# *CHENNAI INSTITUTE OF TECHNOLOGY*

Sarathy Nagar, Kundrathur, Chennai-600069

*An Autonomous Institute Approved by AICTE and Affiliated to Anna University, Chennai*

## DEPARTMENT OF BIOMEDICAL ENGINEERING

# DESIGN OF BREATH ANALYSER FOR NON-INVASIVE DIAGNOSIS OF TUBERCULOSIS

A Report on Core Course Project

Department of Biomedical Engineering

By

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**Oct / Nov - 2023**

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## CHENNAI-69

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## CERTIFICATE

This is to certify that the "**Design of breath analyser for non-invasive diagnosis of tuberculosis**" Submitted by **Vignesh raj S (210421121058), PriyaDharshan D (210421121035), Illayaboopathy U (210421121018)** is the work done by them and submitted during **2023-2024** academic year, in partial fulfilment of the requirements for the award of the degree of **BACHELOR OF ENGINEERING** in **DEPARTMENT OF BIOMEDICAL ENGINEERING**, at **Chennai Institute of Technology, Chennai-69.**

**Core Course Project Coordinator** **Internal Examiner**

**Head of the Department** **External Examiner**

# ACKNOWLEDGEMENT

We express our gratitude to our Chairman **Shri.P.SRIRAM** and all trust members of Chennai institute of technology for providing the facility and opportunity to do this project as a part of our undergraduate course.

We are grateful to our Principal **Dr.A.RAMESH M.E**, **Ph.D.** for providing us the facility and encouragement during the course of our work.

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We would like to extend our thanks to our **faculty coordinators of the Department of Biomedical Engineering**, for their valuable suggestions throughout this project.

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We wish to acknowledge the help received from the **Lab Instructors of the Department of Biomedical Engineering** and others for providing valuable suggestions and for the successful completion of the project.

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# PREFACE

I, a student in the Department of Biomedical Engineering need to undertake a project to expand my knowledge. The main goal of my core project is to acquaint me with the practical application of the theoretical concepts I've learned during my course.

It was a valuable opportunity to closely compare theoretical concepts with real-world applications. This report may depict deficiencies on my part but still it is an account of my effort.

The results of my analysis are presented in the form of an industrial Project, and the report provides a detailed account of the sequence of these findings. This report is my Core Course Project, developed as part of my 3$^{rd}$ year project. As an engineer, it is my responsibility to contribute to society by applying my knowledge to create innovative solutions that address their changes.

## ABSTRACT

Tuberculosis (TB) is a disease caused by germs that are spread from person to person through the air. TB usually affects the lungs, but it can also affect other parts of the body, such as the brain, the kidneys, or the spine. A person with TB can die if they do not get treatment. The bacteria usually attack the lungs, but TB bacteria can attack any part of the body such as the kidney, spine, and brain. Not everyone infected with TB bacteria becomes sick. A positive TB skin test or TB blood test only tells that a person has been infected with TB bacteria. It does not tell whether the person has latent TB infection (LTBI) or has progressed to TB disease. Other tests, such as a chest x-ray and a sample of sputum, are needed to see whether the person has TB disease. Our idea focuses on the diagnosis of tuberculosis by the change in breath components using gas sensors in a portable breath analyser.

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# CHAPTER 1
# INTRODUCTION

## 1.1 INTRODUCTION

Tuberculosis (TB) is a disease caused by germs that are spread from person to person through the air. TB usually affects the lungs, but it can also affect other parts of the body, such as the brain, the kidneys, or the spine. A person with TB can die if they do not get treatment. The bacteria usually attack the lungs, but TB bacteria can attack any part of the body such as the kidney, spine, and brain. Not everyone infected with TB bacteria becomes sick. A positive TB skin test or TB blood test only tells that a person has been infected with TB bacteria. It does not tell whether the person has latent TB infection (LTBI) or has progressed to TB disease. Other tests, such as a chest x-ray and a sample of sputum, are needed to see whether the person has TB disease. Our idea focuses on the diagnosis of tuberculosis by the change in breath components using gas sensors in a portable breath analyser. (DHT 11 Sensor, GRAPHENE SENSOR)

## 1.2 PROBLEM STATEMENT

- Tuberculosis remains a global health threat killing over 1 million people per year.
- A diagnostic procedure of TB by skin or blood provides minimal information about the TB bacteria and does not provide quantitative information on the disease progression.
- To identify latent TB infection (LTBI) in a patient either a sample of sputum or chest X-ray is currently used.
- To reduce TB incidence and mortality, there is a continuous need for lower cost, simpler and more robust means of diagnosis. One method that may fulfil these requirements is in the area of breath analysis.
- Our idea focuses on the diagnosis of tuberculosis by the change in breath components using gas sensors in a portable breath analyser.

## 1.3 OBJECTIVES

- Create an easy-to-use monitoring device for individuals with Tuberculosis.
- To create the non-invasive device for TB Detection.
- To consume time and comfort for the patient.
- Using a DHT11 sensor for tuberculosis detection involves monitoring environmental conditions.

- The objectives might include studying how specific environmental factors, like temperature and humidity, correlate with the prevalence or transmission of tuberculosis.
- This can aid in developing early warning systems or understanding environmental influences on the disease.
- integrating DHT11 data with other diagnostic methods could contribute to a comprehensive approach for tuberculosis detection and monitoring.

