

MICROPROCESSOR BASED EXHALED GAS COMPOSITION ANALYZER FOR THE DETECTION OF RESPIRATORY DISORDERS

Submitted in partial fulfillment of the requirements for the award
of Bachelor of technology in Biomedical Engineering

by

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SCHOOL OF BIO AND CHEMICAL ENGINEERING**

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(DEEMED TO BE UNIVERSITY)**

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BONAFIDE CERTIFICATE

This is to certify that this Interdisciplinary Project Report is the bonafide work of A. Ancy Hannah Charlet (39240007), P. Lochana (39240023), J. Meena Manjuri (39240025) . who carried out the Interdisciplinary project entitled "**Microprocessor based exhaled gas composition analyzer for the detection of respiratory disorders**" under my supervision from Jan 2022 to May 2022.

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Submitted for Viva voce Examination held on 30.04.2022

Internal examiner

External examiner

DECLARATION

We, **A. Ancy Hannah Charlet , P. Lochana , J. Meena Manjuri** hereby declare that the Interdisciplinary Project Report entitled **Microprocessor based exhaled gas composition analyzer for the detection of respiratory disorders** done by us under the guidance of Dr. Grace Kanmani at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Biomedical engineering.

DATE:28-04-2022

SIGNATURE OF THE CANDIDATE



PLACE:CHENNAI



J. Meena Manjuri

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ABSTRACT

This project is about diagnosing respiratory disorder like Asthma, Lung Cancer Pneumonia by using a Gas sensor CJMCU 811 and Mic MAX 9814. Exhaled human breath analysis is a promising field of research having great potential for diagnosis of diseases in non invasive way. The agenda of this project is to epitomize a new risk free and potentially inexpensive diagnostics of respiratory diseases by detecting volatile organic compounds (VOC's) present in exhaled breath. In this proposed system, parameters like TVOC's , CO₂ and breathing pattern are analyzed for various respiratory disorder. Some VOC's / gases in exhaled breath are biomarkers of different diseases and their presence in excess amount is indicative of unhealthiness. Breath analysis has the potential for early detection diseases. This project is intended to provide an overview of major biomarker present in exhaled breath, importance of their analysis towards respiratory disease monitoring and promising materials for breath analysis. The detection of exhaled analysis forms major application in therapeutic field.

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Chapter -1

INTRODUCTION

Respiration is a metabolic process that occurs in all organisms. It is a biochemical process that occurs within the cells of organisms. Respiration involves two processes Inhalation and Exhalation . Inhalation is a process of taking in air and other substances into our lungs. The air, along with other gases, enters our body through inhalation. Exhalation is defined as the process wherein the air moves out from the lungs through the airways in the body. The respiratory system disorders or respiratory diseases are the medical terms used to study about the various types of infections, allergies and other diseases related to the different organs, tissues and specialized cells of the human respiratory system. According to WHO, in India, deaths due to respiratory diseases account for 11% of total deaths in the country. In every one lakh people, an estimated amount of 142 people die from lung disease. The country bears 18% of the world population but 32% of the global burden of respiratory diseases. So exhaled breath analysis an important area of research work which has gained tremendous interest recently owing to the advances in analytical techniques and nanotechnology. This is a non-invasive method for disease detection, therapeutic monitoring, and metabolic status monitoring by analyzing the volatile organic compounds (VOCs) present in the exhaled breath. Along with point of care detection breath analysis has the advantage of non-invasive, cost-effective, real time, qualitative/quantitative disease diagnosis and hence it staking.

