PORTABLE SPIROMETER

PHY 1901
Introduction to
Innovative Projects

OUR TEAM

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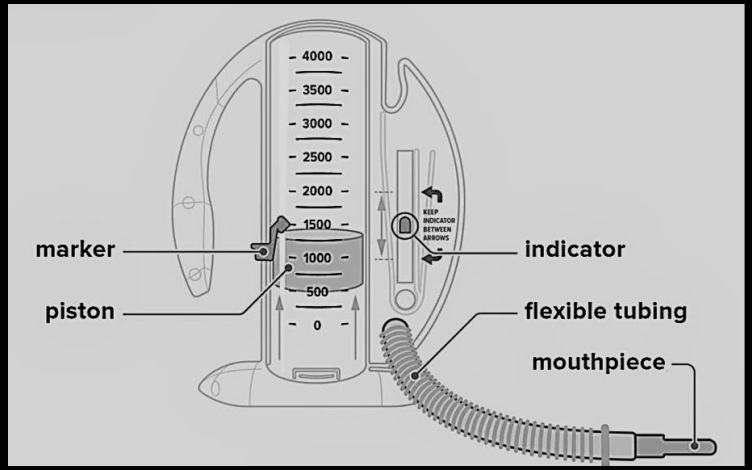
WHAT IS A SPIROMETER?



A spirometer is an apparatus for measuring the volume of air inspired and expired by the lungs.
A spirometer measures ventilation, the movement of air into and out of the lungs. The spirogram will identify two different types of abnormal ventilation patterns, obstructive and restrictive.

01 MOTIVATION

Through a set of medical tests Spirometer is used to identify and quantify defects and abnormalities of various lung conditions in human respiratory system. These tests also help in monitoring the response of lungs to medical treatment. With the help of a spirometer, Chronic Obstructive Pulmonary Disease (COPD) can be detected well in advance. Monitoring cough and wheezing may not provide an accurate assessment of the severity of asthma in a patient. With the help of the breathing tests conducted using a spirometer, the response and improvement in an asthma patient's condition during the treatment can be monitored accurately. This improves the quality of treatment by reducing the judgement errors.

Chronic Respiratory Diseases cause an immense worldwide health burden. It has been estimated that around 235 million people suffer from asthma while more than 200 million people suffer from Chronic Obstructive Pulmonary Disease (COPD). Besides, asthma is the most common cause of respiratory illness affecting 14% of the children globally and is rising.

— FORUM OF INTERNATIONAL RESPIRATORY SOCIETIES (FIRS)

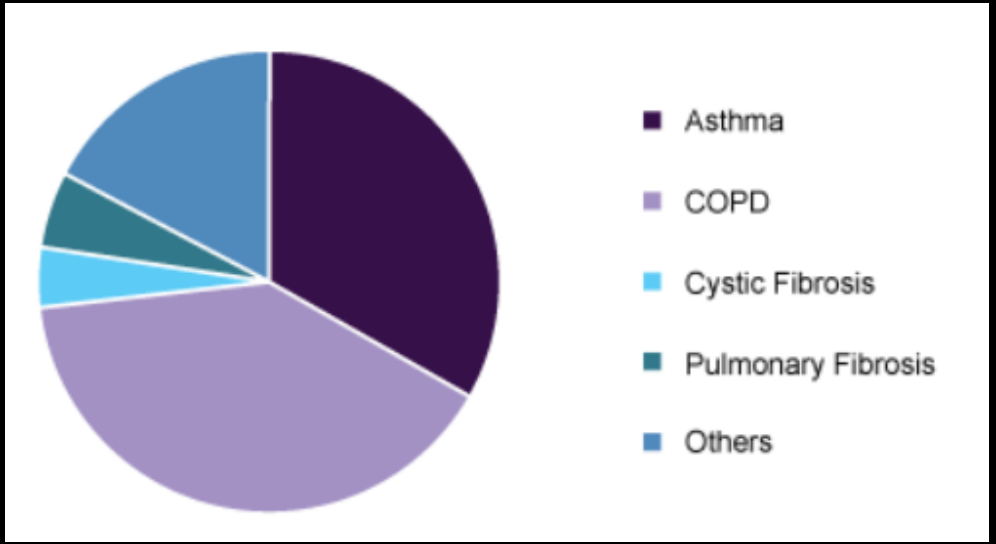
Costs of Different Spirometers available in the Market

₹36,800
RMS Helios 401 Spiro Plus Spirometer

₹21,900
Contec Automatic Spirometer Respiratory Machine

₹23,055
Niscomed Digital Spirometer Lung Exerciser SP 10

SPIROMETER IS MOSTLY USED TO DIAGNOSE….



