REAL TIME SYSTEM AND INTERNET OF THINGS FINAL PROJECT REPORT
DEPARTMENT OF ELECTRICAL ENGINEERING
UNIVERSITAS INDONESIA

AirQu : AIR QUALITY MONITORING SYSTEM

GROUP A7

Albertus Timothy Gunawan	**2106639472**
Muhammad Cavan Naufal Azizi	**2106702730**
Muhammad Suhaili	**2106731535**
Raditya Ihsan Dhiaulhaq	**2106733912**

PREFACE

Praises and thanks are continuously offered to the Almighty God for his blessings and grace, which have enabled us to complete our final project report titled 'AirQu: Air Quality Monitoring System'. This report is designed to fulfill the requirements of the Real Time System and Internet of Things Practicum class of 2023 at the Faculty of Engineering, Department of Computer Engineering, University of Indonesia. Certainly, the preparation and completion of this final project report were not possible without the help and support of various parties. Therefore, we would like to express our heartfelt gratitude to all those involved, especially to:

1. Mr. Fransiskus Astha Ekadiyanto as the lecturer of the Real Time System and Internet of Things class of 2023.
2. The Digital Lab assistants who has assisted and guided us during the Real Time System and Internet of Things practicum.
3. Our parents and fellow practicum friends who have provided their support, both in terms of material and ideas.

We are fully aware that there are still many mistakes in the preparation of this report, both in terms of vocabulary, grammar, and content. Therefore, we expect the readers to provide their criticisms and suggestions as much as possible regarding this report.

Thus, this final project report on Real Time System and IOT practicum is completed. Hopefully, this report will be beneficial for us as the authors and also for the readers as an introduction as well as improvement to the computer engineering field.

Depok, December 08, 2023

Group A7

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT

In this day and age, air pollution poses a significant threat to public health, environmental sustainability, and overall quality of life. The rapid industrialization, urbanization, and increased vehicular traffic have led to the release of various pollutants into the atmosphere. These pollutants, including particulate matter, nitrogen dioxide, sulfur dioxide, and volatile organic compounds, have detrimental effects on respiratory health, cardiovascular systems, and the environment.

Recognizing these challenges, our air quality monitoring system project emerges as a solution-driven initiative. This project aims to bridge the existing gaps in air quality monitoring infrastructure by developing a comprehensive, cost-effective, and scalable system using sensors and software integration so that it could be used remotely by using the internet and as simple as a mobile phone to monitor the air quality around the sensor.

1.2 PROPOSED SOLUTION

To overcome the challenges and threat we face, our air quality monitoring system project proposes the following features and approaches:

- BME680 Sensor Functionality
  The BME680 sensor, on renowned for its ability to measure multiple environmental parameters, including temperature, humidity, pressure, and gas resistance, provides a holistic view of air quality. For this reason, we do not have to use multiple sensors to provide in-depth information in the vicinity therefore just using one sensor to provide all the functionality we need.
- Blynk Integration
  In order to make the air quality data more accessible, our project will integrate the data using Blynk platform. Blynk offers a user-friendly interface accessible through mobile devices, allowing users alike to monitor air quality parameters

seamlessly. Users can view real-time data captured by the sensor, historical trends, and receive notifications through the Blynk app.

- Real-Time Alerts with Alarm/Buzzer and LED Indicators
  As a proactive measure, our project incorporates an alarm/buzzer and LED indicators as part of the solution. When the BME680 sensors detect elevated levels of pollutants exceeding predefined thresholds, the alarm/buzzer will be triggered, accompanied by visual alerts through LED indicators.

1.3 ACCEPTANCE CRITERIA

The acceptance criteria of this project are as follows:

1. Successfully design and build an air quality monitoring system using BME680 sensor and ESP32.
2. Sensor reading that is fully works and performs well under changes around air quality in the vicinity.
3. Air quality index calculation matches the current surrounding air condition.
4. Data writing based on the sensor onto the LCD to provide information needed to the user.
5. Successfully integrates Blynk with the sensor and ESP32 to display the current sensor reading in a friendly user interface.
6. Real time alerts with buzzer and LED that will do their work when the sensor captures a certain amount of threshold or goes beyond the threshold.

