# LOW COST VENTILATOR

**Final Year Project**

**Session 2018-2022**

A project submitted in partial fulfillment of the degree of

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Department of Computer Science

Faculty of Computer Science & Information Technology

Superior University, Lahore

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**Project Group Members**

| Sr.# | Reg. # | Student Name | Email ID | *Signature |
|---|---|---|---|---|
| (i) | Bcsm-f18-204 | HAMZA ALI | ha220554@gmail.com | |
| (ii) | Bcsm-f18-207 | SAHIL SALEEM | sahilsaleem71@gmail.com | |
| (iii) | Bcsm-f18-370 | MUSTAFA DILSHAD | bcsm-f18-370@gmail.com | |

*The candidates confirm that the work submitted is their own and appropriate credit has been given where reference has been made to work of others

## Plagiarism Free Certificate

This is to certify that, I _____ S/D of Muhammad Siddique, group leader of FYP under registration no _____at Computer Science Department, The Superior University, Lahore. I declare that my FYP report is checked by my supervisor.

Date: Name of Group Leader: _____ Signature: _____

Name of Supervisor: Mr. Hamayun Khan

Designation: Lecturer

Signature: _____

HoD: Dr. Irfan ud din

Signature: _____

# Project Report

## [LOW COST VENTILATOR]

## Change Record

| Author(s) | Version | Date | Notes | Supervisor's Signature |
|---|---|---|---|---|
| | 1.0 | | <Original Draft> | |
| | | | <Changes Based on Feedback from Supervisor> | |
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# APPROVAL

**PROJECT SUPERVISOR**

Comments: _____

_____

Name:_____

Date:_____ Signature: _____

**PROJECT MANAGER**

Comments: _____

_____

Date:_____ Signature:_____

**HEAD OF THE DEPARTMENT**

Comments: _____

_____

Date:_____ Signature:_____

# Dedication

*This work is dedicated to our family and friends and teachers who support us in every situation.*

# Acknowledgements

We would like to express our sincere thanks to Mr. Hamayun Kahn for his patient guidance, invaluable suggestions, useful information, practical advice, enthusiastic encouragement and helpful criticism of this project. Without his guidance and unwavering help, this project would not have been possible.

# Executive Summary

We are designing ventilator. The idea came from the worse situation of covid19. When people are dying because they can't afford the service of a ventilator. After the attack of this virus, when its effect on the lungs the patient gets critically sick. So he needs the ventilator to inhale the oxygen. The machine helps pump oxygen into your body. So our target audience is the people who can't afford this service. We will design it with low-cost equipment. Ventilators cannot cure any illness but keeps the patient alive when he/she healing from any disease. So basically our machine will be for those people who can't afford it.

# Table of Contents

# List of Figures

# Chapter 1
# Introduction

# **Chapter 1:** Introduction

We are designing a life support machine that is known as ventilator. If the lung functions have been severely damage due to any injury(covid19) then a patient may need a ventilator for breathing. Ventilators cannot cure any illness but keeps the patient alive when he/she healing from any disease. So basically our machine will be for those people who can't afford it. like Covid19 Poor or rich, no one is safe from this. Many people can't afford the service of a ventilator in this pandemic. And the estimation is that about 6% of people who are suffering from COVID19 get critically sick. And about 1 in 4 of them may need a ventilator to help them breathe. The situation becomes worse day by day because this infection continues to spread in the world very quickly. So our purpose is to design a low-cost ventilator.

## 1.1. Background

Now a day people who suffering from COVID-19 face the problem regarding unavailability of ventilator and high cost of ventilator. Most of the patient of COVID-19 are expires due to breath issues.

According to a report presented by the Ministry of Planning and Development in the National Assembly of Pakistan, about **24.3%** of Pakistanis lived below the poverty line, which means **55** million people.

The **LOW COST VENTILATOR** fill this gap for poor as well as for rich. Our main Purpose is to provide ventilators to every COVID-19 patient with low cost.

## 1.2. Motivations and Challenges

As our main focus is to serve humanity using technology and that motivates us to work on that particular project. We search for the problem in this pandemic situation that motivates us to build the ventilator with affordable price.

The biggest challenge for us is to build a trustworthy relationship with the people who suffering from COVID-19 and our product.

## 1.3. Goals and Objectives

We are working to serve the people who are suffering from COVID-19. We are proving them the basic breathing equipment to save their lives. If they can't afford high cost of ventilator they will recommend to use our product with the lower cost.

In the beginning we will start from the main cities and then we will provide the **LOW COST VENTILATOR** all over the Pakistan.

## 1.4. Literature Review/Existing Solutions

Basically the need of ventilators increases day by day in this covid-19 situation. Existing system providing services to the patients when they are in a very critical situation. And sometime the amount of ventilators is low than the amount of patients. So our purpose is to provide a local system to the local people. It is like a first aid. Which will provide spontaneous breathing action to the patient.

## 1.5. Gap Analysis

As we want to work regarding COVID-19 that's why we search for the basic facilities for treatment and we find the lake of ventilators and high cost for these particular ventilators. We find, that is the main gap in the market of unavailability of ventilators and high cost of ventilators.

We introduce the **LOW COST VENTILATOR** to fill this particular gap.

## 1.6. Proposed Solution

We will design a low-cost machine. which will provide the functions same as the high-cost machine. As we all know ventilator cannot cure any illness. it keeps the patient alive when he/she fighting any disease. Our machine will have the full functions that a ventilator patient needs. Our main focus is on the cost. We will make it a low-cost machine that anyone can afford.

