# AUTOMATIC INHALATION RESUSCITATOR

*A Project Report Submitted By*


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*in partial fulfillment of the requirements for the award of the Degree of*

**Bachelor of Engineering**
**in**
***Electronics and Communication Engineering***

**from**
**Visvesvaraya Technological University, Belagavi**

NITTE EDUCATION TRUST | NMAM INSTITUTE OF TECHNOLOGY

**Nitte-574110, Karnataka, India**
**June-2021**

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# *Certificate*

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# Abstract

Ventilator also known as a mechanical ventilator is widely used as a breathing aid while a disease makes the respiration difficult or cannot bring enough oxygen into the blood. It works like a bellow for moving air in (oxygen) and out (Carbon Dioxide) of the lungs. It can be fitted with a mask, a helmet, or a breathing tube if the respiration problem is more serious to get air into the lungs. The major advantages of the use of a ventilator are, no trouble occurs in respiring because the muscles are relaxing in the patients' breathing. In addition, the patient will recover from the failure of normal breathing. Ventilators can play a significant role for COVID-19 patients having Acute Respiratory Distress Syndrome (ARDS) and pneumonia.

Market is already witnessing number of ventilators which are efficient and portable in nature. But where those ventilators are very effective, they are also very costly. In this project we are focusing on building a mechanical ventilator that provides all the basic functionalities which a commercial ventilator provides but at a lower cost. We are making use of an Atmega328P micro-controller along with a servo motor, a heartbeat sensor, a pressure sensor and an LCD display for displaying all the control parameters.This ventilator uses Bag Valve Mask (BVM) whereas all the other ventilators available in the market are designed with credentials of customary mechanical components.BVM's are very cheap as compared to other technologies which serves as a plus point for this technology and make sure their availability most of the times.

# Acknowledgement

Our project would not have been successful without the encouragement, guidance and support by various personalities. First and foremost, we would like to express our sincere gratitude towards our project guide **Dr. Durga Prasad**, Associate Professor and **Mr. Prajwal Hegde**, Assistant Professor, Department of Electronics and Communication Engineering, N. M. A. M. Institute of Technology, Nitte, for their guidance, encouragement and inspiration throughout the project work.

We extend our gratitude to **Dr. Rekha Bhandarkar**, Former Head of the Department and Professor and **Dr.K.V.S.S.S.S Sairam** , Head of the Department and Professor, Department of Electronics and Communication Engineering, N. M. A. M. Institute of Technology, Nitte, for their encouragement and providing necessary facilities in the department.

We wish to acknowledge the support of **Dr. Niranjan N. Chiplunkar,** Principal, N. M. A. M. Institute of Technology, Nitte, for providing motivational academic environment.

We would like to express our sincere thanks to all the teaching and non-teaching staff of the department of Electronics and Communication Engineering, N. M. A. M. Institute of Technology, Nitte, for their patience and help during our project work.

Finally, we would like to thank all our friends and well-wishers who have helped us whenever needed and supported us.

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# Chapter 1
# Introduction

Mechanical ventilation is a very important component in the delivery of modern critical care. Ventilators are mandatory in hospital-based environments and are used ubiquitously in emergency medical services. Although they are safe and reliable, modern devices have remained hampered by high costs, reliance on inconvenient consumables such as compressed gas supplies, and practical inefficiencies such as size and complexity. These issues are particularly relevant in relation to transport or emergency ventilators for which convenience, size, and cost are paramount. Modern microprocessor-controlled electronic devices have high manufacturing and maintenance costs, while pneumatic-powered alternatives lack durability and resilience by virtue of the complexity of their parts and reliance on a source of compressed gas. Hand-delivered positive-pressure ventilation systems such as BVMs are commonly used for short-term ventilation during emergencies but prevent the operator from simultaneously performing other crucial clinical interventions. As imprecise techniques, they also potentially expose the patient to greater risk from conditions such as volutrauma, barotrauma, and hyperventilation which damages the lungs of the patient [1].
Complex, high-tolerance digital pressure sensors, and pneumatic components, in addition to complex software, contribute to the high cost and mechanical or electrical liability of many technologies. Such bulky and delicate equipment is not ideal when working in extreme, remote, or austere environments with limited space, personnel, and resources. In addition, the high economic cost and complexity of existing technologies create difficulties in the deployment of sufficient ventilators in the event of a mass casualty situation like Corona Virus Disease (COVID)-19. Current approaches mandate the triaging of ventilator usage; however, a low-cost alternative technology may provide a scalable solution to this issue. A new approach is required that is capable of providing safe, reliable portable ventilation to those patients who need it most to use it at a price that they can afford.