1.4 ROLES AND RESPONSIBILITIES

The roles and responsibilities assigned to the group members are as follows:

Roles	Responsibilities	Person
Programmer	Membuat kode implementasi ESP32, integrasi sensor dengan LCD dan blynk	Raditya Ihsan Dhiaulhaq, Muhammad Suhaili, Muhammad Cavan Naufal Azizi

Desain Skematik	Membuat rangkaian schematic ESP32, Sensor BME680, LED, Buzzer agar dapat terhubung.	Muhammad Cavan Naufal Azizi
Desain Rangkaian	Menyusun rangkaian dan melakukan proses menyolder.	Albertus Timothy Gunawan, Muhammad Cavan Naufal Azizi
PPT & Laporan	Menyusun Laporan, Menyusun PPT, dan menyediakan kebutuhan kebutuhan rangkaian	Raditya Ihsan Dhiaulhaq, Albertus Timothy Gunawan, Muhammad Suhaili

Table 1. Roles and Responsibilities

1.5 TIMELINE AND MILESTONES

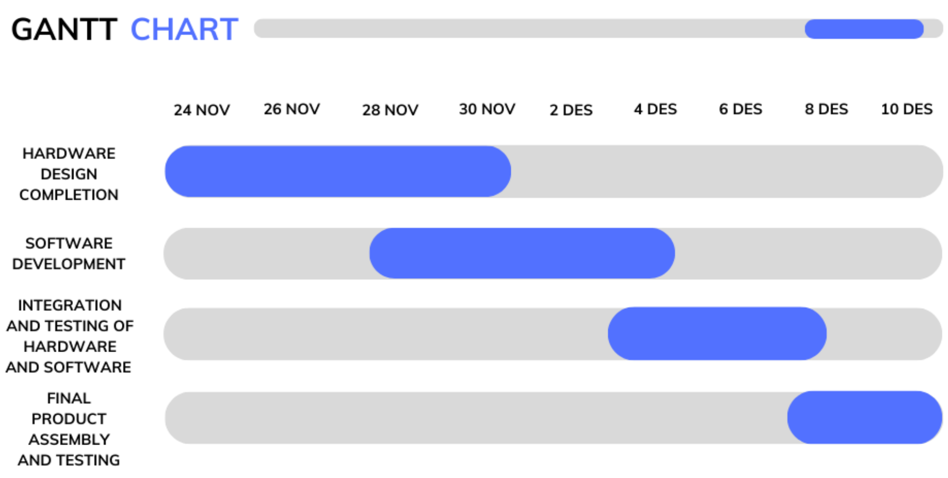


Fig 1. Gantt Chart

CHAPTER 2

IMPLEMENTATION

2.1 HARDWARE DESIGN

Our hardware design includes an ESP32, an LED lamp, a buzzer, protoboard, LCD serial interface, jumper cables, and lastly the most important one, the BME680 sensor. The connection uses I2C communication between ESP32 and BME680 that involves linking SDA and SDL pin to the I2C pins on the ESP32 which are GPIO21 and GPIO22. On the other hand, the LCD serial interface also uses I2C communication, therefore we use a protoboard to hold things onto place and for shared pin connection.

ESP32 serves as the central processing unit responsible for collecting data from the BME680 sensor, communicating over the I2C protocol. When the sensor is turned on the heater heats the metal oxide surface and oxygen is absorbed on the surface. In the clean air the electrons in the Metal Oxide are attracted to Oxygen molecules in the air and forms a potential barrier which resists the flow of electric current. So when VOC gases comes in contact with the metal oxide sensitive surface the gases react with the oxygen molecules on the surface thus the electrons are free from oxygen molecules which reduces the potential barrier and increases the flow of electric current.

