Summer Training Report

on

Drone for Air pollution monitoring and Control

Submitted in partial fulfillment of the

requirements for the completion of one month's summer internship/training
ART 355

Name: Mayank Sharma

Enrollment Number: 08119012022

Under the supervision of

Mr. Sourabh Anand

UNIVERSITY SCHOOL OF AUTOMATION AND ROBOTICS
GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
EAST DELHI CAMPUS, SURAJMAL VIHAR, DELHI- 110032

Certificate by AICTE Idea Lab GGSIPU

GGSIPU/IDEA Lab/Summer/2024/ 60

AICTE IDEA Lab

&

University School of Information, Communication & Technology
Guru Gobind Singh Indraprastha University
Sector-16C, Dwarka, New Delhi - 110 078
https://ggsipu-idealab.tech/

Summer Internship 2024

ज्योतिर्वृणीत तमसो विजानन

INDRAPRASTHA UNIVERSITY

AICTE

All India Council for Technical Education

AICTE IDEALab

Certificate of Completion

This is to certify that Mr. Mayank Sharma Student of USAR, GGSIPU has successfully completed a Six week Summer Internship Programme 2024 held at AICTE IDEA Lab-GGSIPU during 24 June To 02 August 2024.

The Title of Project work : Drone for Air Pollution Monitoring and Control

Dr. Ruchi Sehrawat
Co-Ordinator, AICTE IDEA Lab-GGSIPU
GGSIP University, New Delhi

Dr. Manoj Kumar Satyarthi
Co-Ordinator, AICTE IDEA Lab-GGSIPU
GGSIP University, New Delhi

Prof. Amit Prakash Singh
Chief Mentor, AICTE IDEA Lab-GGSIPU
GGSIP University, New Delhi

AICTE IDEALab

Prof. Anjana Gosain
Dean, USIC&T
GGSIP University, New Delhi

DECLARATION

I hereby declare that the Summer Training Report entitled **Drone for Air Pollution Measurement and Analysis** is an authentic record of work completed as requirements of Summer Training (ART 355) during the period from 24/06/2024 to 02/08/2024 in **AICTE IDEA Lab-Guru Gobind Singh Indraprastha University New Delhi - 110078** under the supervision of **Mr. Sourabh Anand .**

(Signature of student)

Mayank Sharma
08119012022

Date: ______________________

(Signature of Supervisor)

Mr. Sourabh Anand

Date: ______________________

Acknowledgement

I would like to express my deepest gratitude to everyone who supported and guided me throughout the course of my summer internship. This project would not have been possible without their invaluable assistance and encouragement.

Firstly, I would like to thank my project mentor, **Mr. Sourabh Anand**, for his continuous guidance, patience, and support. His expertise and insights have been instrumental in the development and success of this project. His willingness to share his knowledge and provide constructive feed-back has greatly enriched my learning experience.

I would also like to extend my gratitude to **Prof. Amit Prakash Singh, Chief Mentor of the AICTE Idea Lab**, for his invaluable support and mentorship throughout the project. His guidance and encouragement have been crucial in navigating the challenges faced during the project, and his dedication to fostering innovation and learning has been truly inspiring.

I am also grateful to the **AICTE IDEA Lab at Guru Gobind Singh Indraprastha University, E-Block, Sector-16C, Dwarka, New Delhi - 110078**, for providing me with this wonderful opportunity and the necessary resources to carry out my project. The supportive and stimulating environment has been conducive to my academic and personal growth.

I would like to extend my heartfelt gratitude to the members of my team: **Hrritwick Roy** from USICT, GGSIPU; **Dhimant Tewari** from VIT Vellore; **Gaurav Raj, Ravi, Muskan, Chayan Khetan** from MAIT, GGSIPU; **Vanshika Mishra** and **Dipti Singh** from USAR, GGSIPU,EDC, for their unwavering support and collaborative efforts. It has been a rewarding experienceto collaborate with each and every one of you.

My sincere thanks to **Prof. Arvinder Kaur**, my dean, for her encouragement and support. Her leadership and dedication have been a great source of inspiration throughout my internship.

I would like to express my heartfelt gratitude to my internal mentor, **Dr. Anshul Bhatia** , for his support and guidance throughout the project. His insights and advice were invaluable to the successful completion of my work.

Special thanks to my colleagues and fellow interns for their camaraderie and collaboration. The discussions and brainstorming sessions we had were invaluable in overcoming challenges and achieving our goals.

Lastly, I would like to thank my family and friends for their unwavering support and encouragement throughout my internship. Their belief in me has been a source of motivation and strength.

Thank you all for your contributions and support.

Contents

About AICTE Idea Lab GGSIPU

Mission and Values:

AICTE-IDEA (Idea Development, Evaluation and Application) Labs are being established across the country for encouraging students for application of science, technology engineering and mathematics (STEM) fundamentals towards enhanced hands-on experience, learning by doing and even product visualization. As a common facility embedded in the University, the IDEA Lab will make engineering graduates more imaginative and creative, besides getting basic training in the 21st century skills like- critical thinking, problem solving, design thinking, collaboration, communication, lifelong learning etc. IDEA Lab can empower the students and faculty to "engage, explore, experience, express and excel", addressing the need of new age learning. IDEA Lab would serve as an infrastructure for faculty to take up and promote multidisciplinary education and research.

Accordingly, faculty would be encouraged to get trained in these Labs and strive for creating problems/ projects/ internships in their own subjects/ disciplines and mentor the students.

Lab Facility: At AICTE IDEA Lab-GGSIPU, we are committed to advancing knowledge and driving innovation in a variety of fields. Our research programmes are focused on addressing some of the world's most pressing challenges and our students have the opportunity to work alongside faculty members on cutting-edge research projects.

List of Tables

List of Figures

Chapter 1

Abstract

Industrial pollution poses a critical threat to environmental health and human well-being, demanding effective monitoring and control measures. Traditional methods often struggle to provide real-time data and incur high operational costs. This project introduces the Industrial Pollution Under Control Drone system, designed to autonomously monitor pollution levels in industrial areas.

