Comsats University Islamabad, Lahore Campus

CPE342 – Microprocessor Systems and Interfacing

Breathing and Respiration Sensor

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1. INTRODUCTION

1.1 Introduction

Breathing monitoring is one of the most crucial elements of accessing human lungs condition. It can provide valuable information regarding lungs health. The medical equipment we have made consist of a belt on which we have implemented IR sensor and a reflector to implement similar phenomenon like a breathing sensor

IR sensor is an electronic device that emits the light to sense some object in the surroundings. IR sensor has two components which are called IR emitter and phototransistor. IR emitter will emits its infrared light towards the reflector and then phototransistor will detect the value. An IR sensor can measure the heat of an object as well as detects the motion. In our case, it will detect the motion of the object or reflector.

Breathing sensor will give the readings. The complication of covid-19 directly affects the respiratory system. Respiration system is one of the places where we can study and analyze to know if a person is having or evolving complications or symptoms related to COVID-19.This is due to the fact that when the patient's respiratory capacity is affected, the latter changes their respiratory rate and amplitude, and it is possible to know when these changes occur by continuously monitoring and comparing the respiration values (frequency, amplitude, inhalation, exhalation). When user wear the belt, it will show the inhale and exhale rate also the respiration rate and will display that whether user is having respiratory problems or not.

It is clear that this sensor can detect symptoms in the patient potentially related to the infection and diseases of COVID-19 is obtained but this project will deal directly with this simple respiration system.

1.2 Motivation

The motivation behind this project was to make less expensive device for people as at present the cost of Breathing measurement equipment in market is $295 which is very expensive for public. There are some respiration sensors on the market today, but these are very expensive, difficult to acquire and have a very limited lifespan, or are changing in response to the most used respiration measurement. People with respiratory problems needed to use expensive devices to test their respiratory system. Whereas this project is cheaper than other devices and it is easy to use.

1.3 Aims and Objectives

During Covid-19 the major symptom was breathing issue ,most of the people don’t even know if their lungs are affected as they don’t have knowledge about the normal respiration rate for a healthy human. The main aim and objective of this project is to make a cost-effective device which will make easier for the people to check their lungs health at home .This will help them to know if they need a proper checkup or not. It will be easy to use and can be available at every clinic and hospital because of its low price as compared to other .

1.4 Report Organization

Chapter 1 is about the introduction of the project, followed by the aims and objectives behind this project.

Chapter 2 contains methodology of the working of project, detailed explanation of the components used in the project, the schematic diagram, followed by the working of the project as a whole and how multiple components communicate together in order to yield a meaningful output, ending with the project analysis with the discussion and relation to environment and sustainability of the project.

Chapter 3, 4, and 5 are the Results obtained, References used, and the Appendix which contains our code for the project.

2. PROJECT IMPLEMENTATION

2.1 Component Details

2.1.1 STM:

Our project is implemented using **STM32F407VG6T**, which is our microcontroller. The only difference between STM32F407 and STM32F01 have is that stm32F407 has more pins than stm32F01. STM32F04 uses C language to program just like any other microcontroller like an STM32F407 microcontroller.