## 1.4 EXISTING SYSTEM

The existing model for an TB detection system incorporates health trackers and mobile apps, both of which are currently in the research and development stages. Although these concepts have a lot of potential, they have not yet been completely developed for consumer use. The existing system's practical use is therefore constrained, and it may not be advantageous for everyone, particularly for those who have technological limitations or have restricted access to cutting-edge technology. These difficulties emphasize the significance of developing an TB detection system that is more inclusive and user-friendly that meets the needs of all people, regardless of their technological capabilities.

## 1.5 PROPOSED IDEA

The proposed solution for the TB detection system aims to provide a non-invasive and user-friendly device for monitoring VOC (volatile organic compound) value, Humidity and Temperature, specifically for individuals with asthma. The device incorporates sensors to assess vital environmental variables continually, such as humidity, temperature, and gas concentrations, which are known to affect TB detection. However, detecting tuberculosis typically requires specific biological indicators. Calculating Volatile Organic Compound (VOC) values could indeed be relevant for detecting certain markers associated with tuberculosis. It's crucial to identify specific VOCs linked to TB and ensure the DHT11 sensor can accurately measure them. Precision in sensor readings and a robust algorithm for data analysis would be key. comparing responses from healthy and affected individuals can help establish patterns in VOC values.

# CHAPTER 2
# LITERATURE REVIEW

## REVIEW PAPER OBSERVATION

1. The paper titled *"Breath Analysis in Disease Diagnosis: Methodological Considerations and Applications"* Célia Lourenço and Claire Turner Pub Med Central Metabolites. 2014 Jun; 4(2): 465–498. Published online 2014 Jun 20. doi: 10.3390/metabo4020465

   The idea proposed in this journal was to first collect samples and the methodology PTR, VOC tests was described, challenges behind the model was explained.

2. The paper titled *"Diagnosis of tuberculosis through breath test: A systematic review"* by Antonia M.I.Saktiawatia bcDavid, DwiPuterad Althaf,Setyawane Yodi, Mahendradha tacfTjip S.van der Werfbg ,E-Biomedicine, Volume 46 ,August 2019, Page 202-214

   The work was performed on a dataset of diagnosis of TB through a breathe test and clinical studies was made.

3. The paper titled *"Tuberculosis Diagnostics, a journey from the past Experiences to the Future Directions"* by Swathy Moorthy1, Emmanuel Bhaskar2, Shivakumar S3 and Santhi Silambanan in Science, AGJSR 39 (2) 2021: 82-99.

   This journal proposes the Tuberculosis analysis method and diagnosis process from the past to the current method and the technology used and the experience which has made the result for future preference.

4. The paper titled *"A simple breath test for tuberculosis using ion mobility: A pilot study"* by Amandip S. Sahota Ravi Gowda, Ramesh P,Arasaradnam, C.Emma Daulton , Elsevier Health Article March 2019(Tuberculosis 99 (2019) 143e146).

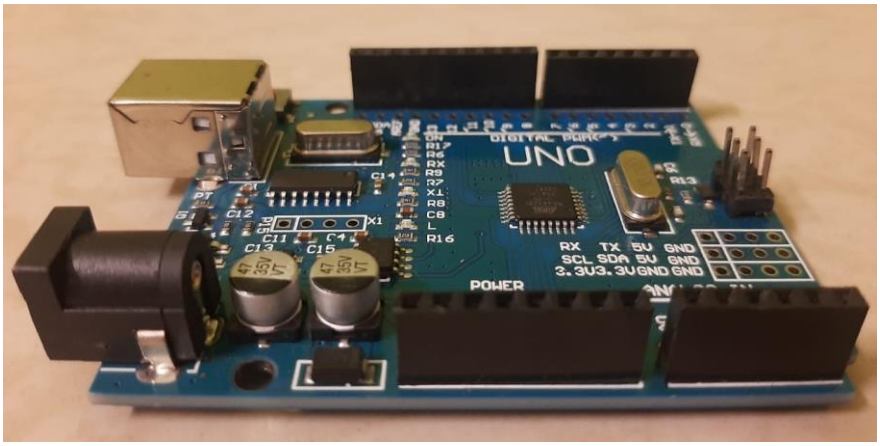
   The workflow for performing the breathe test for tuberculosis using Ion Mobility Spectrometry (IMS) in particular, has potential as a technology that can be applied to breath testing for clinical diseases including TB.

**5.** The paper titled *"Breath biomarkers of active pulmonary tuberculosis"* by Michael Phillips 1, Victoria Basa-Dalay, Graham Bothamley, Renee N Cataneo, Phung Kim Lam, Maria Piedad R Natividad, Peter Schmitt, James Wai Tuberculosis (Edinb).2020 Mar;90(2):145-51. doi: 10.1016/j.tube.2010.01.003. Epub 2020Feb 26.

This paper proposed a identification of Volatile organic compounds (VOCs) in breath may contain biomarkers of active pulmonary tuberculosis derived from the infectious organism.

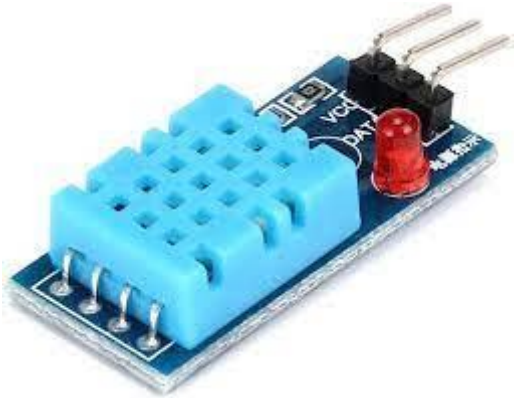
# CHAPTER 3
# HARDWARE REQUIREMENTS

## 3.1 ARDUINO UNO




Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino. The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by a USB cable or a barrel connector that accepts voltages between 7 and 20 volts, such as a rectangular 9-volt battery.