The Drone system integrates advanced drone technology with specialized sensors to achieve real-time monitoring of pollutants. It features a robust drone platform comprising four brushless DC (BLDC) motors, high-efficiency propellers, and a KK2.1.5 flight controller for stable navigation. A durable carbon fiber or plastic frame ensures resilience in industrial environments, supported by a Lithium-Polymer (Li-Po) battery for extended operational capability.Key sensors include the MiCS-2714 for nitrogen dioxide (NO2), MQ-135 for ammonia, sulfur, benzene, and smoke detection, and MQ-2 for combustible gases such as methane and propane. These sensors interface with an Arduino Uno microcontroller and a NodeMCU for data processing and transmission. Software components include data acquisition and real-time processing software to manage sensor data effectively. The system aims to provide accurate pollution data in real-time, aiding in regulatory compliance and proactive pollution control efforts.

The project emphasizes seamless hardware integration and deployment, with rigorous testing and calibration protocols to ensure reliable operation. By leveraging drone technology, the Drone system aims to enhance pollution monitoring efficiency, facilitate timely interventions, and contribute to environmental sustainability. In conclusion, the Drone system represents a significant advancement in industrial pollution monitoring, offering a cost-effective and scalable solution to mitigate environmental risks and safeguard public health.

Chapter 2

Introduction

Industrial activities play a pivotal role in economic development worldwide, driving innovation and prosperity. However, the consequential environmental impact of industrial operations, particularly in terms of pollution, poses significant challenges to sustainability and public health. Emissions of harmful pollutants such as particulate matter, volatile organic compounds (VOCs), nitrogen oxides (NOx), sulfur dioxide (SO2), and carbon monoxide (CO) from industrial sources contribute to air pollution, posing serious health risks and environmental degradation.

Conventional methods of monitoring industrial pollution typically involve stationary monitoring stations and periodic inspections, which often fail to provide real-time data necessary for proactive management and immediate intervention. This limitation underscores the critical need for innovative solutions that can enhance the efficiency, accuracy, and timeliness of industrial pollution monitoring.

The Industrial Pollution Under Control Drone system represents a groundbreaking approach to address these challenges. By harnessing the capabilities of unmanned aerial vehicles (UAVs) and advanced sensor technology, the Drone system is designed to autonomously navigate industrial environments, collecting comprehensive data on pollution levels in real-time. This capability enables continuous monitoring of pollutant emissions from various sources within industrial complexes, providing stakeholders with timely and actionable insights.At the heart of the Drone system lies a robust hardware architecture tailored for industrial applications. The drone is equipped with four brushless DC (BLDC) motors and high-efficiency propellers, ensuring efficient propulsion and maneuverability. A KK2.1.5 flight controller provides precise navigation and stabil- ity, essential for safe operation in dynamic industrial settings. The drone's frame, crafted from lightweight yet durable materials such as carbon fiber or high-strength plastic, ensures resilience against environmental stressors like temperature variations and dust.

Sensor integration is pivotal to the Drone's functionality, with key sensors including the MiCS-2714 for detecting nitrogen dioxide (NO2), the MQ-135 for monitoring a wide range of air quality parameters including ammonia, sulfur, benzene, and smoke, and the MQ-2 for detecting combustible gases like methane and propane. These sensors, interfaced with microcontrollers such as Arduino Uno and NodeMCU, facilitate real-time data acquisition, processing, and transmission.

The software ecosystem supporting the Drone system is equally sophisticated, encompassing data acquisition software for interfacing with sensors, real-time data processing algorithms for

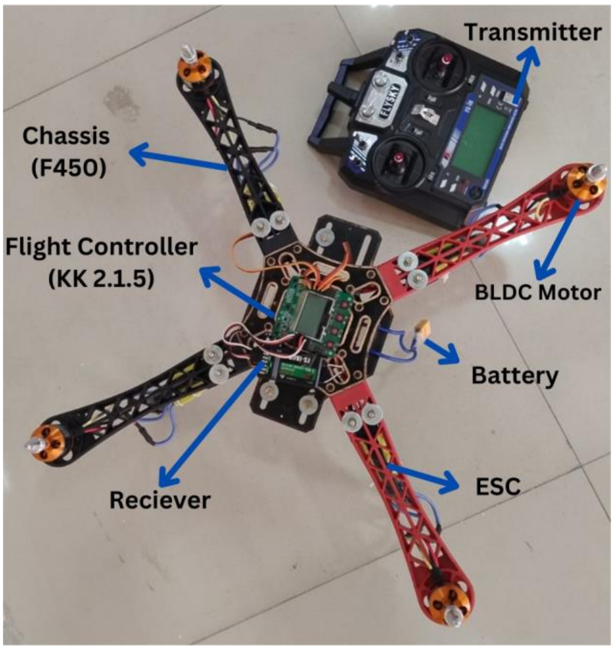

Figure 2.1: Detailed Diagram of Drone

immediate analysis of pollution data, and visualization tools to present actionable insights. A dedicated communication infrastructure enables seamless transmission of data to a central monitoring station, ensuring stakeholders have access to up-to-date pollution information for informed decision-making.

By enhancing the accuracy and efficiency of industrial pollution monitoring, the Drone system aims to achieve several critical objectives. These include facilitating regulatory compliance with environmental standards, enabling proactive pollution control measures, protecting public health by identifying and mitigating pollution hotspots, and contributing to overall environmental sustainability by promoting cleaner industrial operations.

In conclusion, the Drone system represents a transformative advancement in the field of industrial pollution monitoring. By leveraging advanced sensor capabilities, and robust software solutions, this project endeavors to empower industries, regulatory bodies, and communities alike in their efforts to mitigate the adverse effects of industrial pollution and safeguard the environment for future generations.

Chapter 3

Problem Statement

Drone for Air pollution monitoring and Control

Industrial pollution is an escalating global issue that poses significant risks to environmental and public health. The rapid industrialization and urbanization have resulted in increased emissions of pollutants, including particulate matter, volatile organic compounds, nitrogen oxides, sulfur dioxide, and carbon monoxide, among others. These pollutants have far-reaching consequences, affecting air, water, and soil quality, thereby impacting ecosystems and human health.

Traditional methods of monitoring industrial pollution, such as stationary monitoring stations and manual sampling, have several limitations. These methods are often labor-intensive, time-consuming, and expensive, and they provide only limited spatial coverage and temporal resolution. As a result, they fail to offer a comprehensive view of pollution patterns and dynamics, which is crucial for effective pollution control and regulatory compliance.

The limitations of traditional monitoring methods highlight the need for innovative solutions that can provide real-time, accurate, and extensive data on industrial emissions. An autonomous, multi-sensor drone system offers a promising approach to address these challenges. Such a system can enhance pollution monitoring by providing high-resolution spatial and temporal data, enabling more effective identification of pollution sources and hotspots, and facilitating timely interventions.