02

02 OBJECTIVE AND METHODOLOGY

Our objective is to make a portable spirometer that is cost effective and is easier to understand for uneducated. As stated previously, spirometers that produce digital output are expensive. We also plan to make a PCB design of it and also make a 3D model of the PCB.

METHODOLOGY

01

DATA ACQUISITION

The first step is the acquisition of the signal, in this case coming from the breathing process.

02

SENSOR BLOCK

The next step for implementing a spirometer is a transducer to convert the air flow into an electrical signal, which can be then processed by electronic means

03

MICROCONTROLLER

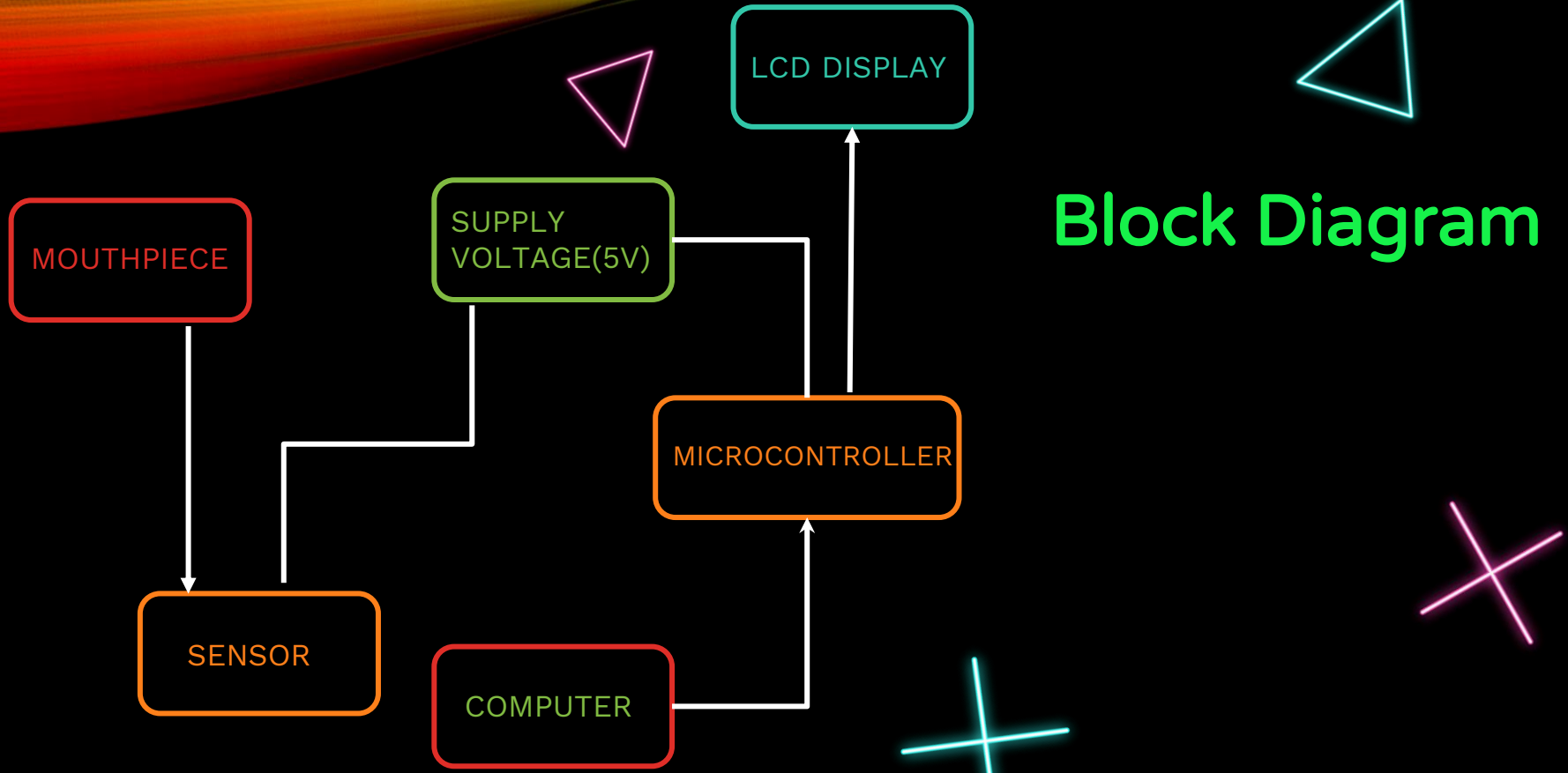
The microcontroller performs the principal functions of the system, from converting the signal delivered by the pressure sensor to calculating the spirometry parameters and sending data and result to data presentation unit.