## 3.2 DHT 11



DHT11 is a commonly used Temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%.

## 3.4 SGP40 VOV Sensor


The SGP40 is Sensirion's new digital VOC (volatile organic compounds) sensor designed for easy integration into air purifiers or demand-controlled ventilation. SGP40 is Sensirion's new digital VOC (volatile organic compounds) sensor designed for easy integration into air treatment devices and air quality monitors. 1 Sensirion's VOC Algorithm processes the SGP40 raw signal externally into a ready-to-use air quality signal. 2 The SGP40 raw signal is proportional to the logarithm of MOX resistance. The SEK-SVM40 evaluation kit has been designed for easy and cost-efficient evaluation of Sensirion's SGP40 VOC sensor

## 3.6 JUMPER WIRES

A jump wire is an electrical wire, or group of them in a cable, with a connector or pin at each end, which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering. Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

# CHAPTER 4
# SOFTWARE REQUIREMENTS

## 4.1 ARDUINO IDE SOFTWARE

The Arduino integrated development environment (IDE) is a cross-platform application (for Microsoft Windows, macOS, and Linux) that is written in the Java programming language. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus. It supports the languages C and C++ using special rules of code structuring.

## 4.2 ADAFRUIT LIBRARY

This library provides a simple device independent interface for interacting with Adafruit IO using Arduino. It allows you to switch between Wi-Fi (ESP8266, ESP32, ESP32-S2, ESP32-S3, ESP32-C3, Airlift, WINC1500, & WICED), Cellular (32u4 FONA), and Ethernet (Ethernet FeatherWing).

## 4.3 DHT LIBRARY

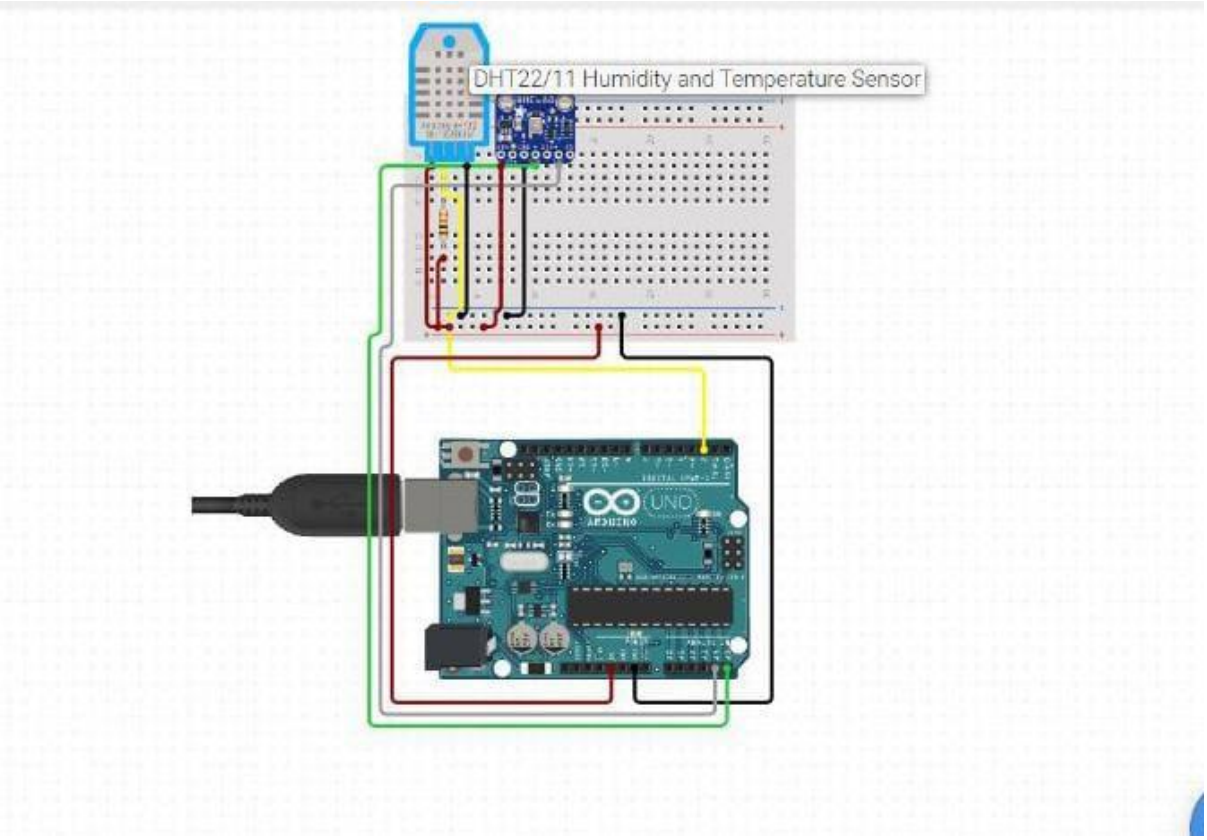
An Arduino library for the DHT11 temperature and humidity sensor. This library provides a simple and easy-to-use interface to read temperature and humidity data from a DHT11 sensor.

## 4.4 BLUETOOTH TERMINAL(1.40)

Serial Bluetooth Terminal' is a line-oriented terminal / console app for microcontrollers, arduinos and other devices with a serial / UART interface connected with a bluetooth to serial converter to your android device.