LITERATURE SURVEY

1. **Ting chan , Ting lieu 2021, Elseveir. Exhaled breath analysis in disease detection** Investigating the use of exhaled breath analysis to diagnose and monitor different diseases has attracted much interest in recent years. This review introduces conventionally used methods and some emerging technologies aimed at breath analysis and their relevance to lung disease, airway inflammation, gastrointestinal disorders, metabolic disorders and kidney diseases. One section correlates breath components and specific diseases, whereas the other discusses some unique ideas, strategies, and devices to analyze exhaled breath for the diagnosis of some common diseases.
2. **JanuszSmulko^aTomaszChludziński^aTomaszMajchrzak^bAndrzejKwiatkowski^a SebastianBorys^cAylenLisset 2022, Elsevier, Analysis for exhaled breath for dengue disease detection.** This paper presents a procedure and a set-up of an electronic nose system analyzing exhaled breath to detect the patients suffering from dengue – a mosquito- borne tropical disease. Low-power resistive gas sensors (MiCS-6814, TGS8100) were used to detect volatile organic compounds (VOCs) in the exhaled breath. The end-tidal phase of patients exhaled breath was collected with a BioVOCTM breath sampler. Two strategies were assessed for breath samples measurement: either direct transfer from the BioVOCTM into the sensors test chamber, or storage in Tenax TA sorbent tubes followed by VOCs release through thermal desorption and then transfer into sensors test chamber.
3. **Anna Paleczek and Artur Rydosz,2022, Journal of Breath Research, Review of the algorithms used in exhaled breath analysis for the detection of diabetes.** Currently, intensive work is underway on the development of truly noninvasive medical diagnostic systems, including respiratory analysers based on the detection of biomarkers of several diseases including diabetes. The prepared review of the literature showed that there are many limitations in the development of the versatile breath analyser, such as high metabolic variability between patients, but the results

obtained by researchers using the algorithms described in this paper are very promising and most of them achieve over 90% accuracy in the detection of diabetes in exhaled air.

4. **Aleksandr A. Ganeev^{1,2,3}, Anna R. Gubal², Gennadij N. Lukyanov³, Andrey , 2018, Russian Reviews, Analysis of exhaled air for early stage diagnosis of lung cancer, oppourtunities and challenges.** Early detection of lung cancer usually markedly increases the efficiency of therapy. However, the currently employed diagnostic approaches are not sufficiently effective, resulting in late detection of the disease and high patient mortality. Therefore, development of a high-throughput and reliable diagnostic method is a priority task requiring fast solution. This review surveys contemporary analytical techniques for analysis of exhaled air, including various spectroscopic and mass spectral methods and also gas sensor-based methods. The key benefits and shortcomings of the techniques, sample injection and pre- concentration methods, and the potential applicability of the methods for lung cancer detection are discussed. The prospects of simultaneous application of several analytical techniques and approaches for the early diagnosis are demonstrated.
5. **S.Venkatesulu¹, SeenaNaik Korra², E.Sudarshan³, A. Rajeshwar Rao⁴, 2020, Journal of mechanics continua and mathematical sciences, Detection of exhale analysis through Arduino and integrated sensor.** Nowadays population growth increasing exponentially and also health diseases increase parallel due to environment and manmade things. A common person live healthy to required things are air, food, water environmental conditions and our body functioning. Due to these above parameters health issues are affecting and medical Diagnosis is too costly. The proposed analysis is helping out to every common people with their exhale; through their exhale they can analyze present environmental and body circumstances. The basic analysis is exhale air quality index comparing some gases like carbon oxide, nitrogen, argon and oxygen. The detection of exhale and analysis forms a major application in therapeutic field. It helps in detecting the deviation real time by using Arduino and integrated sensors. The developed system systematically monitors the gases Parameters to get down various consequences so that early detection of diseases symptoms is possible.

CHAPTER-3

AIM AND SCOPE

AIM

- Using Arduino incorporated with mic (MAX – 9814) and gas sensor (CJMCU – 811) we are diagnosing the respiratory disorder
- The mic (MAX – 9814) is a sensitive sensor which is used to analyze the breathing patterns of an individual
- The gas sensor (CJMCU – 811) is used to estimate the amount of CO₂ and TVOC (Total Volatile Organic Compounds) in the exhaled gas
- And all the values and datas will be displayed in a LCD display

SCOPE

- It is essential to monitor Breathing Pattern , CO₂ and TVOC levels for the early diagnosis of respiratory disorder.
- The scope of this project is to epitomize a new risk free and potentially inexpensive diagnostics of respiratory disorders.