04

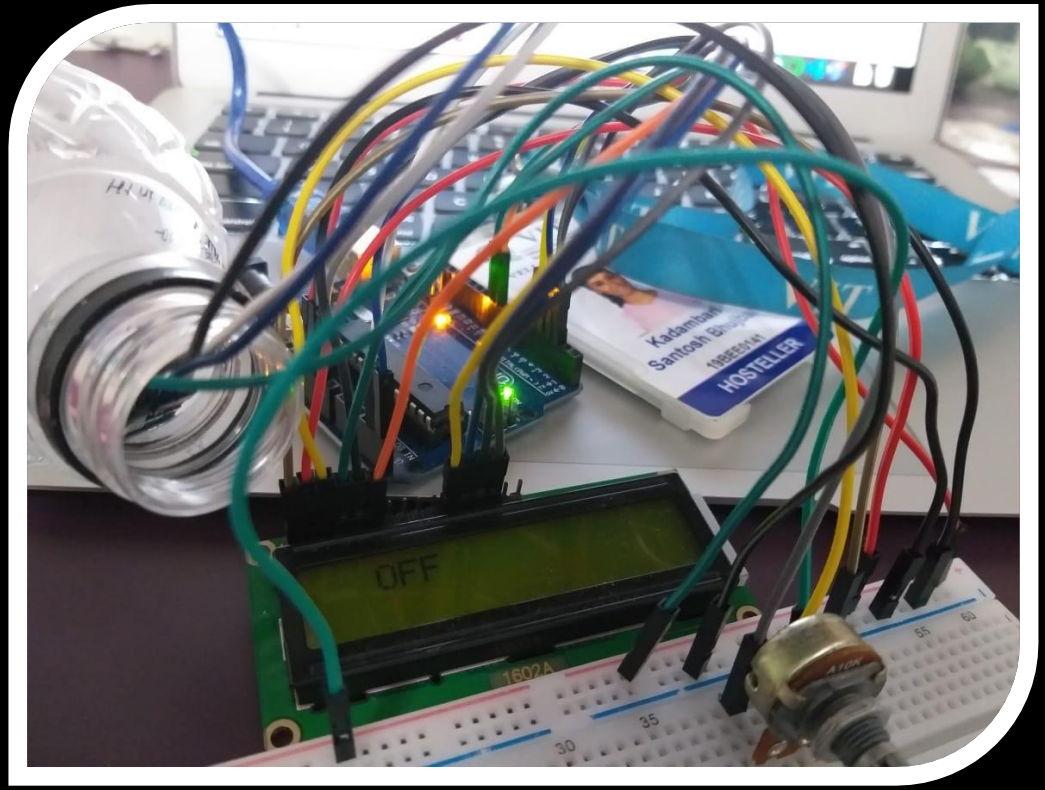
DATA PRESENTATION UNIT

It is used to perform the translation function of putting the measured quantity in a form that is understandable by us.

Block Diagram



HARDWARE



03

03

LITERATURE REVIEW

COMPONENTS AND SOFTWARES USED

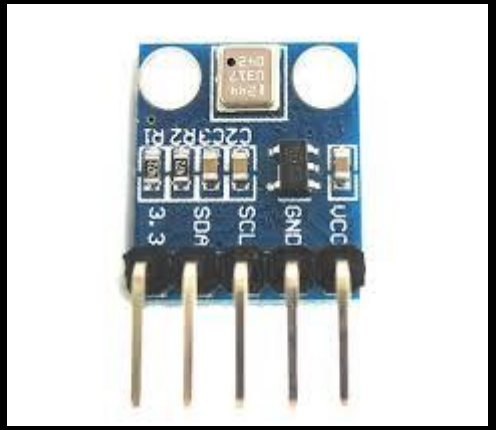
Components Used:

- BMP180 Barometric sensor
- 16:2 LCD DIsplay
- Arduino UNO
- Potentiometer

Softwares Used:

- Eagle Software for PCB designing
- Fusion 360 for 3D modelling

BMP180 BAROMETRIC SENSOR



BMP180 is one of sensor of BMP XXX series. They are all designed to measure Barometric Pressure or Atmospheric pressure. BMP180 is a high precision sensor designed for consumer applications. It senses that pressure and provides that information in digital output.