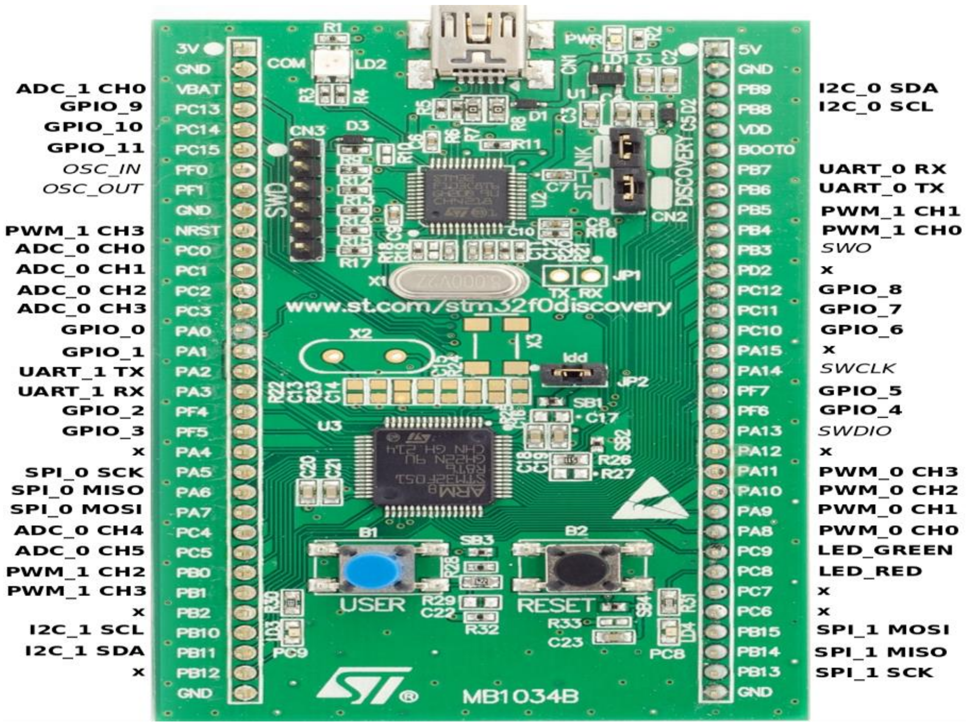

Figure 2.1.1 STM32F04VG6

2.1.2 16X2 Liquid Crystal Display (LCD):

Another component that we used in the displaying of the outputs is the 16x2 LCD. This LCD is very common and widely used in the industry and educational institutes. It is also used in printers, calculators, TV sets as well as laser printers. One LCD can display up to one 8-character line or two 8-

character lines.

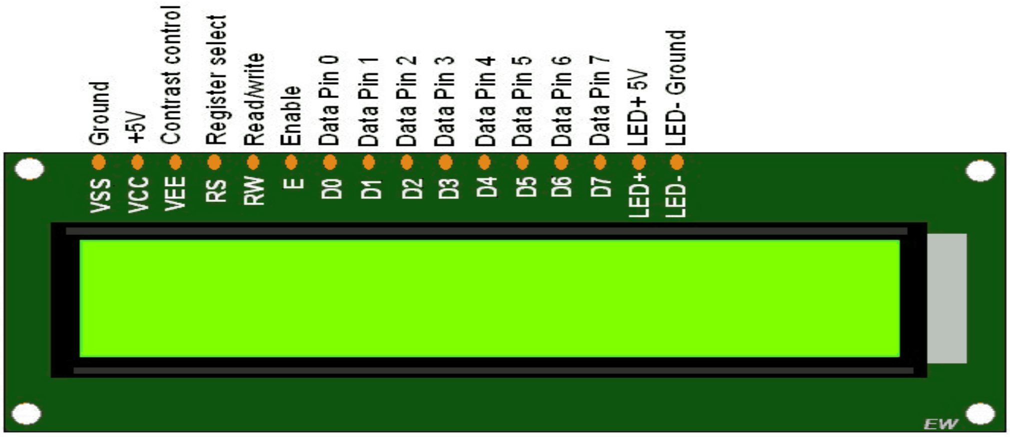

Figure 2.1.2 Pin Configuration of 16x2 LCD

An LCD can display numbers, strings, characters, and small graphics. This gives us a vast option as compared to an LED for the displaying of result because LED will only turn on and off while on anther hand LCD will display proper results i.e., show values and statements etc. These LCDs are also easy to program using the Data pins which are connected to any microcontroller.

An LCD has two types of registers which are built in.

- Command Register
- Data Register

A Command Register is responsible for giving internal commands such as clearing a screen or moving a cursor to the next line. Meanwhile a Data Register is responsible for inserting data into the LCD.

2.1.3 **IR Proximity Sensor:**

An important component of our project is an IR sensor. IR stands for Infrared sensors. An IR sensor is an electronic device that emits the light to sense some object in the surroundings. IR sensors have two components that are IR LED and IR photodiode. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode. Photodiode is sensitive to IR light of the same wavelength which is emitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltages will change in proportion to the magnitude of the IR light received.