## 1.7. Project Plan

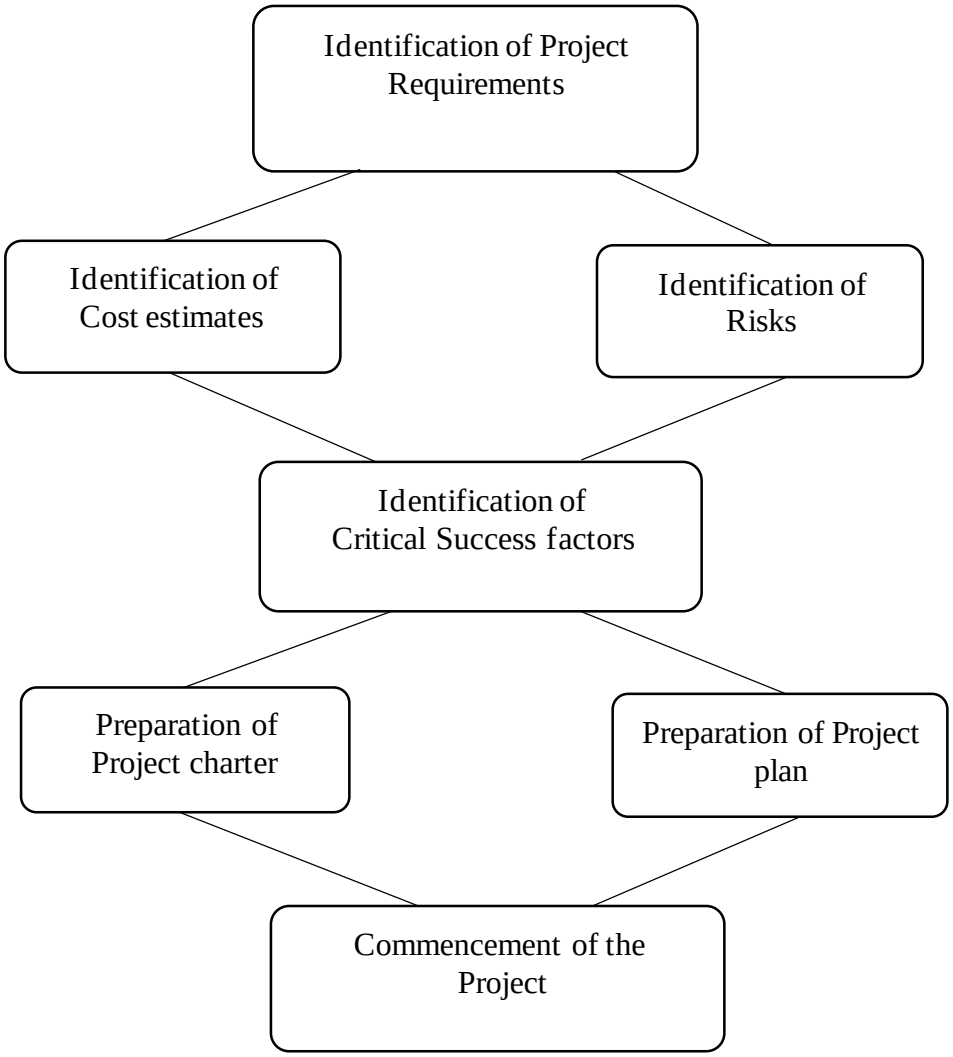


**Figure**:1.1 **Project Plan**

### 1.7.1. Work Breakdown Structure

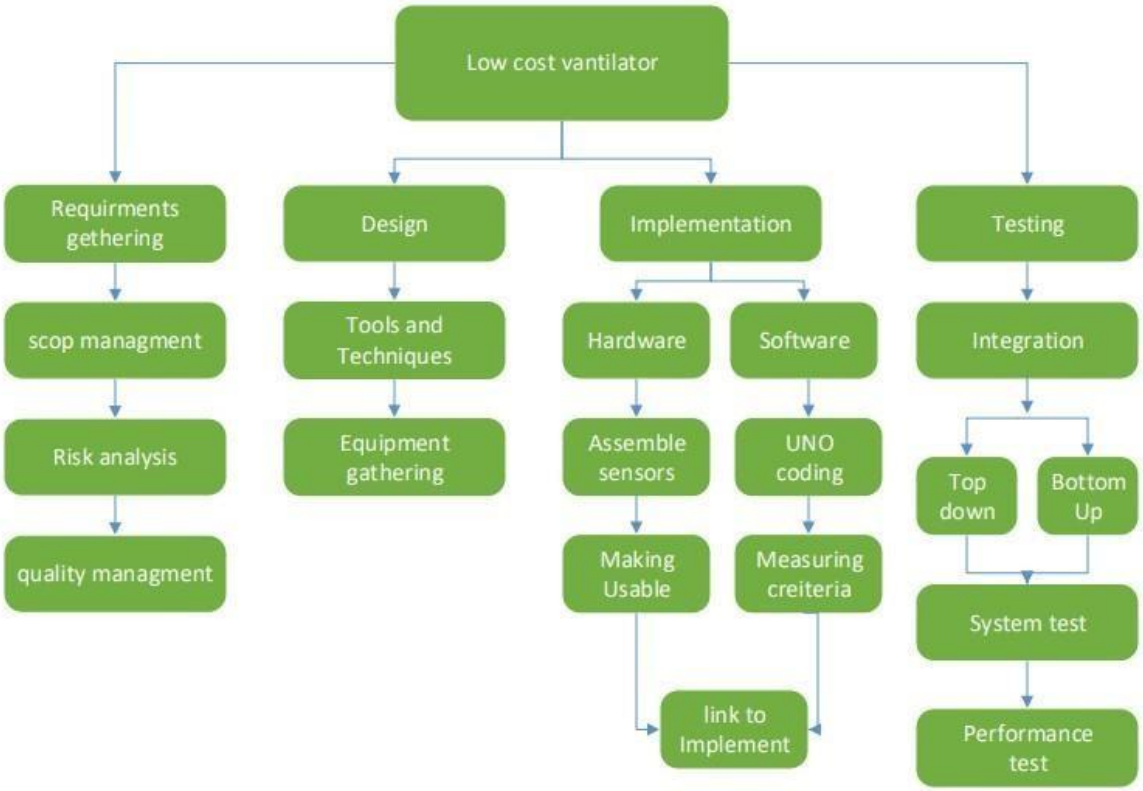


**Figure**:1.2 **Work Breakdown Structure**

## 1.7.2. Roles & Responsibility Matrix

| WBS # | WBS Deliverable | Activity # | Activity to Complete the Deliverable | Duration (# of Days) | Responsible Team Member(s) & Role(s) |
|---|---|---|---|---|---|
| 1 | Project management | 1 | Identify problem & Analyze requirements | 15 | All |
| 2 | Development techniques | 2 | Selecting Equipment | 30 | All |
| 3 | Documentation | 3 | Making reports | 60 | All |
| 4 | Implementation | 4 | Hardware implementation | 60 | All |
| 5 | Marketing | 5 | Marketing of our product | 15 | All |

### 1.7.3. Gantt Chart


**Figure**:1.3 **Gantt Chart**

## 1.8. Report Outline

This report describes we are providing the first aid to COVID-19 patient. We will design a lowcost machine named as **LOW COST VENTILATOR.** As ventilator cannot cure any illness but it will give the ease to patient to have breathing. We will make it a low-cost machine that anyone can afford. And it will fill the gap of unavailability of ventilators in that pandemic situation.

# Chapter 2

# Software Requirement Specifications

# **Chapter 2:** Software Requirement Specifications

## 2.1. Introduction

### 2.1.1. Purpose

SRS means to provide a detailed description of the functional and working of the system. This will cover each feature of the device. This document will cover all intended feature and technical dependencies.

If we talk about the scop so the normal ventilator must be able to give the breaths between 10 to 30 per minute. It also gives the ability for adjusting the duration of the inhalation to exhalation ratio. Also the major part of this process that, the ventilator must have the ability to manage the volume of oxygen that is pushed into the lungs with each and every breath. At last it allows to set ascending increments in sets of 2 breaths.

### 2.1.2. Document Conventions

Standard rule of documentation has been followed in order of standardize the work. This software requirement document use following conventions.

| **Description** | **Appearance** |
|---|---|
| Ventilator | Product |
| Patient | Client |

### 2.1.3. Intended Audience and Reading Suggestions

We use this document for project manager, developer, and hardware engineer of this product but also for the interested one who wish to read about what the project can do. And SRS contains work flow of the system.

- For developer there is need to start from introduction and understand a work flow diagrams.
- For project manager sequence of reading is from introduction to class diagram and use cases.

- For users of applications there is need to read from introduction and read all description including scope and functionalities.

### 2.1.4. Product Scope

The ventilation mechanism desires so one can offer 10-30 breaths according to minute and may coordinate the upward steps in units. in addition, the ventilator need to be capable of regulate the amount of air that is driven into the lungs with each breath. The last thing is the setting to modify the length of inhalation for exhalation.

The ventilator designed and developed here for the use of the Arduino UNO is made up of these types of essentials to extend a reliable and inexpensive DIY ventilator to help during a pandemic. Here we use silicone fan bag connected driven by SERVO motors with 2 side push mechanism to push the fan bag. For switching, we use a toggle switch and a variable potentiometer to set the breath length and BPM value for the patient.

The system of the ventilator is controlled by an Arduino UNO controller to achieve the desired results and assist patients in COVID pandemics and other emergencies like breathing problems.

## 2.2. Overall Description

### 2.2.1. Product Perspective

This product is designed and developed to facilitate people who have disease like (COVID-19). If the patient has problem in breathing they can simply set to **LOW COST VENTILATOR** for smooth breathing. We can set the **BPM** (breath per minute) by adjusting the time duration.

And we can also change the Breath pressure by adjusting the push angle. By adjusting these attributes, we can achieve the normal human breath for the patient. With this product the ventilator cost will also decrease. And every person (rich or poor) can be facilitated by this amazing product.

As the current prices limit the availability of commercial mechanical ventilators in the middle-income countries, a large number of patients with respiratory failure (breathing problem) cannot be equally treated. Our goal is to design the ventilator that will reduce the shortage of ventilators for patients

with respiratory problems and this will be the real word affordable and easy-to-assemble low-cost ventilator.

### 2.2.2. Product Functions Functional requirements

functional requirements describe the interaction between a system and its environment, regardless of implementation. For this system functional requirements are listed below:

- Set BPM
- Set Breath Pressure
- Set Speed

### Non-functional requirements Accessibility:

- Every person who have problem in breathing can get service.
- It will also be provided to patients with respiration problem, when there is shortage of ventilators in market.

#### Maintainability:

- This may be achieved by maintaining the issues if occurs in software.

#### Reliability:

- The product should be reliable, that is it should not get failure, if it fails then it should not take much time for the operation.

### 2.2.3. User Classes and Characteristics

Our user is patient that is suffering from breathing problem. He/She can achieve normal breathing by getting oxygen from ventilator.

### 2.2.4. Operating Environment

In making of this hardware project we are using, Arduino, Mat lab, Google Chrome, all software will help to perform different kind of functionalities and will help our product to work properly.

### 2.2.5. Design and Implementation Constraints

During the designing process the hardware will be designed in different modules based on priorities and different modules will be integrated. When one module completes it is tested which is called unit testing and when it is integrated with the second module integration testing is done. In unit testing If any ambiguity occurs during this process it is removed 1st before the integration of next.

### 2.2.6. User Documentation

The user documentation will be provided within the application so that any user can anytime read it. This will help new users to keep up with the application. The user documentation will contain each and every little detail for each type of user.

### 2.2.7. Assumptions and Dependencies

The servo motor which will be used in the system can stop working due to any failure that can also effect the software that's why we are planning to use the sensor that can detect the condition of particular hardware.

## 2.3. External Interface Requirements

### 2.3.1. User Interfaces

**UI** is designed for the LCD display that is attached to the ventilator on this simple display user can change settings regarding breath rate. The user interface is designed simple and user friendly So, that anyone can understand it easily.

## 2.3.2. Hardware Interfaces

Every hardware component is assembled in way, so it can interact easily with the Software.

**We are using**

- **Arduino UNO**

  This is the microcontroller board and can be integrated into a number of electronic projects. It is Arduino UNO is a low-cost, flexible, easy-to-use and programmable. This mini microcontroller can be connected to computer and can works according to instructions that a given in the code.it can control many electronic equipment like relays, LEDs, servos and motors as outputs.