- Pressure range: 300 to 1100hPa
- High relative accuracy of ±0.12hPa
- Can work on low voltages
- 3.4Mhz I2C interface
- Low power consumption (3uA)
- Pressure conversion time: 5ms
- Cheap and Readily available

ARDUINO UNO

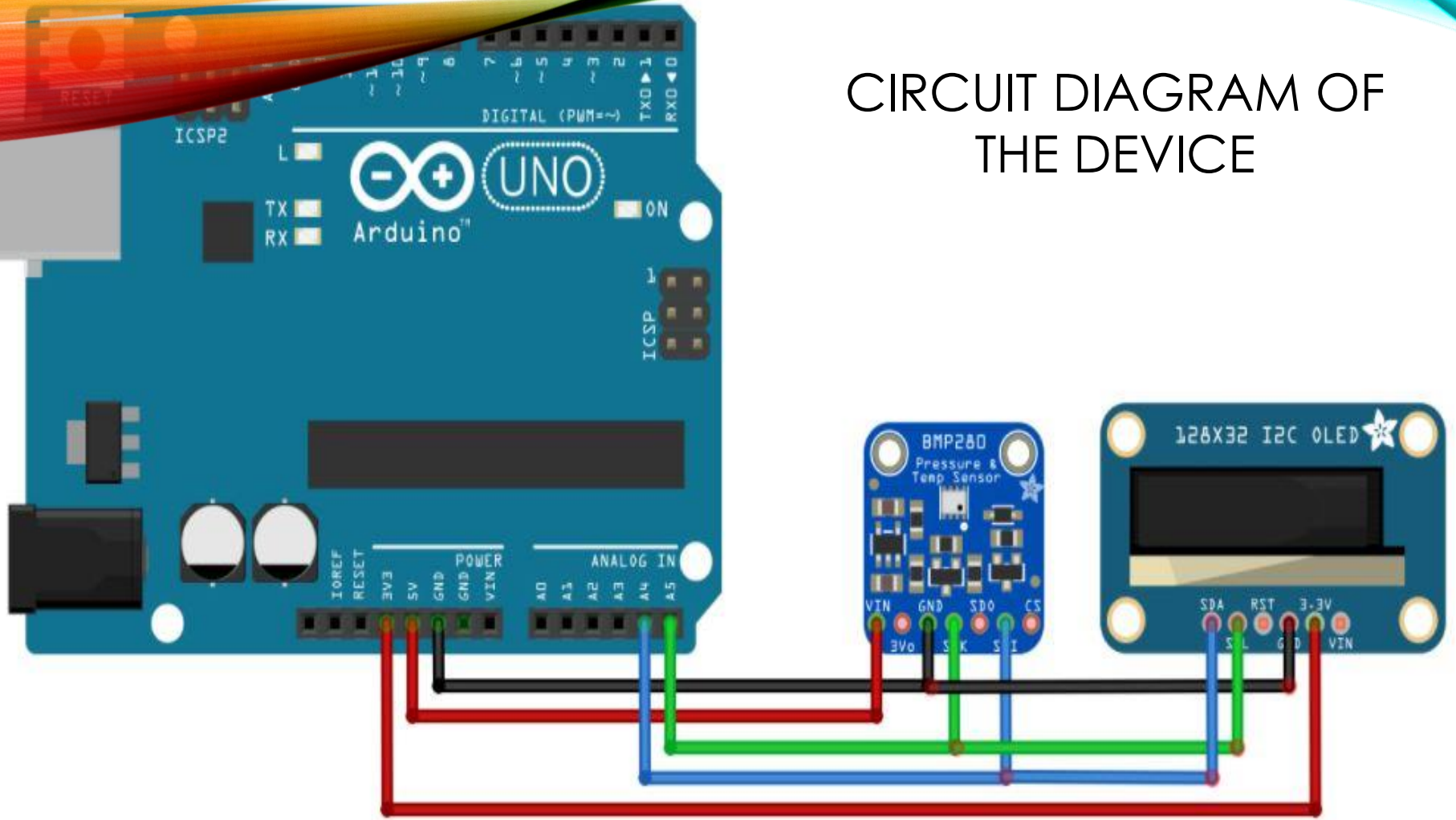
Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices.

- The operating voltage is 5V
- The recommended input voltage will range from 7v to 12V
- The input voltage ranges from 6v to 20V
- Digital input/output pins are 14
- Analog input pins are 6
- DC Current for each input/output pin is 40 mA
- DC Current for 3.3V Pin is 50 mA
- Flash Memory is 32 KB
- CLK Speed is 16 MHz

EAGLE SOFTWARE

EAGLE is a scriptable electronic design automation application with schematic capture, printed circuit board layout, auto-router and computer-aided manufacturing features. EAGLE stands for Easily Applicable Graphical Layout Editor and is developed by CadSoft Computer GmbH.

CIRCUIT DIAGRAM OF THE DEVICE



PRESSURE RANGE FOR LUNGS

BAD

Pressure of air blown is less than 99999 Pa, then the lung capacity is bad and need medical attention.

GOOD

If the pressure is between 99999 Pa and 104000 Pa then lung health is good.

EXCELLENT

Lung capacity and health is considered excellent is the pressure is more than 104000 Pa.

