DESIGN AND DEVELOPMENT OF CONTINUOUS POSITIVE AIRWAY PRESSURE USING SMART-PHONE

A PROJECT REPORT

Submitted by

ANANDHI RAGHURAMAN

ASMITHA A

in partial fulfillment for the award of the degree

of

BACHELOR OF ENGINEERING

in

ELECTRONICS AND INSTRUMENTATION ENGINEERING

EASWARI ENGINEERING COLLEGE

ANNA UNIVERSITY: CHENNAI 600 025

MAY 2021

ANNA UNIVERSITY: CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report "**DESIGN AND DEVELOPMENT OF CONTINUOUS POSITIVE AIRWAY PRESSURE USING SMART-PHONE**" is the bonafide work of " **ANANDHI RAGHURAMAN** and **ASMITHA A** " who carried out the project work under my supervision.

SIGNATURE	**SIGNATURE**
DR. S. NAGARAJAN	**MR. T. SURENDRAN**
HEAD OF THE DEPARTMENT	**SUPERVISOR**
	Assistant Professor,
Department of Electronics and	Department of Electronics and
Instrumentation Engineering,	Instrumentation Engineering,
Easwari Engineering College,	Easwari Engineering College,
Ramapuram, Chennai-89 .	Ramapuram, Chennai-89.

ABSTRACT

Sleep is essential for humans although its basic physiological function remains obscure. The monitoring of breathing dynamics is an essential diagnostic tool in various clinical environments, such as sleep analysis, intensive care and central nervous and physiological disorder analysis. Sleep Apnea is defined as cessation of airflow to the lungs during sleep for 10 sec or more. It normally results from either lack in neural input from the central nervous system (Central Sleep Apnea) or Upper airway collapse (Obstructive Sleep Apnea). Microcontroller based sleep Apnea monitor consists of a Respiration sensor for measuring and monitoring the breath condition, SPO2 and Pulse Sensor for monitoring the heart rate and blood oxygen saturation level, and Digital Humidity and Temperature sensor. All the parameters are monitored by the microcontroller. Once the microcontroller detects any difficulties in breathing conditions it'll automatically turn on the supportive system for the patient. Thus, in this study, we aim to address the design the experimental CPAP device with sensory instrumentation for providing data to a micro-controlled system, electro-pneumatic circuits and signal conditioning boards of sensors have been fitted to achieve optimized CPAP function with low energy consumption.

LIST OF TABLES

TABLE NO.	TABLE	PAGE NO.
2.1	Arduino Nano pin description	

LIST OF FIGURES

FIGURE NO.	FIGURE	PAGE NO.
Figure 1.1	Blockage of airway in patient	13
Figure 1.3	Schematic diagram of proposed system	15
Figure 2.1	Block diagram of experimental setup	21
Figure 2.4.1.1	Block diagram of power supply	23
Figure 2.4.1.2	Circuit diagram of power supply	24
Figure 2.4.1.3	Graph for full wave rectification	25
Figure 2.4.1.4	Graph for filter	26
Figure 2.4.2	channel 5V relay Pins	29

Figure 2.4.3	Arduino Nano pin layout	33
Figure 2.4.4	Schematic diagram of LM393	34
Figure 2.4.5	Dimensions of DHT11	36
Figure 2.4.6	System block diagram of MAX30100	37
Figure 2.4.7.1	Important parts of Compressor motor	40
Figure 2.4.8	Pinout diagram of LCD	42
Figure 2.5.1.1	Arduino Nano	43
Figure 2.5.2.1	Diagram of Bluetooth module	46

Figure 2.5.2.2	Available devices of Bluetooth	47
Figure 3.1.1	Results of Manual modes of operation	48
Figure 3.1.2	Results of Automatic modes of operation	49

LIST OF ABBREVIATIONS

ADC	Analog to Digital Converter
AHI	Apnea Hypopnea Index
ALC	Ambient Light Cancellation
AVR	Advanced Virtual RISC
COM	Common
CPAP	Continuous Positive Airway Pressure
CRT	Cathode Ray Tube
FIFO	First In First Out
FTDI	Future Technology Devices International Limited
I2C	Inter-Integrated Circuits
I2C	Integrated Circuit
IR	Infra Red
LCD	Liquid Crystal Display
LED	Light Emitting Diode
NC	Normally Closed
NO	Normally Open

NTC	Negative Temperature Coefficient
OSA	Obstructive Sleep Apnea
RDS	Respiratory Distress Syndrome
RMS	Root Mean Square
RX	Receiver
SPI	Serial Peripheral Interface
SPO2	Saturation of Peripheral Oxygen
TTL	Time To Live
TWI	Two Wire Interface
TX	Transmitter
UART	Universal Asynchronous Receiver and Transmitter
USART	Universal Synchronous and Asynchronous Receiver and Transmitter
WHO	World Health Organization

TABLE OF CONTENTS

CHAPTER NO.	TITLE	PAGE NO.
	ABSTRACT	**3**
	LIST OF TABLES	**4**
	LIST OF FIGURES	**5**
	LIST OF ABBREVIATIONS	**8**
1	**INTRODUCTION**	
	1.1 Overview	12
	1.2 Existing System	13
	1.3 Proposed System	14
	1.4 Motivation	15
	1.5 Literature Review	
	1.5.1 Obstructive Sleep Apnea Syndrome	17
	1.5.2 Humidifier for breathable gas apparatus	17
	1.5.3 Flow generator chassis assembly with suspension seal	18
2	**PROJECT IMPLEMENTATIONS**	
	2.1 General Principle Design	20

2.2 Project work modules 21

2.3 Methodology 22

2.4 Hardware Components

2.4.1 12V/1A Power supply 23

2.4.2 Relay 28

2.4.3 Microcontroller unit 30

2.4.4 Respiration sensor 34

2.4.5 Humidity and temperature sensor 35

2.4.6 Pulse oximeter and heart rate sensor 36

2.4.7 Compressor motor 38

2.4.8 Liquid crystal display 36

2.5 Software Components

2.5.1 Arduino IDE 40

2.5.2 Bluetooth module 45

3 CONCLUSIONS

3.1 Result 47

3.2 Accomplishment 49

3.3 Future scope 50

Appendices 51

References 63

CHAPTER 1

INTRODUCTION

1.1 Overview

The sleep apnea disorder can be defined as pauses in breathing or shallow breaths in sleep. The breathing pauses can last from a few seconds to minutes. Furthermore, they might occur thirty times or even more in an hour. The normal breathing would start again with a loud snort or choking sound. In the literature, three types of sleep apnea are described: central apnea, hypopnea and obstructive apnea. OSA is the most frequently diagnosed type of sleep apnea and occurs when the patient's upper airway is blocked partially or completely. This disorder is more common among the overweight people and the most common symptoms are loud and chronic snoring

and daytime sleepiness. It can be treated, if the patient makes important life-style changes or utilizes some breathing devices. When an apnea event occurs, a person often moves out of deep sleep into a light sleep and therefore the person suffering from sleep apnea would have a poor sleep quality. Sleep apnea is the most common among children between two and six years and less common in babies younger than six months. If a child is born before 37 weeks it is termed as premature and post term respectively. The 80% of infants weighing under two kilograms will experience sleep apnea events defined as a period of 15 or more seconds without breathing. It can occur somewhat regularly or it may only occur once, but it is enough to end a child's life. However it cannot be completely ruled out in infants of this age group. In most cases, the risk decreases as the brain matures. It is an unexplained death of an infant less than one year of period that usually occurs during sleep.

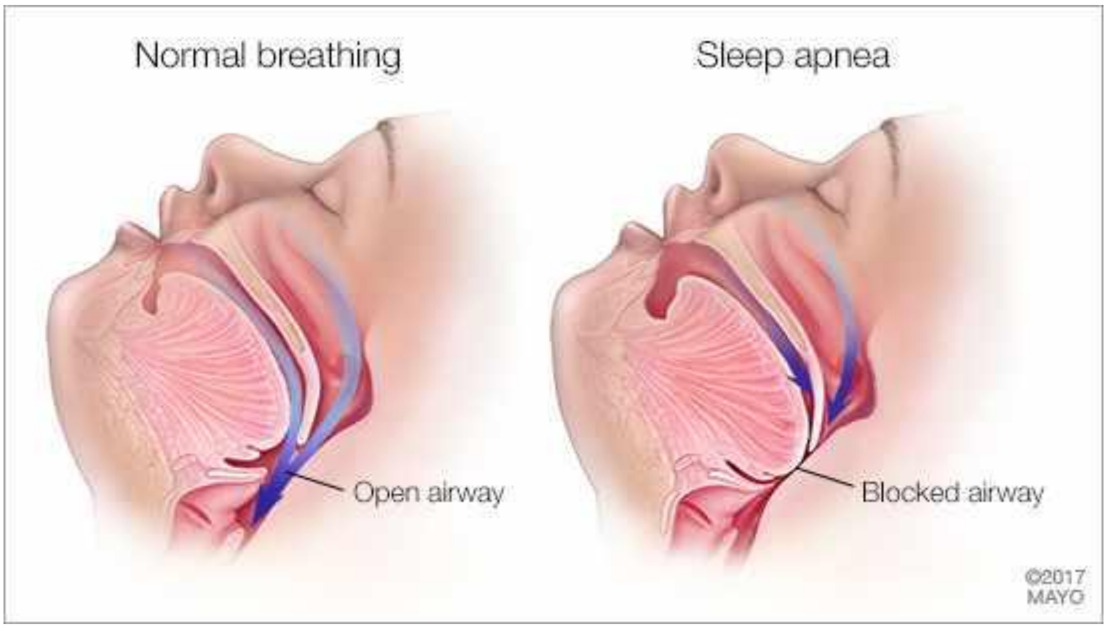

Figure 1.1 Blockage of airway in patient

1.2 Existing system

CPAP was first developed in the 1980s and its underlying principle is that of continuous mild air pressure which serves to stent open the airway, and thereby overcome anatomical areas of collapse or obstruction. The key elements of the system include a CPAP machine (which creates the pressure gradient) and tubing, which attaches to, and transmits pressure to, the CPAP mask. The CPAP mask usually covers the nose only (nasal CPAP, nCPAP) but can be used via a nose and mouth mask (full face mask), or, in the form of nasal prongs. If your doctor advises you to use a CPAP machine, you have two options: rent from the medical equipment company or purchase your own. The cost alone can discourage many people from using the treatment, but the good news is most insurance companies cover the cost. Cost of the existing device is too high. The size of the existing device is big compared to our proposed one.