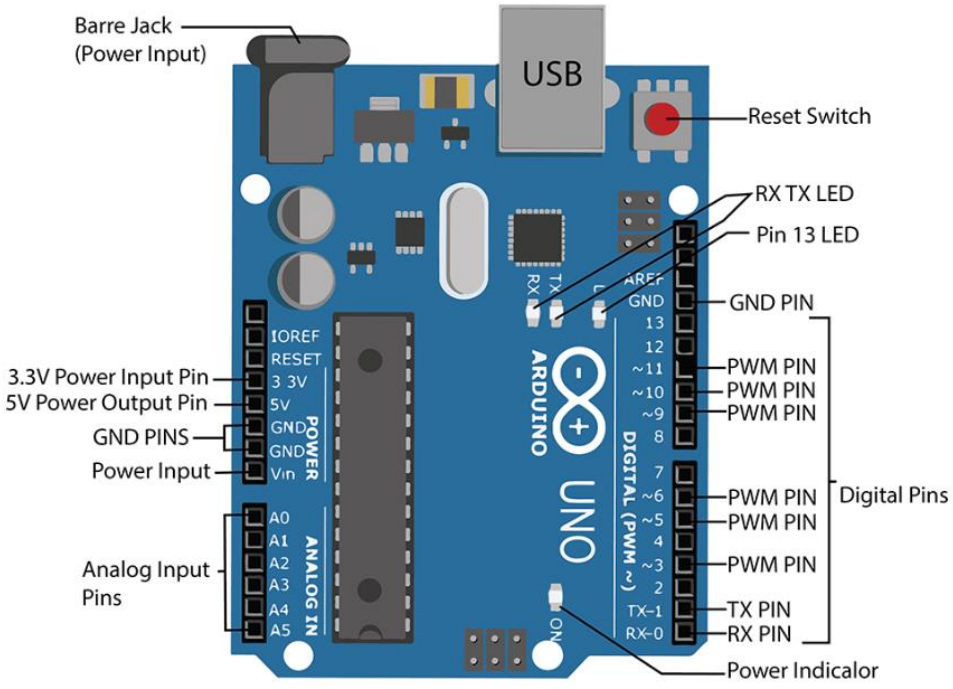


**Figure**:2.1 **Arduino Description Diagram**

- **Stepper motor**

The stepper motor, also known as a stepping motor or double turn motor, Actually, the reason is that the motor position can be commanded two directions balancing between the steps without any feedback position sensor (open loop controller). We can say It is a brushless electric motor that can be full rotated into several equal steps. The stepper motor is properly sized for the application with regard to torque and speed.

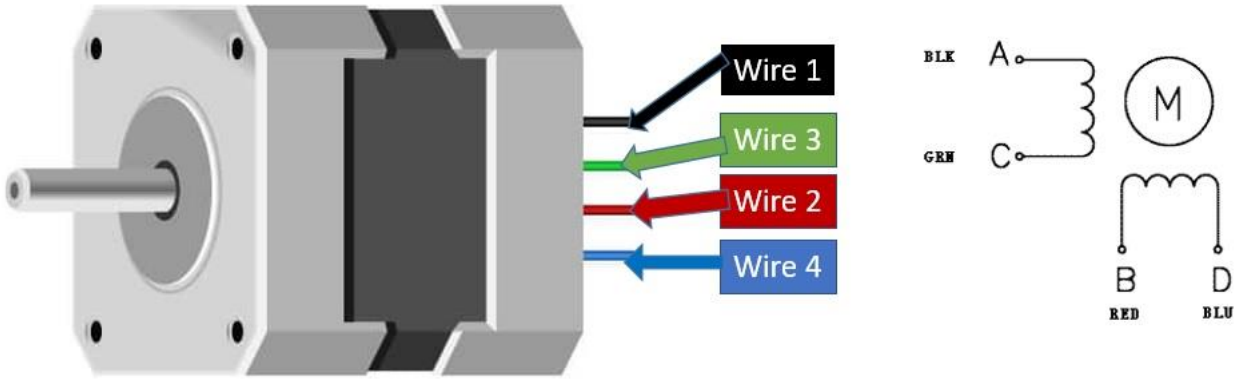


**Figure**:2.2 **Stepper Motor Pinout Diagram**

**Motor driver**

An interface between motors and circuits to interact motor to circuit with recommended power. The function of the motor controller is to take a low current control signal and convert it into a high current signal that can drive the motor. As the motor requires a large amount of current while the regulator circuit operates on low current signals so motor driver helps in this scenario.

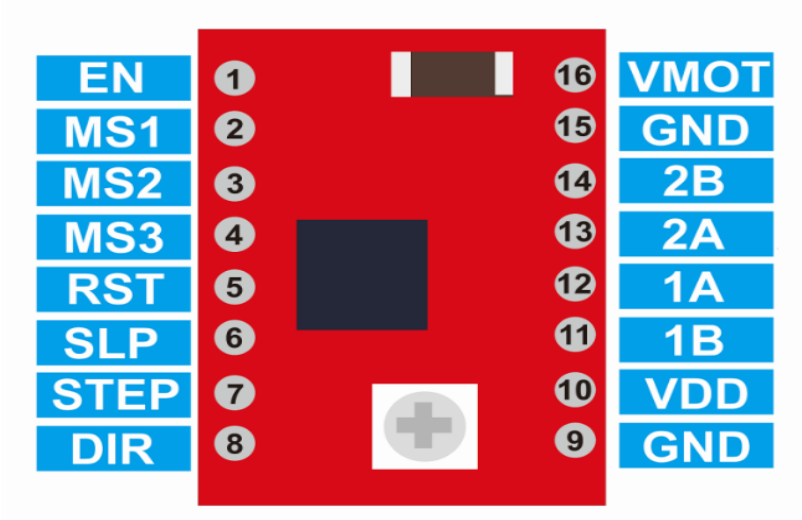

**Figure**:2.3 **Motor Driver Pinout Diagram**

- **Buttons**

  Buttons are used to maintain the proper breath per minute in our hardware. Values can be customized by using these buttons.

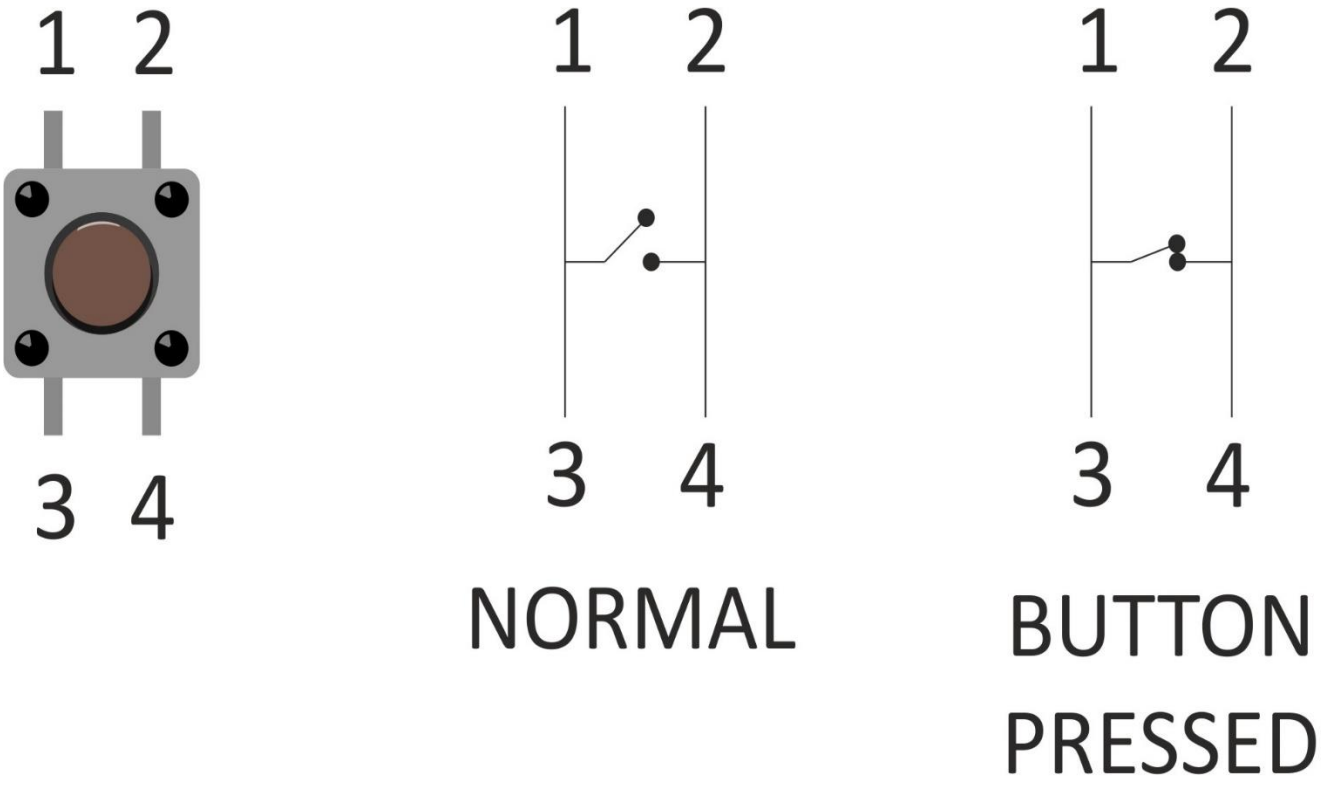


**Figure**:2.4 **Button Pinout Diagram**

- **Laser cut angles**

  These angles work as the backbone of the machine as they are attached to motor to generate required Breath sequence.