LIBRARIES USED FOR THE ARDUINO CODE

ADAFRUIT_BMP085

This library is used to calculate the pressure

LIQUIDCRISTAL.H

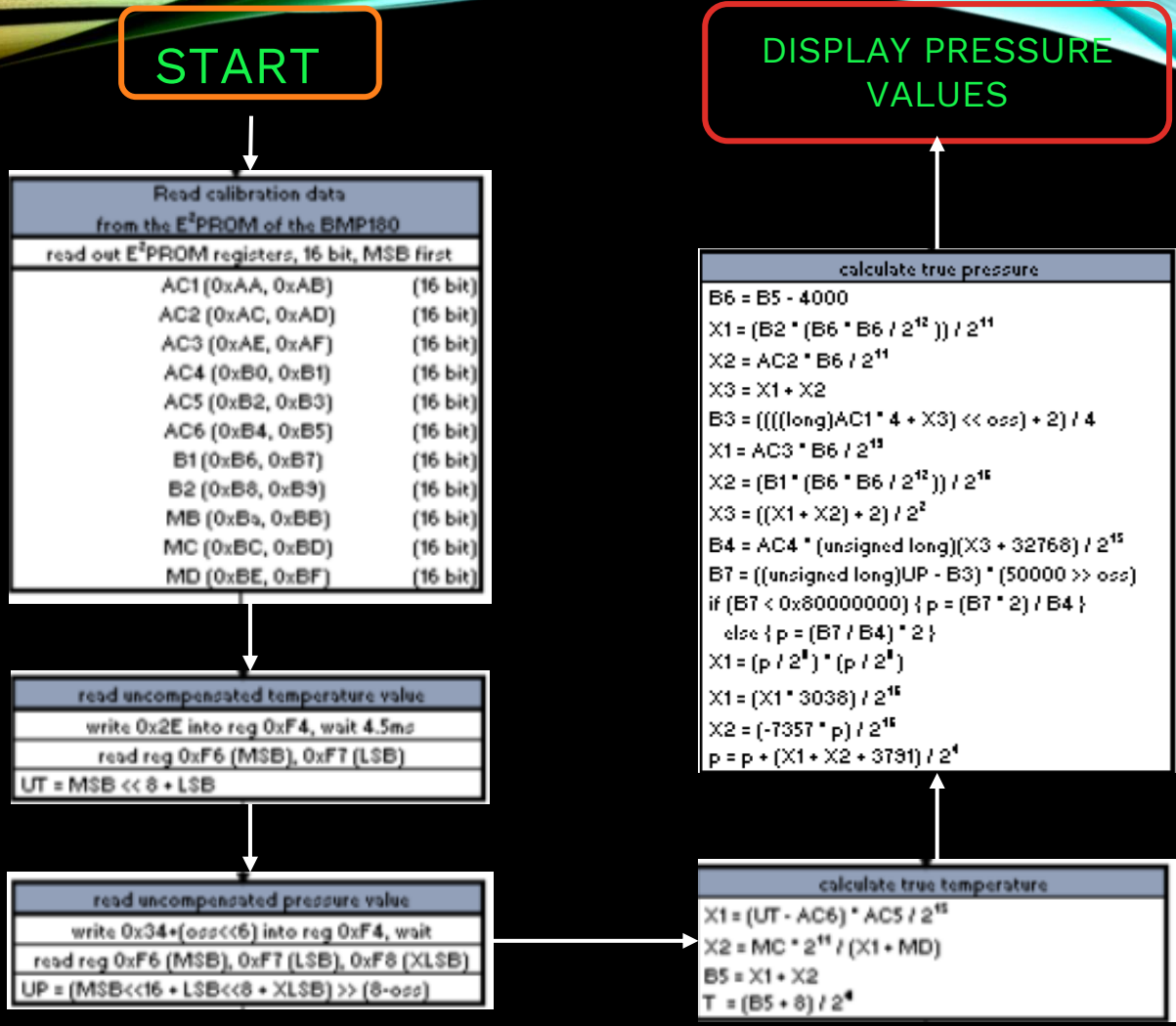
This library allows an Arduino board to control Liquid Crystal displays (LCDs)

WIRE.H

The Wire library allows you to communicate with I^2C devices, often also called "2 wire" or "TWI" (Two Wire Interface).

ALGORITHM FOR CALCULATING PRESSURE

As stated before this algorithm is quite complicated and requires a lot of math. Adafruit_BMP085 library does this complicated maths for us. This algorithm is available in the datasheet of the sensor.