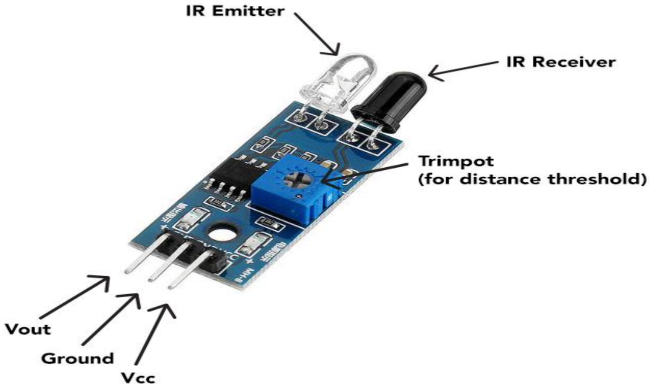

Figure 2.1.3 Pin Configuration of IR Sensor

2.1.4 Elastic Belt and Reflector:

Remaining hardware tools are a reflector and an elastic belt. Reflector is a simply an object which will act as an obstacle for IR sensor and a non-stretchable belt except for a small section of which is made of stretchable material. IR sensor and the reflector will be attached on the belt which will help in analyzing the respiratory phenomenon and in measuring the breathing rate of a person.

2.2 Schematic Diagram

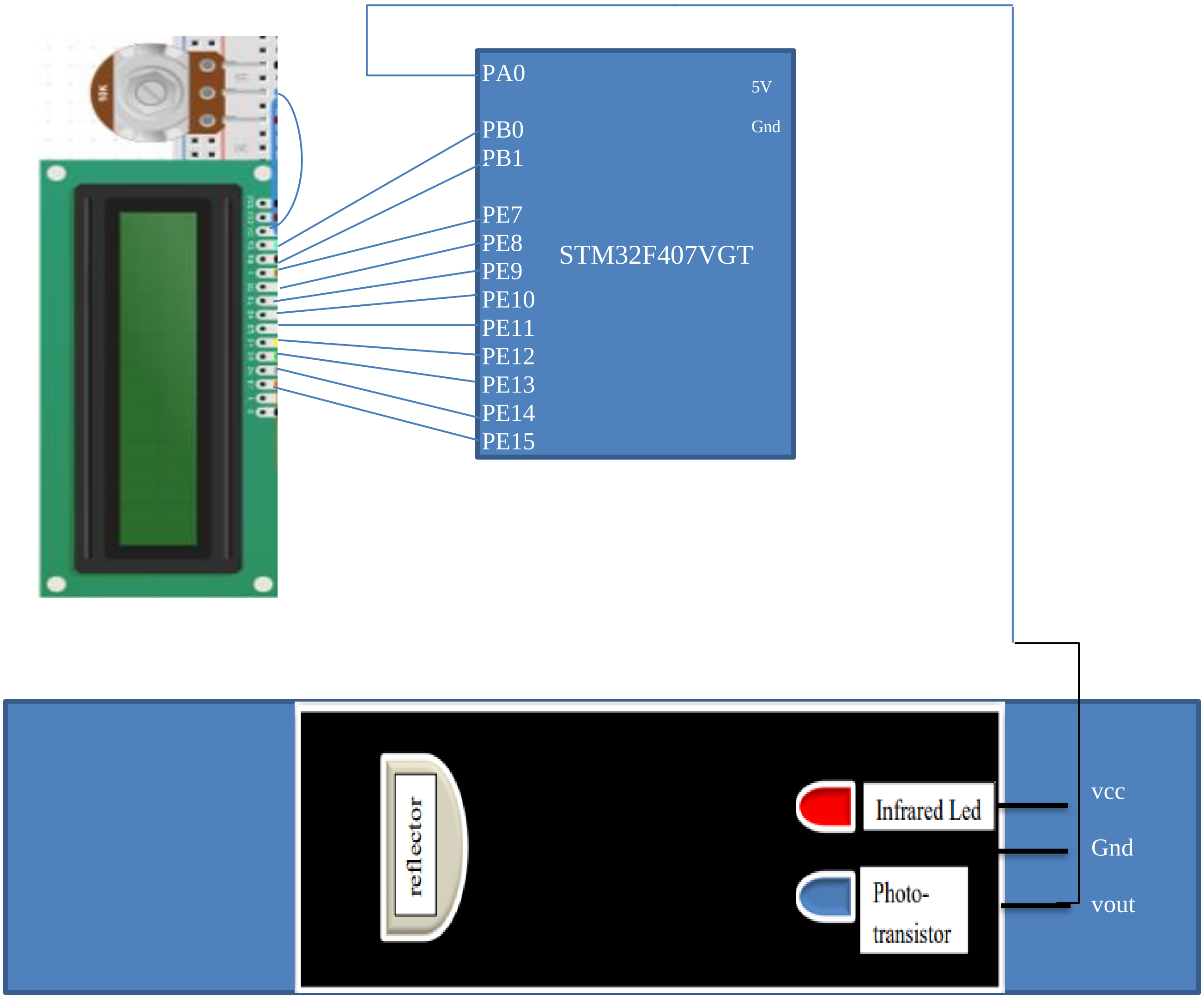

Figure 2.2.1 Schematic diagram of Breathing Sensor

2.3 **Working of Project**

The mechanism we have used in this project is according to Johns Hopkins [1], **the respiration rate refers to the number of breaths a person takes in one minute**. When a person will inhale and exhale it will give the inhale and exhale rate and tell whether a person breathing rate and respiratory system is correct or not. To take an accurate measurement, we must watch the person's chest rise and fall. One complete breath comprises of one inhalation when the chest rises, followed by one exhalation when the chest falls means that when a person will inhale and exhale that would be its one complete breath. To measure the respiratory rate, we counted the number of breaths for an entire minute or count for 30 seconds and multiply that number by two.