1.3 Proposed system

The key point for designing a successful proof of concept on CPAP is monitoring the patient in several aspects. This proposed system consists of a Respiration sensor for measuring and monitoring the breath condition, SPO2 and Pulse Sensor for monitoring the heart rate and blood oxygen saturation level and Digital Humidity and Temperature sensor. All the parameters are monitored by the microcontroller. There are two modes of operation one is auto mode and another one is timer mode or manual mode. Once the microcontroller detects any difficulties in breathing conditions it'll automatically turn on the supportive system for the patient. By using our proposed supportive system patients can able to breathe stably. Considering these requirements, smart phones are the good candidate for monitoring the parameters through an android application. In our system the pricing is less than

1/3rd the amount of the actual one. The system is also portable in size and easily rechargeable.

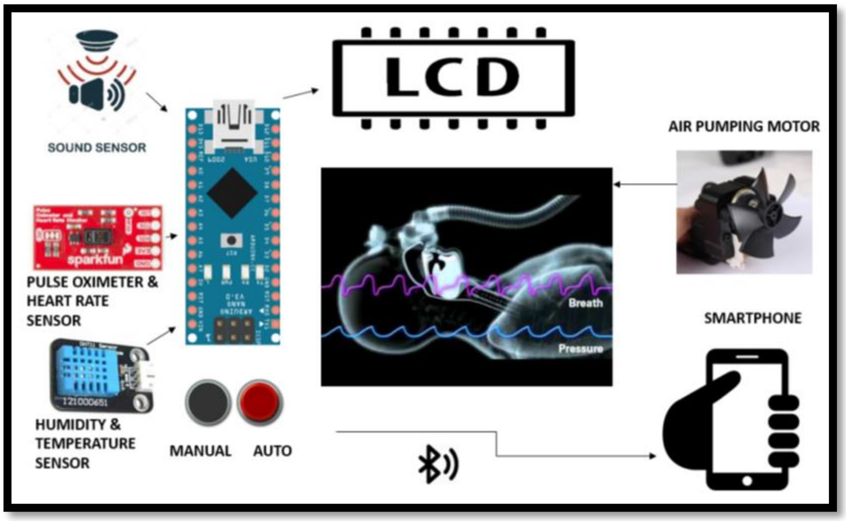

Figure 1.3 Schematic diagram of proposed system

1.4 Motivation

Sleep is essential for humans although its basic physiological function remains obscure. Sleep apnea is defined as cessation of airflow to the lungs during sleep for 10 sec or more. It normally results from either lack in neural input from the central nervous system (Central Sleep Apnea) or Upper airway collapse (Obstructive sleep apnea). completely. This disorder is more common among the overweight people and the most common symptoms are loud and chronic snoring and daytime sleepiness. When an apnea event occurs, a person often moves out of deep sleep into a light sleep and therefore the person suffering from sleep apnea would have a poor sleep quality. It can happen in persons of all ages, but it is mainly risky for infants, as their immature respiration systems often lead to inconsistent breathing patterns. Infant apnea is an extensive condition, where new born babies fail to breathe efficiently and this condition may result in death. Continuous Positive Airway Pressure (CPAP) is a mode of non-invasive mechanical ventilation commonly used in neonatology. The incorporation of new therapeutic and technological advances may impact the survival of very low birth weight preterm infants. However, one of the difficulties faced is the high cost of this device and its numerous add-on functions, such as Apnea Hypopnea Index (AHI), flow limitation, among others. Worldwide, more than one in 10 babies are born premature. Eleven countries, have preterm birth rates of more than 15%. Prematurity (born before 37 weeks of gestation) is closely linked to acute respiratory infections, which is, a leading cause of death in children under 5 years. Because their lungs are underdeveloped, preemies are especially susceptible to respiratory problems. One such leading cause of global child mortality is Respiratory Distress Syndrome (RDS). Current technology (recommended by WHO) is CPAP (Continuous Positive Airway Pressure), which helps in keeping the alveoli open by providing continuous supply of regulated air/oxygen. This ensures that the babies always have residual air in the lungs, thus, they do not struggle to breathe and are saved of further complications such as hypoxia and even death. A stand-alone CPAP device cost upwards of INR 150,000

($2300) which is too expensive for most developing world hospitals. In most the hospitals in the resource constrained settings, nasal oxygen therapy is often the solution available, for the babies who are suffering from the respiratory distress.

1.5 Literature review

1.5.1 Obstructive Sleep Apnea Syndrome

Obstructive sleep apnea and hypopnea syndrome is characterized by repeated airway collapse during sleep. The literature describes multiple causes of the disease. The main cause is a reduction of the expansion forces of the pharyngeal dilator muscles, as in situations of genioglossal muscle dysfunction, and dis coordination between the inspiratory activity of the muscle and respiratory effort, which play an important role in progression of the disease. Other described causes are soft tissue disorders, such as macroglossia or tonsillar hypertrophy, and skeletal structural alterations such as micrognathia and retrognathia. The syndrome is also more frequent in obese people, where the accumulation of fat in the neck region produces narrowing of the pharyngeal airway, thereby diminishing the passage of air. This review focuses on the pathogenesis, epidemiology, main features and diagnosis of the disease, and on its main forms of treatment.

1.5.2 Humidifier for breathable gas apparatus

A humidifier for use with a breathable gas supply apparatus includes a hollow body adapted for partial filling with water to a predetermined maximum water level, a gas inlet to the body above the maximum water level and a gas outlet from the body above the maximum water level. The humidifier further includes a constant temperature heating element for heating the water and/or an adjustable flow divider adapted to divide the interior of the body above the maximum water level into a relatively dry gas region and a relatively wet gas region. The position of the divider is variable so as to vary the relative proportion of the gas flowing from the inlet to the outlet that passes through the relatively dry and relatively wet gas regions to thereby vary the amount of humidification thereof.

1.5.3 Flow generator chassis assembly with suspension seal

A seal is provided for a chassis assembly of a flow generator configured to provide a flow of breathable gas. The chassis assembly includes an upper chassis and a lower chassis. The seal includes a blower receptacle sealing portion configured to seal a blower receptacle of the chassis assembly configured to receive a blower configured to generate the flow of breathable gas; a flow sensor sealing portion configured to seal a flow sensor provided in the chassis assembly and configured to measure the flow of breathable gas; a blower mount configured to receive a portion of the blower and mount the blower to the seal; and a blower mount suspension configured to connect the blower mount to the blower receptacle sealing portion, wherein in an assembled condition the seal and the chassis assembly define a flow path from an inlet of the chassis assembly to the blower receptacle of the chassis assembly to an outlet of the chassis assembly. A flow generator for generating a flow of breathable gas includes a chassis assembly comprising a lower chassis and an upper chassis, the lower chassis and the upper chassis defining a blower receptacle; a blower provided in the blower receptacle; and the seal.

CHAPTER 2

PROJECT IMPLEMENTATIONS

2.1 General principle design

The general principle of operation was designed using Embedded C programming and ensuring that the air flow supply was initiated once the values reached the threshold. The design also ensures the purposes of size and portability at this cost. The circuit is divided into two sections:

1. Input section
2. Output section

The input section comprises of power supply, sound sensor, pulse oximeter and heart rate sensor and humidity and temperature sensor. The output section consists of LCD, air compressor motor and smartphone. 230V AC power is supplied from the mains and fed to the power supply. The transmitted AC voltage is then fed to the rectifier which converts it to DC. A capacitive filter is used to eliminate any ripples. The rectified voltage is fed to the voltage regulator LM7805 to ensure that the voltage is regulated and constant. The output is regulated 5V dc. This power then goes to the power the microcontroller.