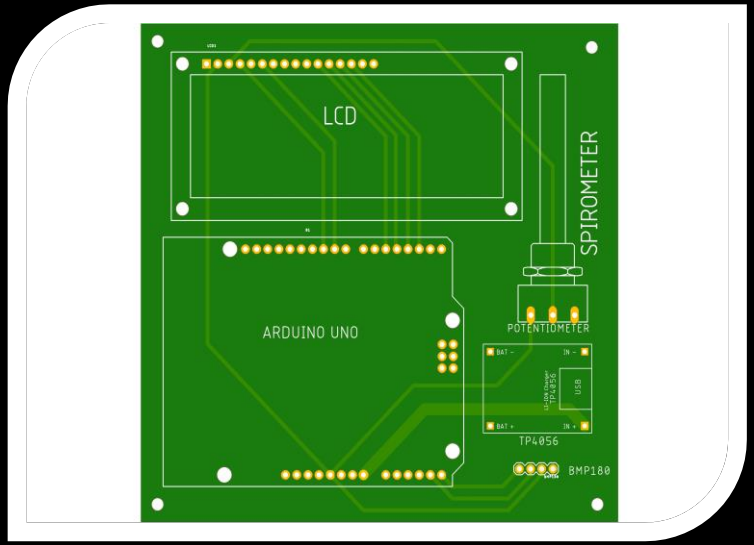


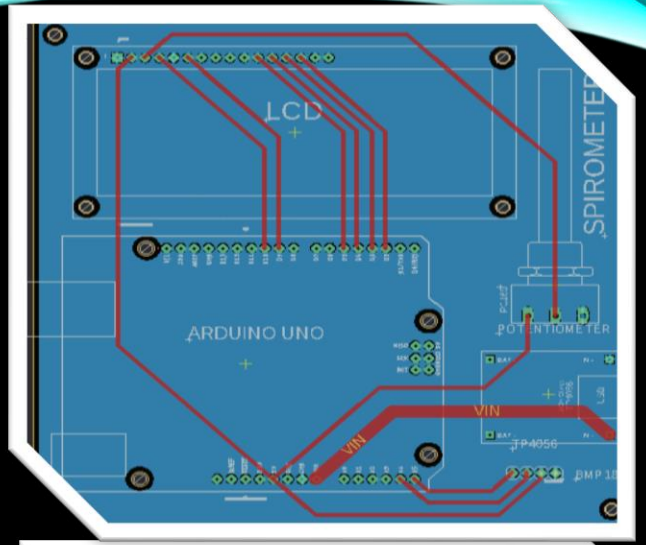
CODE

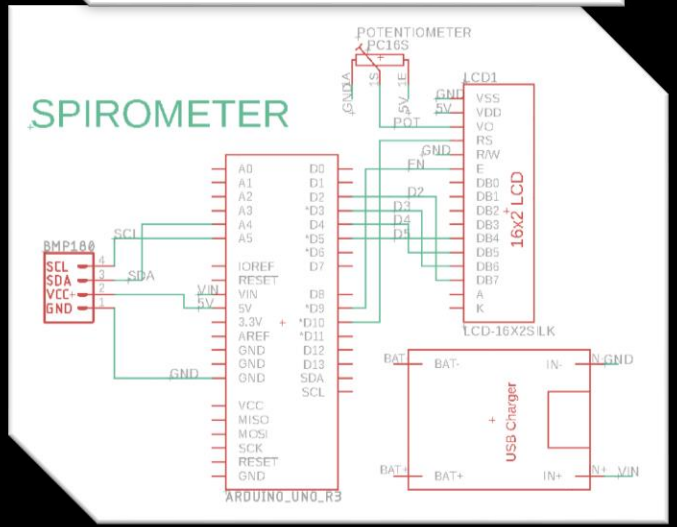
```
#include <Adafruit_BMP085.h>

#include<Wire.h>
//#include<Adafruit_BMP085.h>
//#include<Adafruit_BMP085.h>
#include<LiquidCrystal.h>

Adafruit_BMP085 bmp;

const int rs =10, en =9, d4= 5, d5=4, d6 =3, d7 =2;

LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
long pres=0;

void setup() {

Serial.begin(9600);
lcd.begin(16, 1);

if (!bmp.begin()){
  Serial.println("Could not find a valid bmp");
  while(1){} }
}


void loop() {

  pres = bmp.readPressure();
  delay(3000);
  lcd.setCursor(0,0);

  if (pres < 97000){

    Serial.println(pres);
    lcd.print(" ");
    lcd.print("OFF");
    Serial.println("OFF\n\n");
    delay(500);
```

```
    lcd.print(" OFF ");
    Serial.println("OFF\n\n");
    delay(500);
    }



    if (pres >97000 && pres < 99999) {

      Serial.println(pres);
      lcd.print(" ");
      lcd.print("Bad");
      Serial.println("Bad\n\n");
      delay(2000);

      }


      if (pres >100000 && pres < 104000) {

        Serial.println(pres);
        lcd.print(" "); lcd.print("Good");
        Serial.println("Good\n\n");
        delay(2000);

        }


        if (pres > 104000) {
          Serial.println(pres);
          lcd.print(" ");
          lcd.print("Excellent");
          Serial.println("Excellent\n\n");
          delay(500);
          }

}
```

