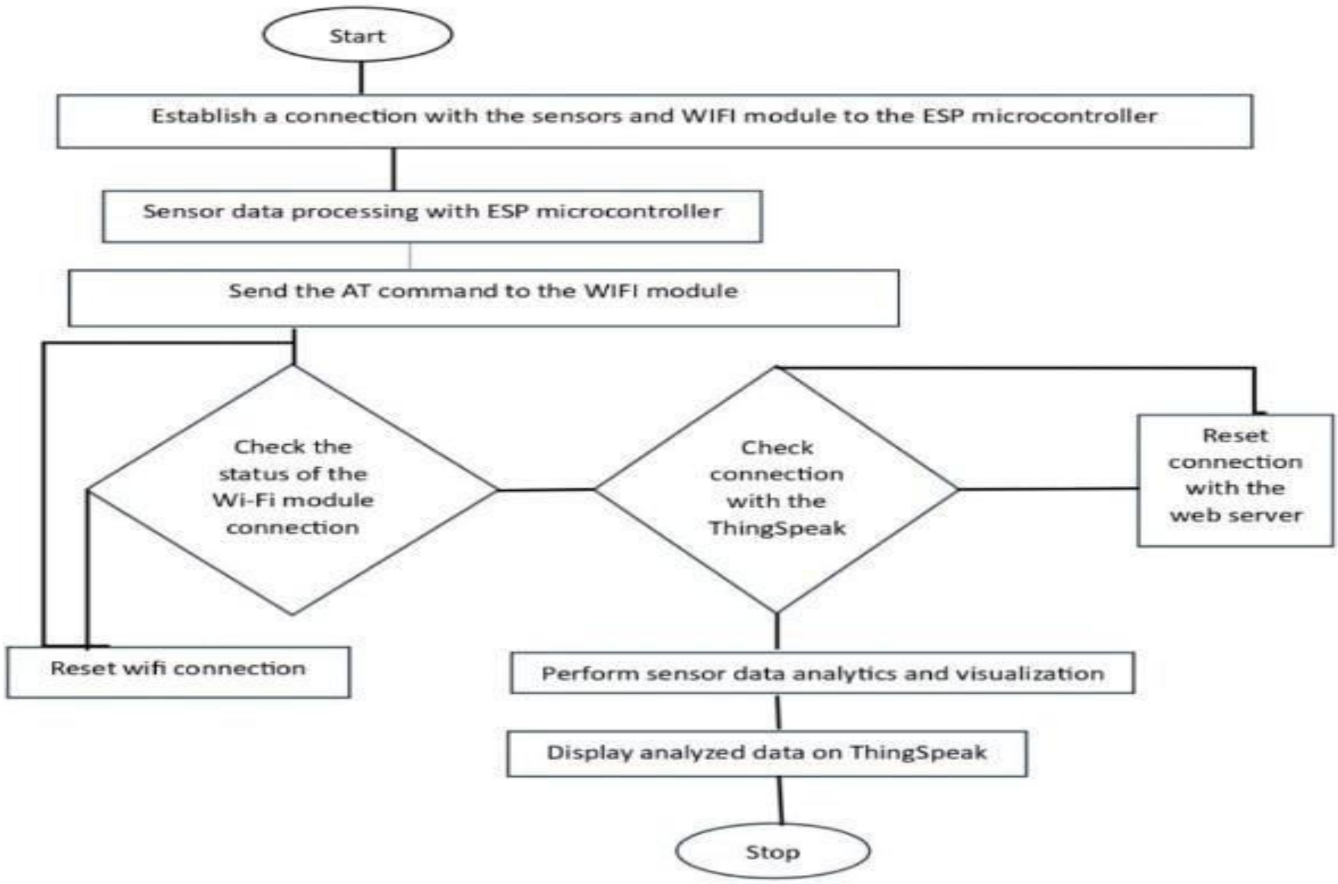


Fig1: System Architecture

The sensor data is processed by the ESP32, which then uses an I2C connection to display it locally on an LCD screen before uploading it to the cloud platform ThingSpeak for remote monitoring and viewing. To monitor real-time data and trends, the user can access the cloud platform using a mobile or web interface. An effective and scalable solution for air quality monitoring is offered by the system architecture, which makes use of a Wi-Fi connection to facilitate smooth integration between the ESP32, sensors, LCD, and cloud.

