KLE Technological University
Creating Value, Leveraging Knowledge

Dr. M. S. Sheshgiri Campus, Belagavi

Department of
Electronics and Communication Engineering

Mini Project Report

on

AIR QUALITY SENSING AND MONITORING

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that project entitled **" Air Quality sensing and monitoring a"** is a bonafide work carried out by the student team of **"Prajwal Kamble (02FE21BEC061), Prajwal Halgi (02FE21BEC059), Pooja Nandgaon (02FE21BEC058), Rakshita Shivapooji (02FE21BEC068)"**. The project report has been approved as it satisfies the requirements with respect to the mini project work prescribed by the university curriculum for B.E. (V Semester) in Department of Electronics and Communication Engineering of KLE Technological University Dr. M.S.Sheshgiri CET Belagavi campus for the academic year 2023-2024.

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-The project team

ABSTRACT

In recent years, the escalating concerns surrounding air quality and its impact on public health have prompted the development of innovative technologies aimed at monitoring and mitigating pollution levels. Among these advancements, the Internet of Things (IoT) has emerged as a powerful tool, revolutionizing the way we collect and analyze data related to air quality. This introduction explores the significance and potential of IoT-based air quality sensing and monitoring systems in fostering a healthier and more sustainable environment.

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Chapter 1

Introduction

In recent years, the escalating concerns surrounding air quality and its impact on public health have prompted the development of innovative technologies aimed at monitoring and mitigating pollution levels. Among these advancements, the Internet of Things (IoT) has emerged as a powerful tool, revolutionizing the way we collect and analyze data related to air quality. This introduction explores the significance and potential of IoT-based air quality sensing and monitoring systems in fostering a healthier and more sustainable environment.As urbanization and industrialization continue to expand globally, so does the emission of pollutants into the atmosphere. The detrimental effects of poor air quality on human health are well-documented, linking it to respiratory issues, cardiovascular diseases, and other health complications

1.1 Motivation

1. **Public Health Concerns: Air pollution is a significant threat to public health, with numerous studies linking it to respiratory diseases, cardiovascular issues, and other adverse health effects. The motivation to deploy IoT-based air quality monitoring systems arises from the imperative to safeguard the well-being of communities and individuals by providing real-time information on pollutant levels.**

2. **Rapid Urbanization and Industrialization: The expansion of urban areas and industrial activities has led to increased emissions of pollutants into the atmosphere. The rising levels of pollutants, coupled with the concentration of populations in urban centers, highlight the critical need for effective monitoring systems to identify pollution sources, assess air quality, and implement mitigation measures.**

3. **Environmental Awareness and Sustainable Development: Growing global awareness of environmental issues and the importance of sustainable development has fueled the motivation to implement technologies that promote cleaner air. IoT-based systems provide a means to gather comprehensive data, facilitating informed decision-making for policymakers, environmental agencies, and communities striving to reduce their ecological footprint.**

4. **Data-Driven Decision-Making: Traditional air quality monitoring methods often involve periodic measurements at fixed locations, providing limited and static data. The motivation behind IoT-based systems lies in the ability to collect real-time, high-resolution data from a network of sensors distributed across diverse geographical areas. This dynamic and continuous data flow**

enables more accurate analysis and informed decision-making for pollution control strategies.

5. **Regularity Compliance and Accountability: Governments and regulatory bodies are increasingly recognizing the importance of enforcing air quality standards to protect public health and the environment. The motivation behind IoT-based air quality sensing and monitoring systems is aligned with the need for accurate, reliable data to ensure regulatory compliance and hold accountable those responsible for excessive emissions.**

1.2 Objectives

Develop a network of IoT-enabled air quality sensors capable of measuring key pollutants such as particulate matter (PM), nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon monoxide (CO), and ozone (O3). Implement a centralized server for data aggregation, processing, and analysis. Design a user-friendly interface, accessible through web or mobile applications, to provide real-time air quality information to the public. Explore applications for the collected data in health research, urban planning, and environmental policy-making.