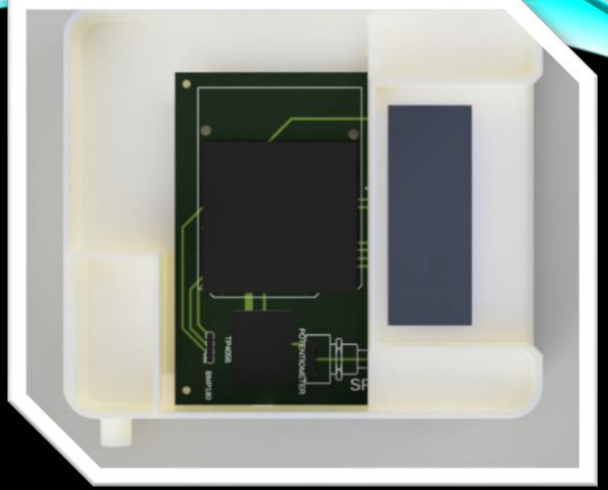
PCB

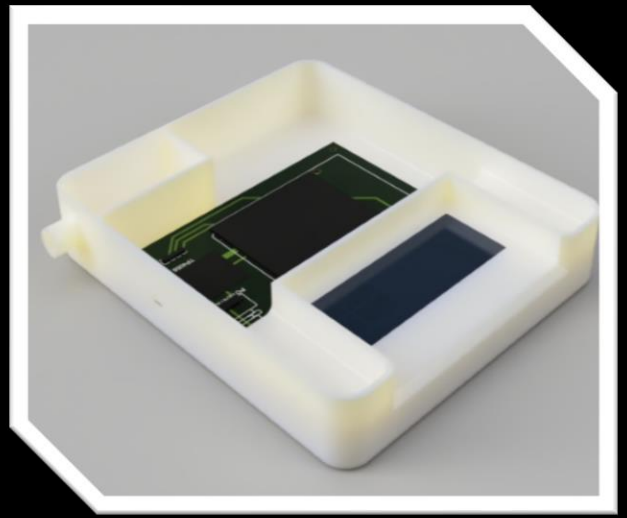

LCD
SPIROMETER
ARDUINO UNO
POTENTIOMETER
TP4056
BMP180

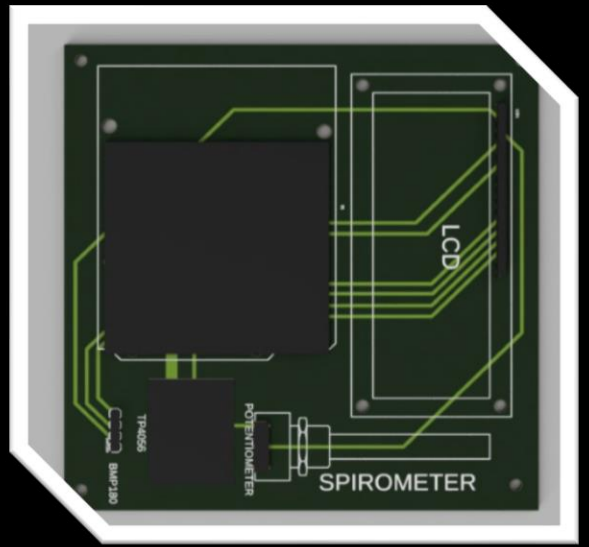

LCD
SPIROMETER
ARDUINO UNO
POTENTIOMETER
VIN
TP4056


SPIROMETER
POTENTIOMETER
PC16S
LCD1
16X2 LCD
LCD-16X2SILK
BMP180
SCL
SDA
VIN
5V
GND
ARDUINO_UNO_R3
USB Charger
BAT-
BAT+
IN-
IN+

3-D MODEL


POTENTIOMETER
BMP180




LCD
TP4056
POTENTIOMETER
BMP180
SPIROMETER

04

05 MARKET FOR OUR PRODUCT

The global spirometer market size was valued at USD 799.5 million in 2019 and is expected to expand at a compound annual growth rate (CAGR) of 9.7% from 2020 to 2027.
We plan to convert our circuit to PCB and have designed a 3D model for our project. This then would be a viable product for the market. The user will just have to blow through the pipe that will be attached to the model. The LCD will print “EXCELLENT”, “GOOD” or “BAD” according to the condition of the lungs.