The ESP32 also interfaces with the LCD display through serial communication pins (TX and RX) for real-time data visualization. Additionally, the LED lamp and buzzer are connected to digital output pins on the ESP32 to provide visual and audible alerts when air quality readings exceed predetermined thresholds.

2.2 SOFTWARE DEVELOPMENT

The software development process for this project involves programming the ESP32 to interact with the BME680 sensor and the LCD serial interface. All the programming needed for this project is written in a single .ino file. For starters, ESP32 and Blynk environment is set up as well as the necessary libraries and blynk template. The connection between the sensor and ESP32 is established using adafruit libraries and for the LCD serial interface, we use liquid crystal library to utilize I2C communication.

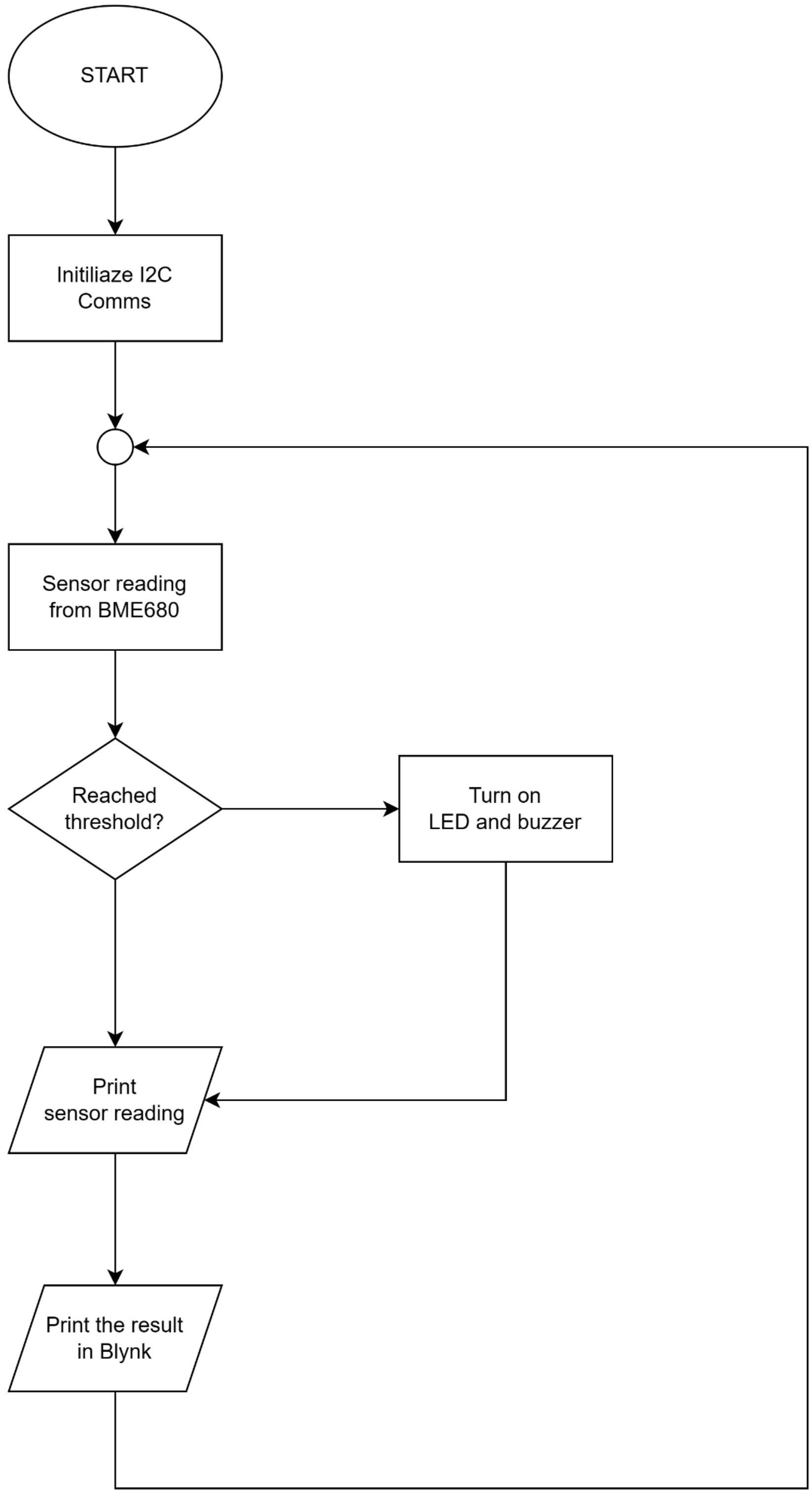


Fig.2 Flowchart

When the program starts, BME680 starts doing its job and getting the information it could and send them to ESP32 for every some time interval. Then, the information will be printed on LCD serial monitor as well as displayed on the Blynk platform using built-in Wi-Fi that ESP32 has. When the reading reached a certain threshold, ESP32 will program LED to turn on and buzzer to play a certain melody or sound.

2.3 HARDWARE AND SOFTWARE INTEGRATION SCHEMATIC

Finally, the hardware and software will be integrated by uploading the program into ESP32 and connecting all necessary components in place and configuring the communication protocols. Forget not the Blynk template for the IoT integration with Wi-Fi connection. Once the hardware and software are ready, the integration phase focuses on establishing communication between the components, and testing the system's functionality.