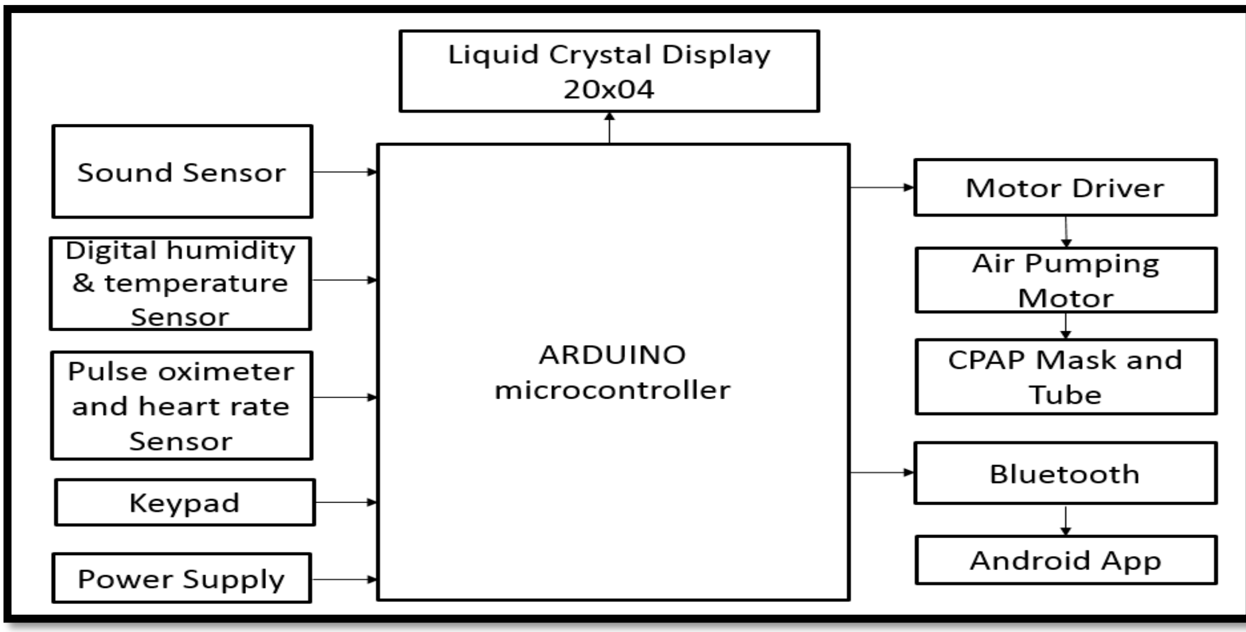

Figure 2.1 Block diagram of experimental setup

2.2 Project work modules

The project is divided into 6 following modules:

I. INTEGRATING MICROCONTROLLER WITH RESPIRATION SENSOR AND LIQUID CRYSTAL DISPLAY

II. INTEGRATING BLUETOOTH AND DIGITAL TEMPERATURE AND HUMIDITY SENSOR

III. INTEGRATION OF AIR PUMPING MOTOR

IV. ANDROID APPLICATION DEVELOPMENT USING MIT APP INVENTOR

V. EMBEDDED C PROGRAMMING USING ARDUINO IDE

VI. INTEGRATING HARDWARE WITH PROGRAM AND TESTING

2.3 Methodology

STEP 1: Two separate microcontrollers on the circuit board are connected to avoid slow processing.

STEP 2: The respiration sensor is connected to microcontroller 1 to detect the blockage of airway if any.

STEP 3: The LCD is connected to microcontroller 1 to display the parameters.

STEP 4: The Bluetooth is connected to microcontroller 1 to facilitate monitoring the parameters obtained through an android application.

STEP 5: The digital humidity and temperature sensor is connected to microcontroller 1 to detect the temperature level inside mask.

STEP 6: The pulse oximeter heart rate sensor is connected to microcontroller 2 which is placed on the patient’s index finger to measure the oxygen saturation and heart rate parameter.

STEP 7: The mask is connected to the air pumping motor via a tube which will be placed on the patient’s face.

STEP 8: The air pumping motor is connected to the microcontroller 1 via a motor driver which controls the motor.

STEP 9: An android application is developed using MIT app inventor to collect sensor input data.

STEP 10: The app displays the parameters such as the heart rate, oxygen saturation, temperature, etc in the smart phone.

STEP 11: The microcontroller is programmed to detect the respiration sound and automatically switch on the motor for air supply in case the values reach the threshold.

STEP 12: Hence, the hardware is interfaced with the program.

2.4 Hardware components

2.4.1 12V/1A Power supply

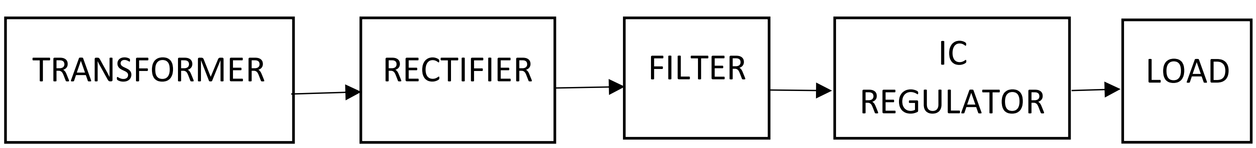

Figure 2.4.1.1 Block diagram of power supply

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

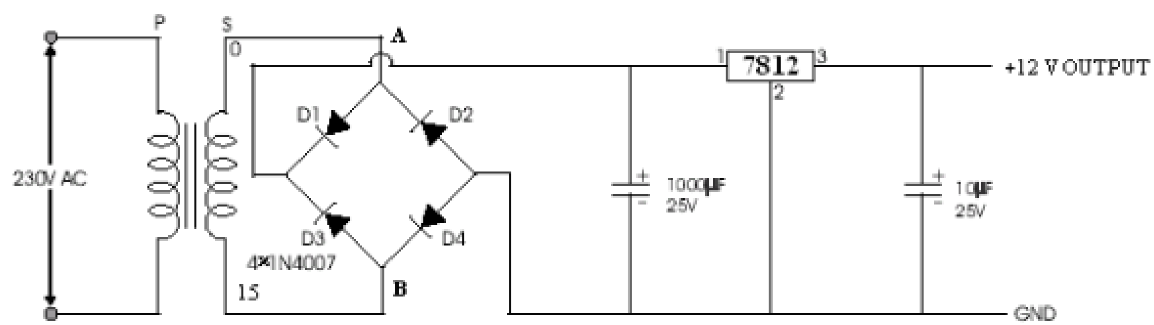

Figure 2.4.1.2 Circuit diagram of power supply

Transformer

The potential transformer will step down the power supply voltage (0-230V) to (0-15V) level. If the secondary has less turns in the coil then the primary, the secondary coil's voltage will decrease and the current or amps will increase or decreased depend upon the wire gauge. This is called a STEP-DOWN transformer. Then the secondary of the potential transformer will be connected to the rectifier.

Bridge rectifier

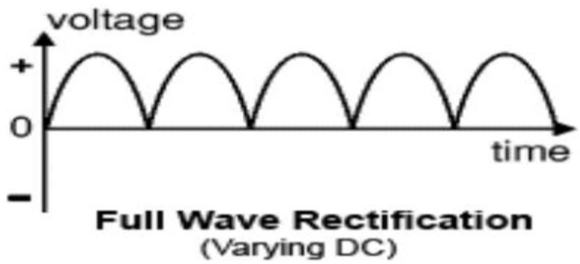

Figure 2.4.1.3 Graph for full wave rectification

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4. The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow. The path for current flow is from point B through D1, up through Load, through D3, through the secondary of the transformer back to point B. One half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through Load, through D2, through the secondary of transformer, and back to point A. Across D2 and D4. The current flow through Load is always in the same direction. In flowing through Load this current develops a voltage corresponding to that. Since current flows through the load during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

Filter

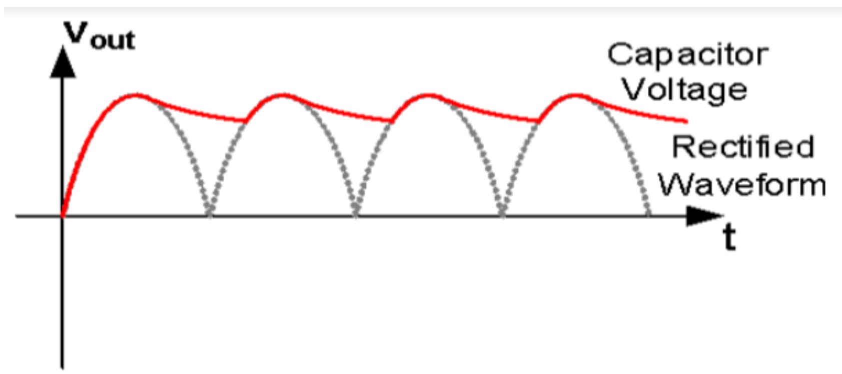

Figure 2.4.1.4 Graph for filter

If a Capacitor is added in parallel with the load resistor of a Rectifier to form a simple Filter Circuit, the output of the Rectifier will be transformed into a more stable DC Voltage. At first, the capacitor is charged to the peak value of the rectified Waveform. Beyond the peak, the capacitor is discharged through the load resistor until the time at which the rectified voltage exceeds the capacitor voltage. Then the capacitor is charged again and the process repeats itself.

IC voltage regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage.

A fixed three-terminal voltage regulator has an unregulated dc input voltage, it is applied to one input terminal, a regulated dc output voltage from a third terminal, with the second terminal connected to ground.

The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

This is a regulated power supply circuit using the 78xx IC series. These regulators can deliver current around 1A to 1.5A at a fix voltage levels. The common regulated voltages are 5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, and 24V. It is important to add capacitors across the input and output of the regulator IC to improve the regulation.

In this circuit we are using 7812 regulators so it converts variable dc into constant positive 5V power supply. If the input voltage goes to below 14.6V means the output also varied. That is why we are using 230/15V step-down transformer. Transformer output is higher than the regulator minimum level input.