V. RESULT AND DISCUSSION

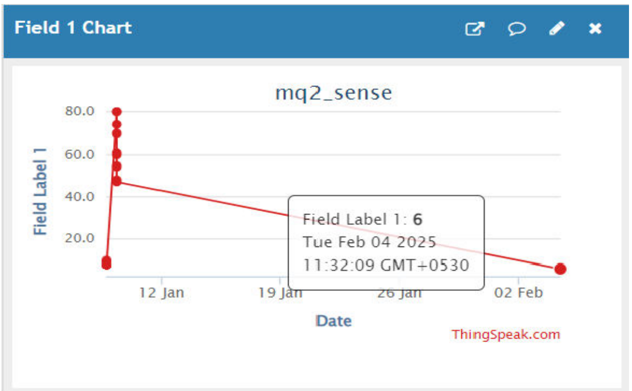
The goal of the successfully constructed and tested air quality monitoring system is to provide real-time data on environmental contaminants. The system detects a variety of air contaminants, such as smoking, alcohol, CO2, and CO2, using several gas sensors. The ESP32 microcontroller was used to gather and handle the sensor readings from the indoor monitoring of these contaminants. The ThingSpeak cloud platform received the processed data and displayed it in real time. The technology accurately measured gas concentrations and effectively warned users of possible health hazards by sending out alerts when thresholds were surpassed.

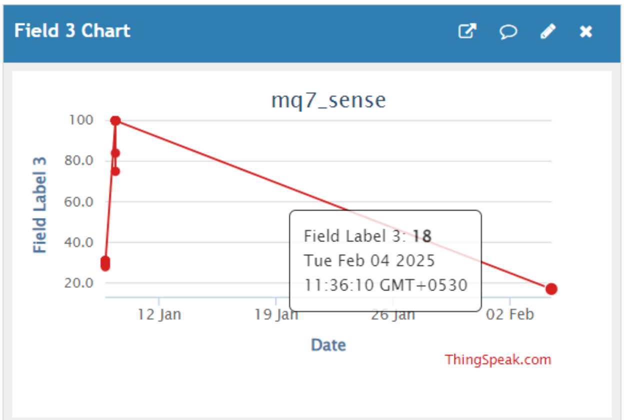
The system's efficacy was greatly influenced by the sensors' accuracy. The MQ sensors were calibrated to make sure the data closely matched the concentrations of air quality seen in the real world. The sensors were tested in controlled settings with known gas concentrations as part of the calibration procedure, and the system's readings were contrasted with reference values. The findings demonstrated that, with minor deviations caused by environmental variables like temperature and humidity, the MQ sensors did a good job of detecting gasses. But for general monitoring, the system worked well, giving precise air quality level estimates.

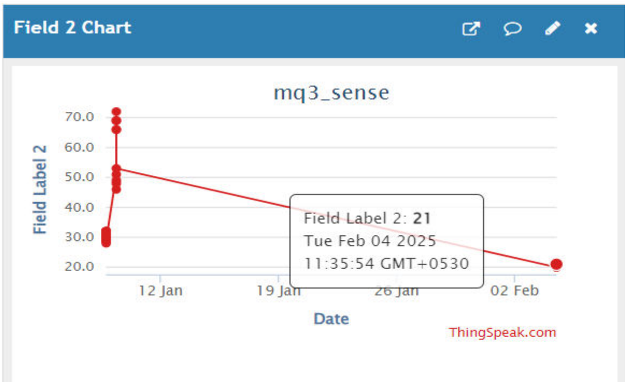
www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

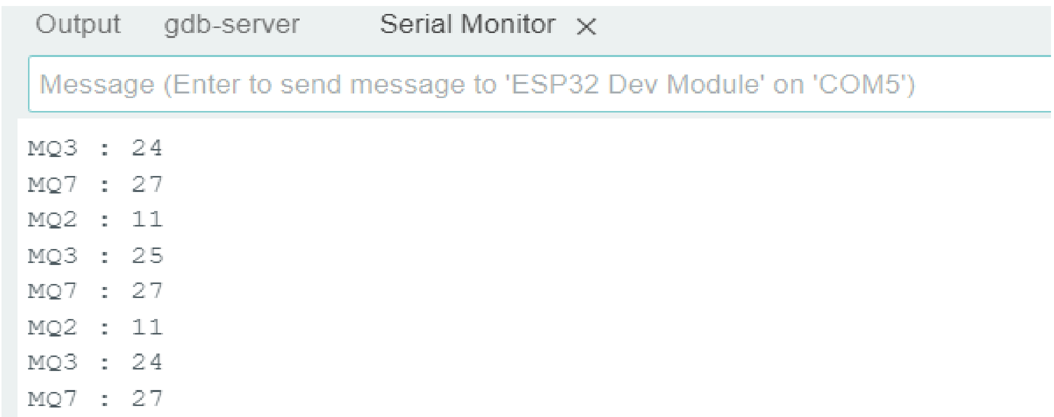
(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)