- **LCD**

  We use 16x2 LCD for displaying the settings and on the spot Breath Per Minute. We use it to manage the angels and speed of stepper motor

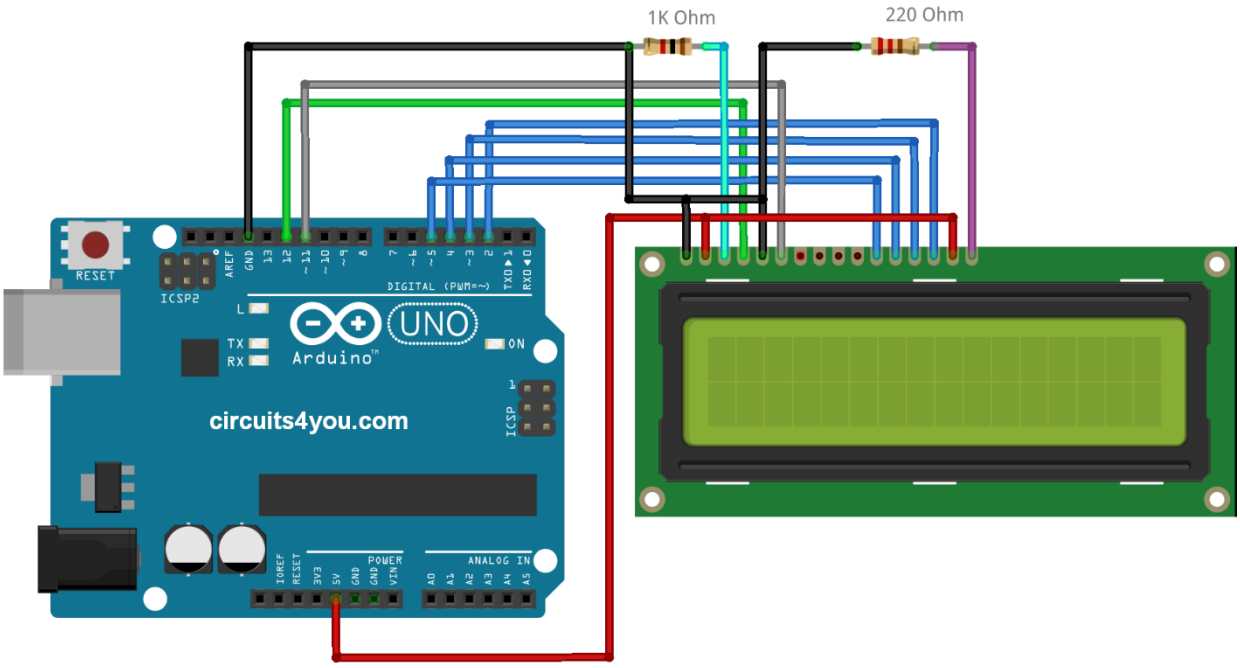


**Figure**:2.5 **LCD Pinout Diagram**

- **Breathing tube**

  It's a medically approved equipment that is used to produce air pressure to the lungs.

**Figure**:2.6 **Breathing Tube**

### 2.3.3. Software Interfaces

We are using Arduino UNO and codding with C++ so the software interface will be simple for us because Arduino provides its on storage to functionalities.

### 2.3.4. Communications Interfaces

It is used in projects that involve serial communication with electronics other than a computer. The USB connection is split via hardware into two digital pins on Arduino UNO

- GPIO 0
- GPIO 1

## 2.4. System Features

This system is designed and developed for the particular features:

1. **Breath Per minute**
2. **Breath pressure**
3. **Speed of pushing**

By adjusting these attributes, we can achieve the normal human breath for the patient. With this product the ventilator cost will also decrease. And every person (rich or poor) can be facilitated by this amazing product.

### 2.4.1. BPM (Breath Per Minute)

#### 2.4.1.1. Description and Priority

We can set the **BPM** (breath per minute) by adjusting the time duration.

#### 2.4.1.2. Stimulus/Response Sequences

User can change the value of delay between the single breath so, that the required breath rate can be achieved.

#### 2.4.1.3. Functional Requirements

System will be well defined to ensure the required **BPM**

- Set BPM

### 2.4.2. Breath Pressure

#### 2.4.2.1. Description and Priority

And we can also change the **Breath pressure** by adjusting the push angle.

#### 2.4.2.2. Stimulus/Response Sequences

User can change the value of angle to give the required pressure to single breath so, that the required breath pressure can be achieved.

#### 2.4.2.3. Functional Requirements

System will be well defined to ensure the required **Breath Pressure**

- Set breath pressure

### 2.4.3. Pushing speed

#### 2.4.3.1. Description and Priority

We can change the **speed of pushing** air bag

#### 2.4.3.2. Stimulus/Response Sequences

User can change the value of speed to push the air bag so, that the required breath speed can be achieved.

#### 2.4.3.2. Functional Requirements

System will be well defined to ensure the required **speed**

- Set breath speed

## 2.5. Other Nonfunctional Requirements

### 2.5.1. Performance Requirements

The performance of the system should be sustainable and not be effected by any other circumstances. As our project is hardware based that's why most of the requirements are based on particular hardware. So the performance of system will not be defected with any physical issues.

### 2.5.2. Safety Requirements

The hardware which will be used in the system can stop working due to any failure that can also effect the software that's why we are planning to use the sensor that can detect the condition of particular hardware.

### 2.5.3. Software Quality Attributes

- Maintainability
- Accessibility
- Reliability

### 2.5.4. Business Rules

- Doctor adjust the breath rate for patient or any other setting.
- Without critical circumstances no one can change functionality of ventilator.