CHAPTER - 4

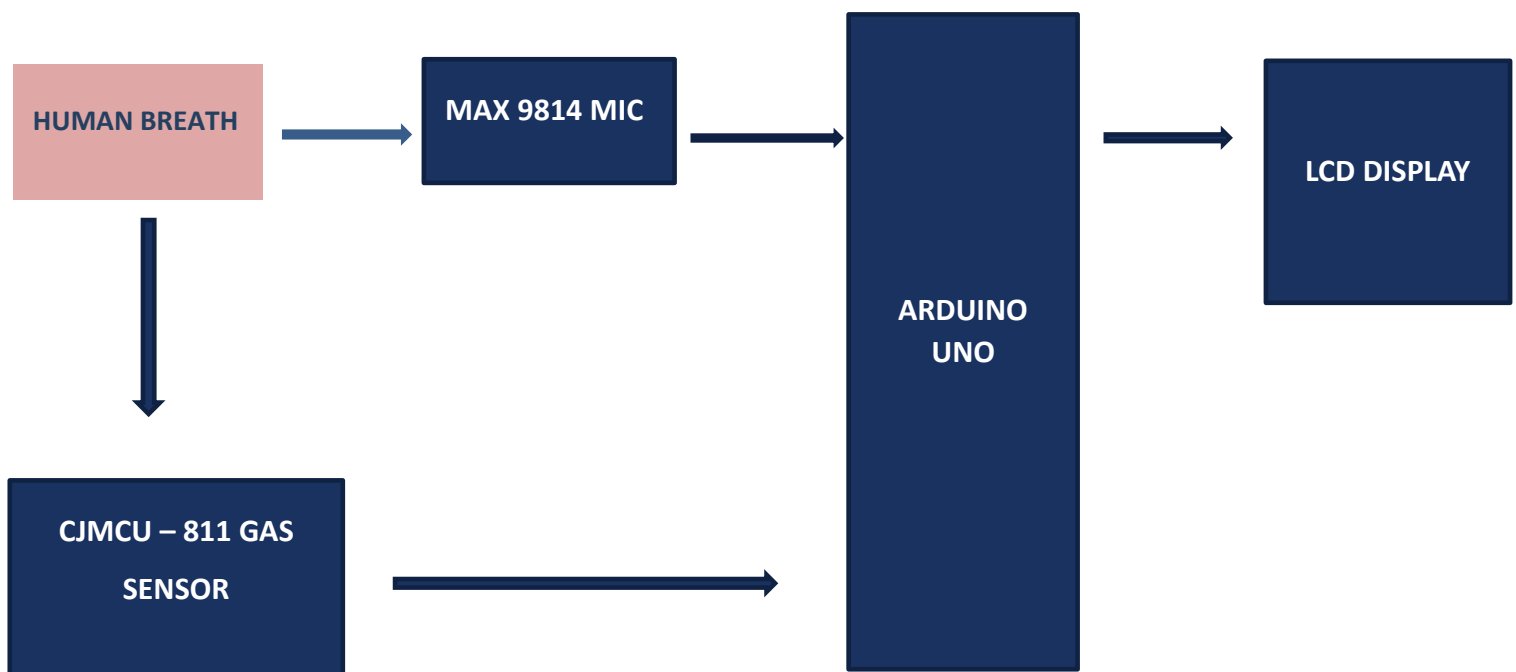
MATERIALS AND METHODS

4.1. METHODOLOGY

Here the arduino uno is connected to LCD crystal display which shows the Co2 and TVOC levels along with breath rate here the breath rate is initially zero and in the program it is multiplied by 6 times the breath rate is taken for about 10 seconds so that according to the program it is multiplied by 6 which gives a value for 1 minute and the arduino is connected to two sensitive sensors CJMCU 811 and MAX 9814 .cjmcu 811 which is used to calculate and show the Co2 and tvoc levels in LCD display and max 9814 is used to show the breath pattern in serial plotter and serial monitor.when exhaled the co2 and tvoc levels increase and when inhaled the co2 and tvoc levels decrease in LCD display.