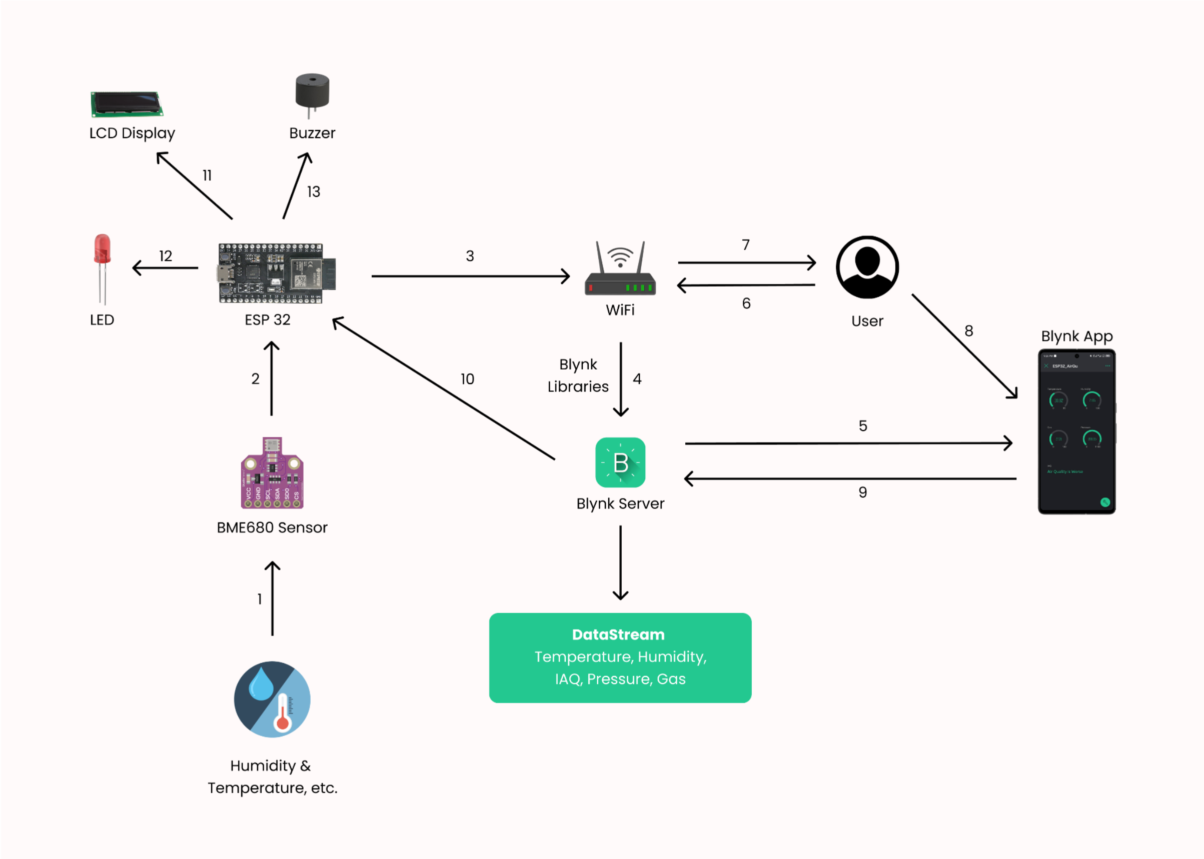


Fig.3. Schematic

Comprehensive documentation is essential, covering hardware assembly, software implementation, calibration procedures, and user instructions. This documentation serves as a valuable guide for effectively utilizing and maintaining the air quality monitoring device. The successful integration of hardware and software components enables smooth operation and ensures a reliable and precise air quality reading.

CHAPTER 3

TESTING AND EVALUATION

3.1 TESTING

In the testing phase of our IoT project, "AirQu: Air Quality Monitoring System," we conducted several tests to ensure that the program and circuit operate according to the established criteria and expectations. In the Blynk 2.0 application, the ESP32 attempts to connect to the WiFi network using the provided SSID and password. Subsequently, the LCD screen will light up and display the values of Temperature, Humidity, Gas, Pressure, and IAQ (Indoor Air Quality). The LED and buzzer will activate under certain conditions. Finally, on the Blynk mobile app, the values of Temperature, Humidity, Gas, and Pressure will be displayed, along with a sentence indicating the current air quality condition based on the IAQ value obtained.