To measure the breathing, here the principle is to wear a belt that can detect the variation in the width of the abdomen when breathing (expanding or increasing in boundary on inhalation and contracting or decreasing its boundary during exhalation) and this is achieved by making the belt of a non-stretchable material, with the exception of a small section of which if it is made of stretchable material and since this is the only part that can be stretched, this section will reflect the expansion or linear contraction caused by breathing, and measured as a simple variation of linear distance.[2]

We chose to measure this variation in distance with a simple infrared led, which emits its infrared light towards a reflector, which is located within a few centimeters of the emitter, next to which is an infrared light phototransistor detector oriented towards the reflector, separated by elastic (the only area of the belt where the variation in linear distance caused by the expansions and contractions of the breath is reflected) and by doing this, this will be varying the distance between the emitter-receiver and the reflector the intensity of infrared light that is reflected and is detected.

This sensor has an active filter to eliminate the interference of light external to that emitted by the infrared led. [3]

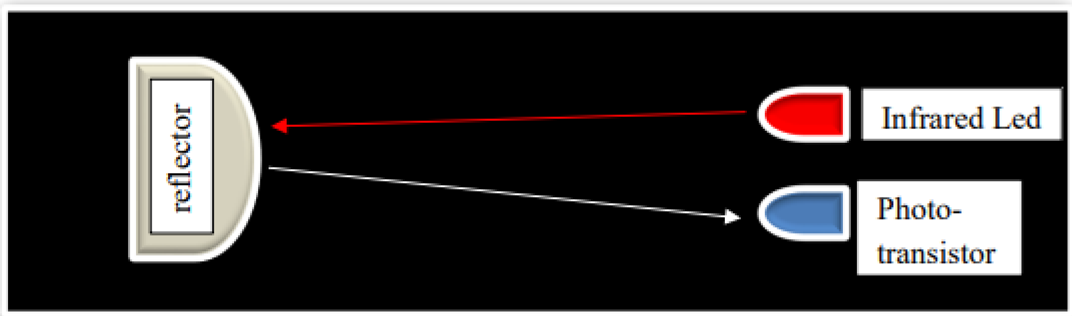

Figure 2.3.1 IR sensor working

2.4 **Project Analysis**

The beginning of the project started with the selection of the microcontroller. There are numerous microcontrollers such as Arduino, STM32F103C8T6, ESP8266 and many more, but we chose STM32F407. The advantage that this microcontroller has over others is that it is a 32-bit processor, has large flash memory which means it can save data when power is off, and it does not require any external burner to burn the code onto the board itself.