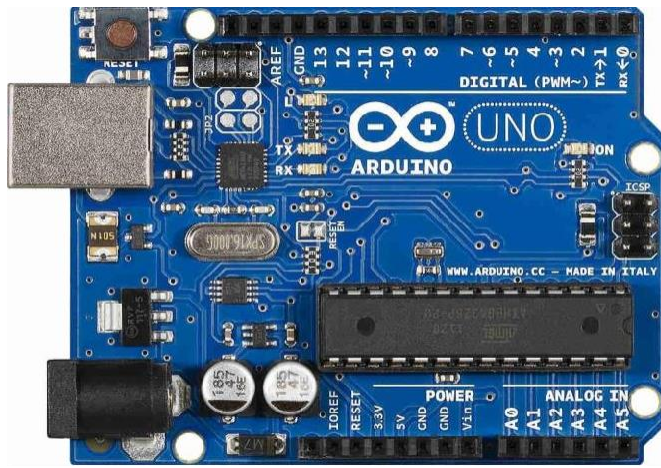
4.1.1. BLOCK DIAGRAM WITH EXPLANATION

When we exhale,the breath is analyzed by both highly sensitive sensors Mic MAX-9814 and gas sensor CJMCU-811 and it delivers to the arduino.The arduino does the necessary processing .And the digital output is finally displayed in a16x2 LCD display.



4.2. HARDWARE USED

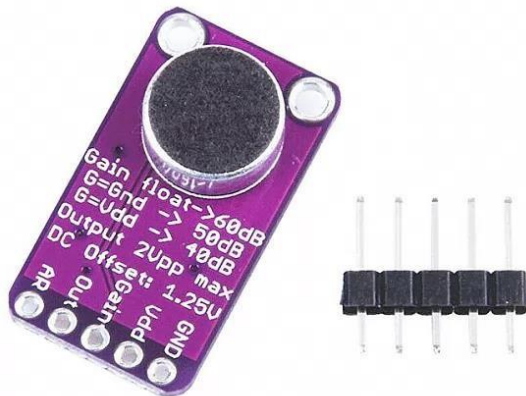
4.2.1 ARDUINO UNO



Arduino Uno is a microcontroller board based on the ATmega328P . It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; we can simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started..

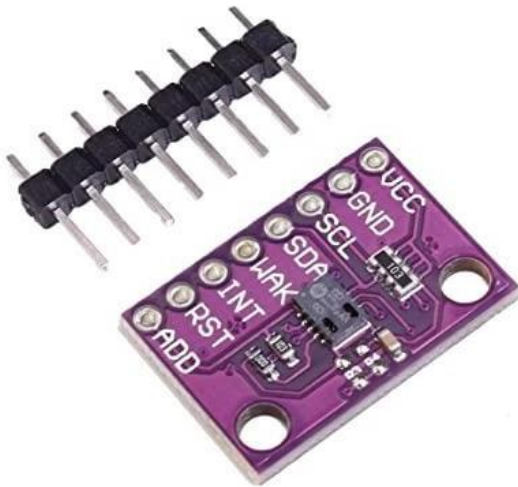
"Uno" means one in Italian. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

4.2.2 MICROPHONE MAX-9814



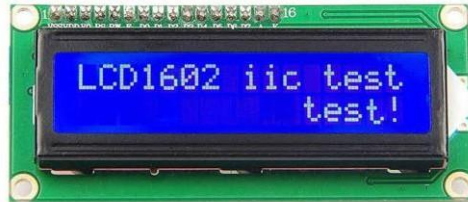
The MAX9814 is a low cost, high performance microphone amplifier with automatic gain control (AGC) and low noise microphone bias. The device features a low-noise front-end amplifier, a variable gain amplifier (VGA), an output amplifier, a microphone bias voltage generator, and an AGC control circuit. The low-noise preamplifier has a fixed 12dB gain, while the VGA gain automatically adjusts from 20dB to 0dB, depending on the output voltage and the AGC threshold. The output amplifier offers selectable gains of 8dB, 18dB, and 28dB. With no compression, the cascade of the amplifiers results in an overall gain of 40dB, 50dB, or 60dB. A tri-level digital input programs the output amplifier gain. An external resistive divider controls the AGC threshold and a single capacitor programs the attack/release times. A tri-level digital input programs the ratio of attack-to-release time. The hold time of the AGC is fixed at 30ms. The low-noise microphone-bias-voltage generator can bias most electric microphones. We can also change the Attack/Release ratio, from the default 1:4000 to 1:2000 or 1:500. The output from the amp is about 2Vpp max on a 1.25V DC bias, so it can be easily used with any Analog/Digital converter that is up to 3.3V input. If you want to pipe it into a Line Input, just use a 1-100uF blocking capacitor in series (100uF sounds best).