Initially, we conducted testing without using the Blynk interface, ensuring that all data obtained from the sensor appeared accurately and completely in the serial monitor. The results were successful, appearing on both the serial monitor.

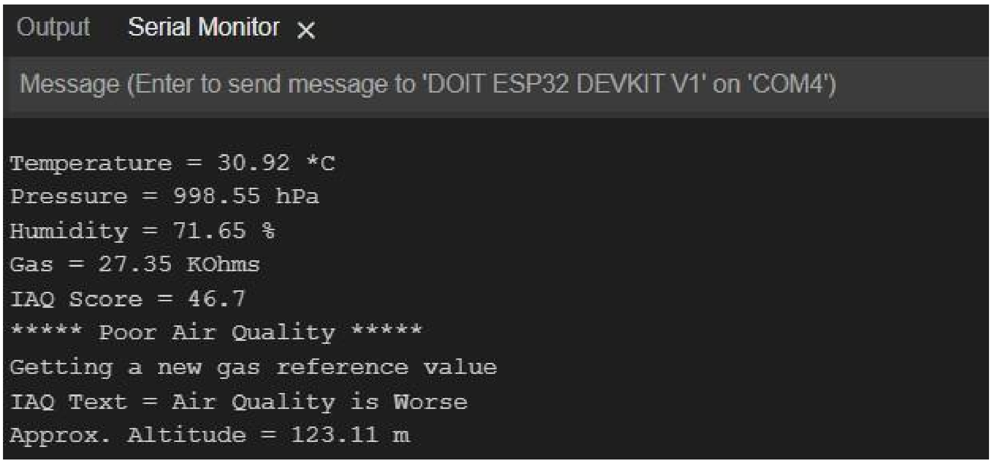


Fig.4. Serial Monitor Testing Result

Afterward, we attempted to display the sensor results on the LCD screen to confirm that the ESP32, BME680 sensor, and 16x2 LCD successfully connected and communicated with each other using the I2C protocol. After confirming the accuracy of the data obtained from the BME680 sensor, the subsequent phase focused on testing the LED indicators and buzzer functionality. Here, we ensured that the LEDs illuminated under predefined conditions established beforehand. Additionally, the buzzer was programmed to activate and emit a sound when the IAQ (Indoor Air Quality) reached a minimum threshold categorized as "Worse."