# CHAPTER 5
# SCHEMATIC REPRESENTATION

## 5.1CIRCUIT DIAGRAM




## 5.2 CONNECTIONS

**1. MQ-2 gas sensor:**

- Connect the MQ-2's VCC to 5V.
- Connect the MQ-2's GND to GND.
- Connect the MQ-2's AOUT to an analog pin (e.g., A1).

**2. DHT11 humidity and temperature sensor:**

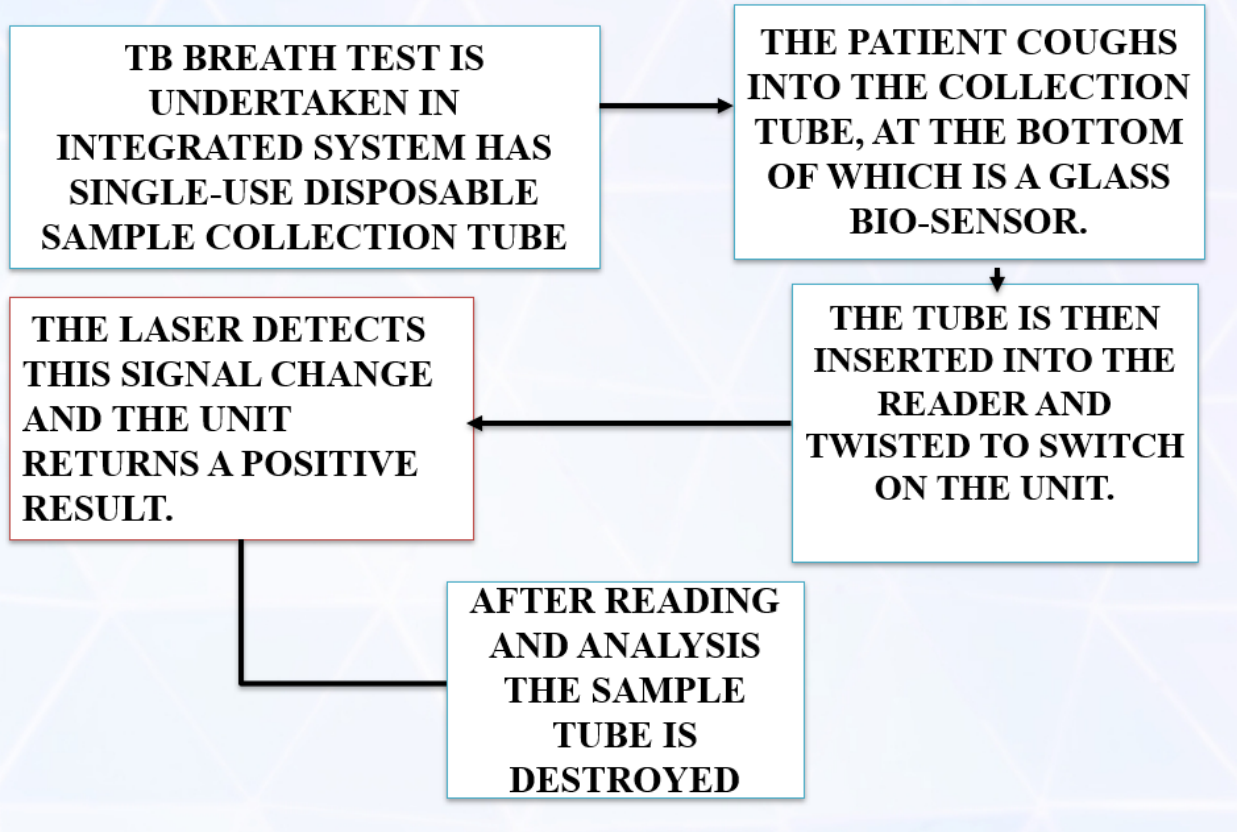
- Connect the DHT11's VCC to 5V.
- Connect the DHT11's GND to GND.
- Connect the DHT11's DATA pin to a digital pin (e.g., D3).

**3. SGP40 VOC Sensor:**

- Connect the HW-827's VCC to 5V.
- Connect the HW-827's GND to GND.
- Connect the HW-827's OUT pin to an analog pin (e.g., A0).