## 1.1 General Introduction

A key challenge in the battle against the disease caused by the novel coronavirus SARSCoV-2, COVID-19, is a potential worldwide shortage of mechanical ventilators. The required number of ventilators is projected to significantly exceed capacity, based on the number of patients expected to contract the disease and the percentage of these likely to require assisted ventilation.The cost of a patient in India is very high per day which makes it unaffordable to many. Mechanical Ventilator is a device designed to provide artificial breathing for patients with lung disease and respiratory failure.By placing a patient on a ventilator, the patient's lungs are permitted to rest and recover while the ventilator performs the functions of supplying oxygen and simulating the actions of breathing. Ventilator respiration in controlled type, the rate of respiration and tidal volume are determined by the ventilator. High- performance ventilators play a critical role in the management of patients with severe respiratory illness, such as COVID19. It is important to not only make it affordable but also several other factors to be kept in mind while designing the ventilator. There are manual resuscitator bags that can be used in case of emergency for a short time, they are not able to control air volume, pressure, rate and flow. To tackle this issue Low cost Ventilator is designed which have important features such as air pressure and volume control and also heart rate sensor.

## 1.2 Aim

The current pricing of commercial mechanical ventilators markedly restricts their availability, and consequently, a considerable number of patients with acute/chronic respiratory failure cannot be adequately treated. The project aims to design and test an affordable and easy-to-build ventilator to allow a reduction in the serious shortage of ventilators at a low cost.

## 1.3 Objective/s

- To construct a low cost medical ventilator that provides all basic functionalities of a conventional ventilator.
- To control and adjust pressure and volume according to the patient's requirement using knobs by the intensive care of a physician.
- To use an Liquid Crystal Display (LCD) screen to display pulse rate, pressure of air flowing and volume range.

## 1.4 Problem Formulation

The implementation requires:

- Real time tracking of Heart rate and Air Pressure.

- Controlling Pressure and Volume of passing into patients lungs.
- Safety of patients.
- Emergency kill switch in case of system failure.

## 1.5 Proposed Method/Technique

- Servo motor controls the movement of Arms.
- A Pressure sensor measures the Air Pressure of flowing air.
- Heart rate sensor measures the patient's pulse constantly.
- Potentiometer knobs to control Volume and Pressure of Oxygen rich air.

## 1.6 Methodology

The ventilator is designed such that a motor compresses a Manual Resuscitator Bag also known as Ambu bag. On compression, it passes Oxygen-rich air to the patient's lungs via a pipe. The pressure and volume of the air can be adjusted according to the user's need, using 2 Potentiometer knobs that control the motor, i.e. the speed and the angle at which it compresses the bag respectively. A pressure sensor will be connected to the pipe that supplies oxygen, it will check if the pressure is suitable for the patient or not and trigger an alarm if its pressure is more. In addition to this, a pulse sensor is used to monitor the heartbeat of the patient. The heart rate sensor measures your heart rate in Beats per Minute using an optical LED light source and an LED light sensor. The system will also have a kill switch which can be used to stop the process in emergency cases.

## 1.7 Literature Survey

COVID-19 patients can experience acute respiratory distress syndrome (ARDS), which causes extreme difficulty breathing due to fluid leaking into the lungs. Mechanical ventilation can help to treat these patients by providing oxygen while the underlying disease runs its course [2].The most devices which are utilised for COVID-19 treatment are: Oxygen therapy devices,ventilator and Continuous Positive Airway pressure (CPAP) devices.Among these ventilators and CPAP devices are comparatively low cost.Similarly, both ventilators and CPAP are light weight where Oxygen therapy device has heavy weight as if consists of many complex parts [3].Different electronic devices such as multiplexer,comparator, oscillator,capacitor,D/A converter,MOSFET,3D printer, digital display are used in all these breathing aid devices.