The development of Drone aims to revolutionize the monitoring and control of industrial pollution. By leveraging advanced drone technology and multi-sensor capabilities, the Drone system can autonomously navigate industrial areas, measure pollution levels, and transmit real-time data to central monitoring stations. This system will significantly improve the efficiency, accuracy, and cost-effectiveness of industrial pollution monitoring, ensuring better environmental compliance and protection.

In summary, the Drone addresses the critical need for a more effective and comprehensive solution to monitor industrial pollution. It aims to overcome the limitations of traditional methods, providing real-time, accurate data to help industries and regulatory bodies mitigate the adverse effects of pollution on the environment and public health.

Chapter 4

Description of Various Training Modules

4.1 Introduction

The successful implementation of our project on drone-based air quality monitoring necessitated a thorough understanding of several technical and non-technical aspects. To equip the team with the required knowledge and skills, various training modules were developed and executed. These modules covered essential areas such as drone technology, sensor integration, data processing, and environmental regulations. This chapter provides a detailed description of each training module.

4.2 Module 1: Drone Technology

4.2.1 Overview

This module introduced the basics of drone technology, including the types of drones, their components, and their applications in different fields.

4.2.2 Key Topics Covered

- Types of Drones: Fixed-wing, Rotary-wing, and Hybrid.
- Drone Components: Frame, Motors, Propellers, Electronic Speed Controllers (ESCs), Flight Controllers, Batteries, and Transmitters/Receivers.
- Principles of Flight: Aerodynamics, Lift, Thrust, Drag, and Weight.
- Assembly and Calibration: Step-by-step guide on assembling a drone and calibrating its components.

4.2.3 Learning Outcomes

By the end of this module, participants were able to:

- Understand the different types of drones and their specific uses.
- Identify and explain the function of each drone component.
- Assemble and calibrate a basic drone.

4.3 Module 2: Sensor Integration

4.3.1 Overview

This module focused on integrating various air quality sensors with drones, including the selection of appropriate sensors, wiring, and coding.

4.3.2 Key Topics Covered

- Sensor Selection: Criteria for choosing sensors based on pollutant types and detection range.
- Common Air Quality Sensors: MiCS-2714 (NO_2), MQ-135 (various pollutants), and MQ-2 (combustible gases).
- Wiring and Connectivity: Connecting sensors to microcontrollers (Arduino Uno, NodeMCU).
- Coding for Data Collection: Writing and uploading code to microcontrollers for sensor data collection and transmission.

4.3.3 Learning Outcomes

By the end of this module, participants were able to:

- Select appropriate sensors for different air quality monitoring needs.
- Connect sensors to microcontrollers and ensure proper data transmission.
- Write basic code for sensor data collection and processing.

4.4 Module 3: Real-Time Data Processing and Transmission

4.4.1 Overview

This module covered real-time data processing techniques and the technologies used for transmitting data from drones to ground control stations.

4.4.2 Key Topics Covered

- Microcontrollers and Microprocessors: Overview of Arduino Uno, NodeMCU.
- Real-Time Data Processing: Techniques and tools for processing data on-the-fly.
- Data Transmission Technologies: Wi-Fi, Bluetooth, and Long-Range (LoRa) communication.
- Integration with Cloud Platforms: Sending data to cloud-based services for storage and analysis.

4.4.3 Learning Outcomes

By the end of this module, participants were able to:

- Understand the capabilities of different microcontrollers and microprocessors for real-time data processing.
- Implement real-time data processing techniques.
- Utilize various data transmission technologies to send data from drones to ground stations or cloud platforms.

4.5 Module 4: Environmental Regulations and Safety

4.5.1 Overview

This module emphasized the importance of adhering to environmental regulations and ensuring safety during drone operations.

4.5.2 Key Topics Covered

- Regulatory Framework: Overview of aviation and environmental regulations applicable to drone operations.
- Safety Protocols: Pre-flight checks, emergency procedures, and safe operation practices.
- Ethical Considerations: Privacy concerns and ethical use of drones for environmental monitoring.
- Case Studies: Examples of successful and failed drone operations due to regulatory and safety issues.

4.5.3 Learning Outcomes

By the end of this module, participants were able to:

- Comply with relevant regulations and obtain necessary permissions for drone operations.
- Conduct safe and ethical drone operations.
- Analyze case studies to understand the importance of regulations and safety in drone-based projects.

4.6 Module 5: Project Management and Documentation

4.6.1 Overview

This module focused on the essential skills required for managing the project efficiently and documenting all stages of the project.

4.6.2 Key Topics Covered

- Project Planning: Setting objectives, timelines, and milestones.
- Resource Management: Allocating resources, budgeting, and managing team roles.
- Documentation: Techniques for documenting project progress, technical details, and findings.
- Presentation Skills: Preparing and delivering project reports and presentations.

4.6.3 Learning Outcomes

By the end of this module, participants were able to:

- Plan and manage the project effectively.
- Allocate and utilize resources efficiently.
- Document the project comprehensively and prepare detailed reports.
- Present project findings clearly and professionally.

4.7 Conclusion

The training modules provided a comprehensive learning experience, equipping the team with the necessary skills and knowledge to successfully implement the drone-based air quality monitoring project. These modules ensured that all aspects of the project, from technical to regulatory, were thoroughly understood and effectively managed.

Chapter 5

Literature Survey

5.1 Introduction

Air pollution remains a significant global challenge, impacting public health, environmental sustainability, and economic development. Traditional methods of air quality monitoring, such as stationary ground-based sensors, often fall short in providing comprehensive, real-time data, especially in industrial areas where pollution sources are dispersed and variable. The integration of drone technology with air quality sensors has emerged as a transformative approach to address these limitations. This literature survey explores the current state of research and technologi- cal developments in using drones for air quality monitoring, highlighting their potential and the challenges that need to be addressed.

5.2 Advances in Drone-Based Air Quality Monitoring

Recent advancements in drone technology have significantly enhanced their application in air quality monitoring. Drones, also known as Unmanned Aerial Vehicles (UAVs), offer several advantages, including mobility, flexibility, and the ability to cover large areas quickly. They can be equipped with a variety of sensors to measure different pollutants, providing real-time data that is crucial for effective environmental management.

5.2.1 Sensor Integration

One of the key technological developments is the integration of miniaturized air quality sensors with drones. Sensors such as MiCS-2714 for nitrogen dioxide (NO_2) detection, MQ-135 for various air pollutants including ammonia, sulfur, benzene, and smoke, and MQ-2 for combustible gases like methane, propane, and butane, have been effectively used in research. These sensors provide accurate and reliable data, essential for monitoring air quality in industrial areas.