1.3 Literature Survey

1. **Implementation of a WiFi based Plug and Sense Device for Dedicated Air Pollution Monitoring using IoT : The article discusses the implementation of a WiFi-based smart device for dedicated air pollution monitoring using the Internet of Things. The device measures various air pollutants and calculates the air quality index (AQI) using a linear segmented principle. The AQI is then used to actuate LEDs for indication and display precaution messages. The data is pushed to a cloud storage platform for future analysis, and real-time pollution levels can be visualized using an Android app.**

2. **Real Time Air Quality Monitoring : The main objective of the proposed system is to build a low-cost system that monitors real-ti2me air quality levels at a micro scale. This is achieved by designing a measuring device that is mobile, allowing data to be captured on a micro scale at any desired location. The system aims to address the limitations of fixed air quality stations by providing real-time air quality data at a more localized level.**

3. **IoT based Air Quality Index Monitoring using ESP32 : The main objective of the paper is to propose a model for an IoT-based Air Quality Index Monitoring System using the ESP32 microcontroller. The system aims to continuously measure, analyze, and monitor the air quality in real-time, specifically focusing on parameters such as PM2.5, Carbon monoxide (CO), Carbon dioxide (CO2), temperature, and humidity. The goal is to provide a platform for users to be informed about the concentration of harmful gases in the air and take appropriate measures when needed. Additionally, the paper emphasizes the use of IoT to make the air quality data accessible to users through an IoT platform, ThingSpeak, and to trigger alerts, such as a buzzer, when the concentration of Carbon dioxide exceeds a certain threshold.**

1.4 Problem statement

Develop an iot based air quality sensing and monitoring

1.5 Applications in Societal Context

The development of a Air Quality sensing and monitoring for various societal applications:

(a) **Early Warning Systems for Health Protection: IoT-based air quality monitoring systems serve as early warning systems, providing real-time data on pollutant levels. This information enables communities to take immediate measures to protect public health. Vulnerable populations, such as individuals with respiratory conditions, can receive timely alerts and adjust their activities to minimize exposure during periods of poor air quality.**

(b) **Public Spaces: Municipalities can install these devices in public spaces to monitor air quality levels, addressing environmental concerns. Citizens can be informed about the air quality in their locality, fostering a sense of environmental responsibilit**

(c) **Workplaces: Offices can deploy this system to ensure a healthy workspace for employees, contributing to their well-being and productivity. Employers can demonstrate their commitment to a sustainable and healthy work environmen.**

(d) **Educational Institutions: Schools and universities can implement this system to create awareness among students about the importance of air quality. Educators can use the data for educational purposes and teach students about environmental science and technology.**

(e) **Indoor Air Quality Monitoring in Homes: Individuals can use this system to monitor the air quality inside their homes, ensuring a healthy living environment. It helps in identifying and mitigating factors that may contribute to poor indoor air quality.**

(f) **Emergency Response and Disaster Management: During environmental incidents such as wildfires or industrial accidents, IoT-based air quality monitoring becomes crucial for emergency response efforts. Rapid identification of pollution sources and the dissemination of real-time data aid authorities in making timely decisions to protect public safety, evacuate affected areas, and allocate resources effectively.**

1.6 Project Planning and Bill of materials

1.6.1 Project Overview:

- **Objectives and Goals:**The objective and goals of an IoT-Based Air Quality Sensing and Monitoring System using the Blynk app are centered around environmental awareness, public health improvement, and data-driven decision-making.

- **Significance:** By raising awareness about air quality conditions, the system promotes a better understanding of the environmental impact of pollutants. This awareness can lead to increased advocacy for sustainable practices and policies to mitigate pollution.

1.6.2 Project Scope:

- **Functionalities and Features:**Develop a user-friendly interface on the Blynk app.
- **Exclusions:** IoT-Based Air Quality Sensing and Monitoring System using the Blynk app, that would depend on the specific requirements of the project and the goals you aim to achieve.