4..2.3 GAS SENSOR CJMCU-811



CJMCU-811 is a digital sensor for measuring changes in tVOCs (total volatile organic compounds), in particular Carbon Dioxide (CO₂). Simply to supply power, connect WAK to Ground, and connect the SDA and SCL pins to the I2C pins on your Arduino, ESP8266, Raspberry Pi, etc. Operating voltage of this sensor ranges 3~5VDC. 2C address 0x5A. It is easy to use on a breadboard with the included 8-pin header. CCS811 Carbon Monoxide (CO) Breakout Board for Arduino Raspberry Pi ESP8266 I2C 3~5VDC CJMCU-811.

4.2.4. 16X2 LCD DISPLAY



This I2C 16x2 Arduino LCD Screen is using an I2C communication interface. It means it only needs 4 pins for the LCD display: VCC, GND, SDA, SCL. It will save at least 4 digital/analog pins on Arduino. All connectors are standard XH2. An electronic device that is used to display data and the message is known as LCD 16×2. As the name suggests, it includes 16 Columns & 2 Rows so it can display 32 characters ($16 \times 2 = 32$) in total & every character will be made with 5×8 (40) Pixel Dots. The I2C protocol involves using two lines to send and receive data: a serial clock pin (SCL) that the Arduino Master board pulses at a regular interval, and a serial data pin (SDA) over which data is sent between the two devices.