06

LIMITATIONS OF THE TEST

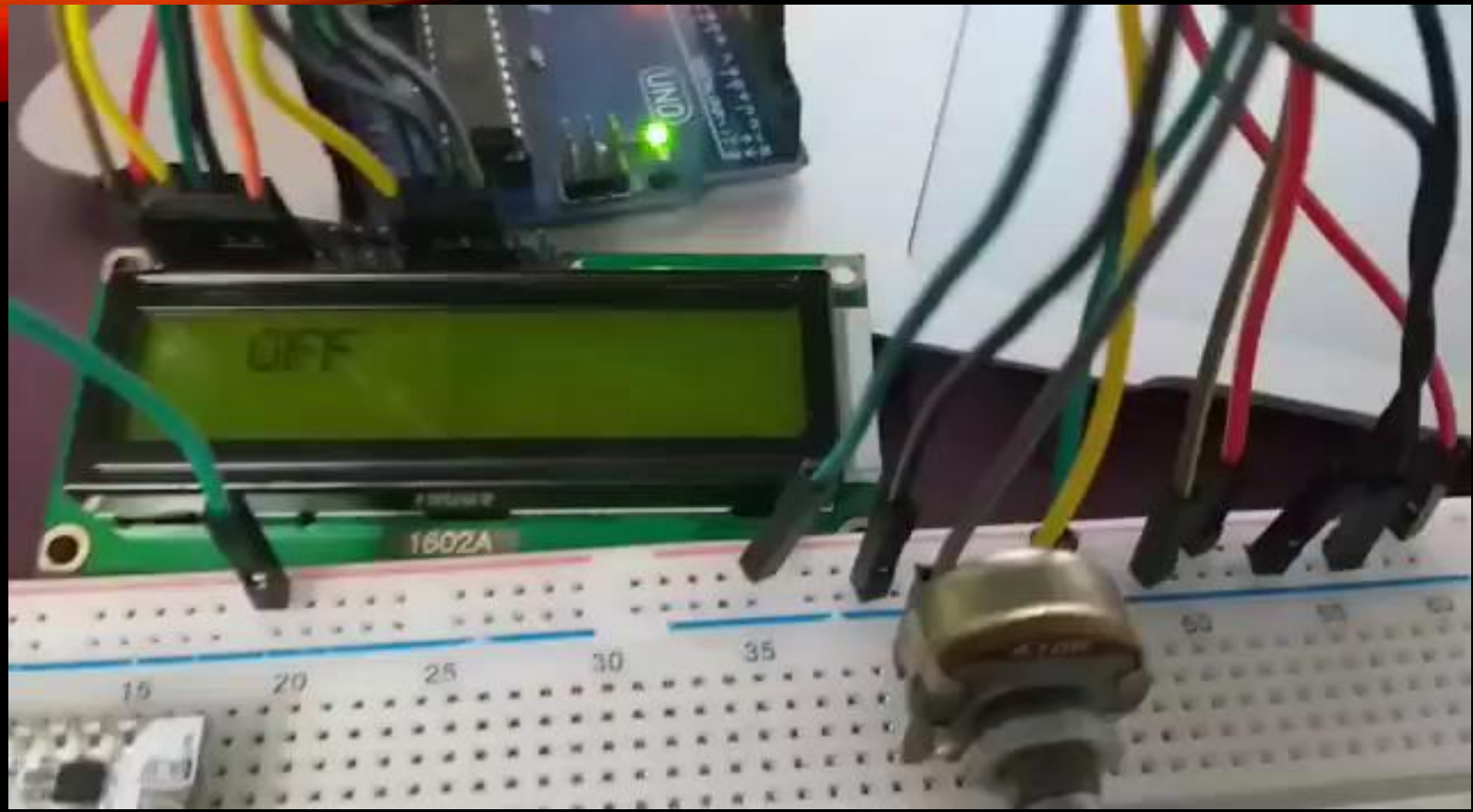
05

The procedure depends on the patient's cooperation and effort. It is normally repeated at least three times to ensure reproducibility. Since results depend on patient cooperation, pressure values may be underestimated, but never overestimated. Because of the importance of patient cooperation, spirometry can only be performed with patients who can understand and follow instructions. Therefore, this test is not appropriate for unconscious patients, In the same way, this test can be practiced only on children old enough to understand and follow the given instructions (from the age of 4 or 5 years). That said, there are other tests on lung function suitable for infants and unconscious. The test requires some exertion, so it isn't recommended if you recently had a heart condition or have other heart problems.

06

IMPROVEMENTS

- We can add an additional LCD touch screen to use a touch screen in combination with a graphical user interface (GUI) to make the programming process more intuitive and to show the exact result on time and to supply with order that restart the device and to be ready for specific test.
- We can also use different micro controller such as Arduino Mega to use more inputs and to provide faster processing
- It's also possible to implement a Bluetooth device so it can be controlled wirelessly.
- Also, it can be made more hygienic.


UNO
OFF
1602A
15
20
25
30
35

07

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