1.6.3 Project Timeline:

- **Key Milestones:**
  - Data Collection
  - Preprocessing
  - Model Development
  - Testing and Evaluation
  - Deployment
- **Visual Representation:** Gantt chart illustrating the timeline for each phase.

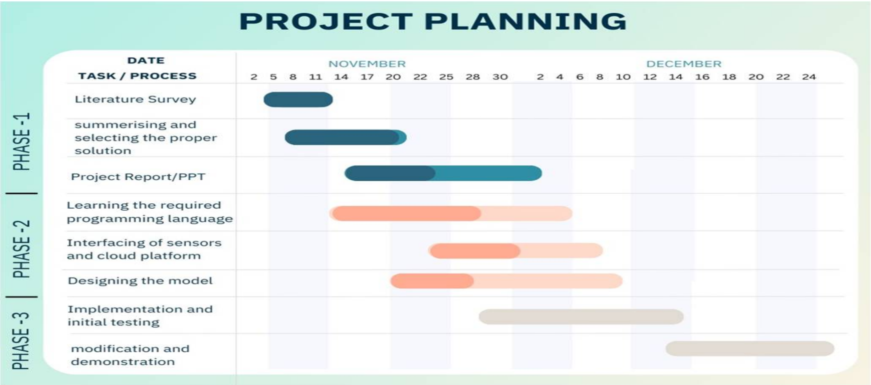

Figure 1.1: Timeline of the project

1.6.4 Resources Needed:

- **Components:**
  1. ESP8266 (NodeMCU)
  2. DHT11 Temperature and Humidity Sensor
  3. MQ135 Gas Sensor
  4. I2C Converter
  5. Blynk Application

S.N.	Components Name	Quantity	Cost (in Rs)
1	NodeMCU ESP8266	1	320
2	Connecting Wires	10	30
3	Breadboard	1	100
4	MQ-135 Air Quality Sensor	1	240
5	DHT11 Sensor	1	160
	Total Cost		850

Figure 1.2: Bill of Materials

1.7 Bill of Materials(BOM):

1.8 Organization of the report

1.8.1 System Design

The system design of the IoT-Based Air Quality Sensing and Monitoring System using the Blynk app is meticulously crafted to provide an efficient and user-friendly solution for real-time environmental monitoring. At its core, the microcontroller, equipped with air quality sensors, serves as the central processing unit, responsible for collecting and analyzing data. The inclusion of a Wi-Fi module facilitates seamless communication between the microcontroller and the Blynk app, enabling users to access real-time air quality information remotely. The Blynk app acts as the user interface, offering an intuitive platform for data visualization, customization of alert thresholds, and interaction with the monitoring system. The system's architecture ensures a continuous flow of data, from sensor readings to the Blynk app, providing users with immediate updates on air quality conditions. Security measures, including end-to-end encryption and user authentication, safeguard the integrity and confidentiality of the transmitted data. Sustainable practices, such as solar panels and rechargeable batteries, contribute to the system's energy efficiency and environmental sustainability.

1.8.2 Implementation details

The implementation design of the IoT-Based Air Quality Sensing and Monitoring System using the Blynk app involves a step-by-step integration of hardware and software components to create a robust and user-friendly solution. Initially, the microcontroller, equipped with air quality sensors, is configured to continuously collect data on pollutants such as CO2, CO, NO2, as well as temperature and humidity. The integration of a Wi-Fi module, typically the ESP8266, facilitates wireless communication, allowing the microcontroller to transmit processed sensor data to the Blynk Cloud server. In parallel, the Blynk app is configured with appropriate widgets to display air quality parameters and enable user interaction. Virtual pins are assigned to relay sensor data from the microcontroller to the

Blynk app. The alerting system is implemented within the microcontroller, monitoring processed data against predefined thresholds and triggering notifications on the Blynk app when air quality exceeds safe levels.

Chapter 2

System design

In this Chapter, we list out the interfaces.