# CHAPTER 6

# BLOCK DIAGRAM

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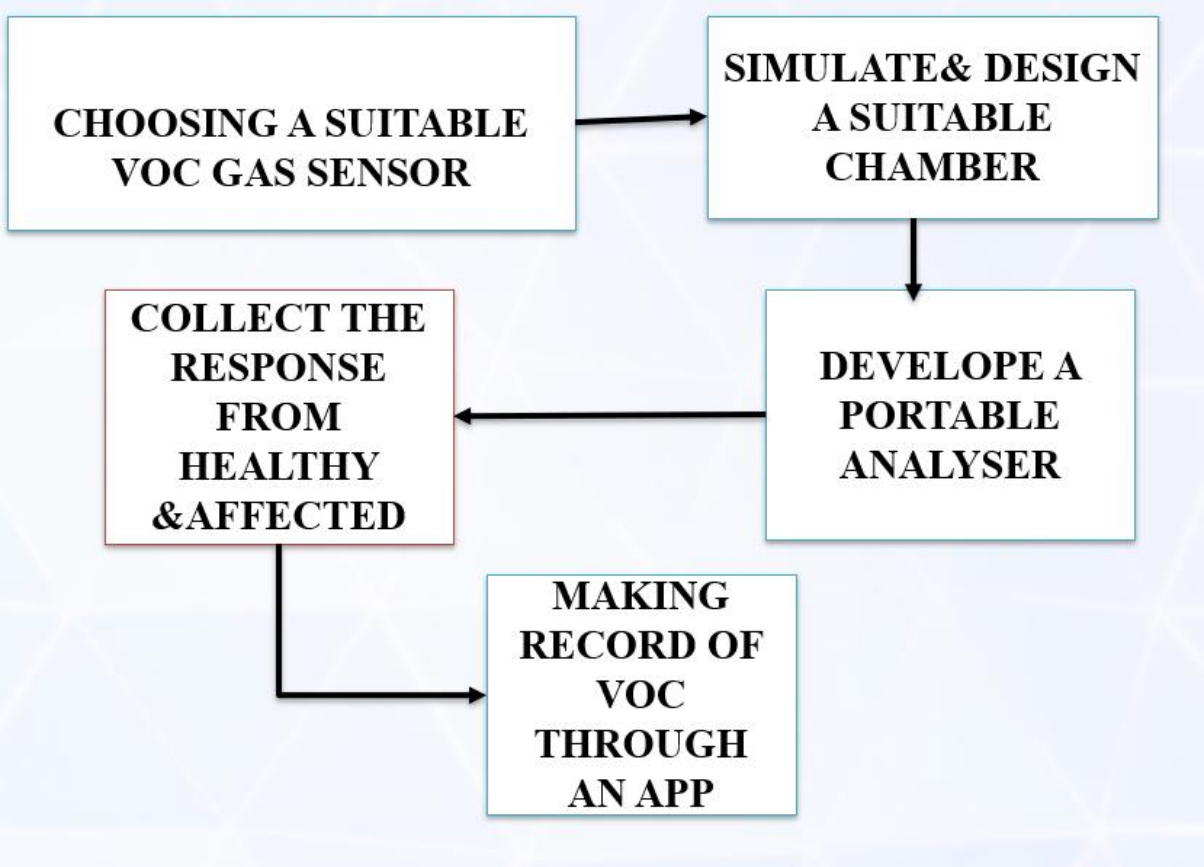
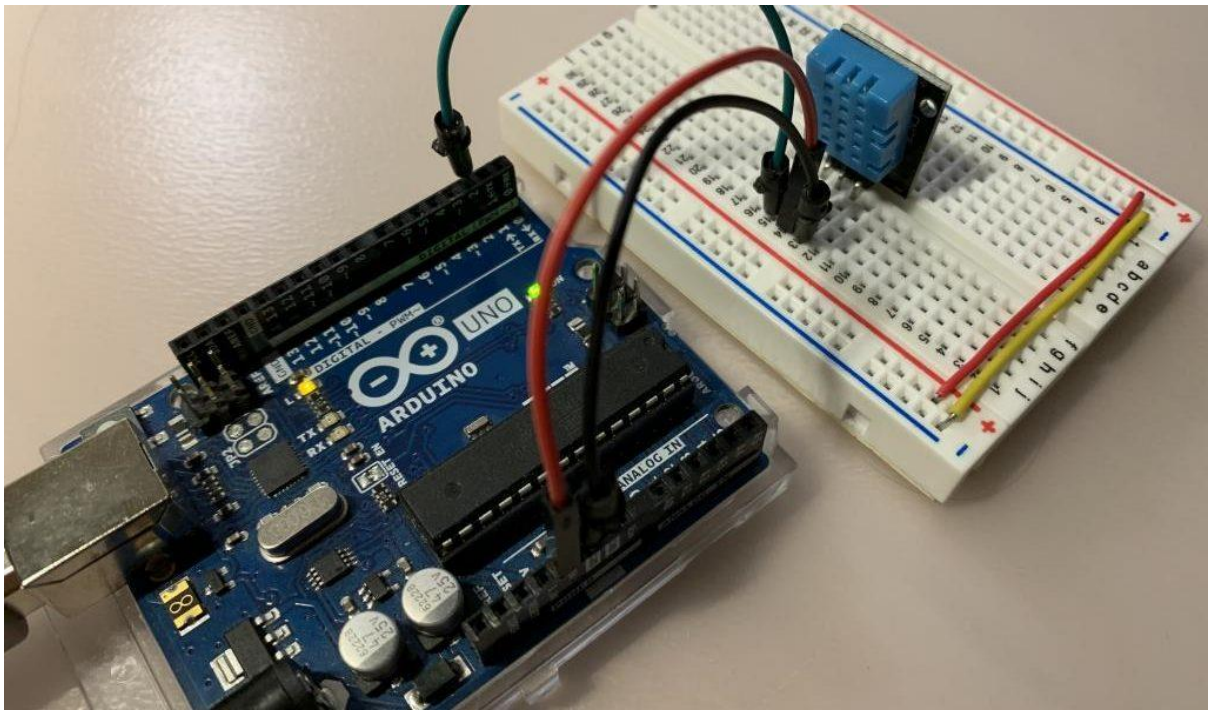
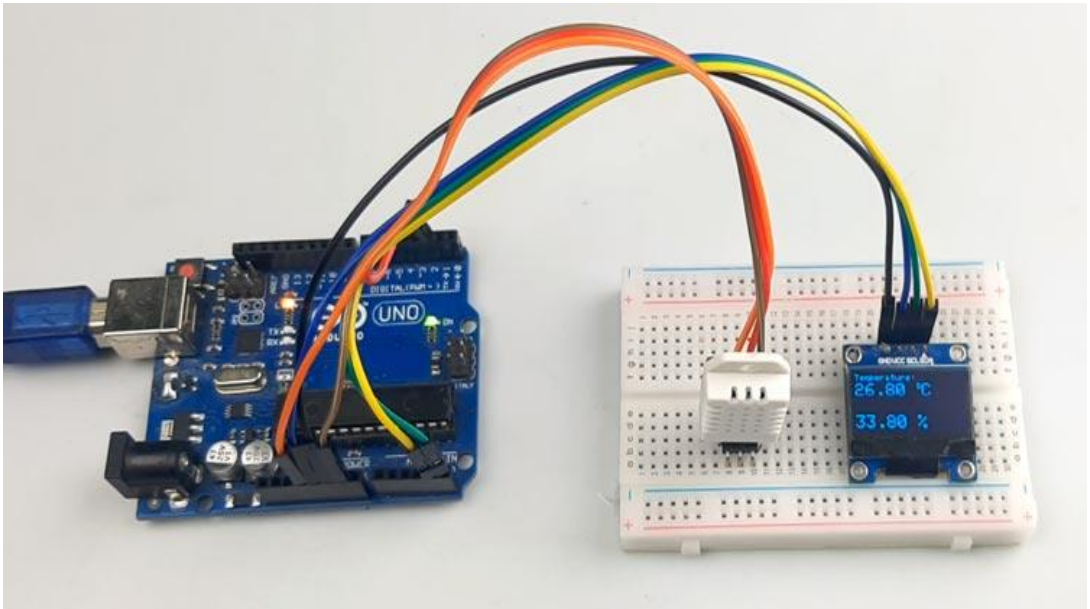