# Chapter 3
# Use Case Analysis

# Chapter 3: **System Analysis**

## 3.1. Use Case Model

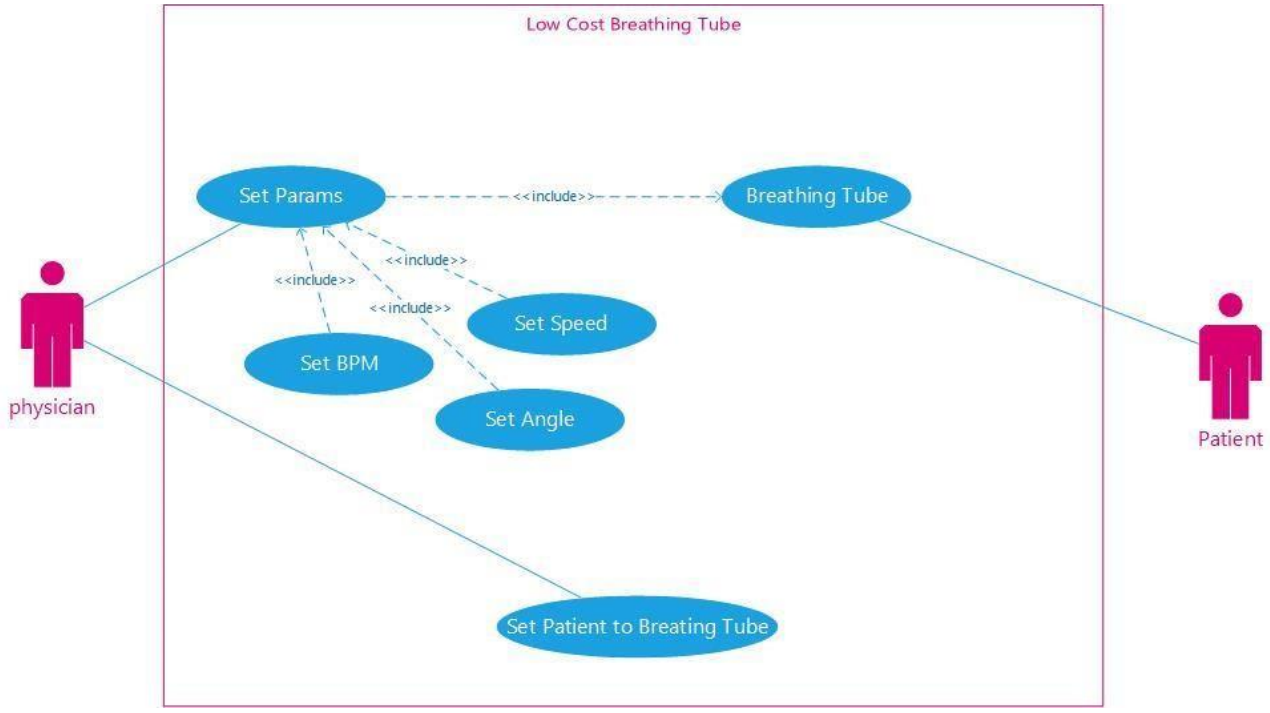


**Figure**:3.1 **Use Case Model**

## Use Case #1

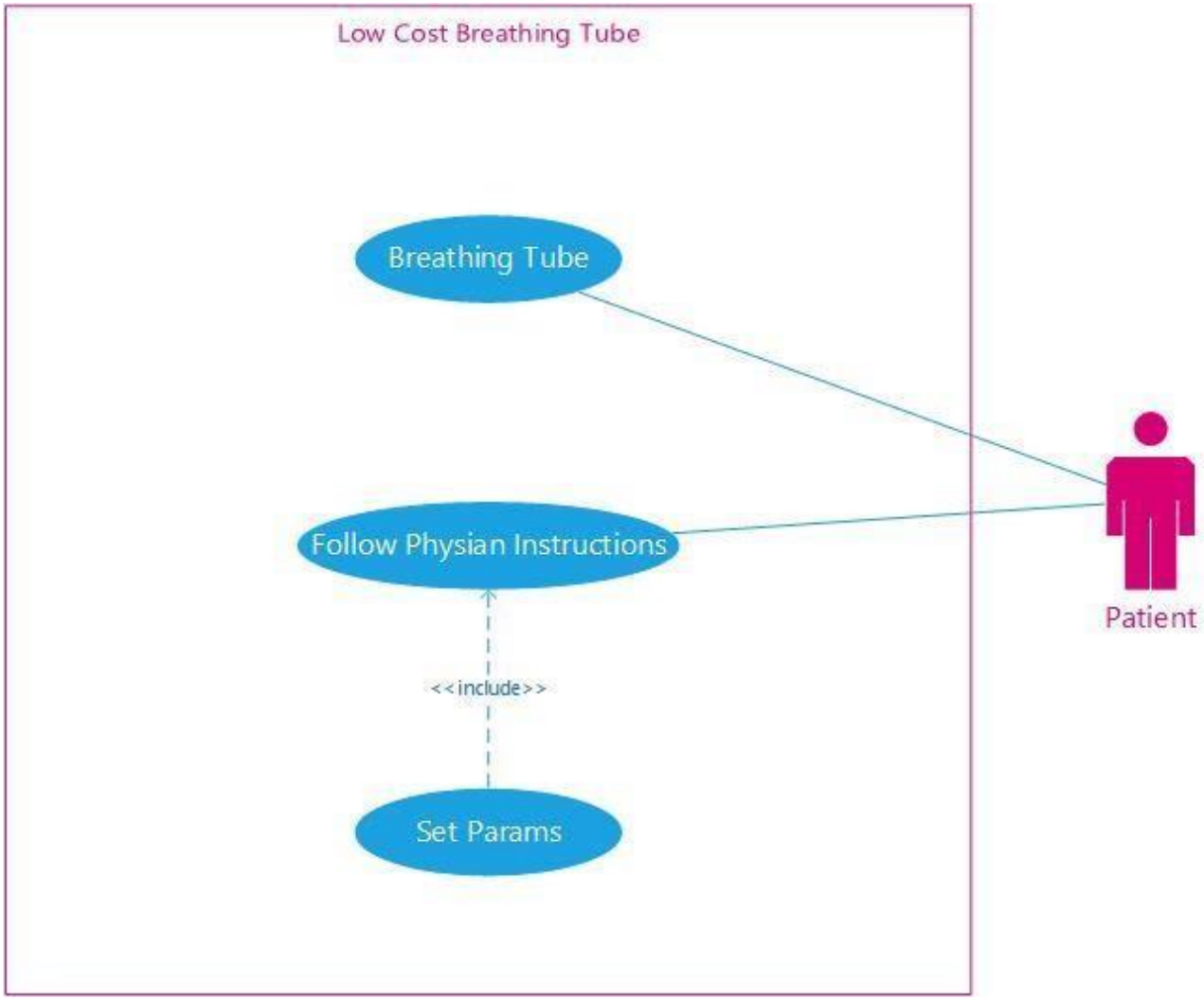


**Figure**:3.2 **Patient Use Case**

## Use Case #2

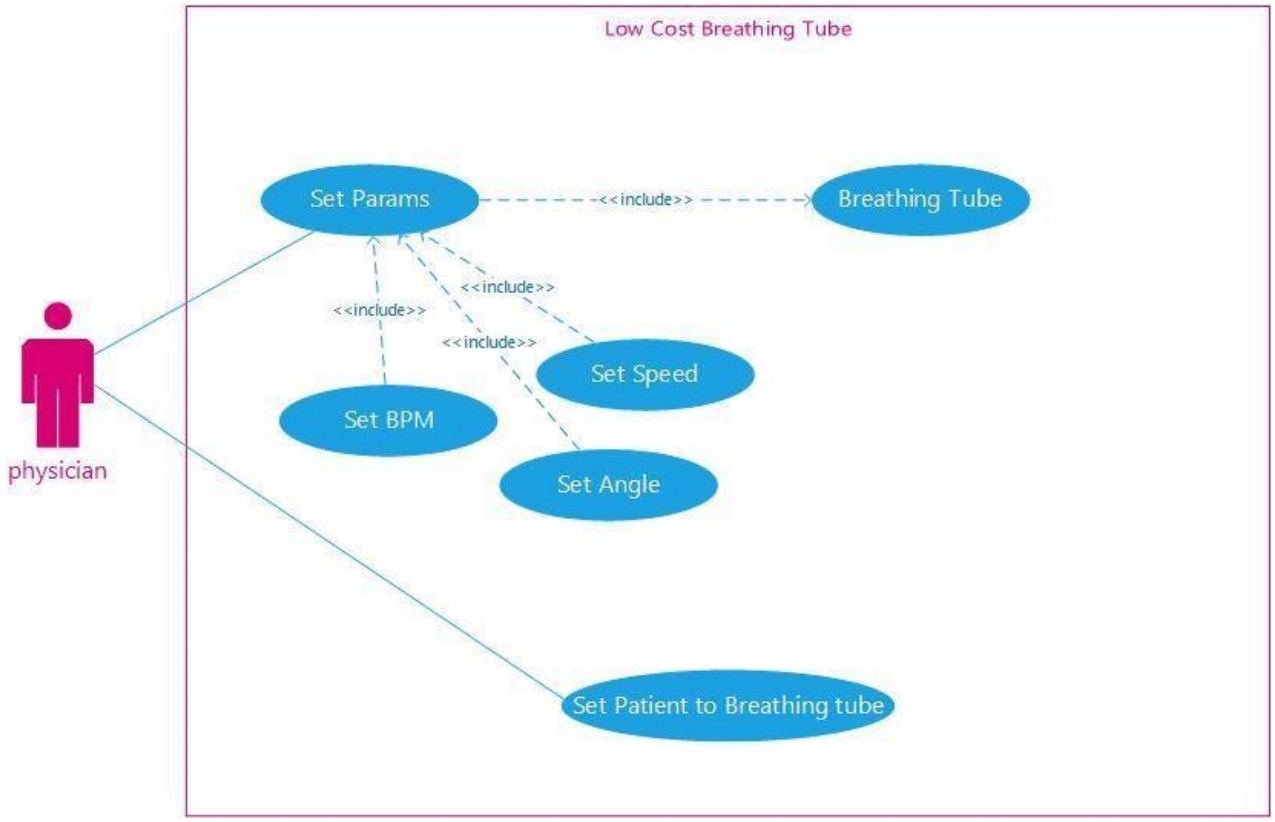


**Figure**:3.3 **Physician Use Case**

## 3.2. Use Case Descriptions

| USE CASE NAME | LOW-COST VENTILATER |
|---|---|
| **CREATED BY** | Hamza Ali, Sahil Saleem and Mustafa Dilshad |
| **CREATUON DATE** | 01-02-2022 |
| **DISCRIPTION** | In this system there is only one user is patient who faces difficulty in breathing get service from our low-cost ventilator and ventilator gets the oxygen from oxygen cylinder and then deliver to patient. |