2.1 Functional block diagram

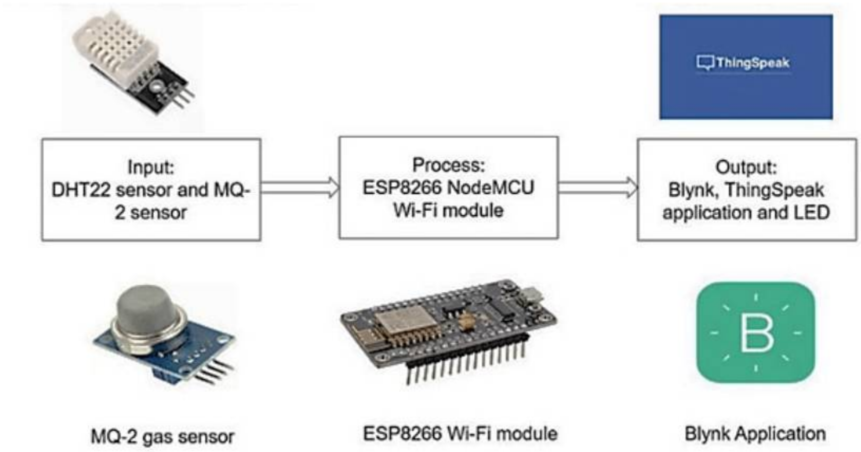

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Figure 2.1: Functional Block Diagram of the project

2.2 Design Alternatives

- **Blynk Alternatives:**
- Instead of Blynk, consider using platforms like ThingSpeak, Cayenne, or Adafruit IO for data visualization
- **Additional Sensors:**
- Depending on specific requirements, add sensors like PM2.5/PM10 sensors for particulate matter measurement.
- **Power Supply:**
- Use a solar panel and rechargeable battery for power in remote locations

2.3 Final Design

The final design of an IoT-Based Air Quality Sensing and Monitoring System using the Blynk app involves integrating various components for effective air quality monitoring. Below is the architecture and key components of the final design:

2.3.1 Microcontroller/Node:

NodeMCU or ESP32 serves as the main processing unit. Connects to various sensors and manages data processing. Air Quality Sensors:

2.3.2 Air Quality Sensors:

MQ series sensors for detecting CO2, CO, and NO2 levels. DHT22 sensor for measuring temperature and humidity.

2.3.3 Wi-Fi Module:

ESP8266 for wireless communication and connection to the Blynk Cloud server.

2.3.4 Internet Connectivity:

Reliable internet connectivity through Wi-Fi for data transmission. Data Processing

2.3.5 End-to-end encryption

To secure data during transmission. User authentication to control access to the Blynk app.

Chapter 3

Implementation details

3.1 Specifications and final system architecture

3.1.1 Specifications

- **ESP8266 Microcontroller:**
  - Utilize the ESP8266 for Wi-Fi connectivity and as the main control unit. Choose a suitable ESP8266 module, such as NodeMCU or Wemos D1 Mini
- **DHT11 Temperature and Humidity Sensor:**
  - Integrate the DHT11 sensor to monitor ambient temperature and humidity levels.
- **ESP8266 Microcontroller:**
  - Integrate the DHT11 sensor to monitor ambient temperature and humidity levels.
- **MQ135 Gas Senso:**
  - Implement the MQ135 sensor to detect various gases, including carbon dioxide (CO2), ammonia, methane, and smoke.
- **Blynk IoT Platformr:**
  - Use the Blynk app to create a user-friendly interface for real-time monitoring and contro

3.1.2 Final System Architecture

- **Hardware Components**:

  ESP8266 NodeMCU (Microcontroller with Wi-Fi capabilities) DHT11 (Temperature and Humidity Sensor) MQ135 (Gas Sensor for CO2 and other pollutants) Power Supply (USB power or external power source)
- **Circuit Connection**:

  Connect DHT11 and MQ135 to the ESP8266 NodeMCU using appropriate pins. Power the components and the NodeMCU using a suitable power supply.