Data transmission and storage were made easier by the ESP32 microcontroller's connection with the ThingSpeak cloud platform. Users were able to remotely monitor air quality because real-time data on air quality was regularly transferred to the cloud without any noticeable latency. An assessment of the trends in air quality over time was made possible, thanks in large part to the visualizations provided by the cloud platform. Bar charts and line graphs made the data easily readable, enabling users to see abrupt increases in pollution levels. The effective cloud storage of data from several monitoring sessions allowed for long-term study of air quality trends, which is essential for locating reoccurring patterns and possible pollution sources.

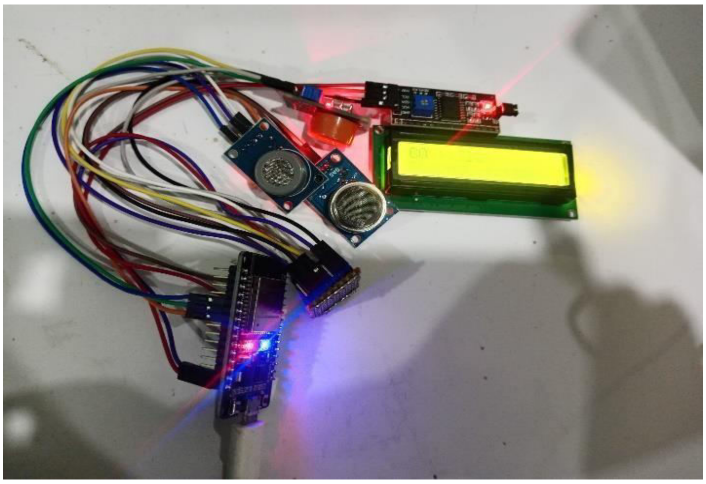


DOI: 10.15680/IJIRCCE.2025.1302043

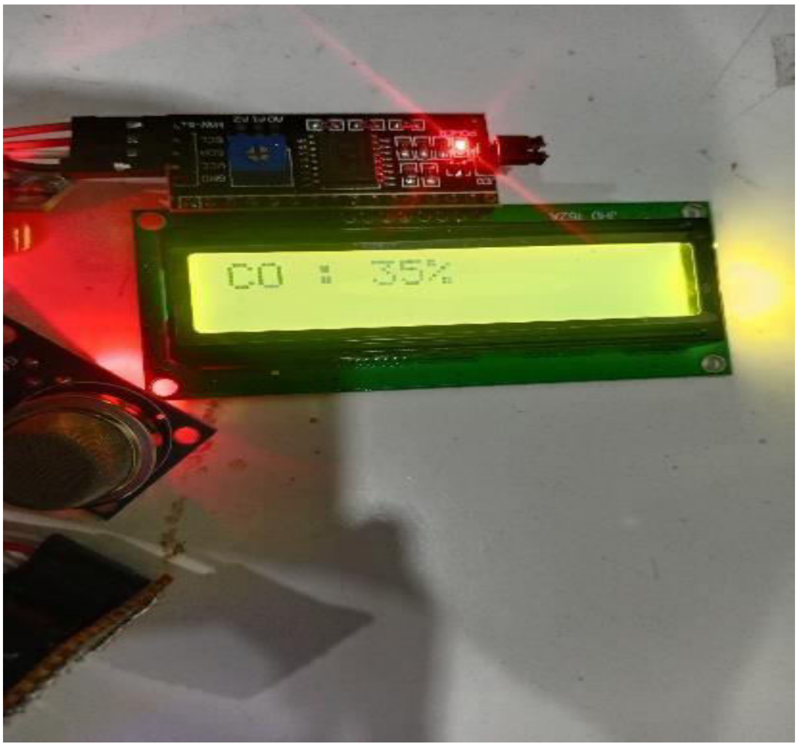
www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



The system's capacity to transmit alarms when pollution levels are above predetermined criteria was one of its primary benefits. Notifications were delivered to users through the ThingSpeak platform when the concentration of gases, including CO or CO2, exceeded safe limits. Additionally, the device alerts users in real time to dangerous air quality circumstances by displaying warning messages on the LCD screen. These warnings made it possible to take quick action, including utilizing air purifiers or improving ventilation, to lessen the consequences of pollution. This real-time feedback system was very helpful in making sure consumers understood the possible health hazards linked to low air quality.



