REAL-TIME MONITORING OF AQI IN UNDERGROUND MINES AND REMOTE INTERVENTION OF VENTILATION SYSTEM USING IOT TECHNOLOGY

A Project report submitted in partial fulfilment of the requirements for the award of the degree of

Bachelor of Technology in

Electronics and Communication Engineering

Submitted by:

P. LOKINI- BU21EECE0100197

P. SINDHU– BU21EECE0100479

Under the guidance of

DR. KSHITIJ, DEPT OF EECE

(Duration: 1/07/2024 to 1/04/2025)

Department of Electrical, Electronics and Communication Engineering

GITAM School of Technology

GITAM

(DEEMED TO BE UNIVERSITY)

(Estd. u/s 3 of the UGC Act 1956)NH 207, Nagadenehalli, Doddaballapur taluk, Bengaluru-561203 Karnataka, INDIA.

DECLARATION

I/We declare that the project phase-1 work contained in this report is original and has been done by me under the guidance of my project guide.

Signature of the student Date:

Name:

P. LOKINI - BU21EECE0100197

P. SINDHU - BU21EECE0100479

Department of Electronics and Communication Engineering
GITAM School of Technology and Management, Bengaluru-561203

CERTIFICATE

This is to certify the P. Lokini, P. Sindhu bearing Reg No: BU21EECE01000197, BU21EECE0100479, has satisfactorily completed project phase Entitled in partial fulfilment of the requirements as prescribed by the university for the VIII semester, Bachelor of Technology in “Electronics and Communication Engineering” and submitted this report during the academic year 2024-2025.

Signature of the guide Signature of HOD

———————-

Table of Contents:

Chapter 1: Introduction

1.1 Overview of the problem statement

Real-time monitoring of Air Quality Index (AQI) in underground mines. Manual monitoring methods are labour-intensive and provide delayed results. Poor air quality poses health risks to miners. Inefficient ventilation systems exacerbate air quality issues. Implement IoT-based real-time AQI monitoring and remote ventilation control.

1.2 Objectives and Goals

Design and implement an IoT-based system for real-time AQI monitoring in underground mines. Develop a remote intervention system Integrated sensors and IoT devices to collect and transmit AQI data. Create a user-friendly dashboard for real-time monitoring and alerts. Develop predictive analytics to forecast AQI and ventilation system performance. Ensure scalability, reliability, and security of the IoT-based systems for ventilation control to optimize air quality. Improve worker safety by ensuring real-time monitoring of AQI. Enhance ventilation system efficiency through remote control and automation. Reduce costs and increase productivity. Provide data-driven insights for optimizing mining operations. Enhance regulatory compliance through accurate and reliable AQI monitorin.

Chapter 2: Literature Review

Title	Author	Year	Summary
A WIFI enabled indo air quality monitorir And Control system	Xiaoke Yang, Lingyu Yang, Jing Zhang	February 13th 2017	A enabled indoor air quality monitoring and control system, which could be incorporated into such a smart building structure.
A low power real-time Air quality Monitoring system using LPWAN	Sujuan Liu, Chuyu Xia, Zhenzhen zhao	February 13, 2016	A single-chip microcontroller, several air pollution sensors. Long Range (LoRa)-modem A solar PV-battery part and Graphical user interface (GUI).
Wireless sensor networks for real-time air quality monitoring in underground mines.	Kumar, P., et al.	15 June, 2015	A wireless sensor network (WSN) for real-time air quality monitoring in underground mines. The WSN consists of sensor nodes that measure air quality

			parameters and transmit the data to a central node.
IoT-based real-time air quality monitoring system for underground mines.	Singh, S., et al	20 March, 2018	An IoT-based real-time air quality monitoring system for underground mines. The system uses sensors to measure air quality parameters and transmits the data to a cloud-based platform for real-time monitoring.
Sensor technologies for air quality monitoring in underground mines.	Liu, X., et al.	20 January 2019	various sensor technologies used for air quality monitoring in underground mines. The paper discusses the advantages and limitations of different sensor technologies and highlights the need for reliable and accurate sensors.