- **Firmware Development**:

  Arduino IDE for programming the ESP8266.Libraries for ESP8266 WiFi, DHT, Adafruit MQ135, and Blynk. Write firmware code to read sensor data and send it to the Blynk server.

  - **Blynk Integration**:

    Blynk app for real-time monitoring and control. Blynk cloud server for communication between the hardware and the app. Widgets in the Blynk app for displaying sensor data (Value Display, Gauge, Super Chart, etc.). Blynk authentication token for secure communication.

  - **Cloud Integration**:

    Optionally, use additional cloud platforms for data storage and historical analysis. Cloud platform can receive data from the Blynk server or directly from the hardware.

  - **Security Measures**:

    Secure handling of Wi-Fi credentials and Blynk authentication token in firmware. Secure communication between the hardware and the Blynk cloud server.

This architecture provides a comprehensive solution for monitoring air quality in real-time, allowing users to access data remotely and potentially analyze historical trends. Customize the system based on specific requirements and preferences, and consider additional features such as data logging, visualization, and integration with other cloud platforms if needed.

3.2 Algorithm

1. **Hardware Setup:**
   - Connect the ESP8266 NodeMCU, DHT11, and MQ135 on a breadboard. Power up the components using a suitable power supply.
2. **Install Software:**
   - Install the Arduino IDE on your computer.
3. **Install Libraries:**
   - Install the necessary libraries for ESP8266, DHT11, MQ135, and Blynk in the Arduino IDE.
4. **Create Blynk Project:**
   - Open the Blynk app and create a new project.
   - Obtain the Blynk authentication token for your project.
5. **Write Firmware Code:**
   - Open the Arduino IDE and write a firmware code for ESP8266.
   - Include libraries for ESP8266 WiFi, DHT, Adafruit MQ135, and Blynk.
   - Set up Wi-Fi credentials and Blynk authentication token.
   - Read data from DHT11 and MQ135 sensors.
   - send sensor data to Blynk server.
6. **Configure Blynk Widgets:**
   - the Blynk app, add widgets such as Value Display, Gauge, or Super Chart for temperature, humidity, and CO2 concentration.

- Map the widgets to the corresponding virtual pins in the Blynk app.

7. **Upload Firmware:**
   - Connect the ESP8266 to your computer.
   - Upload the firmware code to the ESP8266 using the Arduino IDE.
8. **Power On the System:**
   - Power on the ESP8266 system with connected sensors.
9. **Monitor Sensor Data:**
   - Open the Blynk app and start monitoring real-time sensor data.
10. **Cloud Integration:**
    - If desired, integrate the system with additional cloud platforms for data storage and analysis.
11. **Alerts and Notifications:**
12. Configure Blynk app to send alerts or notifications based on predefined thresholds for air quality parameters.