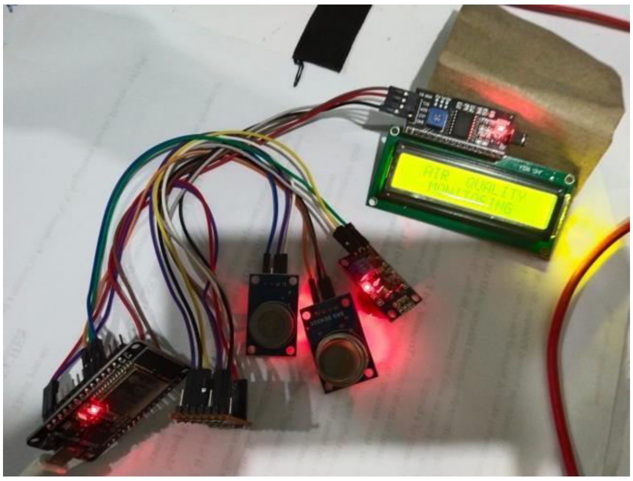
While the system performed well in terms of monitoring and reporting air quality, there were some limitations observed during testing. The sensors, although effective, had limitations regarding their sensitivity to certain gases, which can be affected by factors such as environmental humidity and temperature. In addition, the system was designed for use in

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

smaller indoor environments, and its performance in larger, more complex spaces may require further testing.



The cloud platform provided accurate visualizations and long-term data storage, but connectivity issues, such as occasional Wi-Fi interruptions, led to minor delays in data transmission. However, these limitations did not significantly impact the system's overall effectiveness for real-time air quality monitoring.

VI. CONCLUSION

In conclusion, the air quality monitoring system developed for this project effectively achieved its goal of providing real-time monitoring of air pollutants, offering valuable insights into indoor air quality. By utilizing sensors to detect key pollutants and transmitting data to the ThingSpeak cloud platform, the system enabled continuous monitoring and immediate alerts when pollutant levels exceeded safe thresholds. Despite some limitations in sensor sensitivity and environmental factors, the system demonstrated strong performance in providing accurate air quality data and facilitating user awareness through notifications. With future improvements, such as enhanced sensor calibration and integration with additional technologies, the system has the potential to serve as an essential tool for improving air quality management in indoor environments.

REFERENCES

[1] Air quality improvement by employing a smart traffic management system controlled by the Internet of Things for Botswana in the sub-Saharan region of Africa. (2022, December 15). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/10051600/

[2] Air quality monitoring and detection system in vehicle cabin based on the internet of things. (2021, October 25). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/9649627/

[3] Alsamrai, O., Redel-Macias, M. D., Pinzi, S., & Dorado, M. P. (2024). A Systematic Review for indoor and outdoor air pollution monitoring systems based on the Internet of Things. Sustainability, 16(11), 4353. https://doi.org/10.3390/su16114353

[4] Balasubramaniyan, C., & Manivannan, D. (2016). Enabled Air Quality Monitoring System (AQMS) using Raspberry Pi. Indian Journal of Science and Technology, 9(39). https://doi.org/10.17485/ijst/2016/v9i39/90414

[5] Cloud-Integrated wireless sensor networks for dynamic household air pollution management. (2024, July 26). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/10673715/

[6] Corral-Plaza, D., Boubeta-Puig, J., Ortiz, G., & Garcia- De-Prado, A. (2020). An internet of things platform for air station remote sensing and smart monitoring. Computer Systems Science and Engineering, 35(1), 5–12. https://doi.org/10.32604/csse.2020.35.005

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

[7] Design and implementation of a Low-Cost Air Quality measurement instrumentation using the Internet of Things platform and cloud-based messaging service. (2021, October 15). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/9649658/

[8] Edupuganti, S., Tenneti, N. S. S., Iqbal, M. M., & Rajaram, G. (2023). An IoT implemented dynamic air pollution monitoring system. EAI Endorsed Transactions on Internet of Things, 9(4). https://doi.org/10.4108/eetiot.v9i4.4316

[9] Grace, R. K., & Manju, S. (2019). A comprehensive review of wireless sensor networks based air pollution monitoring systems. Wireless Personal Communications, 108(4), 2499–2515. https://doi.org/10.1007/s11277-019-06535-3

[10] Improving data quality of Low-Cost Light-Scattering PM sensors: Toward automatic air quality monitoring in urban environments. (2024, September 1). IEEE Journals & Magazine | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/10539257/