# Chapter 4
# System Design

## 4.1. Architecture Diagram

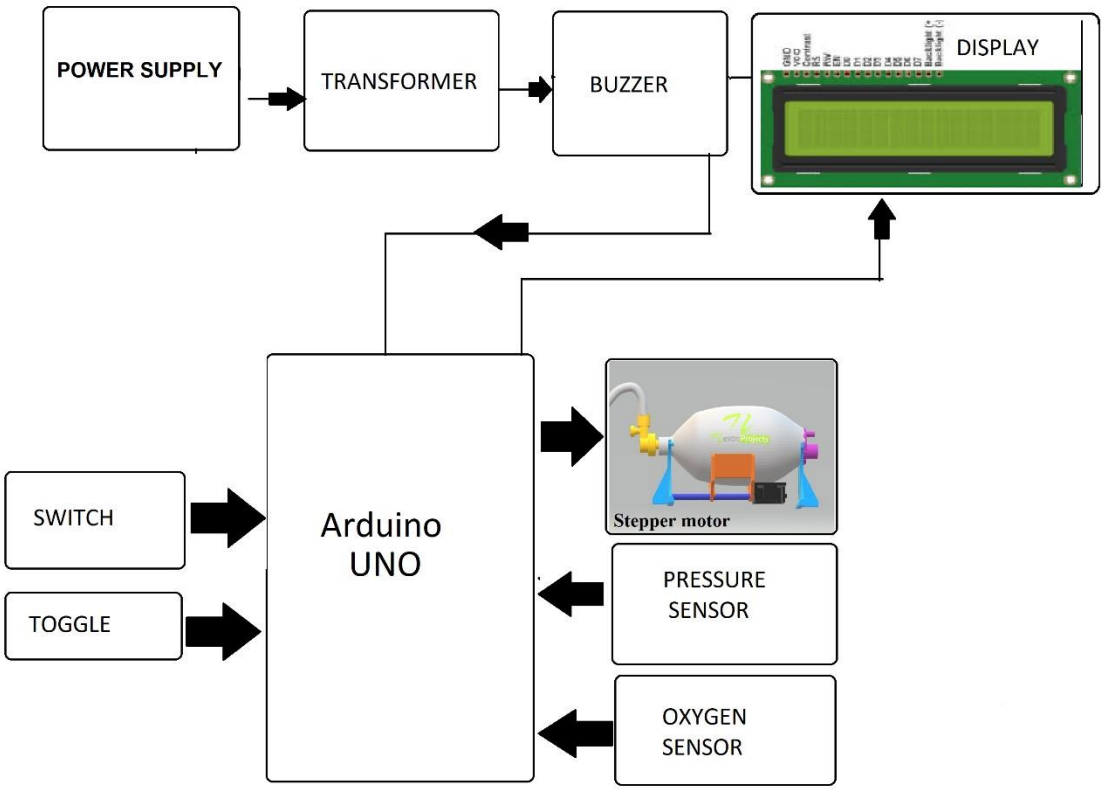


**Figure**:4.1 **Architecture Diagram**

## 4.2. Domain Model

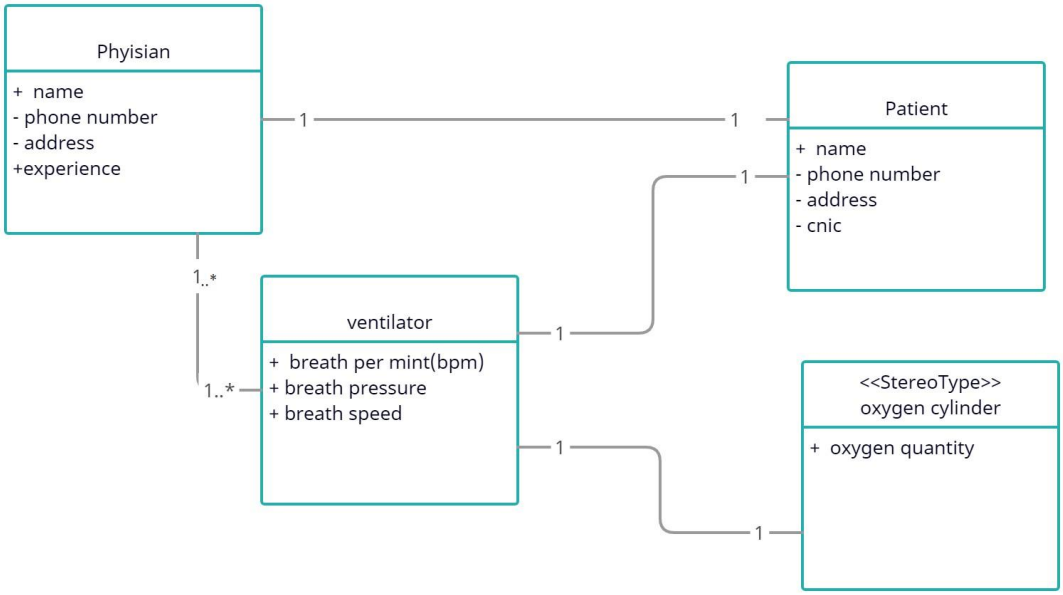


**Figure**:4.2 **Domain Model**

## 4.3. Entity Relationship Diagram with data dictionary

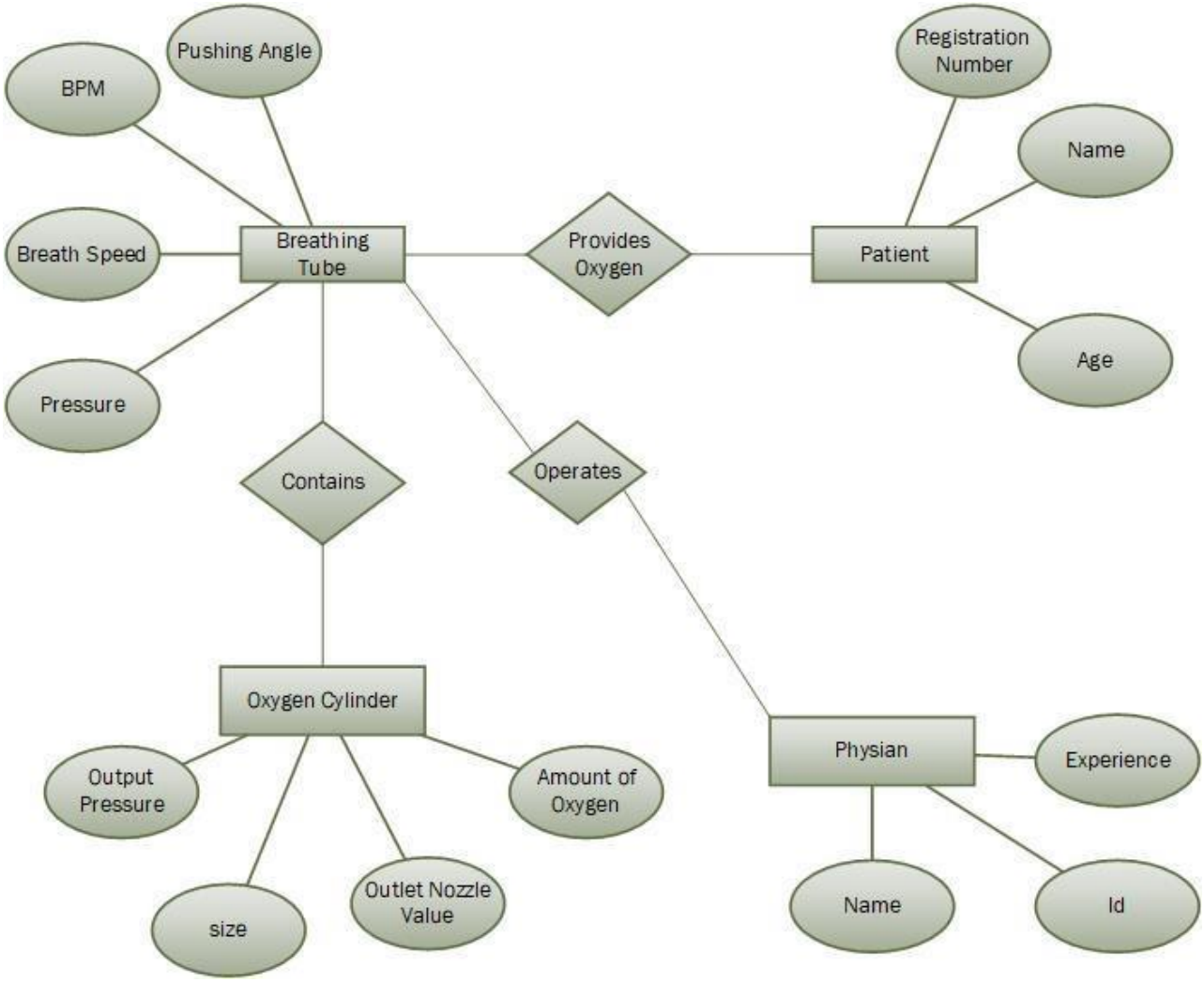


**Figure**:4.3 **Entity Relationship Diagram with data dictionary**

## 4.4. Class Diagram

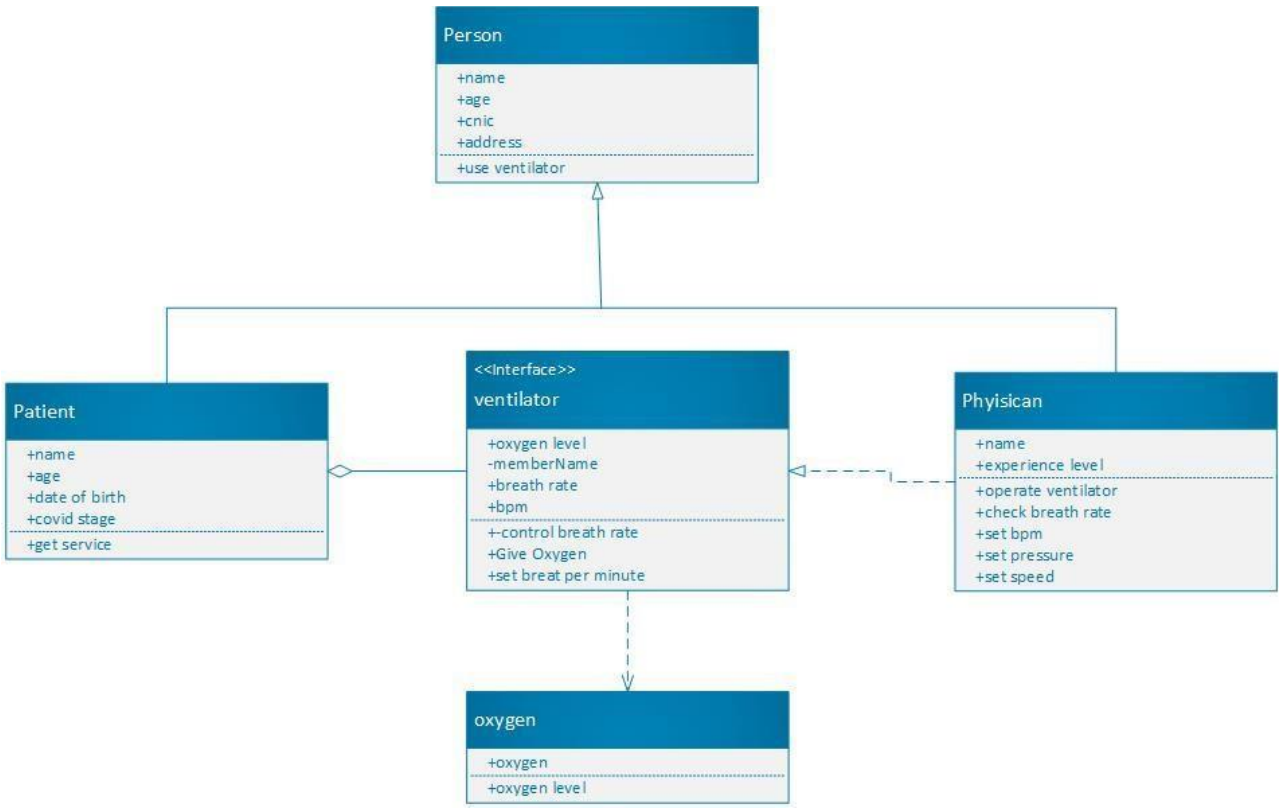


**Figure**:4.4 **Class Diagram**

## 4.5. Sequence / Collaboration Diagram

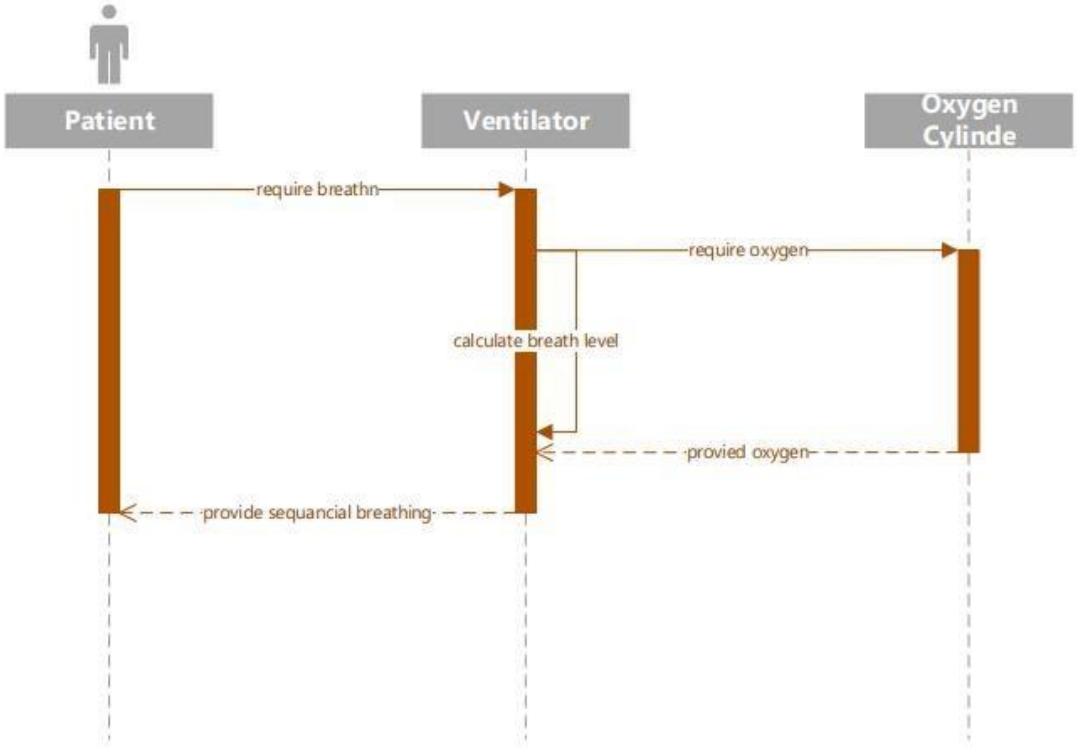


**Figure**:4.5 **Sequence Diagram**

## 4.6. Operation contracts

- Breath per minute

  Set breath per minute according to patient condition.

- Set angle

  Set angle from 0 to 140.