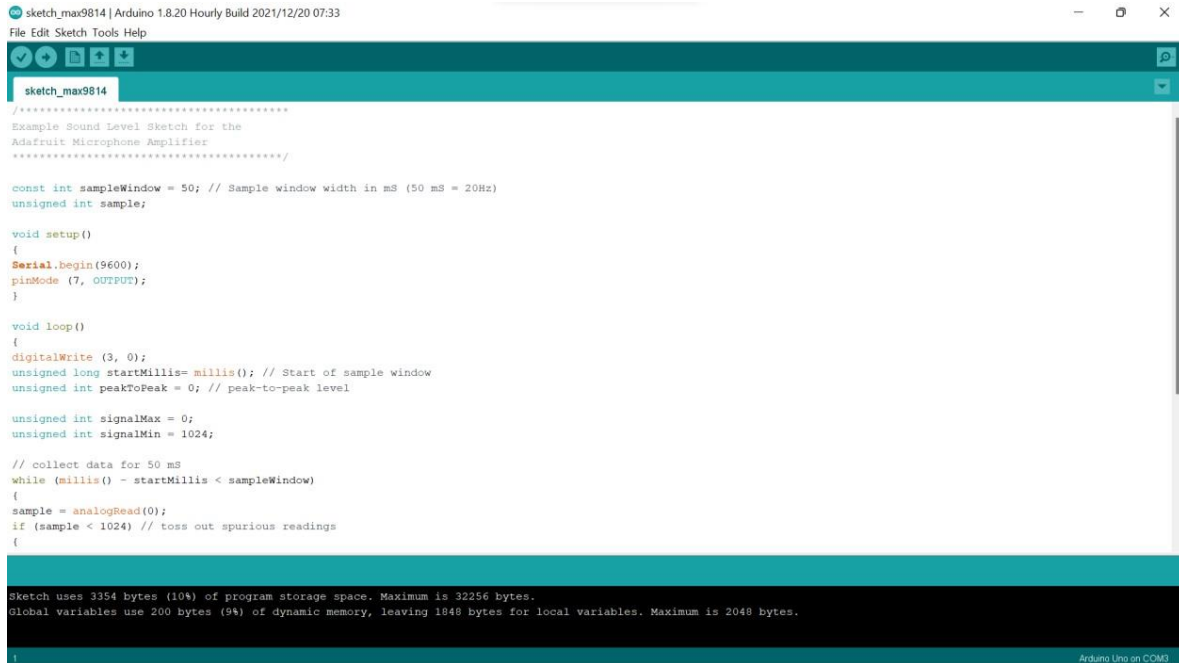
4.2.5. MALE TO FEMALE JUMPER WIRES



Jumper wires typically come in three versions: male-to-male, male-to-female and female-to-female. The difference between each is in the end point of the wire. Male ends have a pin protruding and can plug into things, while female ends do not and are used to plug things into. Jumper wires are used for making connections between items on your breadboard and your Arduino's header pins. Use them to wire up all our circuits.

4.3 SOFTWARE USED

CODING FOR BREATHING PATTERN:



```
sketch_max9814
/*****
Example Sound Level Sketch for the
Adafruit Microphone Amplifier
*****/

const int sampleWindow = 50; // Sample window width in ms (50 ms = 20Hz)
unsigned int sample;

void setup()
{
  Serial.begin(9600);
  pinMode(7, OUTPUT);
}

void loop()
{
  digitalWrite(3, 0);
  unsigned long startMillis= millis(); // Start of sample window
  unsigned int peakToPeak = 0; // peak-to-peak level

  unsigned int signalMax = 0;
  unsigned int signalMin = 1024;

  // collect data for 50 ms
  while (millis() - startMillis < sampleWindow)
  {
    sample = analogRead(0);
    if (sample < 1024) // toss out spurious readings
    {
      if (sample > signalMax)
        signalMax = sample;
      if (sample < signalMin)
        signalMin = sample;
    }
  }
  peakToPeak = signalMax - signalMin;
  unsigned long peakToPeak2 = peakToPeak * peakToPeak;
  unsigned long averagePower = peakToPeak2 / sampleWindow;
  unsigned int averagePower2 = sqrt(averagePower);
  Serial.print("Average power: ");
  Serial.println(averagePower2);
  delay(1000);
}
```

Sketch uses 3354 bytes (10%) of program storage space. Maximum is 32256 bytes.
Global variables use 200 bytes (9%) of dynamic memory, leaving 1848 bytes for local variables. Maximum is 2048 bytes.