Finally, once all components functioned according to expectations, we proceeded with the integration testing involving Blynk 2.0. Initially, we ensured that the data obtained from the BME680 sensor, displayed on both the serial monitor and the 16x2 LCD screen, were accurately mirrored on the Blynk interface. It was imperative that all three sources reflected precisely identical values. Moreover, we meticulously examined the timing delay between value updates showcased on the LCD and Blynk, ensuring that any disparity remained insignificant. Additionally, the sentence displayed on the Blynk interface was cross-verified to correspond accurately to the IAQ condition, enabling users to receive accurate and immediate information regarding their indoor air quality.

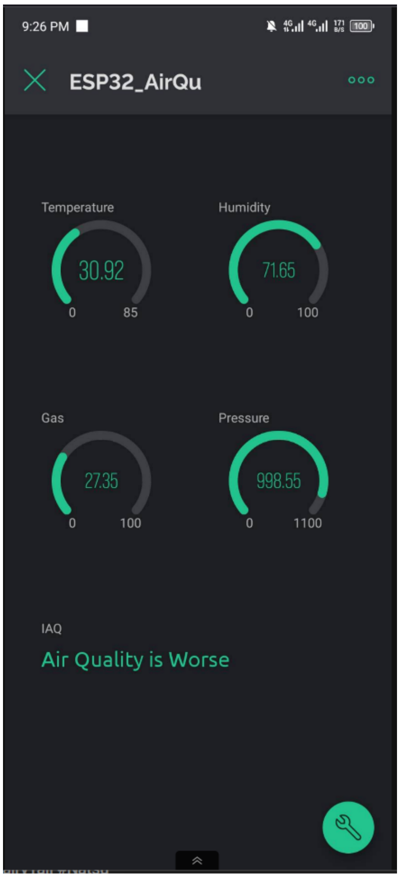


Fig 5. Blynk Result

This integration testing phase focused on synchronizing the data output across the serial monitor, LCD screen, and Blynk interface, ensuring coherence and real-time accuracy. Attention was particularly paid to minimizing delays in data synchronization between the local display and the Blynk platform, ensuring users received prompt and consistent updates on their air quality status via the Blynk mobile app. Additionally, the alignment between the displayed sentence on Blynk and the actual IAQ condition aimed to enhance user comprehension and facilitate informed decision-making regarding the surrounding air quality.

3.2 RESULT

The results from the three tests conducted on the original circuit using the Blynk platform all aligned with the established expectations and predefined criteria. Throughout these tests, the entire system's functions and responses were directly evaluated to ensure the circuit operated optimally and seamlessly integrated with Blynk in real-time.