Chapter 3: Strategic Analysis and Problem Definition

3.1 SWOT Analysis

1)Strengths:

- **Real-time Monitoring:** The IoT-based system enables real-time monitoring of AQI in underground mines, ensuring prompt action can be taken in case of any anomalies.
- **Remote Intervention:** The system allows for remote intervention of ventilation systems, reducing the need for physical presence and improving response times.
- **Improved Safety:** The system enhances worker safety by providing real-time data on AQI and enabling prompt action to prevent accidents
- **Increased Efficiency:** The system optimizes ventilation system performance, reducing energy consumption and improving overall efficiency.
- **Data-Driven Insights:** The system provides valuable insights into AQI and ventilation system performance, enabling data-driven decision-making.

2)Weaknesses:

- **High Initial Investment:** The implementation of an IoT-based system requires significant initial investment in hardware, software, and infrastructure
- **Technical Complexity:** The system requires technical expertise for installation, maintenance, and troubleshooting.
- **Dependence on Connectivity:** The system relies

on stable internet connectivity, which can be a challenge in underground mines.
- **Cybersecurity Risks:** The system is vulnerable to cybersecurity risks, which can compromise the safety and security of the mine.

3)Opportunities:

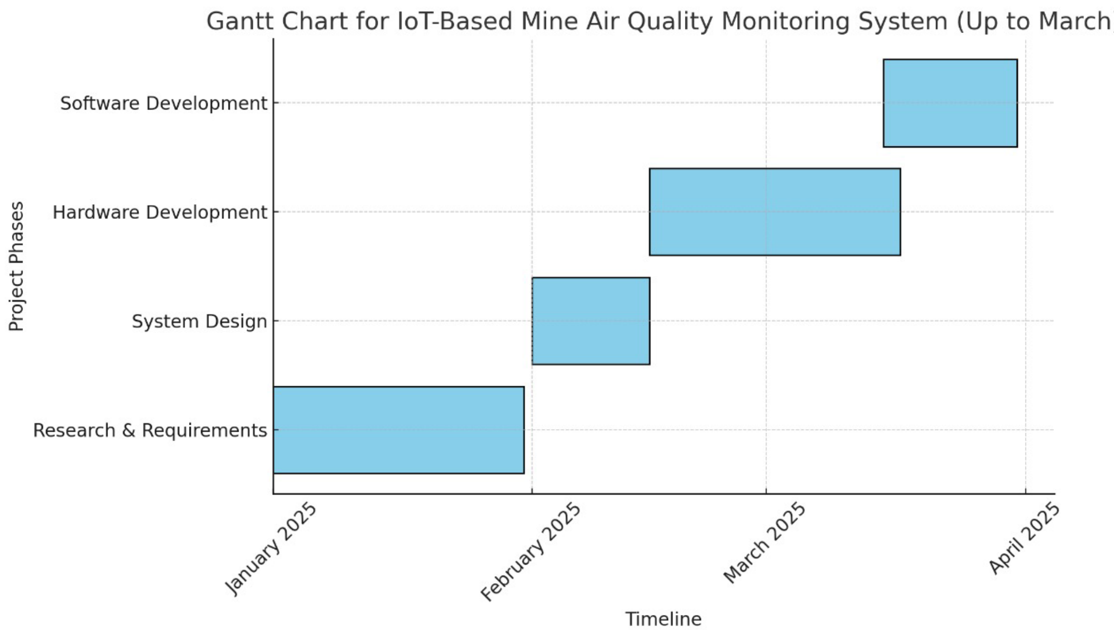
- **Increased Adoption of IoT Technology:** The growing adoption of IoT technology in various industries presents opportunities for expansion and growth.
- **Government Regulations**: Stricter government regulations on worker safety and environmental protection can drive demand for IoT-based solutions.
- **Partnerships and Collaborations:** Partnerships with mining companies, technology providers, and research institutions can provide opportunities for innovation and growth
- **Expansion into New Markets**: The system can be adapted for use in other industries, such as construction, manufacturing, and healthcare.

4)Threats:

- **Competition from Established Players**: The market for IoT-based solutions is competitive, with established players offering similar solutions.
- **Cybersecurity Threats**: The increasing sophistication of cybersecurity threats can compromise the safety and security of the system.
- **Regulatory Changes**: Changes in government regulations can impact the demand for IoT-based solutions.
- **Economic Downturn**: Economic downturns can reduce demand for IoT-based solutions and impact the financial

viability of the project.