2.4.2 Relay

Sometimes the Arduino is used to control AC powered devices like lamps, fans or other household devices. But because the Arduino operates at 5 volts, it cannot directly control these higher voltage devices. So, we use a relay module to control the AC mains and Arduino to control the relay. A relay is an electromagnetic switch operated by a relatively small current that can control much larger current. Initially the first circuit is switched off and no current flows through it until something (either a sensor or switch closing) turns it on. The second circuit is also switched off. When a small current flow through the first circuit, it activates the electromagnet, which generates a magnetic field all around it. The energized electromagnet attracts a contact in the second circuit toward it, closing the switch and allowing a much bigger current to flow through the second circuit. When the current stops flowing, the contact goes back up to its original position, switching the second circuit off again. Typically, the relay has 5 pins, three of them are high voltage terminals (NC, COM, and NO) that connect to the device you want to control.

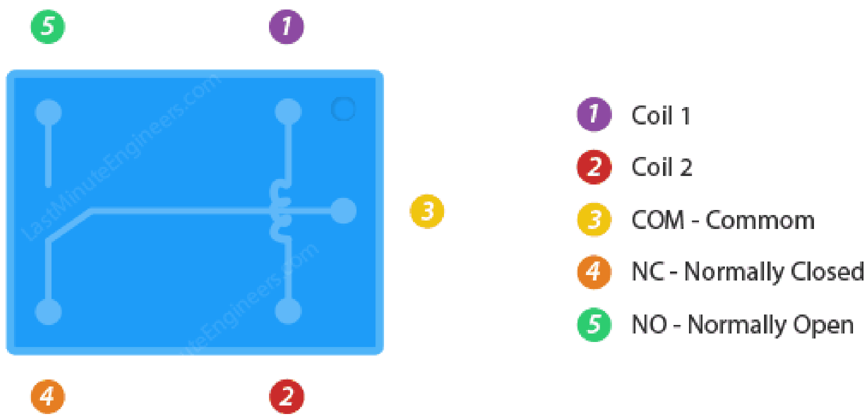

Figure 2.4.2 channel 5V relay Pins

The mains electricity enters the relay at the common (COM) terminal. While use of NC & NO terminals depends upon whether you want to turn the device ON or OFF. Between the remaining two pins (coil1 and coil2), there is a coil that acts like an electromagnet.

When current flows through the coil, the electromagnet becomes charged and moves the internal contacts of the switch. At that time the normally open (NO) terminal connects to the common (COM), and the normally closed (NC) terminal becomes disconnected.

When current stops flowing through the coil, the internal contact returns to its initial state i.e. the normally closed (NC) terminal connects to the common (COM), and the normally open (NO) terminal reopens.

2.4.3 Microcontroller unit

A simple definition of the microcontroller is a computer on a chip. The microcontroller enables the project to be a standalone system which is able to produce varied reactions to various situations according to preset controls. The microcontroller in this project is the AT mega 328P microcontroller. The system here is used to get all the input parameters from the sensors used, display it on the LCD and switch on the compressor motor when it reaches the threshold values. To do these actions on its own, the microcontroller needs to be loaded with a program to enable it execute all these actions.

Types of Microcontrollers

There are several ways in which microcontrollers can be classified. The several aspects of classification lead to several types of microcontrollers. Classification based on internal bus width This classification results into three sub groups. Considering the length of the internal bus, a microcontroller can either be 8-bit, 16-bit or 32-bit.

8-bit microcontrollers

8-bit microcontrollers, as the name suggests have a bus width of 8 bits. Examples of such microcontrollers are Intel 8031/8051, PIC 1X and Motorola MC68HC11 families

16-bit microcontroller

Have greater precision than the 8-bit microcontroller. Has a range of 0X0000 – 0XFFFF (0- 65535) for every cycle. Examples of these microcontrollers are the extended 8051XA, PIC2X, Intel 8096 and the Motorola MC68HC12 families.

32-bit microcontroller

Used in automated devices, engine control systems, office machines and other embedded systems. From the name, the bus width is 32 bits and have even greater accuracy than the 16 bit types. Examples are Intel/Atmel 251 family and PIC3X families

Application of Microcontrollers

Microcontrollers have many applications across the technological fields' nowadays. Some of the most common applications are

In day to day activities

- Light sensing & controlling devices
- Temperature sensing and controlling devices
- Fire detection & safety devices
- Industrial instrumentation devices
- Process control devices

- Industrial instrumentation devices

In Industries

- In Metering and measurement devices
- Measuring revolving objects
- Volt Meter
- Hand-held metering systems
- Current meter

ATmega328P

This is a single chip microcontroller created by the Atmel cooperation and it belongs to the 8 bit AVR family. Typical features of this microcontroller are

- Operating voltage is 5V
- Input voltage (Vin) is 7V to 12V
- Input/Output Pins are 22
- Analog i/p pins are 6 from A0 to A5
- Digital pins are 14
- Flash memory is 32 KB
- Supports three communications like SPI, IIC, & USART

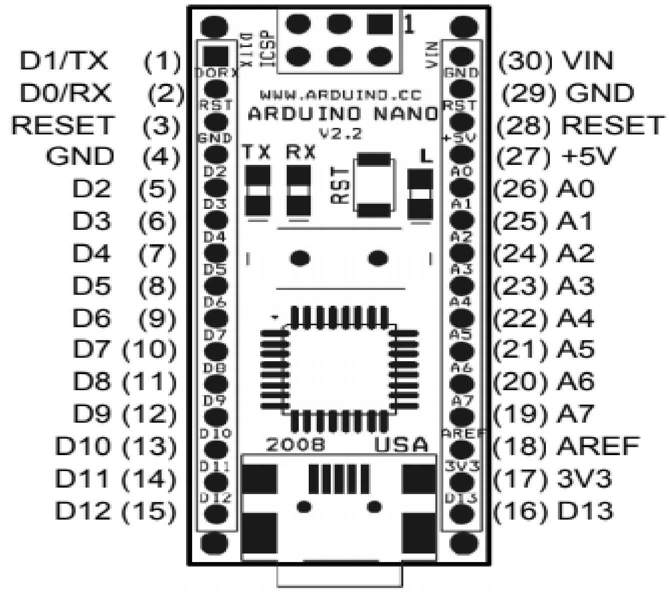

Figure 2.4.3 Arduino Nano pin layout

Pin No.	Name	Type	Description
1-2, 5-16	D0-D13	I/O	Digital input/output port 0 to 13
3, 28	RESET	Input	Reset (active low)
4, 29	GND	PWR	Supply ground
17	3V3	Output	+3.3V output (from FTDI)
18	AREF	Input	ADC reference
19-26	A7-A0	Input	Analog input channel 0 to 7
27	+5V	Output or Input	+5V output (from on-board regulator) or +5V (input from external power supply)
30	VIN	PWR	Supply voltage

Table 2.1 Arduino Nano pin description

The Arduino Nano has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An

FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with the Arduino software) provide a virtual com port to software on the computer. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the FTDI chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A SoftwareSerial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus.

2.4.4 Respiration sensor

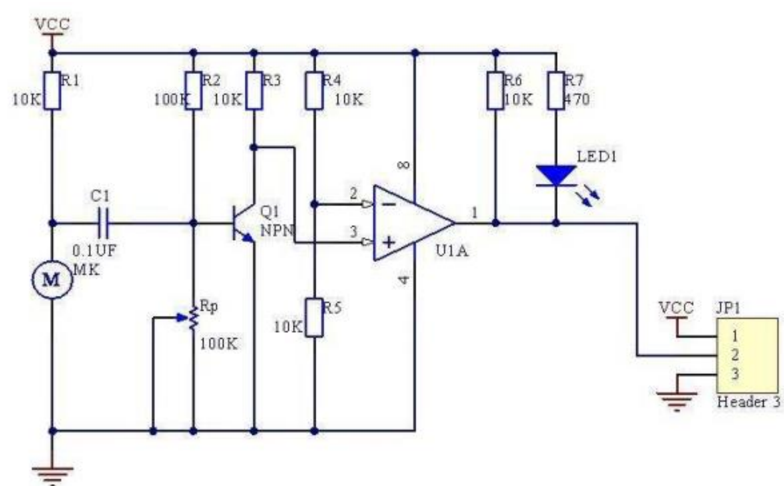

Figure 2.4.4 Schematic diagram of LM393

The sound sensor module provides an easy way to detect sound and is generally used for detecting sound intensity. This module can be used for security, switch, and monitoring applications. Its accuracy can be easily adjusted for the convenience of usage. It uses a microphone which supplies the input to an amplifier, peak detector and buffer. When the sensor detects a sound, it processes an output signal voltage which is sent to a microcontroller then performs necessary processing. Sound detection sensor module for arduino detects whether sound has exceeded a threshold value. Sound is detected via microphone and fed into an LM393 op amp. The sound level set point is adjusted via an on board potentiometer. When the sound level exceeds the set point, an LED on the module is illuminated and the output is set low.

2.4.5 Humidity and Temperature sensor

DHT11 digital temperature and humidity sensor is a composite Sensor contains a calibrated digital signal output of the temperature and humidity. Application of a dedicated digital modules collection technology and the temperature and humidity sensing technology, to ensure that the product has high reliability and excellent long-term stability. The sensor includes a resistive sense of wet components and an NTC temperature measurement devices, and connected with a high-performance 8-bit microcontroller. DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form. The temperature range of DHT11 is from 0 to 50 degree Celsius with a 2-degree accuracy. Humidity range of this sensor is from 20 to 80% with 5% accuracy. The sampling rate of this sensor is 1Hz .i.e. it gives one reading for every second. DHT11 is small in size with operating voltage from 3 to 5 volts. The maximum current used while measuring is 2.5mA. DHT11 sensor has four pins- VCC, GND, Data Pin and a not connected pin. A pull-up resistor of 5k to 10k ohms is provided for communication between sensor and micro-controller.