[11] Indoor environmental quality. (n.d.). Google Books. https://books.google.com/books?hl=en&lr=&id=3Rf8DwAAQBAJ&oi=fnd&pg=PA29&dq=air+quality+monitoring+s ystem+with+thing+speak+integration&ots=VwnDLzEe0w&sig=Z7HrY4w8pjcoX_E7qbjfmQ73Ly4

[12] Internet of things. (n.d.). Google Books. https://books.google.com/books?hl=en&lr=&id=rHYGZ0wxLP0C&oi=fnd&pg=PR1&dq=air+quality+monitoring+syst em+with+thing+speak+integration&ots=N_FqrXvBCr&sig=2pdjDUDJ7D3_ClPUZXTa06rGuQs

[13] Internet of Things-Based Air Pollution Monitoring System for the indoor environment utilizing light fidelity technology. (2023, October 5). IEEE Conference Publication| IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/10308844/

[14] INTI International University. (n.d.). The Air and Sound Pollution Monitoring System using Internet of Things and Cloud Based Data Analysis - INTI Institutional Repository. http://eprints.intimal.edu.my/1142/

[15] Kelechi, A. H., Alsharif, M. H., Agbaetuo, C., Ubadike, O., Aligbe, A., Uthansakul, P., Kannadasan, R., & Aly, A. A. (2021). Design of a Low-Cost air quality monitoring system using Arduino and ThingSpeak. Computers, Materials & Continua/Computers, Materials & Continua (Print), 70(1), 151–169. https://doi.org/10.32604/cmc.2022.019431

[16] Khan, S. I. (2021, October 1). Internet of Things (IoT) based air quality index measurement system for Dhaka city. https://dspace.bracu.ac.bd/xmlui/handle/10361/16566

[17] Murad, S. a. Z., Bakar, F., Azizan, A., & Shukri, M. (2021). Design of internet of things based air pollution monitoring system using ThingSpeak and Blynk application. Journal of Physics Conference Series, 1962(1), 012062. https://doi.org/10.1088/1742-6596/1962/1/012062

[18] Parmar, A., Sara, S., Dwivedi, A. K., Reddy, C. R., Patwardhan, I., Bijjam, S. D., Chaudhari, S., Rajan, K. S., & Vemuri, K. (2024). Development of end-to-end low-cost IoT system for densely deployed PM monitoring network: an Indian case study. Frontiers in the Internet of Things, 3. https://doi.org/10.3389/friot.2024.1332322

[19] Rana, A., Rawat, A. S., Afifi, A., Singh, R., Rashid, M., Gehlot, A., Akram, S. V., & Alshamrani, S. S. (2022). A Long-Range Internet of Things-Based Advanced Vehicle Pollution Monitoring System with Node Authentication and Blockchain. Applied Sciences, 12(15), 7547. https://doi.org/10.3390/app12157547

[20] "Smart Air purification: Enhancing Indoor Air quality using Arduino Uno and ThingSpeak Integration." (2024a, May 3). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/10561320/

[21] "Smart Air purification: Enhancing Indoor Air quality using Arduino Uno and ThingSpeak Integration." (2024b, May 3). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/10561320/

[22] Tahtawi, A. R. A., Andika, E., Yusuf, M., & Harjanto, W. N. (2020). Design of Quadrotor UAV and Internet-of-things-based air pollution monitoring systems. IJITEE (International Journal of Information Technology and Electrical Engineering), 3(4), 120. https://doi.org/10.22146/ijitee.51203

[23]Taştan, M. (2022). A low-cost air quality monitoring system based on the Internet of Things for smart homes. Journal of Ambient Intelligence and Smart Environments, 14(5), 351–374. https://doi.org/10.3233/ais-210458

[24]ThingsPeak-Based Environmental Monitoring System using IoT. (2022, November 25). IEEE Conference Publication IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/10053167/

[25]Wireless sensor networks. (n.d.). Google Books. https://books.google.com/books?hl=en&lr=&id=ihCQDwAAQBAJ&oi=fnd&pg=PA121&dq=air+quality+monitoring+system+with+thing+speak+integration&ots=GD7s7cebW2&sig=uSD2FBgBl36wrUukvoXmAq9la7Y

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

INNO SPACE
SJIF Scientific Journal Impact Factor

doi crossref

निस्केयर NISCAIR

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

9940 572 462 6381 907 438 ijircce@gmail.com

Scan to save the contact details

www.ijircce.com