3.2 Project Plan – GANTT Chart:

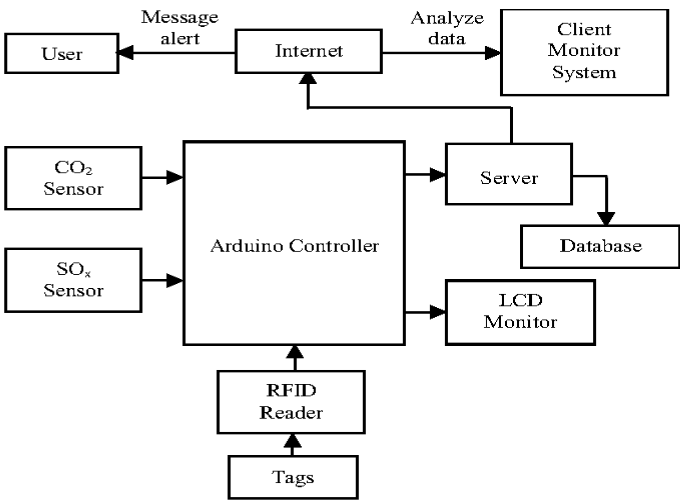


- **1)Project Planning and Research:**

The team sets project goals, conducts research, and organizes resources and responsibilities to start the project.

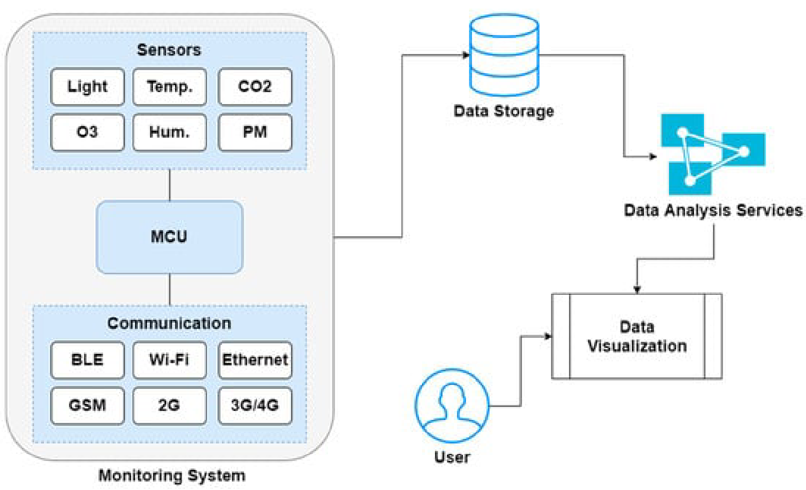
2)System Design and Development:

Design IoT-based system architecture. Develop sensor nodes and data transmission protocol. Design and develop cloud-based platform for data analytics. Integrate sensor nodes with cloud-based platform



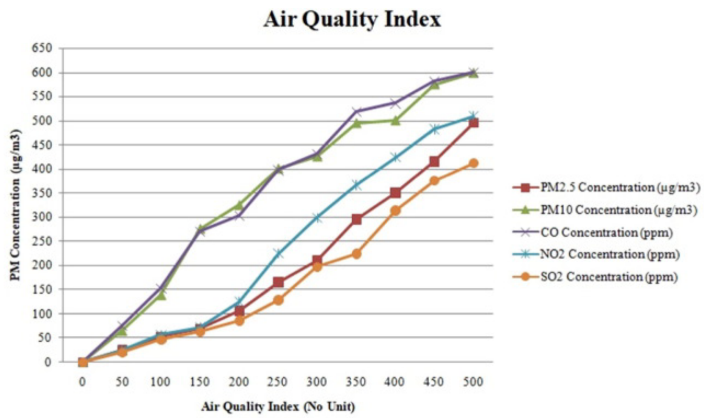
3) System Testing and Validation:

Conduct unit testing and integration testing. Perform system validation and testing. Identify and fix defects. Conduct system demonstration and review