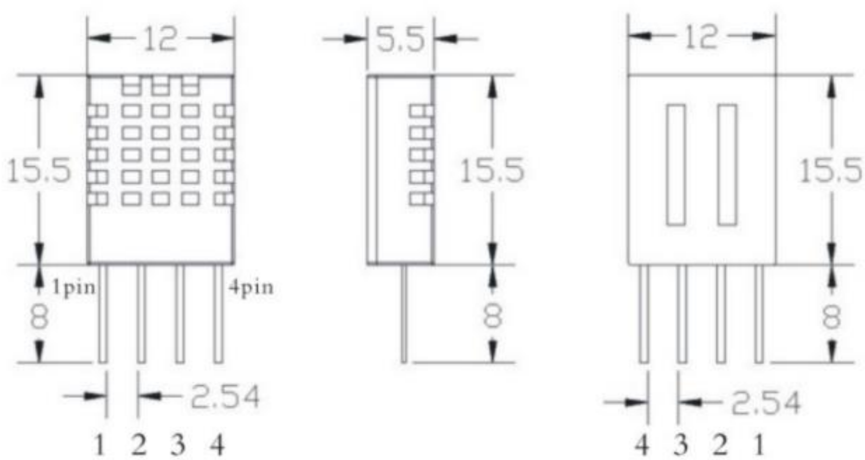

Figure 2.4.5 Dimensions of DHT11

2.4.6 Pulse oximeter and heart rate sensor

The MAX30100 is an integrated pulse oximetry and heart-rate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. The

MAX30100 operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times. The MAX30100 is fully configurable through software registers, and the digital output data is stored in a 16-deep FIFO within the device. The FIFO allows the MAX30100 to be connected to a microcontroller or microprocessor on a shared bus, where the data is not being read continuously from the device's registers.

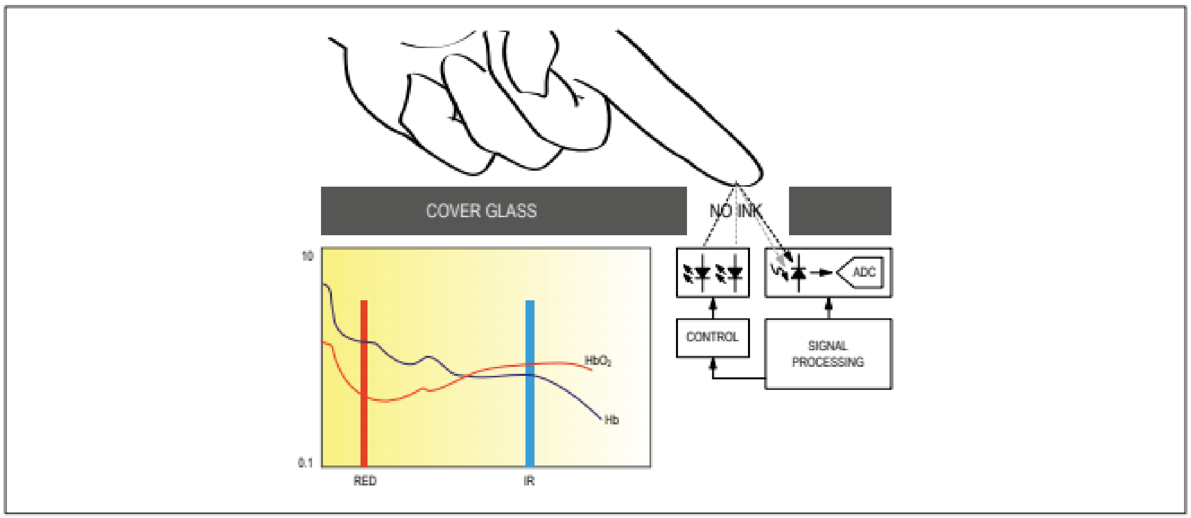

Figure 2.4.6 System block diagram of MAX30100

SpO2 Subsystem

The SpO2 subsystem in the MAX30100 is composed of ambient light cancellation (ALC), 16-bit sigma delta ADC, and proprietary discrete time filter. The SpO2 ADC is a continuous time oversampling sigma delta converter with up to 16-bit resolution. The ADC output data rate can be programmed from 50Hz to 1kHz. The MAX30100 includes a proprietary discrete time filter to reject 50Hz/60Hz interference and low-frequency residual ambient noise.

Temperature Sensor

The MAX30100 has an on-chip temperature sensor for (optionally) calibrating the temperature dependence of the SpO2 subsystem. The SpO2 algorithm is relatively insensitive to the wavelength of the IR LED, but the red LED’s wavelength is critical to correct interpretation of the data. The temperature sensor data can be used to compensate the SpO2 error with ambient temperature changes.

LED Driver

The MAX30100 integrates red and IR LED drivers to drive LED pulses for SpO2 and HR measurements. The LED current can be programmed from 0mA to 50mA (typical only) with proper supply voltage. The LED pulse width can be programmed from 200µs to 1.6ms to optimize measurement accuracy and power consumption based on use cases.

2.4.7 Compressor motor

The main parts consist of i) inlet casing with converging nozzle ii) the impeller

iii) the diffuser iv) the outlet casing. The function of the inlet casing with the conversant nozzle is to accelerate the entering fluid to the impeller inlet. The inlet nozzle accelerate the fluid from the initial condition to the entry of the Inlet Guide Vanes (IGV) which direct the flow in the desired direction at the

inlet of the impeller (state 1).

The impeller convert the supplied mechanical energy into fluid energy whereby the fluid kinetic energy and the static pressure rises. The inducer receives the flow between the hub and tip diameters (dh and dt) of the impeller eye and passes on to the radial portion of the impeller blades. The flow approaching the impeller may be with or without swirl.

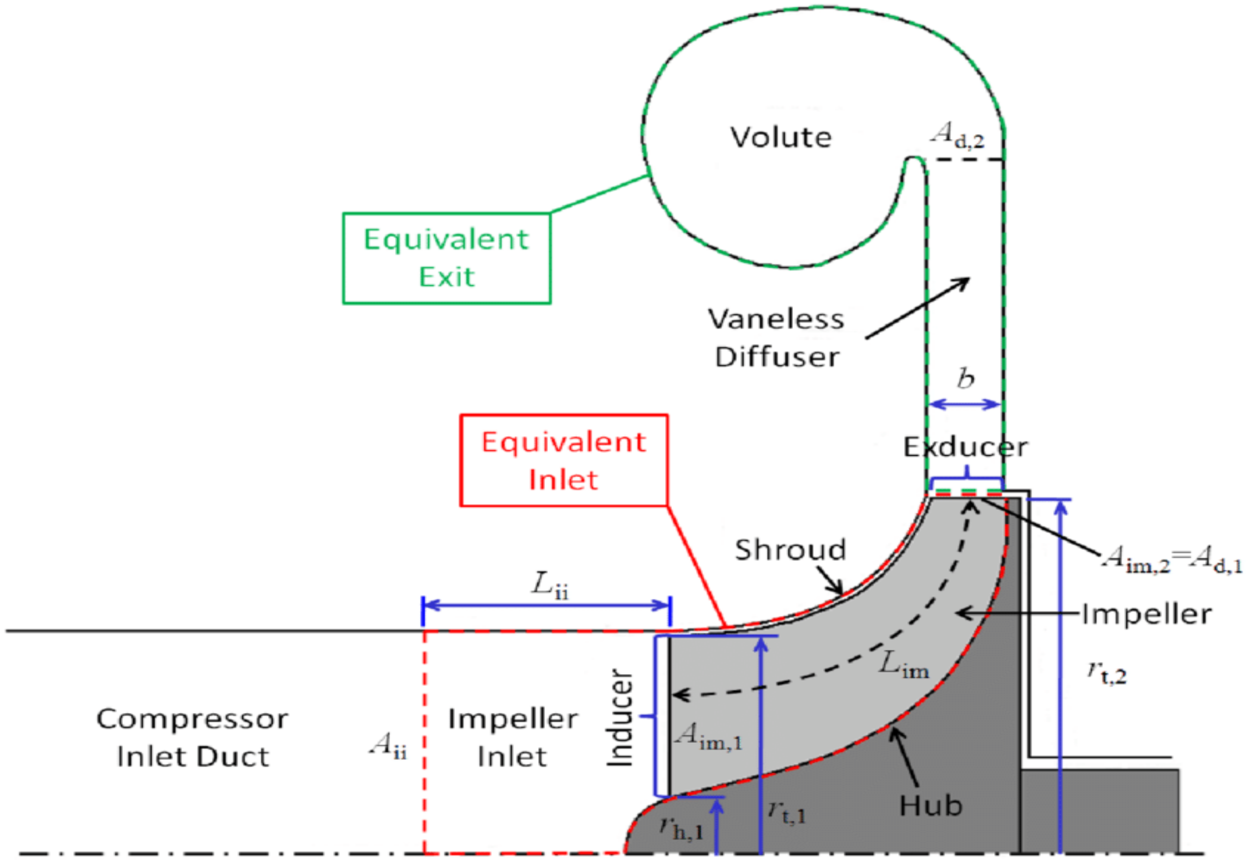

Figure 2.4.7.1 Important parts of Compressor motor

2.4.8 Liquid crystal display:

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal. An LCD consists of two glass panels, with the liquid crystal material sandwiched in between them. The inner surface of the glass plates is coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle. One each polariser is pasted outside the two glass panels. These polarisers would rotate the light rays passing through them to a definite angle, in a particular direction. When the LCD is in the off state, light rays are rotated by the two polarisers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarisers, which would result in activating highlighting the desired characters. The LCDs are lightweight with only a few millimetres thickness. Since the LCDs consume less power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCDs don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCDs have long life and a wide operating temperature range. Changing the display size or the layout size is relatively simple which makes the LCDs more customer friendly. The LCDs used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