- Breath speed

  Set breath according to patient condition

## 4.7. Activity Diagram

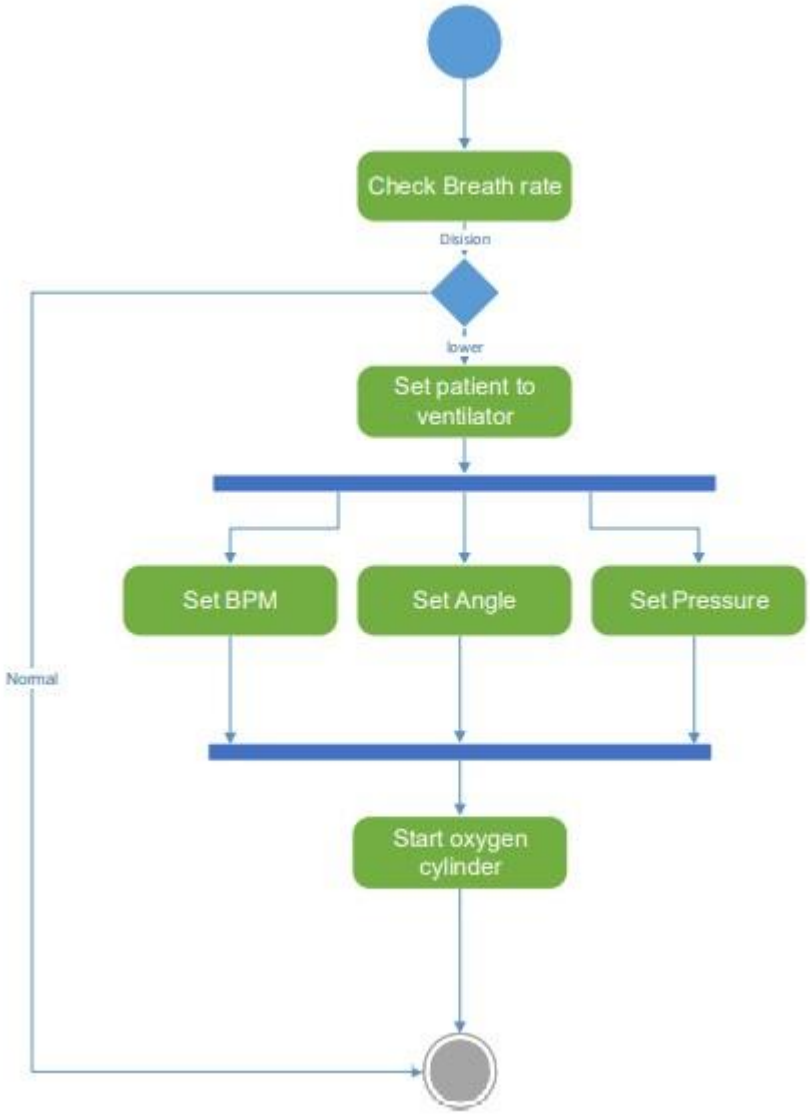


**Figure**:4.6 **Activity Diagram**

## 4.8. State Transition Diagram

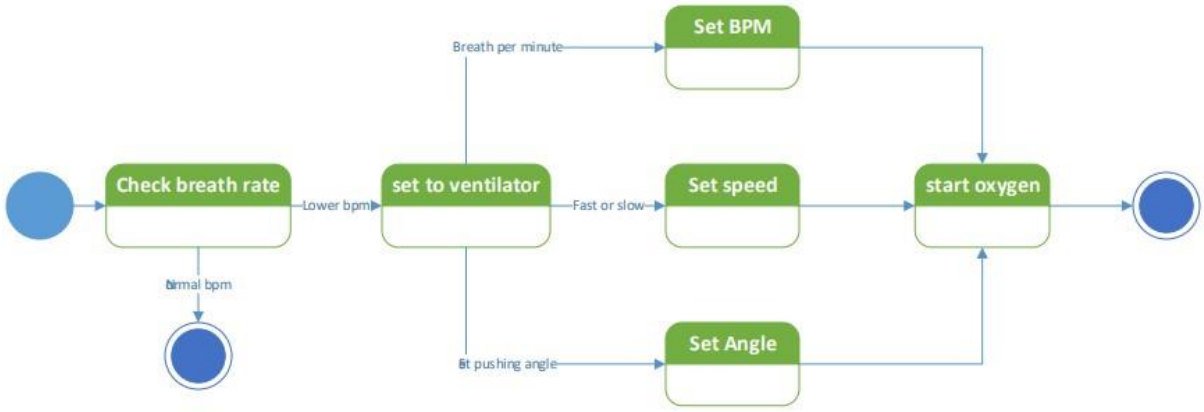


**Figure**:4.7 **State Transition Diagram**

## 4.9. Component Diagram

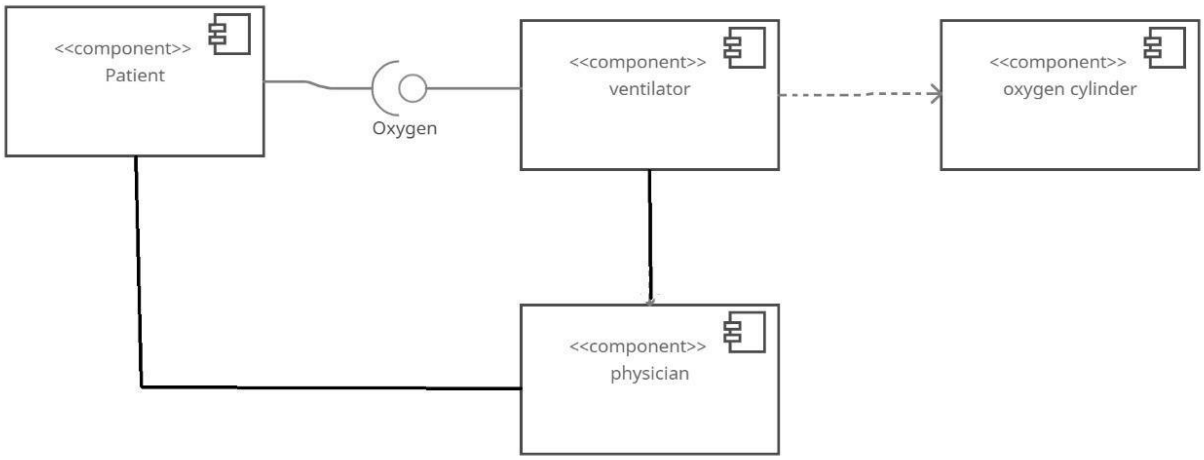


**Figure**:4.8 **Component Diagram**

## 4.10. Data Flow diagram

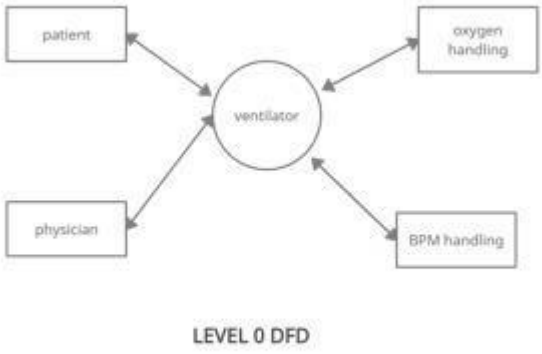


**Figure**:4.9 **Level 0 Data Flow Diagram**

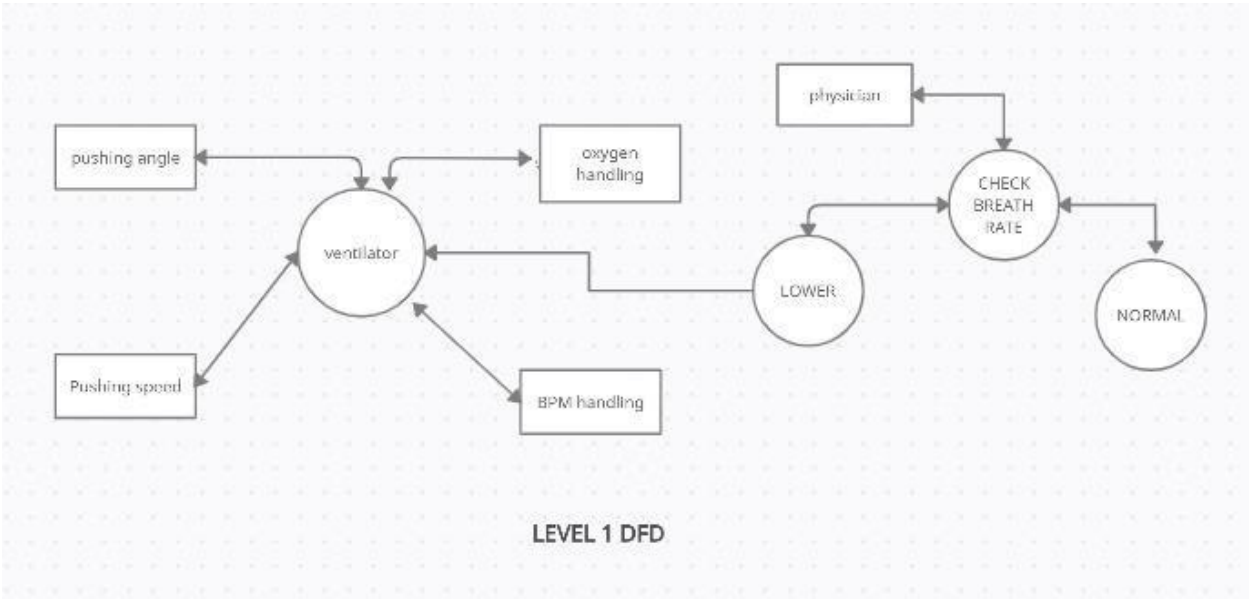


**Figure**:4.10 **Level 1 Data Flow Diagram**

# Chapter 5
# Implementation

# Chapter 5: Implementation

## 5.1. Important Flow Control/Pseudo codes

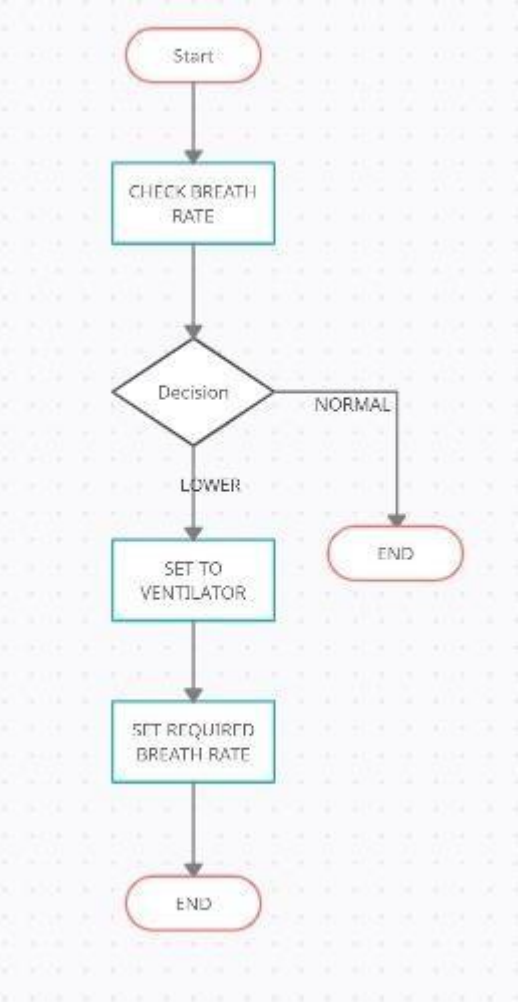


**Figure**:5.1 **System Flow Control**

## 5.2. Components, Libraries, Web Services and stubs

Libraries: Arduino UNO libraries including servo motor and button control libraries.

## 5.3. Deployment Environment

Arduino IDE

## 5.4. Tools and Techniques

Development:

Development is done using Arduino IDE environment for handling major three parameters of servo motor.

Software Designing:

Microsoft Visio

Documentation:

Microsoft Office, Microsoft Visio

## 5.5. Best Practices / Coding Standards

1. Consistent Naming Scheme.
2. Limit Line length
3. Files and Folder Organizations 4. Capitalize Database Special Words.
5. Object Oriented Approach.
6. Code Refactoring

# Chapter 6
# Testing and Evaluation

# Chapter 6: Testing and Evaluation

## 6.1. Use Case Testing

We test all the expected use cases for better reliability in our project. Use cases of the system represent the functional requirements from the user's perspective. We test all functions properly that are major to operate or hardware.

## Equivalence partitioning

Equivalence partitioning is very helpful in testing software. In our development phase we will test the entire module or form with all the validate value. We fix the minimum and maximum value of heart beat, blood pressure, pump per minute.

## 6.2. Boundary value analysis

It is a software testing technique used to check for error at the boundaries of the input domain. Simply put, the input is split into higher and lower end values. For example, if we enter heart beat level in number the boundary value is including all the positive number. The input domain is all the positive numbers and negative numbers are not included. If the boundary values have passed the test, then all values that are between the boundary values are pass for test. We will perform the boundary value analysis in our project.

## 6.3. Unit testing

During the development process, unit testing will be done to ensure that the entire modules are built correctly. Every smallest module that is the part of the application will be test individually and independently are tested to determine whether they are fit for use.

## 6.4. Integration testing

Integration testing will be done after we have built the entire component and combined them into the application. We test breathing tube, circuit, oxygen pipe and oxygen level.

## 6.5. Performance testing

It is a testing technique performed to determine the performance of a system in terms of sensitivity, reactivity and stability under a specific workload. We will implement this testing technique in our project. We change the oxygen level from time to time. We will check the stability or sensitivity of our project under a specific load.