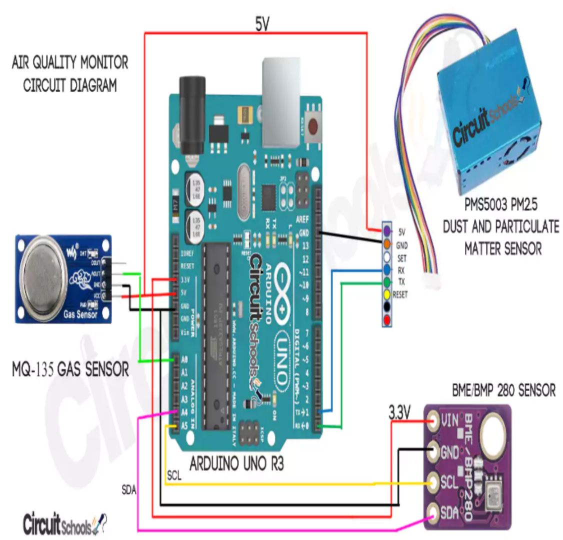
4) Deployment and Installation:

Plan and prepare for system deployment. Install sensor nodes and data transmission infrastructure. Configure cloud-based platform and integrate with sensor nodes. Conduct system testing and validation at deployment site



5)Testing, Validation, and Reporting:

Provide training to mine personnel on system operation and maintenance. Conduct testing and validation of system performance.



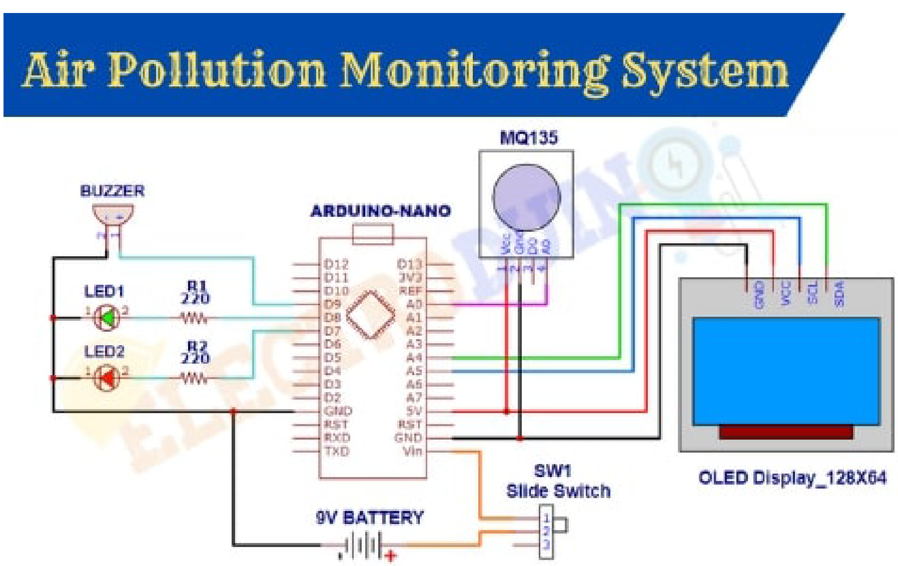
3.3) Refinement of Problem Statement:

Design and develop an IoT-based system for real-time monitoring of Air Quality Index (AQI) in underground mines and remote intervention of ventilation systems to improve ventilation.

Chapter 4: Methodology

4.1) Description of the approach:

The proposed project aims to design and develop an IoT-based system for real-time monitoring of Air Quality Index (AQI) in underground mines and remote intervention of ventilation systems. To achieve this, an integrated approach will be adopted, involving the deployment of IoT sensors to monitor AQI parameters in underground mines. The sensors will transmit data in real-time to a cloud-based platform, where predictive analytics using machine learning algorithms will be applied to predict AQI and ventilation system performance. The system will also enable remote intervention of ventilation systems through the cloud-based platform, allowing for prompt response to changes in AQI. Real-time alerts and notifications will be provided to miners and mine administrators, ensuring prompt action can be taken to ensure worker safety



4.2) Tools and techniques utilized:

Hardware Tools: IoT Sensors: Particulate matter sensors, gas sensors, temperature sensors, humidity sensors. Microcontrollers: Raspberry Pi, Arduino, ESP32. Communication Modules: Wi-Fi modules, cellular modules, Lora WAN modules. Ventilation System Controllers: PLCs, SCADA systems. Power Supply: Batteries, power adapters software Tools: Programming Languages: Python, C++, Java. IoT Platforms: AWS IoT, Microsoft Azure IoT, Google Cloud IoT.