CHOOSING A SUITABLE VOC GAS SENSOR
SIMULATE& DESIGN A SUITABLE CHAMBER
DEVELOPE A PORTABLE ANALYSER
COLLECT THE RESPONSE FROM HEALTHY &AFFECTED
MAKING RECORD OF VOC THROUGH AN APP

# CHAPTER 7
# RESULT

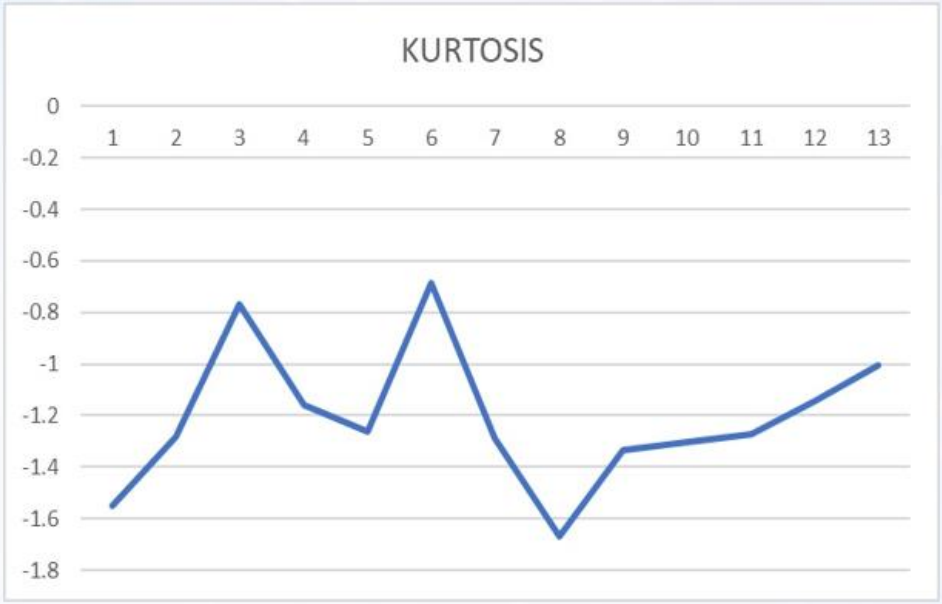
## 7.1 HARDWARE MODEL



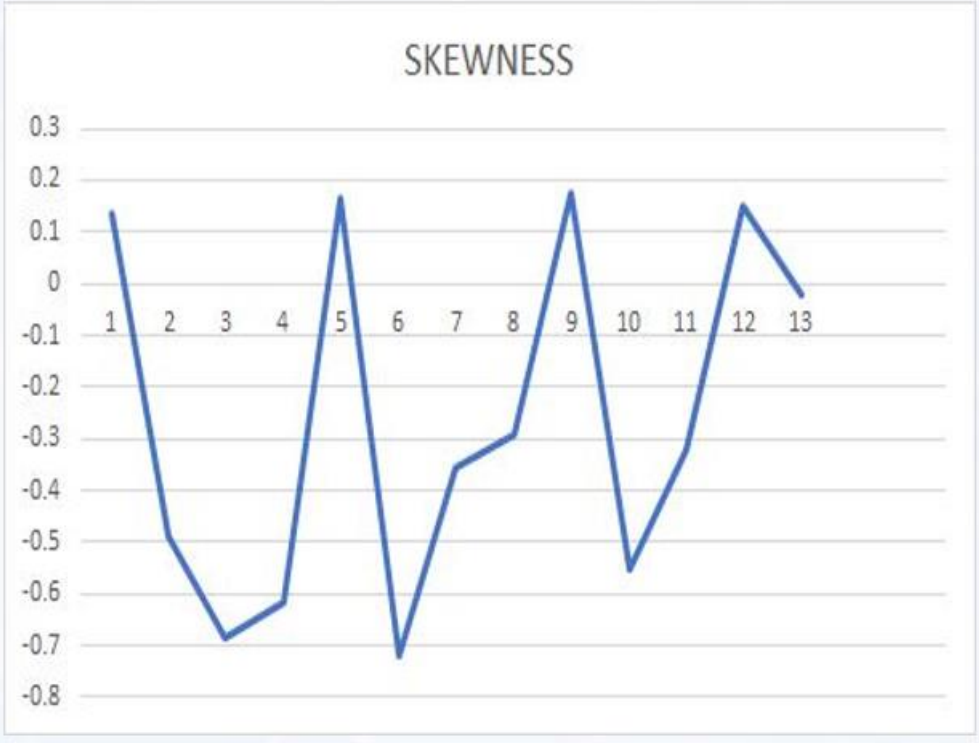



## GRAPHICAL REPRESENTATION

### GRAPH- KURTOSIS VALUE FOR TB



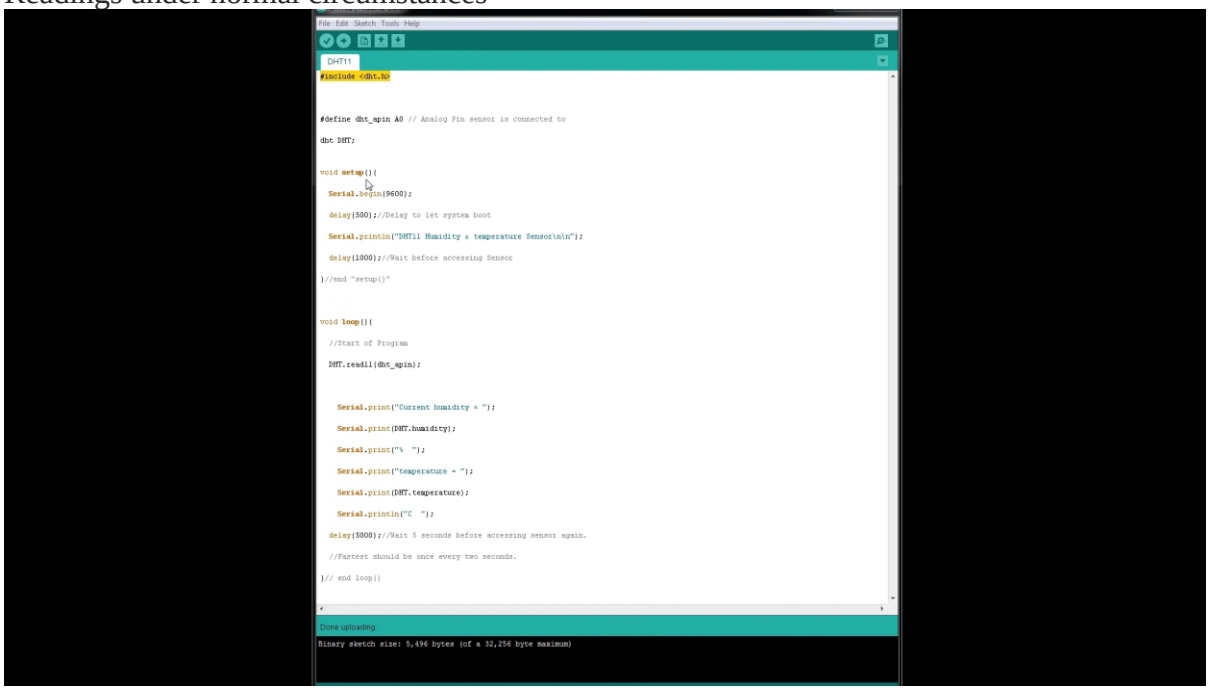

### GRAPH- SKEWNESS VALUE FOR TB



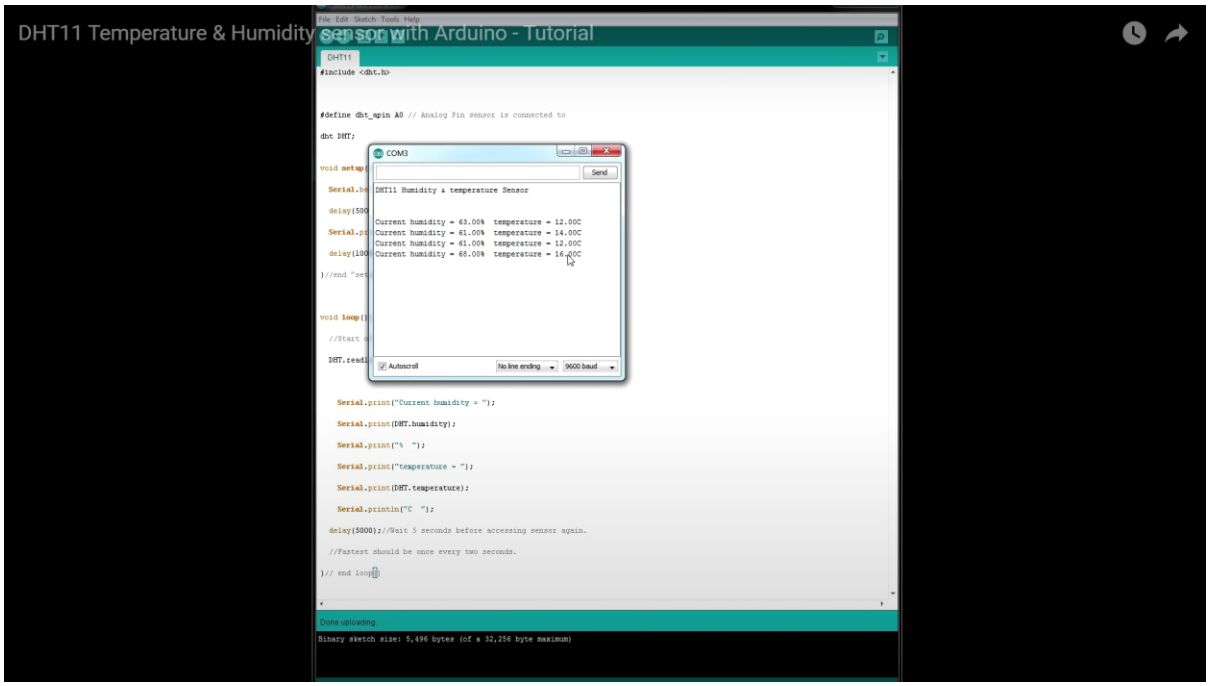
# CHAPTER 8
# COMPREHENSIVE ANALYSIS

## 8.1 PROJECT INTERPRETATION

Readings under normal circumstances




Readings under the influence of certain environmental triggers




## 8.2 APPLICATION

- This system can assist individuals with TB in monitoring their environment and vital signs.
- It can be used in early detection of Tuberculosis.
- The DHT22 measures temperature and humidity, while the VOC sensor detects volatile organic compounds.
- The observe of air quality changes in environments associated with TB, aiding early detection or providing data for research.

## 8.3 NOVELTY

- Users might get a treatment before it’s too late.
- Fewer trips to the hospital or emergency room could mean less money spent on medical bills.
- Real-time data processing enables the system to quickly identify risk factors that can exacerbate Tuberculosis symptoms.

- Its independence from mobile applications guarantees universal accessibility, making it an important tool in the control of Tuberculosis.
- The project can provide valuable information for research, which could lead to better ways to prevent death from Tuberculosis.

## 8.4 FUTURE DEVELOPMENT

- Consider creating a smartphone app for those who use them, making it easier to access data.
- Connect the system with telehealth services so doctors can monitor patients remotely.