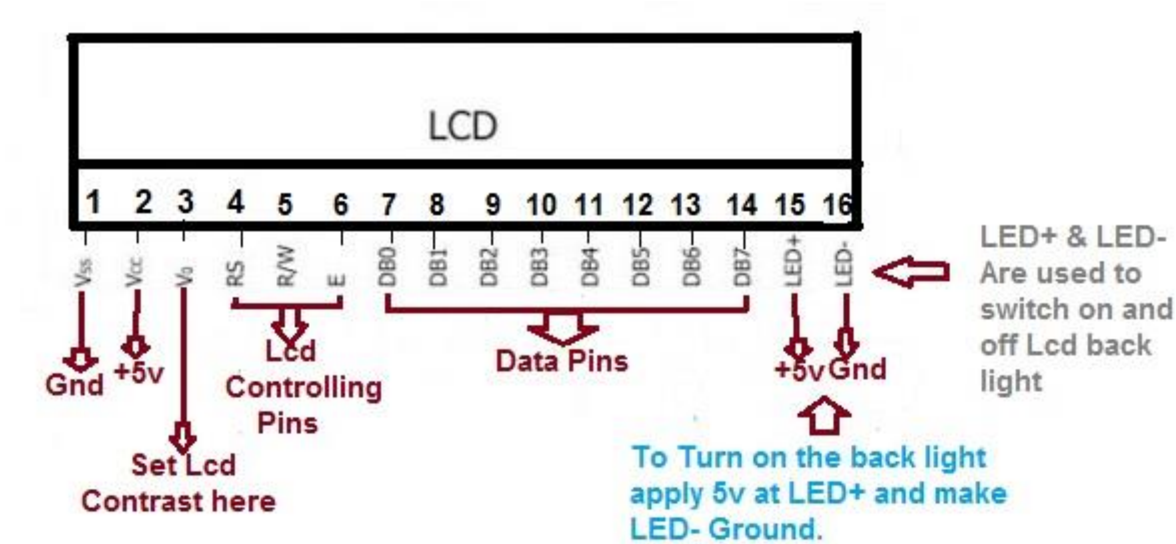

Figure 2.4.8 Pinout diagram of LCD

2.5 **Software Components**

2.5.1 Arduino Nano

Arduino NANO is the open-source microcontroller development board based on the ATMEGA328P microcontroller IC. The microcontroller IC on which the Arduino UNO and Arduino NANO is based is usually the same by the way sometimes the difference lies in the package type of the microcontroller IC. The Arduino NANO is sometimes preferred over the Arduino UNO when there is limitation on the space constraint. Arduino NANO is quite small in size as compared to the Arduino UNO and can easily be mounted on the Breadboard making it useful in Breadboard based prototypes. The Arduino NANO looks like the one in the following figure:

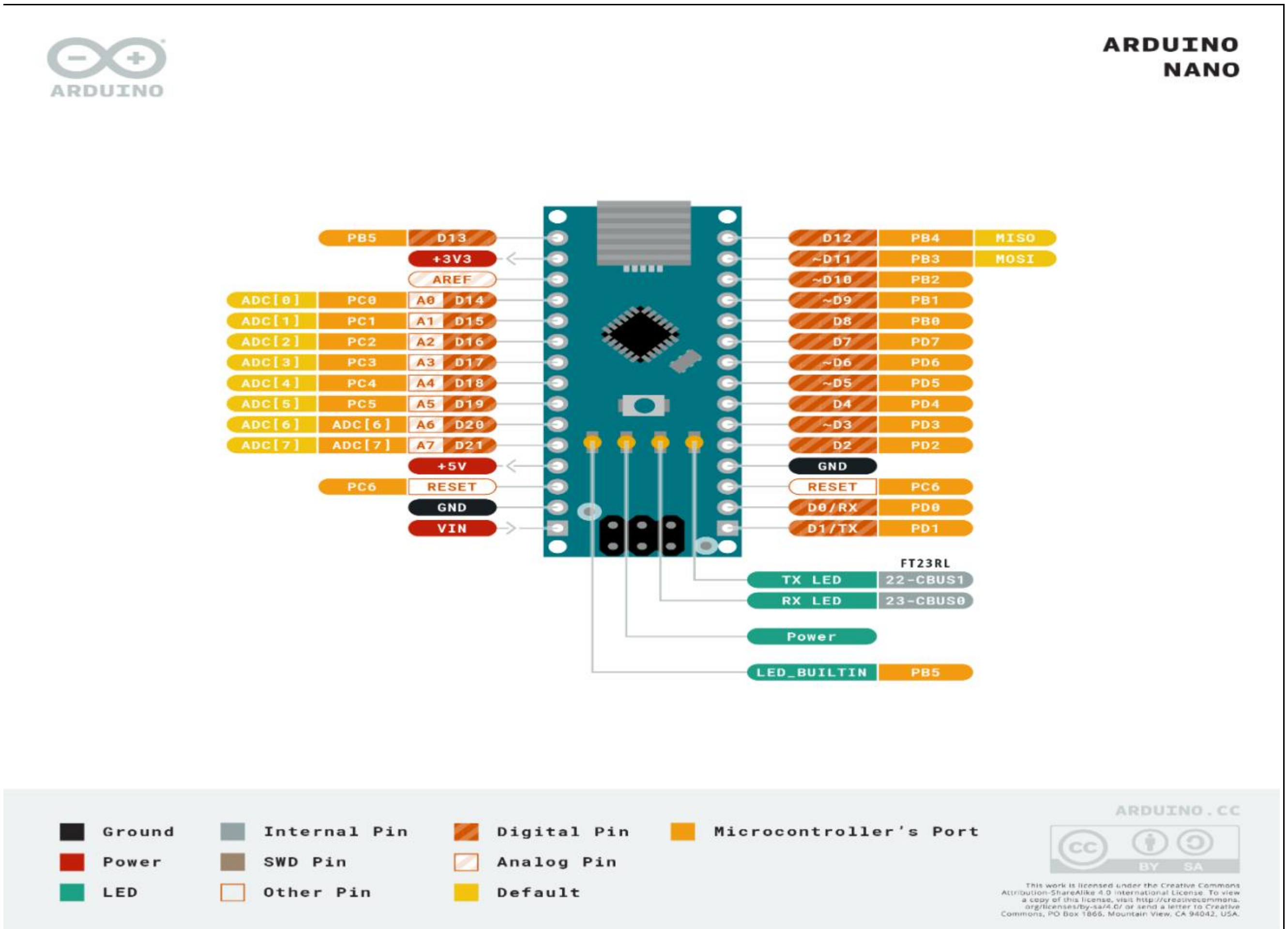

Figure 2.5.1.1 Arduino Nano

The Arduino NANO has micro USB port with the help of which Arduino NANO can be programmed or monitored. Arduino NANO has a micro USB connector implying that the USB cable required for the programming of Arduino NANO is different. Arduino NANO has no power jack.

Arduino Integrated development Environment (Arduino IDE):

The Arduino NANO can also be programmed with Arduino IDE that is the programming of the Arduino NANO is not different from that of the Arduino UNO .We program a microcontroller by writing the code in the editor, and then compiling that code in the compiler after which you the HEX file of that code is uploaded in the microcontroller IC using another program. The first step would be install the Arduino IDE which is available for download for free from the below link. After installing Arduino we also install the drivers. Once arduino IDE is installed on the computer, connect the board with computer using USB cable. Now open the arduino IDE and choose the correct board by selecting Tools>Boards>Arduino/Nano, and choose the correct Port by selecting Tools>Port. Arduino Uno is programmed using Arduino programming language based on Wiring. To get it started with Arduino Uno board and blink the built-in LED, load the example code by selecting Files>Examples>Basics>Blink. Once the code is loaded into your IDE, click on the 'upload' button given on the top bar.

2.5.2 Bluetooth Module

The **HC-05** has two operating modes, one is the Data mode in which it can send and receive data from other Bluetooth devices and the other is the AT Command mode where the default device settings can be changed. We can operate the device in either of these two modes by using the key pin as explained in the pin description.