3.3 Flowchart

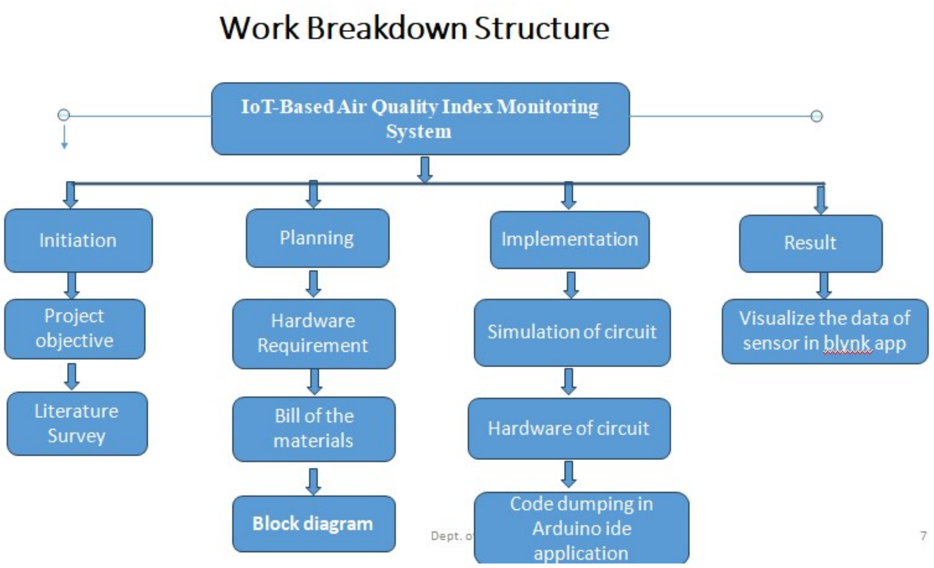

Figure 3.1: Flowchart of the project

Chapter 4

Optimization

4.1 Introduction to optimization

ESP8266 Microcontroller: The ESP8266 microcontroller serves as the brain of the system, providing connectivity and processing capabilities. Its low-cost, low-power consumption, and built-in Wi-Fi functionality make it an ideal choice for IoT applications.

DHT11 Sensor: The DHT11 sensor measures temperature and humidity with high accuracy. These parameters are crucial in assessing air quality as they directly impact human comfort and well-being. Real-time monitoring of temperature and humidity enables a comprehensive understanding of the environmental conditions

MQ135 Sensor: The MQ135 sensor is employed to measure various air quality parameters, including carbon dioxide (CO2), ammonia (NH3), methane (CH4), and other harmful gases. Monitoring these pollutants is essential for evaluating indoor and outdoor air quality, ensuring a safe and healthy environment.

Blynk Platform: Blynk serves as the cloud-based platform for data visualization and control. It enables users to remotely monitor air quality parameters and receive alerts when predefined thresholds are exceeded. The intuitive Blynk mobile app provides a user-friendly interface for interacting with the system

- **Optimization Strategiess:**
- Energy Efficiency: Implementing sleep modes and optimizing the power consumption of the ESP8266 ensures prolonged device operation, particularly in scenarios where continuous monitoring is critical
- By setting threshold values for air quality parameters, the system can send immediate alerts when pollution levels reach critical points. This ensures timely response and intervention.
- Remote Calibration: The ability to remotely calibrate sensors ensures accuracy and reliability over time, as environmental conditions may change. This feature allows for adaptive optimization of the monitoring system.
- Data Transmission Optimization: Efficient data transmission protocols and strategies, such as data compression and sending only relevant information, reduce the load on the network and enhance the responsiveness of the system

4.2 Types of Optimization

4.2.1 Power Optimization:

- Implement sleep modes on the ESP8266 to reduce power consumption during idle periods.
- Use low-power modes for sensors when not actively reading data.

4.2.2 Data Optimization:

- Optimize data transmission frequency to Blynk to reduce bandwidth usage and improve energy efficiency..
- Batch sensor readings and send them in a single transmission to reduce overhead.

4.2.3 Sensor Optimization:

- Calibrate the MQ135 sensor regularly to ensure accurate air quality measurements.
- Implement a calibration routine that adapts to environmental changes.

4.2.4 Security Optimization:

- Secure communication between the ESP8266 and the Blynk server using secure protocols
- Secure the Wi-Fi connection with strong encryption to prevent unauthorized access.

4.2.5 Power Consumption Optimization:

- Use low-power components where possible.
- mplement sleep modes on the ESP8266 to conserve power when not actively collecting or transmitting data.

4.3 Selection and justification of optimization method

In IoT applications, optimization is crucial for efficient resource utilization, power consumption, and response time. One common optimization technique is to implement sleep modes for the ESP8266. This is especially important in battery-powered applications to conserve energy

4.3.1 Selection of Algorithmic Optimization

Optimizing the algorithm for this air quality monitoring system involves efficient use of resources and improving the accuracy of sensor readings. Consider the following optimization techniques:

- **Sensor Calibration:** Calibrate the MQ135 sensor for accurate air quality readings. Calibration involves measuring known concentrations of gases and adjusting the sensor readings accordingly.
- **Data Filtering:** Implement data filtering techniques to reduce noise in sensor readings. Techniques like moving average or Kalman filtering can be applied to smooth out the data.