5.2.2 Real-Time Data Processing

Another significant advancement is in real-time data processing capabilities. With the use of microcontrollers like Arduino Uno and NodeMCU, drones can process and transmit data instantaneously. This real-time capability is crucial for immediate response and intervention, enabling authorities to take swift actions to mitigate pollution.

5.2.3 Extended Flight Times and Enhanced Stability

The development of high-capacity batteries, such as Lithium-Polymer (Li-Po) batteries, and advanced flight controllers, like the KK2.1.5, have improved the flight times and stability of drones. These advancements allow drones to perform longer missions and collect data over extended periods, enhancing the comprehensiveness of air quality monitoring.

5.2.4 Communication Technologies

Advancements in communication technologies, including Wi-Fi and Bluetooth modules, have facilitated better data transmission and remote control of drones. These technologies enable seamless integration with ground control stations and cloud platforms, ensuring that data is easily accessible for analysis and decision-making.

5.3 Potential of Drone-Based Air Quality Monitoring

The potential of drone-based air quality monitoring lies in its ability to provide high-resolution, spatially distributed data. This capability is particularly valuable in industrial areas where pollution sources are often scattered and traditional monitoring methods are insufficient.

5.3.1 Spatial Coverage

Drones can cover large and difficult-to-reach areas, providing comprehensive spatial coverage that stationary sensors cannot achieve. This ability to map pollution levels across different locations allows for a more detailed understanding of pollution sources and dispersion patterns.

5.3.2 Flexibility and Responsiveness

The flexibility of drones enables them to be deployed quickly in response to pollution incidents. This responsiveness is critical for real-time monitoring and intervention, helping to minimize the impact of pollution on public health and the environment.

5.3.3 Cost-Effectiveness

Compared to the extensive infrastructure required for traditional monitoring networks, drones offer a cost-effective solution. They reduce the need for multiple stationary sensors and associated maintenance, making air quality monitoring more affordable and scalable.

5.4 Challenges and Future Directions

Despite the promising potential, several challenges need to be addressed to fully leverage drone-based air quality monitoring.

5.4.1 Regulatory and Safety Concerns

Regulatory restrictions on drone flights, especially in urban and industrial areas, pose a significant challenge. Ensuring compliance with aviation regulations and addressing safety concerns are critical for widespread adoption.

5.4.2 Data Accuracy and Calibration

Ensuring the accuracy and reliability of sensor data requires rigorous testing and calibration. Drones must be equipped with sensors that can provide precise measurements, and regular calibration protocols are necessary to maintain data integrity.

5.4.3 Battery Life and Flight Duration

Although advancements in battery technology have improved flight times, further improvements are needed to enhance energy efficiency and operational duration. This is particularly important for large-scale monitoring tasks that require extended flight times.

5.4.4 Integration and Scalability

Seamless integration of hardware and software components is essential for the efficiency of drone-based monitoring systems. Additionally, scalable solutions are needed to extend monitoring capabilities to larger areas or multiple sites simultaneously.

5.4.5 Environmental Factors

Drones must be able to operate effectively in various environmental conditions, including extreme weather and varying altitudes. Ensuring the durability and reliability of drones in diverse conditions is crucial for consistent data collection.

5.5 Conclusion

Drone-based air quality monitoring represents a significant advancement in environmental management. The integration of advanced sensors, real-time data processing, and improved communication technologies has enhanced the capabilities of drones to provide comprehensive, real-time data on air pollution levels. While there are challenges to be addressed, including regulatory concerns, data accuracy, and operational efficiency, continued research and technological developments hold the promise of fully realizing the potential of this innovative approach. By leveraging these advancements, drone-based monitoring systems can play a critical role in ensuring regulatory compliance, protecting public health, and promoting environmental sustainability.