Breathing and respiratory sensor which we are making is one of the most inexpensive options because its components are not expensive. An IR sensor will measure value with the help of reflector and an elastic belt. Results will be displayed on LCD.

The whole project is estimated to be around PKR 13000-15000. This is very cost effective as compared to other options in the market that are very costly.

This implementation will help us to ensure to make the world much safer and more reliable. The components used in this project are also easily repairable or even changed which helps us to safeguardthe environment, reduce the e-waste and have zero effect on environment.

2.4.1 **Environment and Sustainability**

The environment of earth is deteriorating at a highly paced speed which must be controlled in order to ensure a healthy and safe environment for our upcoming generations.

Our project is designed and manufactured while keeping the environment in mind. Many companies who manufactured expensive, unrepairable, and hard to recycle products, we designedour product in such a way that any faulty component can be replaced at almost little to none cost whileensuring the integrity and quality of our product. This product will be easy to buy and have no effect on Mother Nature since the whole operational working equipment has nothing do to with toxic radiations. Hence,our mission is simple, keeping the cost down while saving Mother Nature.

2.4.2 **Engineer and Society (PLO - 6)**

According to IEEE Code of Ethics 1-1:

To hold paramount the safety, health, and welfare of the public, to strive to complywith ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment; [4]

According to NSPE (National Society of Professional Engineers) Code of Ethics – Professional Obligations 2-A:

"Engineers are encouraged to participate in civic affairs; career guidance for

youths; and work for the advancement of the safety, health, and well-being of theircommunity." [5]

Breathing and respiration sensor ensures the safety and welfare of the common by providing accurate readings through engineering knowledge and proves to be beneficial for the well-being of the public in the best of interest. The biggest advantage of this system is that it much simpler and cheaper than other electronic devices. The reliability of this system is ensured for the best interest of public and industrialuse while also ensuring to help reduce electronic waste by implementing such a design that is easily repairable by trained personals. Thus, this project is in accordance with Ethics in Engineering and Codeof Ethics of NSPE, and IEEE.

3. RESULTS

The breathing and respiration sensor system project is completed with the following attached results alongwith their outputs and brief explanations of each step.

Figure 3.1 Breathing and Respiration Sensor

Figure 3.1 shows our complete setup of breathing and respiration sensor and all the components which are used. The brief overview of the working of an IR sensor, what outputs are shown on 16x2 LCD, and what output parameters are initiated witheach response is discussed below.