- Explore options for putting the system into wearable devices like smartwatches.
- Find ways to make the system more affordable and accessible to a wider range of people.
- Make sensors more accurate to better detect Tuberculosis early stage in the environment.

## 8.5 DRAWBACKS

- **Environment detection**: These sensors might not directly detect TB bacteria but rather environmental conditions.
- **Sensitivity**: False positives/negatives can occur, and the system may lack the specificity and sensitivity required for accurate diagnosis.
- **Accuracy**: calibration challenges and external factors like other pollutants might affect sensor accuracy.

# CHAPTER 9
# CONCLUSION

## 9.1 CONCLUSION

Non-invasive diagnosis of tuberculosis is a detecting system of humidity, temperature, VOC (volatile organic compound), DHT 22 sensor and VOC sensors detects a tuberculosis abnormal level by comparing the normal range of tuberculosis.

However, it's essential to acknowledge its limitations. It focuses primarily on environmental air and may not cover the full breath of the patient can affect individual. calibration challenges and external factors like other pollutants might affect sensor accuracy that should be considered.

Ultimately, employing the DHT22 sensor and VOC sensor with Arduino for tuberculosis detection showcases a promising intersection of technology and healthcare. This innovative approach not only demonstrates the versatility of sensor integration but also holds potential for early and efficient diagnosis. As we strive for advancements at this intersection, the fusion of electronics and medical science presents a path towards enhancing diagnostic accuracy and, ultimately, improving public health outcomes.

## 9.2 REFERENCES

[1] The paper titled *"Breath Analysis in Disease Diagnosis: Methodological Considerations and Applications"* Célia Lourenço and Claire Turner Pub Med Central Metabolites. 2014 Jun; 4(2): 465–498. Published online 2014 Jun 20. doi: 10.3390/metabo4020465