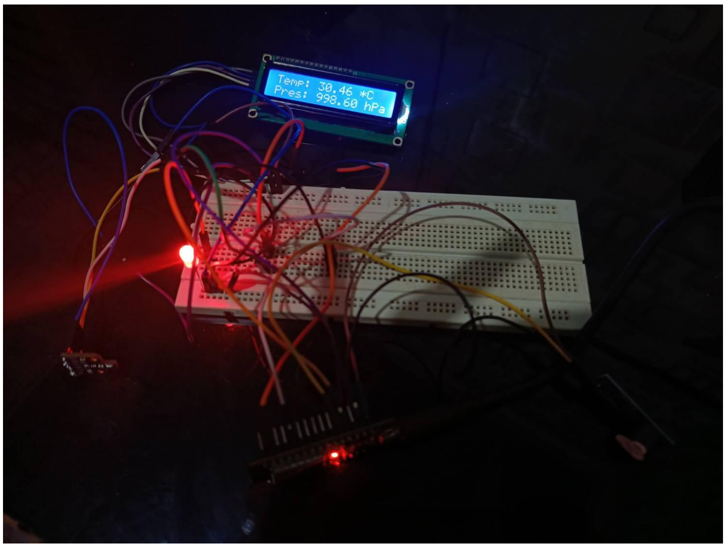


Fig 6. Final Result

Based on the comprehensive testing outcomes, the IoT project "AirQu: Air Quality Monitoring System" successfully integrated software and hardware components to create a smart air quality monitoring system. This system effectively reads data from the BME680 sensor and promptly displays it on the LCD screen and user devices using Blynk. Beyond this, the system also includes LED indicators that illuminate according to the IAQ conditions and a buzzer designed to sound an alert when the indoor air quality deteriorates, aiming to alert users and prevent potential health issues.

3.3 EVALUATION

The evaluation phase scrutinized the performance, usability, and overall efficacy of the "AirQu: Air Quality Monitoring System" following comprehensive testing and user feedback.

Throughout testing, the system consistently delivered precise, real-time data encompassing temperature, humidity, gas levels, pressure, and IAQ. Integration of the ESP32, BME680 sensor, LCD display, LED indicators, buzzer, and Blynk interface exhibited robustness and efficiency. The system's responsiveness to preset conditions, triggering LED indications and buzzer alerts aligned with IAQ thresholds, validated its functionality.

User interaction with the system via the Blynk mobile app was intuitive and user-friendly. It offered convenient access to crucial air quality data, presenting clear visual representations and concise IAQ updates. Synchronization across local and Blynk displays facilitated seamless monitoring on multiple devices. LED indications and audible alerts from the buzzer enhanced user awareness and enabled prompt responses to air quality changes.

The system efficiently monitored indoor air quality by swiftly collecting and displaying BME680 sensor data on LCD and Blynk interfaces. Alignment between the Blynk-displayed sentence and actual IAQ conditions improved communication, aiding informed decision-making. LED indicators and buzzer alerts played a crucial role in preemptive health measures by promptly notifying users of unfavorable air quality.

Overall, evaluation affirmed that the "AirQu: Air Quality Monitoring System" met objectives, providing a reliable, user-friendly, and effective solution for indoor air quality monitoring. Its successful integration of hardware, software, and user interface elements validated its practicality and suitability for diverse indoor settings, promoting healthier living environments.

CHAPTER 4

CONCLUSION

The development of the air quality monitoring system represents a significant step towards addressing the pressing challenges posed by air pollution. The integration of the BME680 sensor, ESP32 microcontroller, and Blynk platform has resulted in a comprehensive solution that not only monitors key environmental parameters but also ensures real-time accessibility for users through a user-friendly interface.

The software development process has been meticulously crafted to ensure optimal performance. The modular code structure, error-handling mechanisms, and integration with the Blynk platform contribute to a responsive system. Users can seamlessly visualize air quality data, receive real-time alerts, and customize their monitoring experience through the Blynk application.

The hardware and software integration phase successfully brought together the components, ensuring they function simultaneously to provide accurate air quality readings. Testing procedures have been established to verify the system's reliability under various conditions, and a comprehensive calibration process has been outlined to maintain precision over time.