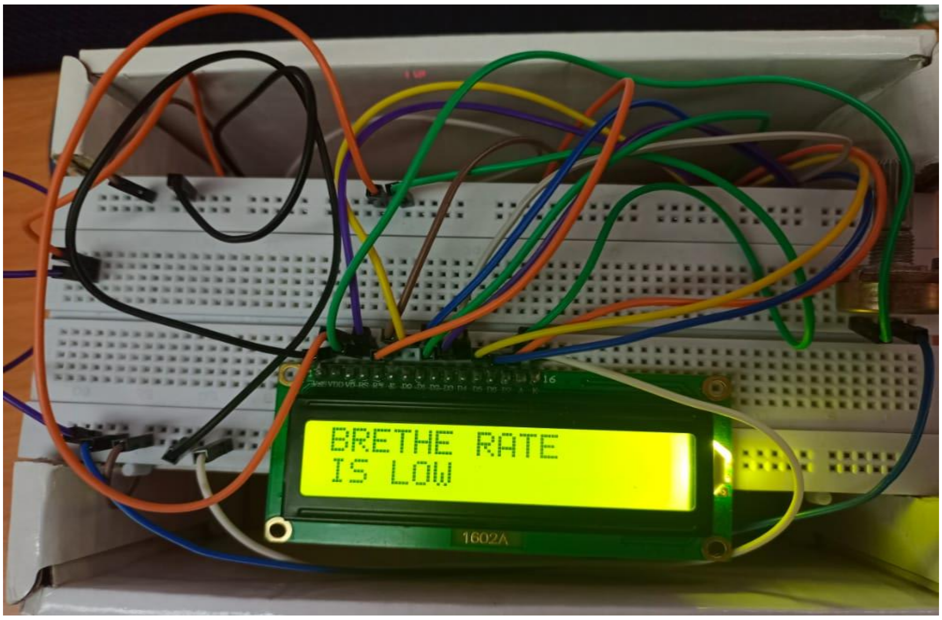

Figure 3.2 Breath Rate is low

When measuring the person's breathing rate, after one minute it will displays person's breathing rate.
When breathing rate of a person is low, it will display "Breathing Rate is Low" on LCD (Fig 4.2).

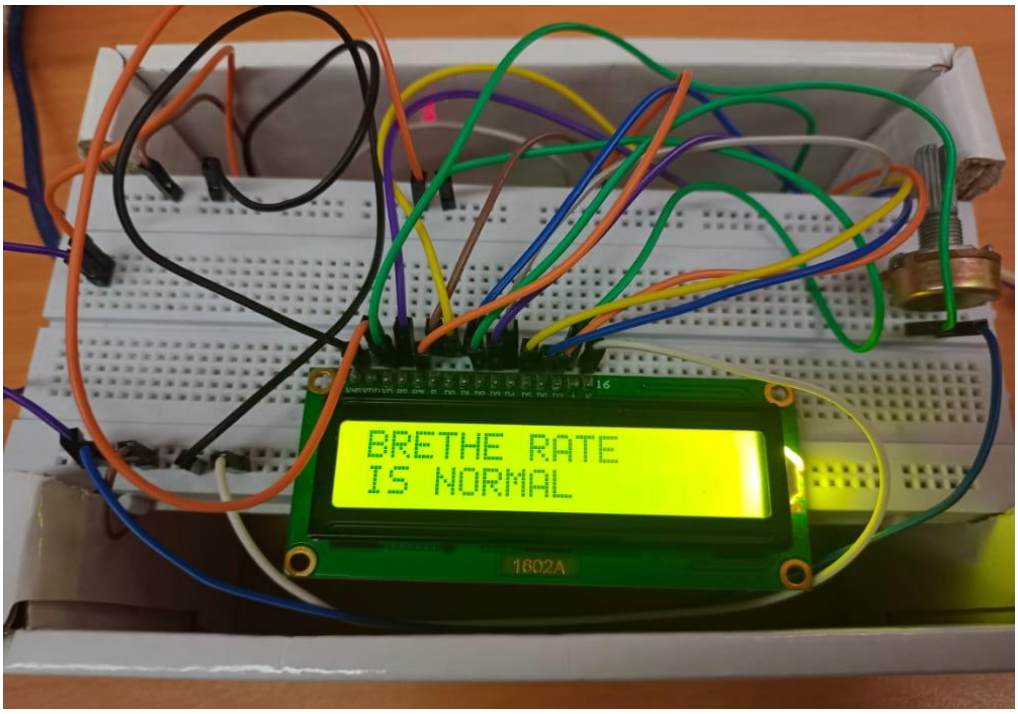

Figure 3.3 Breathing Rate is Normal

When measuring the person's breathing rate, after one minute it will displays person's breathing rate.
When breathing rate of a person is normal, it will display "Breathing Rate is Normal" on LCD (Fig 4.3).

Figure 3.4 Patient wearing belt

Here the user/patient is wearing belt and its breathing rate is being measured. After measuring values it successfully displayed results on LCD.