- **Dynamic Sampling:** Adjust the sensor sampling rate dynamically based on the detected changes in air quality. Increase the sampling frequency during periods of potential pollution.
- **Sleep Mode:**Use sleep mode on the ESP8266 between readings to conserve power, especially if the system doesn't need to operate continuously.

4.3.2 Justification

Algorithmic optimization is justified based on the specific requirements and characteristics of the Air quality monitoring project:

- **Cost-effectiveness:**Minimizing data transmission helps reduce potential costs associated with data plans or cloud services, making the system more affordable in the long run.
- **Sustainability:** Lower power consumption contributes to a more sustainable solution, prolonging the lifespan of battery-powered devices and reducing environmental impact.
- **User Experience:** Code efficiency and fault tolerance contribute to a smoother and more reliable user experience, enhancing the overall usability and accessibility of the air quality monitoring system.

Algorithmic optimization is a strategic choice to enhance the overall performance and responsiveness of the aligning with the project's objectives and requirements.

Chapter 5

Results and discussions

5.1 Result Analysis

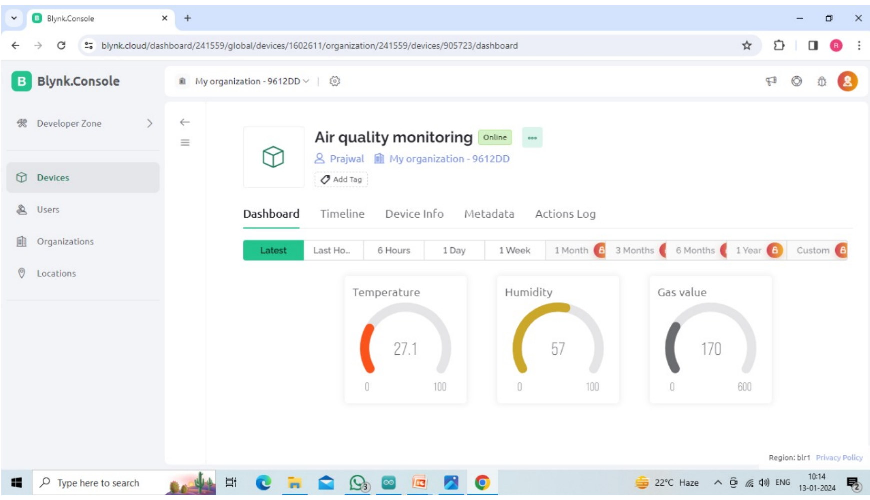

Figure 5.1: Output

The system will continuously monitor temperature, humidity, and air quality and the Blynk app will display real-time data on your mobile device. We can set thresholds in the code and use notifications in the Blynk app to alert you when air quality exceeds predefined limits.

5.1.1 Performance Metrics

- **Data Accuracy:** Measure the accuracy of temperature and humidity readings compared to a calibrated reference.Validate air quality data from the MQ135 sensor against known pollutant levels
- **Data Transmission:** Evaluate the speed and reliability of data transmission to the Blynk server.Check for data loss during transmission.
- **Response Time:** Measure the time taken from data collection to its display on the Blynk app
- **Power Consumption:** Monitor the power consumption of the ESP8266 and optimize for energy efficiency.

- **Sensor Calibration:**Determine the accuracy of the sensors over time and calibrate as needed

5.1.2 User Feedback Analysis

Positive Feedback :

Real-time Monitoring: Users appreciate the ability to monitor air quality in real-time through the Blynk app, allowing them to make informed decisions about their environment

Alert Notifications: Users value the alert feature that notifies them when air quality levels are beyond acceptable limits.

Negative Feedback :

Connectivity Issues: Some users may experience occasional connectivity issues between the NodeMCU and the Blynk app, leading to disruptions in data updates.