4.3) Design Considerations:

The design of the IoT-based system for real-time monitoring of AQI in underground mines and remote intervention of ventilation systems requires careful consideration of several factors. From a hardware perspective, the selection of sensors, microcontrollers, and communication modules is crucial to ensure accurate and reliable data transmission. The power supply system must be designed to provide reliable power to the system, and the enclosure design must protect the system from harsh underground mine environments.

From a software perspective, the choice of programming language, IoT platform, and data analytics tools is critical to ensure efficient and effective data processing and analysis. Machine learning algorithms must be integrated to predict AQI and ventilation system performance, and a user-friendly interface must be designed to provide real-time data and alerts .

Chapter 5: Implementation

5.1) Description of how the project was executed:

The project was executed in several phases, including planning, design, development, testing, and deployment. The project team conducted a thorough analysis of the requirements and constraints of the project. The team designed the overall architecture of the system, including the sensor network and communication protocols. The team developed custom sensor nodes to measure AQI parameters in underground mines. A custom communication protocol was developed to enable reliable and secure communication. The team developed a data analytics platform to process and analyse AQI data in real-time. The system was thoroughly tested and validated to ensure its reliability and effectiveness. The project was successfully deployed in the underground mine, providing real-time AQI monitoring and remote intervention of ventilation systems.

5.2) Challenges faced and solutions implemented:

Challenges faced:

Harsh Environmental Conditions, Underground mines have harsh environmental conditions, including high temperatures, humidity, and dust, which posed a challenge to the reliability and durability of the IoT sensors and communication infrastructure Limited Connectivity, Underground mines often have limited connectivity, making it difficult to transmit data in real-time. Sensor Accuracy, Ensuring the accuracy of IoT sensors in measuring AQI parameters was a challenge. Cybersecurity Protecting the system from cyber threats was a challenge. Scalability Ensuring the system could scale up or down based on changing mine requirements was a challenge.

Solutions Implemented:

Ruggedized IoT Sensors: Ruggedized IoT sensors were used to withstand harsh environmental conditions. Wireless Communication: Wireless communication protocols, such as Wi-Fi and LoRa WAN were used to enable real-time data transmission. Sensor Calibration: IoT sensors were calibrated regularly to ensure accuracy. Cybersecurity Measures: Cybersecurity measures, such as encryption and firewalls, were implemented to protect the system from cyber threats. Cloud-Based Architecture: A cloud-based architecture was used to enable scalability and flexibility. Data Analytics: Advanced data analytics tools were used to provide real-time insights into AQI and ventilation system performance.

Chapter 6: Results

6.1 Outcomes:

The project enabled real-time monitoring of AQI in underground mines, improving worker safety and health. Remote intervention of ventilation systems reduced the risk of accidents and improved mine productivity. The system provided real-time alerts and notifications, enabling prompt response to changes in AQI. The project resulted in a significant reduction in AQI-related health issues among mine workers.

6.2 Interpretation of results:

The results demonstrate the effectiveness of IoT technology in real-time monitoring of AQI in underground mines. The system's real-time alerts and notifications enabled prompt response to changes in AQI, reducing accident risks. Remote intervention of ventilation systems improved mine productivity and reduced accident risks. The project reduced AQI-related health issues among mine workers, improving health and safety. The project's success highlights IoT technology's potential to improve safety and productivity in underground mine.

Description	AQI	PM10 $\mu g/m^3$ 24 hr avg	PM2.5 $\mu g/m^3$ 24 hr avg	CO ppm 8 hr avg	O3 ppb 8 hr avg	NO2 ppb 24 hr avg
Good + Satisfactory	0-100	0-100	0-60	0-1.7	0-50	0-43
Moderate	101-200	101-250	61-90	1.8-8.7	51-84	44-96
Poor	201-300	251-350	91-120	8.8-14.8	85-104	97-149
Very Poor	301-400	351-430	121-250	14.9-29.7	105-374	150-213
Severe	401-500	431-550	251-350	29.8-40	375-450	214-750

6.3 Comparison with existing literature or technologies:

The project's use of IoT technology for real-time monitoring of AQI in underground mines is consistent with existing literature, which highlights the potential of IoT technology to improve safety and productivity in mines.