Arduino Uno on COM3

```
sketch_max9814 | Arduino 1.8.20 Hourly Build 2021/12/20 07:33
File Edit Sketch Tools Help

sketch_max9814
{
  digitalWrite(3, 0);
  unsigned long startMillis= millis(); // Start of sample window
  unsigned int peakToPeak = 0; // peak-to-peak level

  unsigned int signalMax = 0;
  unsigned int signalMin = 1024;

  // collect data for 50 ms
  while (millis() - startMillis < sampleWindow)
  {
    sample = analogRead(0);
    if (sample < 1024) // toss out spurious readings
    {
      if (sample > signalMax)
      {
        signalMax = sample; // save just the max levels
      }
      else if (sample < signalMin)
      {
        signalMin = sample; // save just the min levels
      }
    }
  }
  peakToPeak = signalMax - signalMin; // max - min = peak-peak amplitude
  double volts = (peakToPeak * 5.0) / 1024; // convert to volts
  Serial.println(volts);
}

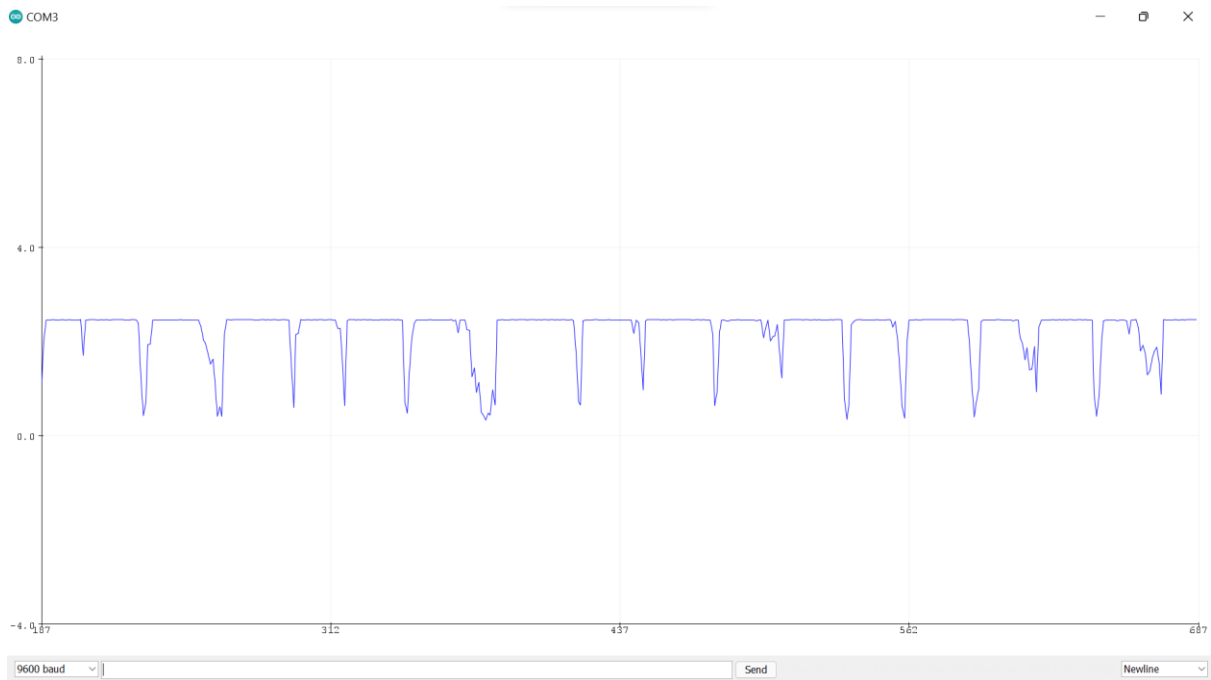
Sketch uses 3354 bytes (10%) of program storage space. Maximum is 32256 bytes.
Global variables use 200 bytes (9%) of dynamic memory, leaving 1848 bytes for local variables. Maximum is 2048 bytes.

Arduino Uno on COM3
```

OUTPUT:

```
COM3
12:08:09.466 -> 0.88
12:08:09.540 -> 0.91
12:08:09.574 -> 0.66
12:08:09.610 -> 0.50
12:08:09.693 -> 0.61
12:08:09.731 -> 0.59
12:08:09.767 -> 0.45
12:08:09.803 -> 0.38
12:08:09.892 -> 0.50
12:08:09.931 -> 2.45
12:08:09.965 -> 2.45
12:08:10.034 -> 2.46
12:08:10.073 -> 2.45
12:08:10.108 -> 2.45
12:08:10.183 -> 2.45
12:08:10.220 -> 2.46
12:08:10.256 -> 2.45
12:08:10.339 -> 2.46
12:08:10.373 -> 2.46
12:08:10.409 -> 2.46
12:08:10.495 -> 2.45
12:08:10.530 -> 2.46
12:08:10.565 -> 2.45
12:08:10.605 -> 2.46
12:08:10.674 -> 2.46
12:08:10.719 -> 2.45
12:08:10.756 -> 2.45
12:08:10.846 -> 2.46
12:08:10.883 -> 2.45
12:08:10.919 -> 2.45
12:08:10.954 -> 2.45
12:08:11.026 -> 2.46
12:08:11.080 -> 2.46
12:08:11.118 -> 2.45
12:08:11.162 -> 2.45
12:08:11.209 -> 2.02
12:08:11.255 -> 1.57
12:08:11.349 -> 0.43

Autoscroll Show timestamp Newline 9600 baud Clear output
```