Chapter 6

Methodology Adopted

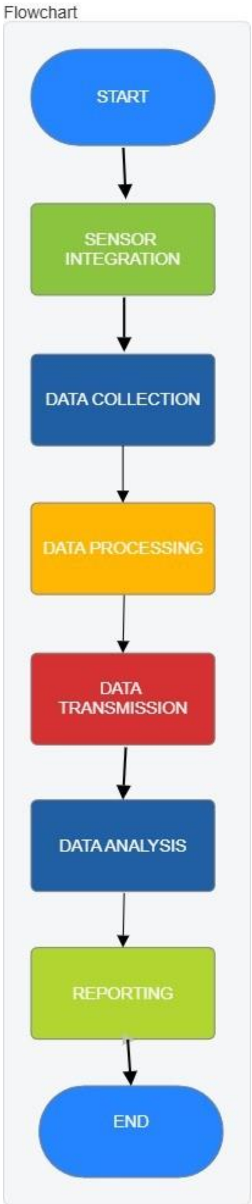

Figure 6.1: Flow Chart

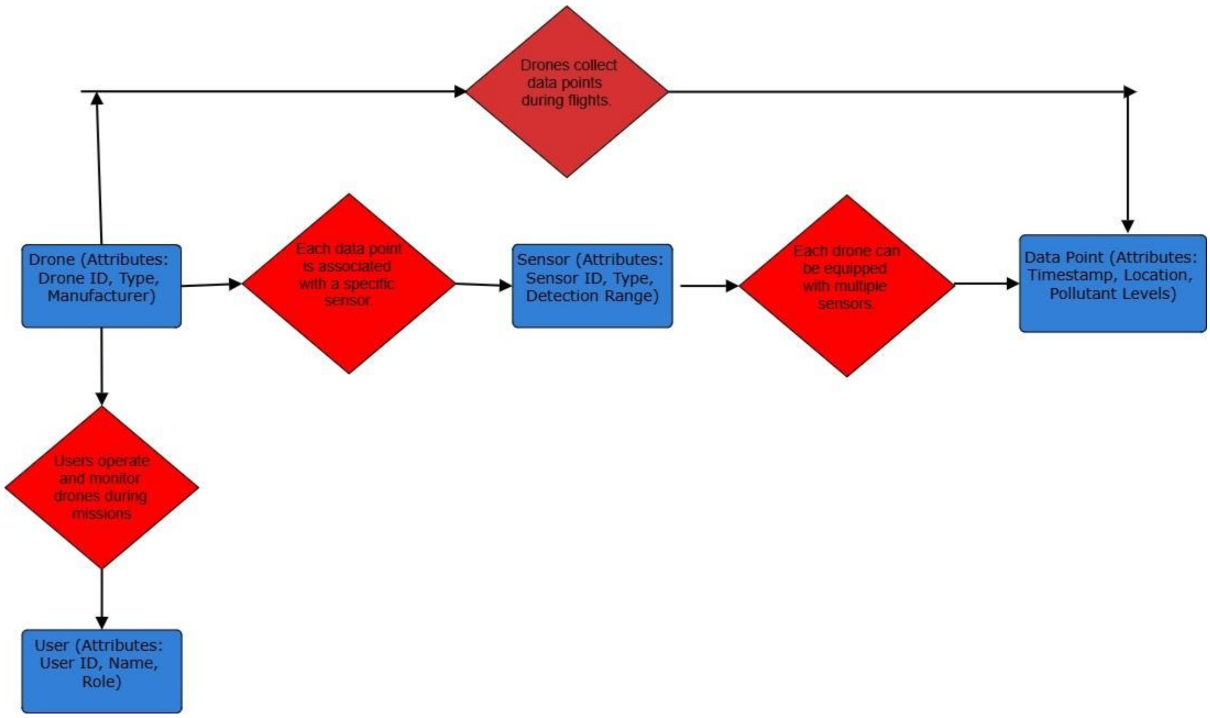

Figure 6.2: Data flow diagram

Chapter 7

Hardware and Software Requirements

7.1 Hardware Requirements

The successful deployment and operation of the Industrial Pollution Under Control Drone system necessitate the integration of various hardware components. These components are crucial for ensuring the drone's functionality, reliability, and efficiency in monitoring industrial pollution. The following sections detail the essential hardware requirements:

1. Drone Platform:

- **Frame:** The drone should have a sturdy and lightweight frame to ensure durability and ease of maneuverability. Carbon fiber or high-strength plastic are preferred materials.
- **Motors and Propellers:**
  - **BLDC Motors:** Four brushless DC (BLDC) motors for efficient and powerful propulsion.
  - **Propellers:** High-efficiency propellers designed to provide optimal lift and thrust.
- **Flight Controller:**
  - **KK2.1.5 Flight Controller:** An advanced flight controller for precise navigation and stability.
- **Battery:**
  - **Lithium-Polymer (Li-Po) Battery:** High-capacity Li-Po battery to ensure extended flight times and reliability in industrial environments.
- **Receiver and Transmitter:**
  - **Radio Receiver and Transmitter:** For remote control and communication with the ground station.
- **Chassis:**
  - **Durable Chassis:** Lightweight and sturdy chassis to house all components securely.

- **Landing Gear:**
  - **Durable Landing Gear:** To protect sensors and other equipment during takeoff and landing.
- **Electronic Speed Controllers (ESC):**
  - **ESC:** Electronic Speed Controllers to regulate the speed and direction of the BLDC motors, ensuring precise control during flight.

2. Pollution Monitoring Sensors:

- **MiCS-2714:** Sensor for detecting nitrogen dioxide (NO2). Its range is 50 ppb to 10 ppm.
- **MQ-135:** Sensor for detecting air quality, including ammonia, sulfur, benzene, and smoke. Range is 10 - 1000ppm.
- **MQ-2:** Sensor for detecting combustible gases such as methane, propane, and butane. Range is 300 to 10000 ppm.
- **Arduino Uno:** Microcontroller for interfacing with sensors and processing data.
- **Breadboard:** For prototyping and connecting sensors.
- **NodeMCU:** Microcontroller with Wi-Fi capabilities for data transmission.

3. Communication Modules:

- **Wi-Fi/Bluetooth Modules:** For short-range communication and easy configuration of the drone.

Table 7.1: Sensor Specifications

Sensor Type	**Measurement Range**	**Dimensions (mm)**	**Power Requirements**	**Applications**
MICS-2714	0-5 ppm NO2	5.08 x 5.08 x 1.55	1.8V to 3.6V, 60 mW	Environmental monitoring, industrial safety
MQ-135	10-1000 ppm (various gases)	16 x 20	5V ± 0.2V, 800 mW	Air quality monitoring, home safety
MQ-2	200-10000 ppm (various gases)	16 x 20	5V ± 0.2V, 800 mW	Gas leak detection, fire detection

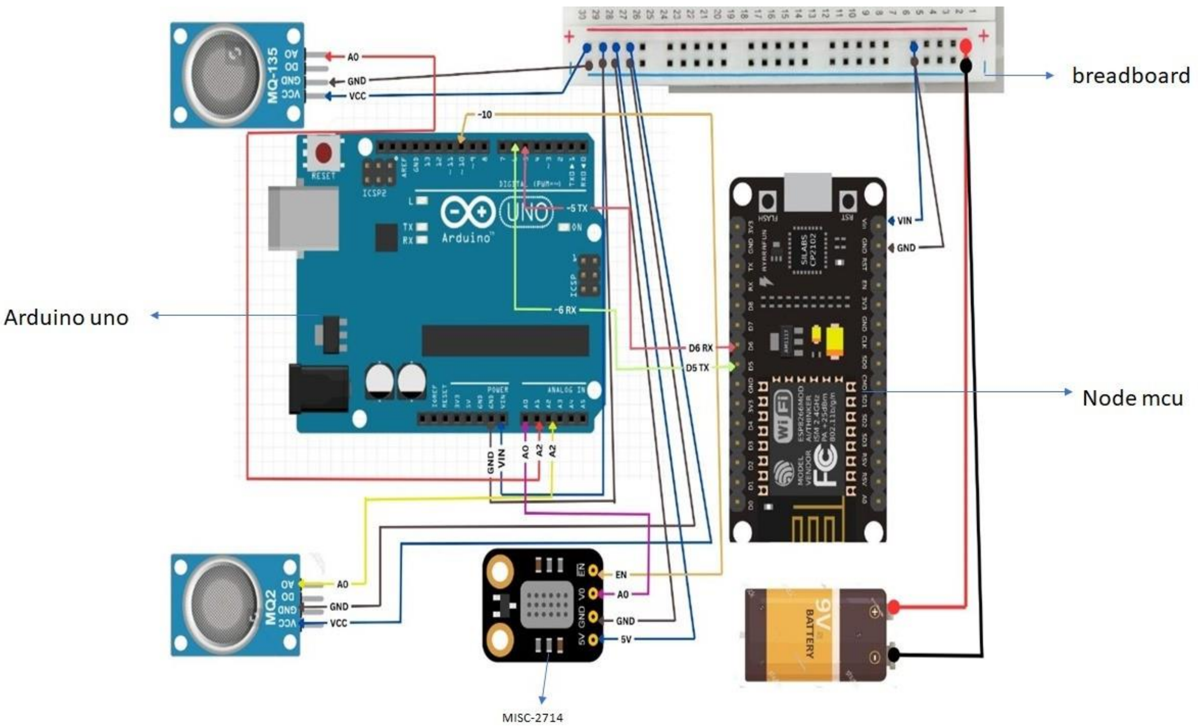

Figure 7.1: Circuit diagram of Sensor Integration

7.2 Software Requirements

The Drone system relies on sophisticated software to control the drone, manage sensor data, and perform real-time analysis. The following sections outline the key software components required for the project:

1. **NodeMCU Firmware:** Runs on the ESP8266 Wi-Fi SoC, enabling it to connect to Wi-Fi and interact with the server.
2. **Arduino IDE:** Used to write and upload the firmware to the NodeMCU.
3. **Sensor Libraries:** For MIC 2714, MQ-2, and MQ-135 sensors, enabling data reading.
4. **Wi-Fi Configuration:** Settings to connect the NodeMCU to a Wi-Fi network.
5. **Web Server:** Receives and stores sensor data from the NodeMCU.
6. **Software Serial Library:** Enables communication between NodeMCU and Arduino.
7. **Arduino Json Library:** Formats and serializes sensor data into JSON for transmission.

7.3 Integration and Deployment

Ensuring seamless integration between the hardware and software components is critical for the success of the Drone system. This involves:

- **Interfacing and Compatibility:** Ensuring all hardware components can interface smoothly with the software systems, including compatibility of communication protocols and data formats.

- **Testing and Calibration:** Rigorous testing and calibration of sensors and systems to ensure accurate data collection and reliable operation.
- **Deployment and Maintenance:** Developing protocols for the deployment, regular maintenance, and troubleshooting of the drone system in industrial environments.

By meticulously specifying and integrating these hardware and software components, the Drone system will be well-equipped to autonomously monitor and control industrial pollution, providing accurate, real-time data to ensure compliance with environmental regulations and protect public health and the environment.