Sensor Calibration Challenges: Calibrating the MQ135 sensor for accurate air quality readings may pose challenges for some users, resulting in potential inaccuracies in the dat

5.2 Discussion on optimization

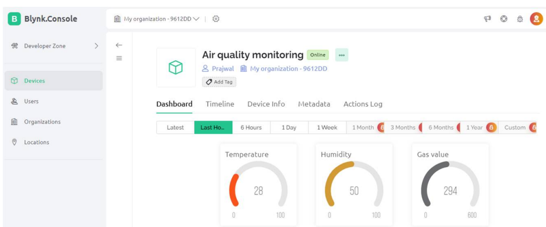

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Figure 5.2: Pre optimization

5.2.1 Pre-Optimization

During this phase the Gas value was above 300 But the ideal gas value ranges below 200.

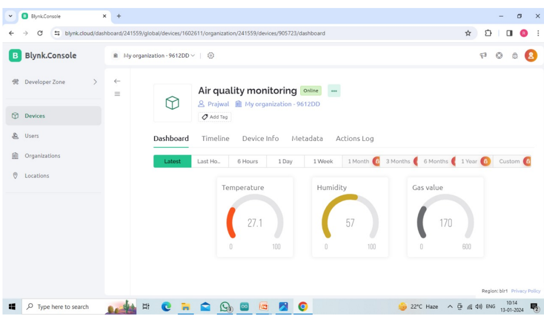

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Figure 5.3: Post optimization

5.2.2 Post-Optimization

After Optimization we got the Accurate Gas value that is below 200. By changing the Threshold value and gas range in the code.

Chapter 6

Conclusions and future scope

6.1 Conclusion

The air quality sensing and monitoring project helps us keep track of how clean or polluted the air around us. By using special sensors that measure different pollutants, we can gather information about the quality of the air in real-time. This data is important because it allows us to understand the levels of pollution and make decisions to improve air quality. The project helps communities, governments, and scientists work together to ensure that the air we breathe is healthy and safe for everyone.

6.2 Future Scope

The future scope of this project involves:

1. **Real-time Monitoring::** IoT enables real-time data collection and transmission, allowing for immediate detection and response to changes in air quality. This is crucial for addressing pollution events promptly.

2. **Data Accuracy and Precision:** IoT sensors provide high precision and accuracy in measuring various air pollutants. This ensures reliable data for assessing air quality, aiding in effective decision-making.

3. **Wide Coverage and Accessibility:** The scalability of IoT allows for the deployment of sensors across a wide geographical area, providing comprehensive coverage.This ensures that even remote or less populated areas can be monitored for air quality.

4. **Integration with Smart Citie:** By analyzing historical data, IoT systems can predict trends and patterns in air quality. This predictive capability can help in planning interventions and implementing preventive measures to manage air quality effectively.

5. **Public Awareness and Engagement:** IoT-based air quality monitoring systems can facilitate public access to real-time air quality data. This information can be used to raise awareness among citizens, encouraging them to take actions to improve air quality collectively.

In conclusion, the future scope of IoT-based air quality sensing and monitoring is promising, offering solutions for environmental sustainability, public health improvement, and smart city development

Bibliography

[1] Joy Dutta, Firoj Gazi, Sarbani Roy, Chandreyee Chowdhury,R.K. Ganti, F. Ye, H. Lei, Mobile Crowd-Sensing: Current State and Future Challenges", IEEE Communications Magazine, vol. 49, no. 11,pp. 32-39, Nov.2011.

[2] ThingSpeak: "IoT Analytics – ThingSpeak Internet of Things", [Online].Available: https://thingspeak.com/ Electr. Eng., 2015.

[3] Rawal R. Air Quality Monitoring System. International Journal of Computational Science and Engineering. 2019

[4] Ali, Hassan , Soe, J. and Weller, Steven. (2015). A real-time ambient air quality monitoring wireless sensor network for schools in smart citie

[5] 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