REFERENCES

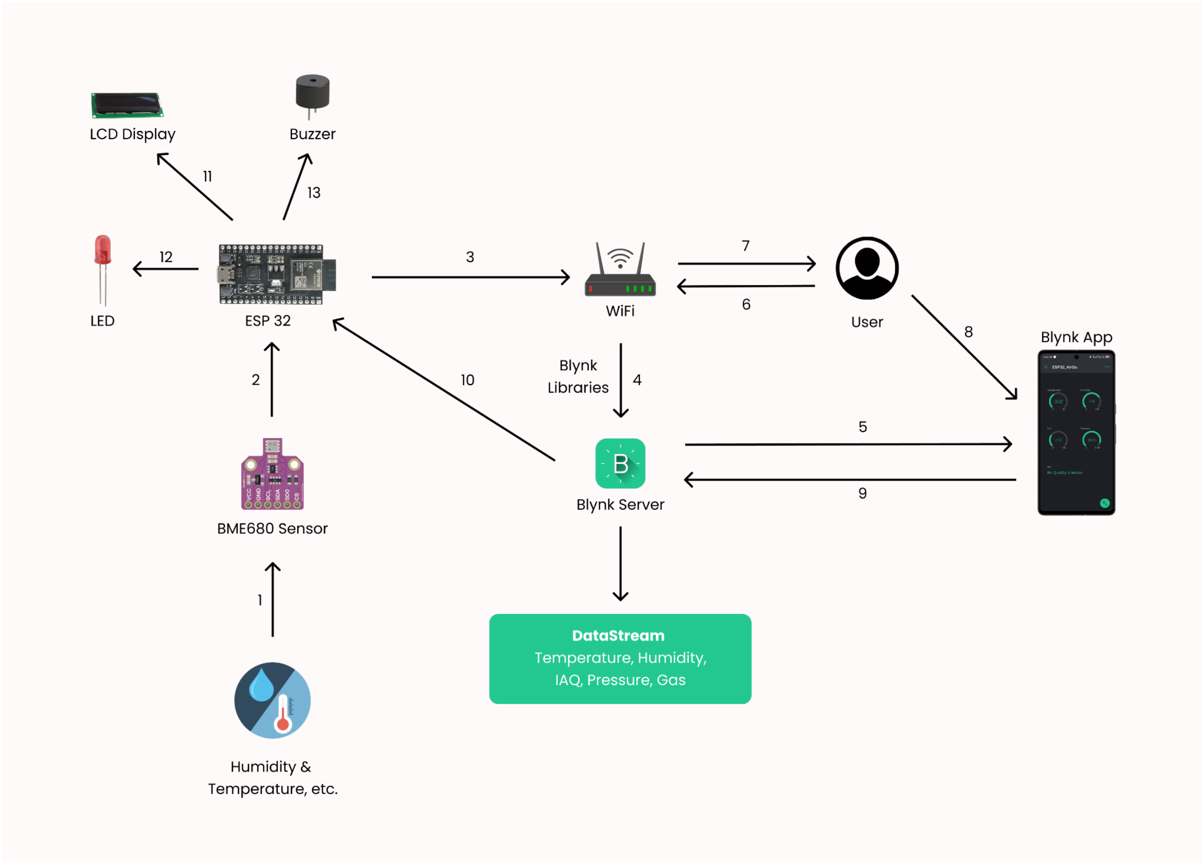
[1] CircuitSchools Staff, ‘Interfacing BME680 with Arduino also measure Indoor Air Quality Index’, Circuit Schools, 16-Jan-2022. [Online]. Available: https://www.circuitschools.com/interfacing-bme680-with-arduino-also-measure-indoor-air-quality-index/.

[2] S. Santos, ‘I2C LCD with ESP32 on Arduino IDE - ESP8266 compatible’, Random Nerd Tutorials, 01-Feb-2019. [Online]. Available: https://randomnerdtutorials.com/esp32-esp8266-i2c-lcd-arduino-ide/.

[3] B. –. Datasheet, ‘Low power gas, pressure, temperature & humidity sensor’, Adafruit.com. [Online]. Available: https://cdn-shop.adafruit.com/product-files/3660/BME680.pdf

APPENDICES

Appendix A: Project Schematic



Appendix B: Documentation