It is very easy to pair the HC-05 module with microcontrollers because it operates using the Serial Port Protocol (SPP). Simply power the module with +5V and connect the Rx pin of the module to the Tx of MCU and Tx pin of module to Rx of MCU as shown in the figure below

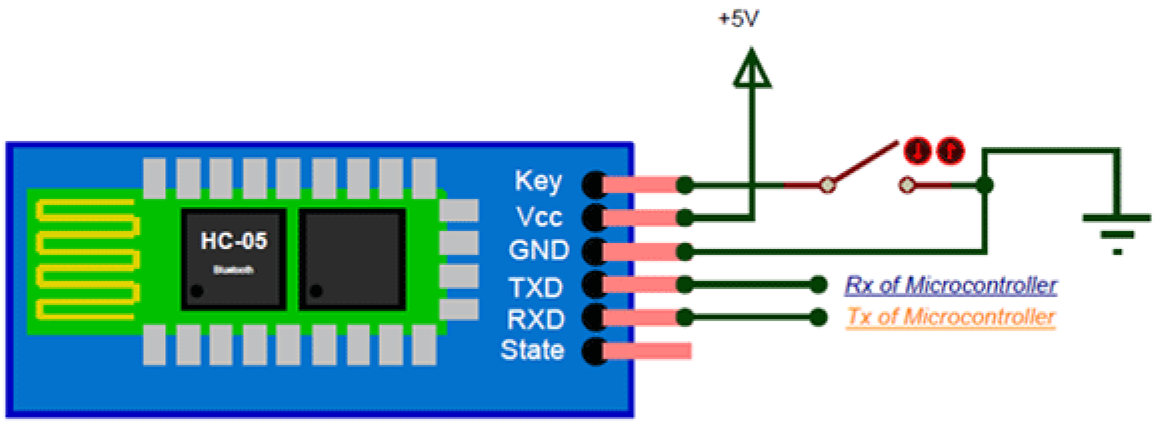

Figure 2.5.2.1 Diagram of Bluetooth module

Make the connections and power on the Bluetooth Module. If this is the first time you are using your Bluetooth Module, then the LED will blink rapidly. In order to pair the module with your phone, open Bluetooth Settings in your phone and connect to “HC-05” with pin “1234”.Once the Bluetooth Module is paired with your phone, you can start using the App. Open the Bluetooth Controller App and click on scan. A list of Bluetooth Devices will appear on the screen. Select HC-05.

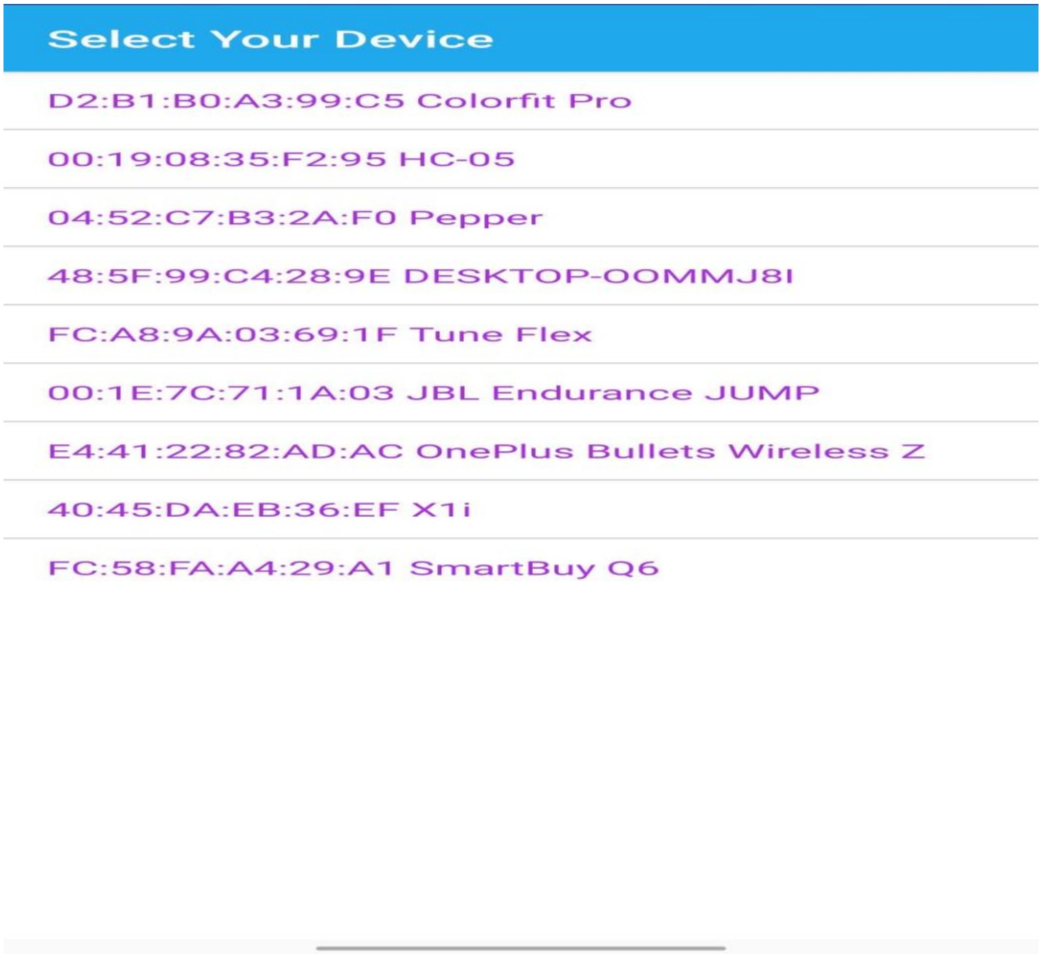

Figure 2.5.2.2 Available devices of Bluetooth

3. **Conclusion :**

3.1 Result :

The results obtained are shown below for different conditions. Based on the requirements of the patient, we have shown the output.

Case 1 :

Manual mode of Operation :

This Manual Mode of Operation works when we manually turn on. It runs till we either shut down the motor or switch to Automatic Mode of Operation. Even in this mode , the parameters are measured and can be constantly monitored in the Smart Phone

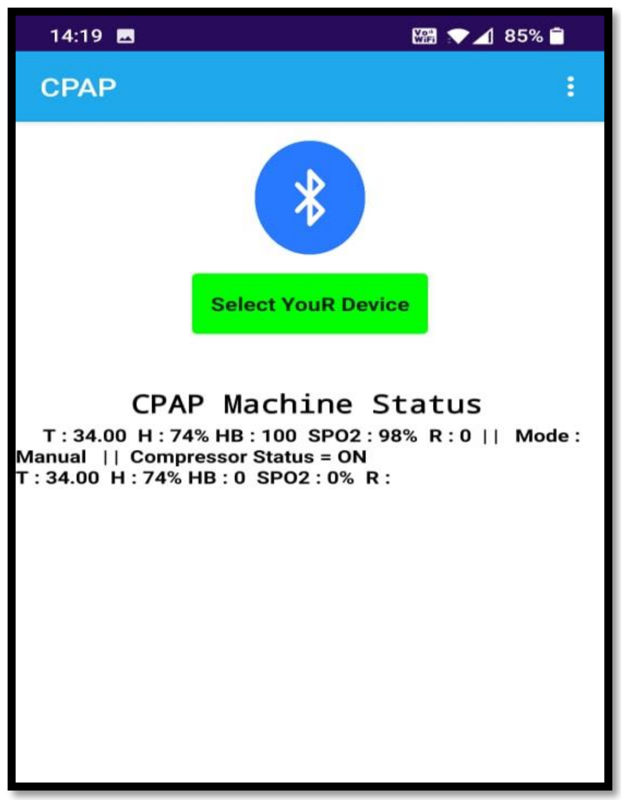

Figure 3.1.1 Results of Manual Mode of Operation

Case 2 : Automatic Mode of Operation

This mode runs when the threshold is met or when the person experiences breathing difficulty and blockage in air pipes. The message “Snoring detected” is displayed on the LCD screen whenever any snore is detected by the sensor. The motor runs for 10 seconds when continuous blockages are met (value = 6)

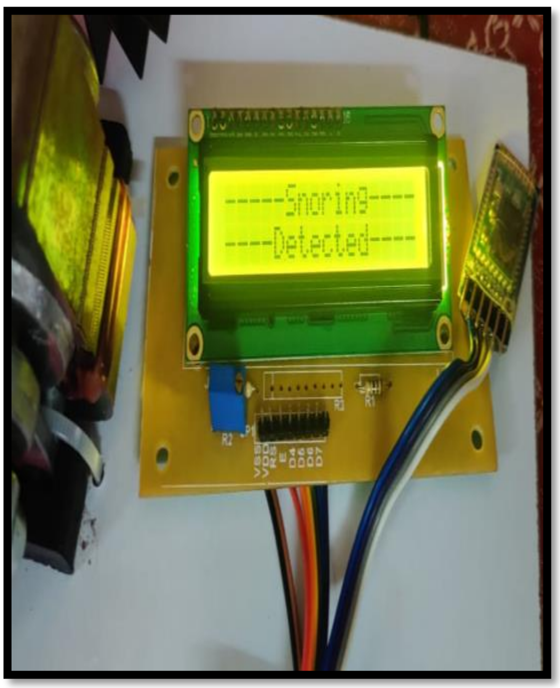

Fig 3.1.2 Results of Automatic modes of Operation

3.2 Accomplishment :

The portablity and non-invasive method and light weight is achieved and We have also achieved to monitor sleep apnea and difficulty in breathing for both adults and in kids with a change in the use of masks .The efficiency in this process is achieved as 75%

3.3 Future Scope :

There are some additional areas that can be included to explore in future research by adding other sensors such as EEG , altimeter and galvanic skin response etc., by collaborating with doctors for further studies . In future studies, more data are collected and the performance of the system is tested with real sleep apnea patients. The speed of the motor can be varied and controlled. Also, the android application can be used to switch on/off the motor from the smartphone using IoT so that the control over the system can be accessed from anywhere and an alerting unit can be set up once the sleep apnea is detected.