4. CONCLUSION

In this Complex Engineering Problem, the study of real time working principles of STM32F407VG along with an IR sensor and LCD were conducted. The approach was to contemplate a real-world scenario and provide a beneficial outcome for the betterment of the society as engineers. The IR sensors were studied in depth according to the criteria at hand. The challenge we face was how to set accurate timer but we resolved it by using stm's own timer.

The conclusion was that the complex engineering problem helped in order to understand the working of an IR sensor and LCDs that are vastly used in today's world and how different components can be integratedmaking a more optimized and more specific result-oriented system that is optimized according to needs.

5. REFERENCES

[1] Hopkins, J. (n.d.). *Measuring Breathing Rate* Available: *https://www.hopkinsmedicine.org/*

[2] Bio_Medical. (n.d.). *respiration-sensor*. Available: Bio_Medical: https://bio-medical.com

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[3] H. LTD., "HD44780U (LCD-II) Dot Matrix Liquid Crystal Display Controller/Driver, Tokyo, Japan," 1980 .

[5] "Breathing Sensor | Respiration Sensor” Project Hub, [Online]. Available: https://create.arduino.cc/

APPENDIX

```
#include <stdio.h>
#include <stm32f4xx.h>
void lcd_ini(void);
void lcd_data(char j);
void lcd_cmd(char i);
unsigned int read(unsigned int val);
void lcdString(char *String);
void display_value(unsigned int value);
void display_float(float value);
float T=0 , V =0,Counter=0,Ir=0,Er=0,rr=0;
float rrE=0.5,rrI=0.5;
unsigned int flagI=1;flagE=1;
volatile uint32_t msTicks; /* counts 1ms timeTicks */
/*---------------------------------------------------------------------------
SysTick_Handler
 (void) {
msTicks++;
}
void Delay (uint32_t dlyTicks)
{
uint32_t loop=0,dly=0,loope=0;
dly = dlyTicks ;
for(loop=0;loop<dly;loop++)
{
for(loope=0;loope<29000;loope++)
{
__NOP();
}}}
unsigned long LCDDATA=0;
unsigned int value;
unsigned int sensor;

MAIN function
*--------------------------------------------------------------------------*/
int main (void) {
SystemCoreClockUpdate(); // Get Core Clock Frequency
Add your code to enable Ports that can be used for this program.
*-----------------------------------------------------------------------------*/
//sensor
RCC->AHB1ENR |=(1<<0); //gpioA enable
GPIOA->MODER =0X00000000;
GPIOA->OTYPER=0X00000000 ;
GPIOA->OSPEEDR=0X00000000;

GPIOA->PUPDR=0X00000000;
//lcd
RCC->AHB1ENR |=(1<<1); //gpioB enable
RCC->AHB1ENR |=(1<<4); //gpioe enable

GPIOB->MODER =0X00000005;
GPIOB->OTYPER=0X00000000 ;
GPIOB->OSPEEDR=0X00000000;
GPIOB->PUPDR=0X00000000;

GPIOE->MODER =0X55555555;
GPIOE->OTYPER=0X00000000;
GPIOE->OSPEEDR=0X00000000;
GPIOE->PUPDR=0X00000000;

GPIOB->BSRR= ((1 << 16) ); // LCD RW -> 0
lcd_ini();
while(Counter<=24 ){
lcd_cmd(0x80); // line 1
lcd_data('I');
lcd_data('N');
lcd_data('H');