CODING FOR GETTING CO2 AND TVOC LEVELS:

```
final | Arduino 1.8.20 Hourly Build 2021/12/20 07:33
File Edit Sketch Tools Help

#include<LiquidCrystal.h>
#include "Adafruit_CCS811.h"
Adafruit_CCS811 ccs;
LiquidCrystal lcd(13,12,11,10,9,8);
#define REPORTING_PERIOD_MS 10000
uint32_t tsLastReport = 0;
int breath_c_count,breath;

void setup() {
  Serial.begin(9600);
  lcd.begin(16,2);
  Serial.println("CCS811 test");

  if(!ccs.begin()){
    Serial.println("Failed to start sensor! Please check your wiring.");
    while(1);
  }

  // Wait for the sensor to be ready
  while(!ccs.available());
}

void loop() {
  if(ccs.available()){
    if(!ccs.readData()){
      lcd.clear();
      lcd.setCursor(0,0);
      lcd.print("CO2:");
      lcd.print(ccs.getCO2());
      lcd.print("ppm");
    }
  }
}
```

```
final | Arduino 1.8.20 Hourly Build 2021/12/20 07:33
File Edit Sketch Tools Help

final
  lcd.print(ccs.getCO2());
  lcd.print("ppm");
  lcd.setCursor(0,1);
  lcd.print("TVOC:");
  lcd.print(ccs.getTVOC());
  lcd.setCursor(12,1);
  lcd.print("B:");
  lcd.print(breath);
}
else{
  Serial.println("ERROR!");
  while(1);
}
}
//-----Respiratory-----
breath_c = 0;
for(int i=0;i<50;i++){
  breath_c += analogRead(A0);
  delay(10);
}
breath_c /=50;
Serial.println(breath_c);
if(breath_c>280){
  count++;
}
if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
  Serial.print("Breath=");
  Serial.println(count);
  breath = 0;
}
```

20 Arduino Uno on COM3

```
final | Arduino 1.8.20 Hourly Build 2021/12/20 07:33
File Edit Sketch Tools Help

final
  lcd.print("B:");
  lcd.print(breath);
}
else{
  Serial.println("ERROR!");
  while(1);
}
}
//-----Respiratory-----
breath_c = 0;
for(int i=0;i<50;i++){
  breath_c += analogRead(A0);
  delay(10);
}
breath_c /=50;
Serial.println(breath_c);
if(breath_c>280){
  count++;
}
if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
  Serial.print("Breath=");
  Serial.println(count);
  breath = 0;
  breath = count*6;
  count=0;
  tsLastReport = millis();
}
delay(50);
}
```

20 Arduino Uno on COM3

CHAPTER - 5

RESULT AND OUTPUT



Hence, the CO₂ and TVOC levels have been obtained by using the sensors and the breathing pattern is also obtained using mic.

CHAPTER – 6

CONCLUSION

Examination of exhaled breath has the potential to change the existing routine approaches in human medicine. The rapidly developing new analytical and computer technologies along with novel, unorthodox ideas are prerequisites for future advances in this field. Measurement of exhaled breath is safe, rapid, simple to perform, and effort independent. Given that human breath contains upwards of 250 chemicals, the potential for developing new applications is high. Exhaled breath constitutes more than 3,500 components, the bulk of which are volatile organic compounds in miniature quantities. Many of these characterize the functioning of the organism as a whole (systemic biomarkers), but some are related to processes taking place in the respiratory system and the airways in particular (lung biomarkers) . Exhaled breath analysis has enormous potential as an easy, non invasive means of monitoring inflammation and oxidative stress in the airways, particularly in non diseased subjects. Exhaled air can be collected without the need of unpleasant stimulation of the airways as occur in sputum induction or lavage sampling. Thus the CO₂ and TVOC levels and breathing pattern has been obtained using the sensors and this method is non invasive user friendly , cost effective and it doesn't need any kind of professional help for usage.

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2. Aleksandr A. Ganeev^{1,2,3}, Anna R. Gubal², Gennadij N. Lukyanov³, Andrey , 2018, Russian Reviews, Analysis of exhaled air for early stage diagnosis of lung cancer, opportunities and challenges.
3. Ting chan , Ting lieu 2021, Elsevier. Exhaled breath analysis in disease detection
4. Anna Paleczek and Artur Rydosz, 2022, Journal of Breath Research, Review of the algorithms used in exhaled breath analysis for the detection of diabetes.
5. Venkatesulu¹, Seena Naik Korra², E. Sudarshan³, A. Rajeshwar Rao⁴, 2020, Journal of mechanics continua and mathematical sciences, Detection of exhale analysis through Arduino and integrated sensor.
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