Chapter 8

Snapshot/Screenshots

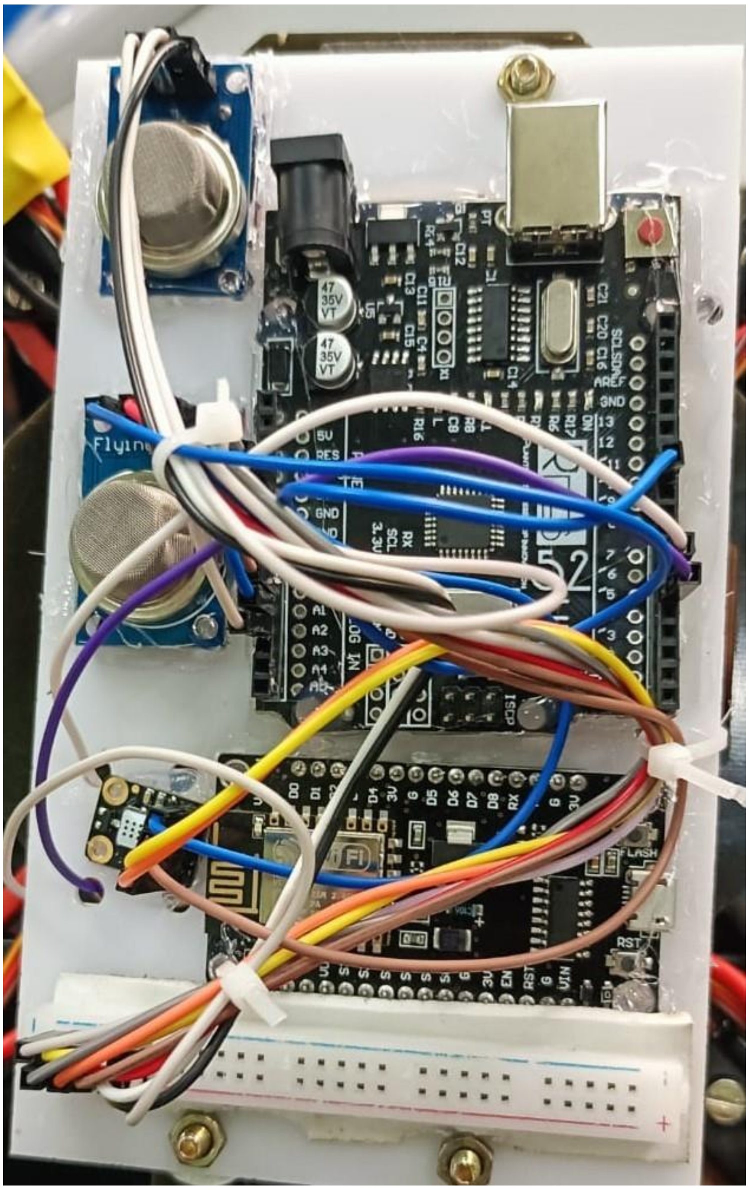

Figure 8.1: Base Board of Drone with various Sensors, Arduino uno and Node MCU

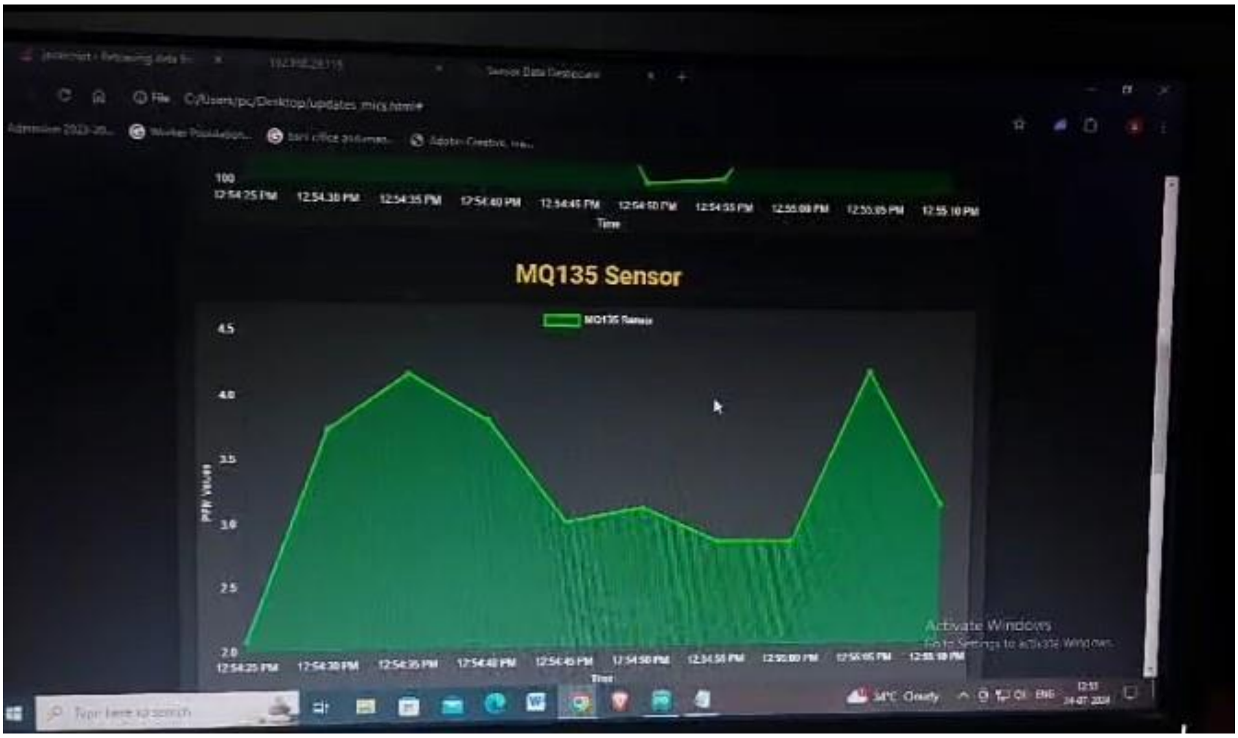

Figure 8.2: Interface at Web Server

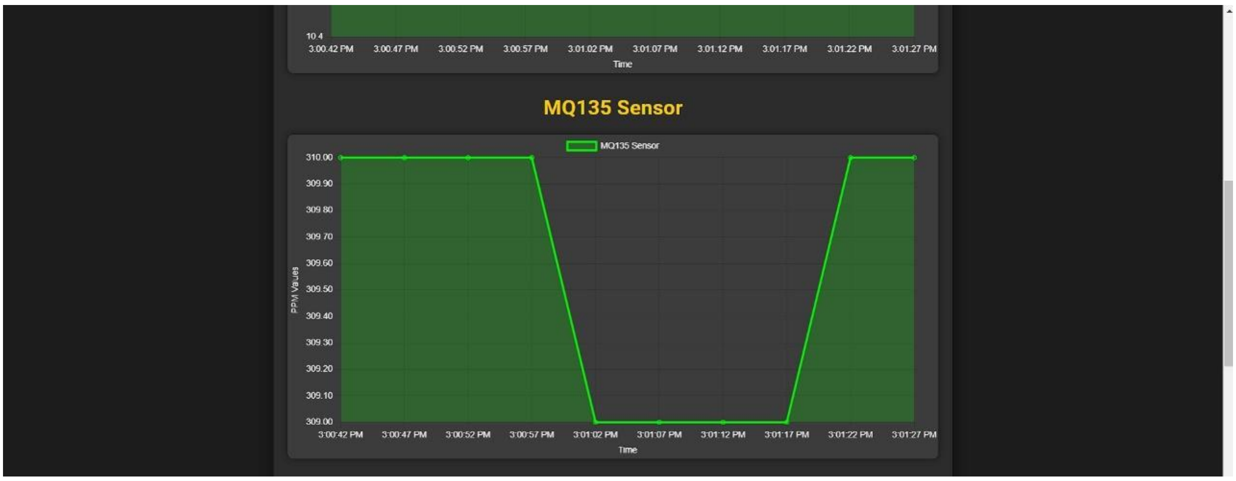

Figure 8.3: Graphical representation of Sensor values

Chapter 9

Results Obtained

Figure 9.1: Drone

The successful implementation of the Drone system involved meticulous integration of various hardware components and advanced software solutions, culminating in a robust platform for monitoring and managing industrial pollution. The drone's hardware configuration included a lightweight yet sturdy carbon fiber frame, which ensured durability and enhanced maneuverability essential for industrial settings. Integration of four BLDC motors paired with high-efficiency propellers provided optimal thrust and lift capabilities, facilitating stable and efficient flight operations. The KK2.1.5 flight controller played a crucial role in maintaining precise navigation and stability during flight maneuvers, crucial for accurate data collection. Additionally, the deployment of a high-capacity Lithium-Polymer (Li-Po) battery extended operational endurance, enabling prolonged monitoring missions without compromising performance.

On the sensor front, the Drone system integrated MiCS-2714 for detecting nitrogen dioxide (NO_2), MQ-135 for monitoring air quality parameters including ammonia, sulfur dioxide, benzene, and smoke, and MQ-2 for detecting combustible gases such as methane, propane, and butane. These sensors were effectively interfaced with an Arduino Uno microcontroller and NodeMCU for real-time data acquisition and transmission, ensuring timely and accurate pollution level assessments.

The software development focused on creating robust data acquisition systems that interact seamlessly with the integrated sensors, ensuring reliable and continuous data collection. Real-time data processing algorithms were implemented to analyze sensor data promptly, providing immediate insights into pollution levels. The web server setup allows for real-time monitoring and control of pollution levels, enhancing operational flexibility and facilitating timely intervention measures.

Throughout the project, rigorous testing and calibration procedures were conducted to validate the system's accuracy, reliability, and performance under varying environmental conditions. These efforts ensured that the Drone system met regulatory standards and operational requirements for deployment in industrial environments. Overall, the Drone system demonstrated significant advancements in autonomously monitoring and controlling industrial pollution, offering actionable data insights to support environmental sustainability efforts and safeguard public health.

Chapter 10

References/Bibliography

Chodorek, Agnieszka, Robert Ryszard Chodorek, and Paweł Sitek. ”UAV-based and WebRTC-based open universal framework to monitor urban and industrial areas.” Sensors 21.12 (2021): 4061.

Markowitz, Gerald, and David Rosner. Deceit and denial: The deadly politics of industrial pollution. Univ of California Press, 2013.

Bakirci, Murat. ”Smart city air quality management through leveraging drones for precision monitoring.” Sustainable Cities and Society 106 (2024): 105390.