Appendices :

```
#include <LiquidCrystal.h>
#include <SoftwareSerial.h>
#include "DHT.h"



LiquidCrystal lcd( 12, 11, 10, 9, 8, 7);
SoftwareSerial blue_tx_rx (2, 3);
define ard_node blue_tx_rx
#define splash splash1
#define DHTTYPE DHT11

#define resp A0
#define DHTPIN A1
#define ky1 4
#define ky2 5
#define compres 6

DHT dht(DHTPIN, DHTTYPE);

int a, b;
int H_B, SPO_2;
int hum;
float temp;
String IncomingData = "";


String outB = "";

String modefn = "";



int res_r, resfn;
int res_r_t = 700;
float res_tim = 0.0;
```

```
int C_Status;
int C_tim = 10;
float cc_tim = C_tim;

int  k1_r, k2_r;
int C_auto;


int DispDelay;



void setup() {
  // put your setup code here, to run once:
  Serial.begin(115200);
  blue_tx_rx.begin(9600);
  dht.begin();
  pinMode(resp, INPUT);
  pinMode(ky1, INPUT_PULLUP);
  pinMode(ky2, INPUT_PULLUP);
  pinMode(compres, OUTPUT);
  digitalWrite(compres, LOW);
  LcDSet();
  lcd.clear();

}


void LcDSet() {


  lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.clear();

  splash(0, "CPAP");
  splash(1, "MACHINE");
  delay(1000);

}
```

```
void loop() {

  setDisp();
  getArd();
  getDht();
  k1_r = digitalRead(ky1);
  k2_r = digitalRead(ky2);
  if (k1_r == 0 and C_auto == 0) {
    splash(1, "Auto Mode OFF");
    delay(100);
    C_auto = 1;

  }

  else if (k1_r == 0 and C_auto == 1) {
    splash(1, "Auto Mode ON");
    resfn = 0;
    res_tim = 0;
    delay(100);
    C_auto = 0;

  }

  if (C_auto == 0) {
    getres();
    outB = "T : ";
    outB += String(temp);
    outB += "  H : ";
    outB += String(hum);
      outB += "% HB : ";
    outB += String(H_B);
    outB += "  SPO2 : ";
    outB += String(SPO_2);


    outB += "%  R : ";
    outB += String(resfn);
```

```
  outB += "  ||  ";
  outB += " Mode : ";
  outB += "Auto ";
  outB += "  ||  ";
  outB += "Compressor Status = ";
  if (C_Status == 1) {
    digitalWrite(compres, HIGH);
    outB += "ON";

  }
  Else

{
    digitalWrite(compres, LOW);
    outB += "OFF";
  }

 }
 else {

  if (k2_r == 0 and C_Status == 0) {
    //      digitalWrite(led, HIGH);

    splash(1, "C ON");
    delay(100);
    C_Status = 1;
  }

  else if (k2_r == 0 and C_Status == 1) {


    splash(1, "C OFF");
    //      digitalWrite(led, LOW);
    lcd.setCursor(0, 0);
    lcd.print("                    ");
    delay(100);
    C_Status = 0;
  }

  outB = "T : ";
```

```
    outB += String(temp);
    outB += "  H : ";
    outB += String(hum);

    outB += "% HB : ";
    outB += String(H_B);
    outB += "  SPO2 : ";
    outB += String(SPO_2);


    outB += "%  R : ";
    outB += String(resfn);
    outB += "  ||  ";
    outB += " Mode : ";
    outB += "Manual ";
    outB += "  ||  ";
    outB += "Compressor Status = ";
    if (C_Status == 1) {
      outB += "ON";
    }
    else
  {
      outB += "OFF";
    }
   }

   if (C_Status == 1) {
    digitalWrite(compres, HIGH);

   }
   Else
  {
    digitalWrite(compres, LOW);

   }
   Serial.println(outB);
   blue_tx_rx.println(outB);
   delay(300);
  }
```

```
void getres()
{

  res_tim += 0.40;


  res_r = analogRead(resp);
  Serial.println(res_r);
  if (C_Status == 0) {
    if (res_r > res_r_t) {
      resfn++;
      splash(0, "Snoring");
      splash(1, "Detected");
    }
  }

  if (res_tim > 8 and resfn > 2 and C_Status == 0) {
    Serial.println("Comp ON");
    C_Status = 1;
    splash(1, "C ON");
    resfn = 0;
    res_tim = 0;
  }

  else if (res_tim > C_tim and C_Status == 1) {
    C_Status = 0;
    splash(1, "C OFF");
    lcd.setCursor(0, 0);
    lcd.print("                ");
    Serial.println("Comp OFF");
    resfn = 0;
    res_tim = 0;
  }

  else if (res_tim > 10) {
    C_Status = 0;

    Serial.println("Normal");
    resfn = 0;
    res_tim = 0;
```

```
  }

}


void getArd() {
  String SS = ""; String SSs = "";
  while (ard_node.available() > 0) {

    char S = ard_node.read();
    SS += S;

    delay(10);

  }
  if (SS.length() > 0) {
    Serial.println(SS);
    String sys = getSplitValue(SS , ',', 0);
    String dia =  getSplitValue(SS , ',', 1);

    H_B = sys.toInt();
    SPO_2 = dia.toInt();


    ard_node.flush();

  }
}




void getDht() {

  int humidity = dht.readHumidity();
  float temperature = dht.readTemperature();
  /* Serial.print(humidity, 1);
    Serial.print("\t\t");
    Serial.println(temperature, 1);*/
  temp = temperature;
  hum = humidity;
```

```
}


void setDisp() {
  DispDelay++;
  if (DispDelay >= 0 and DispDelay < 15) {
    display_ard(H_B, SPO_2);

  }
  if (DispDelay >= 15 and DispDelay < 30) {
    display_T(temp, hum);

  }
  else  if (DispDelay >= 30 ) {
    DispDelay = 0;
  }

  if (C_Status == 0) {

    lcd.setCursor(0, 1);
    lcd.print("S :              ");
    lcd.setCursor(3, 1);
    lcd.print(resfn);
    lcd.setCursor(12, 1);
    lcd.print(res_tim);
    cc_tim = C_tim;
  }
  else if (C_Status == 1 and C_auto == 1 ) {
    lcd.setCursor(0, 0);
    lcd.print("Air Flow ON              ");

  }
  else
{
    lcd.setCursor(0, 0);
    lcd.print("Air Flow ON              ");
    lcd.setCursor(0, 1);
    lcd.print("                    ");
    lcd.setCursor(12, 1);
    lcd.print(cc_tim -= 0.38);
```

```
  }

}
void display_ard(int val1 , int val2) {

  lcd.setCursor(0, 0);
  lcd.print("HB:                ");
  lcd.setCursor(3, 0);
  lcd.print(val1);
  lcd.setCursor(7, 0);
  lcd.print("SPo2:              ");
  lcd.setCursor(12, 0);
  lcd.print(val2);
  lcd.setCursor(15, 0);
  lcd.print("% ");

}
void display_T(float val1 , int val2) {


  lcd.setCursor(0, 0);
  lcd.print("T:                ");
  lcd.setCursor(3, 0);
  lcd.print(val1, 1);
  lcd.setCursor(8, 0);
  lcd.print("H:                ");
  lcd.setCursor(11, 0);
  lcd.print(val2);
  lcd.setCursor(14, 0);
  lcd.print("% ");
}
```

Arduino Code

```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#include <SoftwareSerial.h>
SoftwareSerial ard_node(2,3);


#define REPORTING_PERIOD_MS     1000

PulseOximeter pox;

uint32_t tsLastReport = 0;

void onBeatDetected()
{
  Serial.println("Beat!");
}


void setup() {
  // put your setup code here, to run once:
  Serial.begin(115200);
  ard_node.begin(9600);
  Serial.print("Initializing pulse oximeter..");


  // Initialize the PulseOximeter instance
  // Failures are generally due to an improper I2C wiring, missing power supply
  // or wrong target chip
  if (!pox.begin()) {
    Serial.println("FAILED");
    for (;;);
  } else {
    Serial.println("SUCCESS");
  }

  // The default current for the IR LED is 50mA and it could be changed
  //   by uncommenting the following line. Check MAX30100_Registers.h for all
the
```

```
  //   available options.
//   pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);

  // Register a callback for the beat detection
  pox.setOnBeatDetectedCallback(onBeatDetected);
}

void loop() {
  // put your main code here, to run repeatedly:
  pox.update();

  // Asynchronously dump heart rate and oxidation levels to the serial
  // For both, a value of 0 means "invalid"
  if (millis() - tsLastReport > REPORTING_PERIOD_MS) {

    Serial.print("Heart rate:");
    Serial.print(pox.getHeartRate());
    Serial.print("bpm / SpO2:");
    Serial.print(pox.getSpO2());
    Serial.println ("%");



    ard_node.print(pox.getHeartRate());
    ard_node.print(",");
    ard_node.print(pox.getSpO2());
    ard_node.print(",");



    tsLastReport = millis();
  }
}
```

References :

1. T. Duke, J. Kelly, M. Weber, M. English, and H. Campbell, “Hospital care for children in developing countries: Clinical guidelines and the need for evidence,” Journal of Tropical Pediatrics, vol. 52, no. 1, pp. 1- 2, Feb. 2006.

2. WHO. The World Health Report 2005: Make Every Mother and Child Count. Geneva: World Health Organization; 2005. Available: http://www.who.int/whr/2005/en/index.html

3. R. Kliegman, R. Behrman, H. Jenson, and B. Stanton, Nelson Textbook of Pediatrics., 18th ed. Philadelphia, Pennsylvania: Saunders, 2004.

4. E. Widmaier, H. Raff, K. Strang, Vander's Human Physiology: The Mechanisms of Body Function, 11th ed. New York, New York: McGraw-Hill, 2008.