## 6.6. Stress Testing

We will perform stress testing in our project. Stress testing is a type of software testing that verifies system stability and reliability. We will make the project stable or reliable. In particular, this test determines whether the system can handle errors under extremely high loads. We will add a specific workload to our project to verify reliability. And it will verify the stability of our project.

## 6.7. Test results

| Angle | Speed | BPM | Result |
|---|---|---|---|
| 10 degree | Fast | 1/10 | 20 |
| 20 degree | Fast | 1/20 | 16 |
| 30 degree | Slow | 1/20 | 11 |
| 35 degree | Slow | 1/25 | 9 |
| 40 degree | Fast | 1/30 | 8 |

# Chapter 7

# Summary, Conclusion and Future Enhancements

# **Chapter 7:** Summary, Conclusion & Future Enhancements

## 7.1. Project Summary

Low cost ventilator is very helpful for COVID and Asthma patient. This machine helps pump oxygen into your body. So our target audience is the people who can't afford this service. We will design it with low-cost equipment. Ventilators cannot cure any illness but keeps the patient alive when he/she healing from any disease. So basically our machine will be for those people who can't afford it.

## 7.2. Achievement and Improvements

When we complete this project we will achieved a perfect platform for COVID and Asthma patient. When we present our project to companies we get very positive response for companies. In future we will add some new functions like our next goal is to handle this ventilator trough mobile.

## 7.3. Critical Review

Low coast ventilator is a medical tool for COVID and Asthma patients. After all the discussion our critical review in this project is it will create a very positive impact in our country. Its low cost and people can easily deploy in their own house. This project is reliable for people and it will reduce human effort.

## 7.4. Lessons Learnt

Too many lessons learnt during the development of this project. If you create some special thing
It needs more energy and more effort. If you work hard you can achieve everything in your life. During the development of this project we learn how to work in a group. How to make different modules that you can test individually. Test the entire module before test the whole program.
Understand the flow or working of a lengthy code.

## 7.5. Future Enhancements/Recommendations

In future we are planning to add Wi-Fi module on it and link it with mobile application so that If you want to setup this breathing tube at home, you can control it with your phone and share details to physician for customizing the sequence.

For market perspective we are planning to compile it into the box having larger pressure motors so that we can send for the test purpose to different hospitals to have attention of market to purchase this product.

As in this prototype we are just showing the method to produce sequential breathing by using certified breathing tube from health care department but in future we will add higher pressure motors to it to attain proper required breath per minute.

As we know the COVID-19 is just for some period of time but we are planning to engage patients of asthma and those who are having respiration problem we will guide them to have this product in their home for First Aid to this disease.

## 7.6. References

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