[2] The paper titled *"Diagnosis of tuberculosis through breath test: A systematic review"* by Antonia M.I.Saktiawatia bcDavid, DwiPuterad Althaf,Setyawane Yodi, Mahendradha tacfTjip S.van der Werfbg ,E-Biomedicine, Volume 46 ,August 2019, Page 202-214

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[5] The paper titled *"Breath biomarkers of active pulmonary tuberculosis"* by Michael Phillips 1, Victoria Basa-Dalay, Graham Bothamley, Renee N Cataneo, Phung Kim Lam, Maria Piedad R Natividad, Peter Schmitt, James Wai Tuberculosis (Edinb).2020 Mar;90(2):145-51. doi: 10.1016/j.tube.2010.01.003.

## PO & PSO Attainment

| PO.No | Graduate Attribute | Attained | Justification |
|---|---|---|---|
| **PO 1** | **Engineering knowledge** | Yes / No | |
| **PO 2** | **Problem analysis** | Yes / No | |
| **PO 3** | **Design/Development of solutions** | Yes / No | |
| **PO 4** | **Conduct investigations of complex problems** | Yes / No | |
| **PO 5** | **Modern Tool usage** | Yes / No | |
| **PO 6** | **The Engineer and society** | Yes / No | |
| **PO 7** | **Environment and Sustainability** | Yes / No | |
| **PO 8** | **Ethics** | Yes / No | |
| **PO 9** | **Individual and team work** | Yes / No | |
| **PO 10** | **Communication** | Yes / No | |
| **PO 11** | **Project management and finance** | Yes / No | |
| **PO 12** | **Life-long learning** | Yes / No | |

| PSO.No | Graduate Attribute | Attained | Justification |
|---|---|---|---|
| **PSO 1** | To analyze, design and develop solutions by applying the concepts of Robotics for societal and industrial needs. | **Yes/No** | |
| **PSO 2** | To create innovative ideas and solutions for real time problems in Manufacturing sector by adapting the automation tools and technologies. | **Yes/No** | |