Ramesh, P. S., and JV Muruga Lal Jeyan. ”Comparative analysis of fixed-wing, rotary-wing and hybrid mini unmanned aircraft systems (UAS) from the applications perspective.” INCAS Bulletin 14.1 (2022): 137-151.

Baichtal, John. Building Your Own Drones: A Beginners’ Guide to Drones, UAVs, and ROVs. Que Publishing, 2015.

Ho, Clifford K., et al. ”Overview of sensors and needs for environmental monitoring.” Sensors 5.1 (2005): 4-37.

Idrees, Zeba, and Lirong Zheng. ”Low cost air pollution monitoring systems: A review of protocols and enabling technologies.” Journal of Industrial Information Integration 17 (2020): 100123.

Singh, Kamna, and Deepa Bura. ”Internet-of-Things (IoT): distinct algorithms for sensor connectivity with comparative study between node MCU and arduino UNO.” NVEO-NATURAL VOLATILES ESSENTIAL OILS Journal— NVEO (2021): 4313-4324.

Chapter 11

Data Sheet

MICS-2714 Sensor

1. General Information

Model Name: MICS-2714

2. Sensor Type and Capabilities

Type of Sensor: Gas Sensor

Target Gas: Nitrogen Dioxide (NO_2)

Measurement Range: 0-5 ppm (parts per million)

Applications:

Air Quality Monitoring

Industrial Safety

Environmental Monitoring

Smart City Applications

3. Technical Specifications

Sensing Method: Metal Oxide Semiconductor (MOS)

Sensitivity Range: 0-5 ppm NO_2

Response Time: ¡ 60 seconds

Recovery Time: ¡ 60 seconds

Operating Principle: Conductance change in the presence of target gas

4. Dimensions and Weight

Dimensions:

Length: 5.08 mm

Width: 5.08 mm

Height: 1.55 mm

Weight: Approximately 200 mg

5. Power Requirements

Voltage: 1.8V to 3.6V

Power Consumption:
Heater Power: 60 mW
Total Power Consumption: ¡ 100 mW

6. Communication Protocols
Interface: Analog
Signal Output:
Resistance change corresponding to gas concentration
Requires external circuitry for signal conditioning and conversion

7. Environmental Specifications
Operating Temperature: -30°C to 85°C
Storage Temperature: -40°C to 120°C
Operating Humidity: 5 percent to 95 percent RH (non-condensing).

8. Certification and Compliance
Certifications: RoHS Compliant
Compliance: Environmental standards for electronic components

9. Additional Features
Low Power Consumption: Suitable for battery-operated devices
Compact Size: Ideal for integration into portable devices
High Sensitivity: Accurate detection of low concentrations of NO_2

MQ-135 Sensor

1. General Information
Model Name: MQ-135

2. Sensor Type and Capabilities
Type of Sensor: Gas Sensor
Target Gases: Air quality sensor that detects a wide range of gases including ammonia (NH_3), nitrogen oxides (NOx), alcohol, benzene, smoke, and carbon dioxide (CO_2)
Measurement Range: 10-1000 ppm (for NH_3, NOx, alcohol, benzene, smoke, CO_2)
Applications:
Air Quality Monitoring, industrial Safety, Environmental Monitoring, Home Safety Devices

3. Technical Specifications
Sensing Method: Metal Oxide Semiconductor (MOS)
Sensitivity Range: 10-1000 ppm for various gases
Response Time: ¡ 10 seconds
Recovery Time: ¡ 30 seconds
Operating Principle: Conductance change in the presence of target gas

4. Dimensions and Weight
Dimensions:
Diameter: 16 mm
Height: 20 mm (including pins)
Weight: Approximately 5 grams

5. Power Requirements
Heater Voltage (VH): 5V ± 0.2V
Load Resistance (RL): Adjustable (10k ohm to 47k ohm typical)
Heater Power Consumption: less than equal to 800 mW

6. Communication Protocols
Interface: Analog
Signal Output:
Analog voltage output that varies with gas concentration
Requires external ADC for digital reading

7. Environmental Specifications
Operating Temperature: -10°C to 50°C
Storage Temperature: -20°C to 70°C
Operating Humidity: 20 percent to 90 percent RH

8. Certification and Compliance
Certifications: RoHS Compliant
Compliance: Environmental standards for electronic components

9. Additional Features
High Sensitivity: Can detect low concentrations of gases
Wide Detection Range: Suitable for various air quality monitoring applications
Simple Circuit: Easy to interface with microcontrollers and development boards
Long Life: Stable and reliable performance over a long period

MQ-2 Sensor

1. General Information
Model Name: MQ-2

2. Sensor Type and Capabilities
Type of Sensor: Gas Sensor
Target Gases: Flammable gases and smoke including LPG, i-butane, propane, methane, alcohol, hydrogen, and smoke.
Measurement Range: 200-10000 ppm (for various gases)

3. Technical Specifications

Sensing Method: Metal Oxide Semiconductor (MOS)

Sensitivity Range: 10-1000 ppm for various gases

Response Time: less than 10 seconds

Recovery Time: less than 30 seconds

Operating Principle: Conductance change in the presence of target gas

4. Dimensions and Weight

Dimensions:

Diameter: 16 mm

Height: 20 mm (including pins)

Weight: Approximately 5 grams

5. Power Requirements

Heater Voltage (VH): 5V ± 0.2V

Load Resistance (RL): Adjustable (10k ohm to 47k ohm typical)

Heater Power Consumption: less than equal to 800 mW

6. Communication Protocols

Interface: Analog

Signal Output: Analog voltage output that varies with gas concentration

Requires external ADC for digital reading

7. Environmental Specifications

Operating Temperature: -10°C to 50°C

Storage Temperature: -20°C to 70°C

Operating Humidity: 20 percent to 90 percent RH

8. Certification and Compliance

Certifications: ROHS Compliant

Table 11.1: Sensor Specifications

Sensor Type	**Measurement Range**	**Dimensions (mm)**	**Power Requirements**	**Applications**
MICS-2714	0-5 ppm NO2	5.08 x 5.08 x 1.55	1.8V to 3.6V, 60 mW	Environmental monitoring, industrial safety
MQ-135	10-1000 ppm (various gases)	16 x 20	5V ± 0.2V, 800 mW	Air quality monitoring, home safety
MQ-2	200-10000 ppm (various gases)	16 x 20	5V ± 0.2V, 800 mW	Gas leak detection, fire detection