lcd_data('A');
lcd_data('L');
lcd_data('E');
lcd_data('=');
sensor=read(value);
Counter=Counter+1;
if(sensor == 0X00000001){
T=T+1;
if(flagE==1){ //inhale check
```

```
rrI=0.5;
flagE=0;
flagI=1;
}
}
else{
V=V+1; //exhale check
if(flagI==1){
rrE=0.5;
flagI=0;
flagE=1;
}
}
Ir=(T/Counter)*100.0;
Er=      (V/Counter)*100.0;
rr=rrI+rrE+rr;
rrI=rrE=0;
display_value(Ir);
lcd_data(' ');
lcd_data('R');
lcd_data('=');
display_value(rr);
lcd_cmd(0xC0); // line 2
lcd_data('E');
lcd_data('X');
lcd_data('H');
lcd_data('A');
lcd_data('L');
lcd_data('E');
lcd_data('=');
//T = 85.543*(1.8663 - V);
display_value(Er);
//lcd_data(value); // S
//display_value( sensor);
//delay(100);
lcd_data(' ');
lcd_data('T');
lcd_data('=');
display_value(Counter);
if(Counter==25){
if(rr<6){
lcd_ini();
lcd_cmd(0x80); // line 1
lcd_data('B');
lcd_data('R');
lcd_data('E');
lcd_data('T');
lcd_data('H');
lcd_data('E');
lcd_data(' ');
lcd_data('R');
lcd_data('A');
lcd_data('T');
lcd_data('E');
lcd_data(' ');
lcd_cmd(0xC0);
lcd_data('I');
lcd_data('S');
lcd_data(' ');
lcd_data('L');
lcd_data('O');
lcd_data('W');
Delay(10);
}
if(rr>=20){
lcd_ini();
lcd_cmd(0x80); // line 1
lcd_data('B');
lcd_data('R');
lcd_data('E');
lcd_data('T');
lcd_data('H');
lcd_data('E');
lcd_data(' ');
lcd_data('R');
lcd_data('A');
```

```
lcd_data('T');
lcd_data('E');
lcd_data(' ');
lcd_cmd(0xC0);
lcd_data('I');
lcd_data('S');
lcd_data(' ');
lcd_data('H');
lcd_data('I');
lcd_data('G');
lcd_data('H');
Delay(10);
}
if(rr>=6 & rr<=12){
lcd_ini();
lcd_cmd(0x80); // line 1
lcd_data('B');
lcd_data('R');
lcd_data('E');
lcd_data('T');
lcd_data('H');
lcd_data('E');
lcd_data(' ');
lcd_data('R');
lcd_data('A');
lcd_data('T');
lcd_data('E');
lcd_data(' ');
lcd_cmd(0xC0);
lcd_data('I');
lcd_data('S');
lcd_data(' ');
lcd_data('N');
lcd_data('O');
lcd_data('R');
lcd_data('M');
lcd_data('A');
lcd_data('L');
Delay(10);
}
}
}
}
//}
void lcd_ini(void)
{
Delay(10);
//lcd_cmd(0X0F);
lcd_cmd(0x38);
lcd_cmd(0x0C);
lcd_cmd(0x01);
Delay(10);
}
void lcd_cmd(char i)
{
unsigned long r=0;
char loop=0;
r |= i;
for(loop=0;loop<=7;loop++)
{
r = r << 1;
}
GPIOB->BSRR = ((1 << 17) );
LCDDATA = r;
GPIOE->ODR &= 0x000000FF;
GPIOE->ODR |= LCDDATA;
GPIOE->BSRR = ((1 << 7) );
Delay(10);//100
GPIOE->BSRR = ((1 << 23) );
}
void lcd_data(char j)
{
unsigned long r=0;
char loop=0;
r |= j;
for(loop=0;loop<=7;loop++)
{
r = r << 1;
```

```
}
GPIOB->BSRR = ((1 << 1) ); //rs
LCDDATA = r;
GPIOE->ODR &= 0x000000FF;
GPIOE->ODR |= LCDDATA;
GPIOE->BSRR = ((1 << 7) );
Delay(10);
GPIOE->BSRR= ((1 << 23) );
}

unsigned int read(unsigned int val){
val=GPIOA->IDR & 0X00000001;
return val;
}

void display_value(unsigned int value){
unsigned int seg1=0,seg2=0,seg3=0,seg=0;
seg3=value%10;
seg2=(value%100)/10;
seg1= value/100;
//lcd_cmd(0x80);  // line 1
lcd_data(seg1 + 0x30 ); // S
lcd_data(seg2 + 0x30); // S
lcd_data(seg3 + 0x30); // S
}// End value(unsigned int value)
```