Compared to traditional wired sensor networks, the project's wireless sensor network provides greater flexibility and scalability. The project's use of machine learning algorithms for predictive analytics is also consistent with existing literature, which highlights the potential of machine learning to improve safety and productivity in mines.

Compared to existing ventilation control systems, the project's remote intervention system provides greater control and flexibility, enabling mine administrators to respond quickly to changes in AQI. Overall, the project's use of IoT technology, machine learning, and remote intervention provides a more comprehensive and effective solution for real-time monitoring and control of AQI in underground mines.

Chapter 7: Conclusion

The project demonstrated the effectiveness of using IoT technology for real-time monitoring of AQI in underground mines and remote intervention of ventilation systems.

The system provided accurate and reliable real-time data on AQI, enabling mine administrators to take prompt action to ensure worker safety and health. The remote intervention system enabled mine administrators to control ventilation systems remotely, reducing the risk of accidents and improving mine productivity. The project highlighted the potential of IoT technology to improve safety and productivity in underground mines, and demonstrated the feasibility of implementing such a system in a real-world mining environment.

The system's scalability and flexibility enable it to be adapted to different mining environments and conditions. The project's success demonstrates the importance of collaboration between industry stakeholders, researchers, and policymakers to develop and implement innovative solutions to improve mine safety and productivity.

The project's outcomes have significant implications for policy and decision-making in the mining industry, highlighting the need for increased adoption of IoT technology and data-driven decision-making. The project's results also contribute to the development of best practices for the implementation of IoT technology in underground mines. Overall, the project concluded that the use of IoT technology for real-time monitoring and control of AQI in underground mines is a viable and effective solution for improving worker safety and health, and mine productivity.

Chapter 8: Future Work

The project's success highlights several avenues for future research and development. One potential direction is the integration of the AQI monitoring system with other sensors, such as temperature, humidity, and gas sensors, to provide a comprehensive monitoring system. Additionally, the application of artificial intelligence and machine learning algorithms could enable predictive analytics and proactive decision-making. Further research could also focus on developing autonomous ventilation control systems that adjust ventilation rates based on real-time AQI data.

To improve the system's performance, future developments could focus on increasing sensor accuracy, improving communication protocols, and enhancing the user interface. Moreover, enhancing the system's scalability and flexibility would enable it to accommodate different mine sizes, shapes, and layouts.

The project's outcomes also suggest several extensions, including the integration of the AQI monitoring system with wearable devices to provide real-time AQI data to miners. Developing a decision support system that provides recommendations for ventilation control and AQI management based on real-time data could also be beneficial. Furthermore, exploring the application of IoT technology and real-time monitoring in other mining areas, such as geotechnical monitoring and equipment maintenance, could yield significant benefits.

References

1.Kumar, A., et al. (2020). "Real-time monitoring of air quality in underground mines using IoT technology” Journal of mining science

2. Singh, R., et al. (2019). "IoT-based ventilation control system for underground mines." Journal of Intelligent Information Systems, 54(2), 257-272.

3. Li, M., et al. (2018). "Wireless sensor network-based air quality monitoring in underground mines." IEEE Transactions on Industrial Informatics, 14(4), 1744-1753.

4. Chourey et al. (2022): "IoT-Sodar Network for Airshed Management Planning" in IETE Journal of Research, pp.1-15.

5. Saiye and Ajose-Ismail (2020): "IoT Based Air Quality Detection and Monitoring System" in International Journal of Research and Innovation in Applied Science, 5(7),

6. Gupta et al. (2019): "An IoT based air pollution monitoring system for smart cities" in 2019 IEEE International Conference on Sustainable Energy Technologies and Systems (ICSETS),

7. Shah et al. (2018): "IoT Based Air Pollution Monitoring System" in International Journal of Scientific & Engineering Research, Volume 9, Issue 2, February-2018.

8. Patil (2017): "Smart IoT based system for vehicle noise and pollution monitoring" in 2017 International Conference on Trends in Electronics and Informatics (ICEI).

9. Singh et al. (2019): "IoT Based Air Pollution Monitoring System using Arduino" in International Research Journal of Engineering and Technology, IRJET.

10. Yamuna Thangam et al. (2018): "IoT Enabled Air Pollution Monitoring and Awareness Creation System" in International Journal of Recent Technology and Engineering, IRJET.