CPAP only provides emergency support in only primary stage of respiratory problems.Oxygen Therapy device is used to improve survival rate of patients though it has fire risk in contact with flame or smoke.The merits of Ventilator is that it is most comfortable and keeps respiratory muscles in rest and demerits is it could sometimes cause infection in lungs [3].

Appropriate oxygen delivery is a mainstay of critical care and in COVID-19 can prevent death from ARDS and hypoxemia [2].Low-complex System Ventilators provide critical monitoring features and the recursive envelope-tracking algorithm allows the system to track breathing, estimate metrics, and detect malfunctions with only a few calculations per sample and a tiny memory footprint. Therefore, the system can be built quickly using nearly any low-cost micro-controller and a few other electronic components.

In the device both mechanical ventilator and Pulse oximeter work in synchronization.The oxygen concentration in the blood of the patient is measured by the pulse oximeter. The measured value is conveyed to the ventilator with serial communication, The amount of oxygen in the air to be delivered to the patient from the ventilator is calculated automatically in this way by using a fuzzy-logic-based controller developed for the ventilator [4].

High-frequency ventilators have been shown to reduce the risk of lung injury through low-volume airflow. However, the machines used today remain bulky, costly, and only for use in hospital settings. To provide intermediate therapy for patients between hospitalization and complete discharge, a portable, light-weight high-frequency ventilator is an urgent need.It has a tunable driving pressure range of 5-45 psi, an inspiration: expiration ratio of 10-70 percent, oxygen concentration of 20 percent-100percent, and a flow rate of 0-40 L/min. All parameters are displayed on an LCD monitor and controlled from a computer interface. The proposed ventilator has a compact size of 20 x 15 x 17 cm3 which is much smaller than existing High Frequency Jet Ventilators and the design is completely portable [5].The Ventilator generates a pressure curve up to a set level in a prescribed rise time. A widely available resuscitator bag is used to drive flow with a simple mechanical system controlled by a widely available stepper motor, controller, and system-on-a-chip computer [6].The proposed ventilator can also be designed with the following specifications are: Working Pressure is Up to 50 cm H2O, Respiratory rate is 10–30 breaths/min, Minute volume flow capability Up to 20 liters/min, Inspiratory flow capability Up to 120 liters/min, Inbuilt UPS functioning feature, Low battery feature for Inbuilt UPS [7].

The ventilator delivers breaths by compressing a conventional BVM with a pivoting cam arm,eliminating the need of a human operator for the BVM.The prototype can be built out of acrylic, measuring 285 x 170 x 200 mm and weighing 4.1kg and also a prototype that has user-controlled breath rate and tidal volume up to maximum of 750ml. It has low power requirements, running for 3.5 hours on one battery charge at its most demanding setting, and has a handle and easy-to-use latches. The prototype can display settings and status on a computer screen [8].

The materials used to build the system are: DC motor,rotating disc and pneumatic piston.The system input is the patient heart beat and output is volume of air to the patient lung with adjusted breathing rate.The ventilator adjusts the breathing rate to the patient depending on heart beat.The Designing and performance analysis of a low-cost portable ventilator can be done successfully using MAT LAB toolbox. Performance of the system can be improved by using Proportional Integral Derivative (PID) and Full-stack Feedback H2 controllers [9].

For making of a low cost and economic friendly ventilator which can be designed under the basic idea of being incorporated in huge human catastrophes in poorly resources enriched environments.The prototype machine is designed with wooden pieces which is portable, weighing 6 kg (heavier than the acrylic model [8]) and measuring 14 x 7 x 9 inches. It shows the status on an LCD And requires a lesser amount of power, running for 2.15 hours on one battery charge [10].

## 1.8 Organization of the Report

The rest of the report is organized as follows:

Chapter 2 shows block diagram and brief working

Chapter 3 briefs about the Hardware and Software Description.

Chapter 4 discusses the Implementation and Design of the Ventilator.

Chapter 5 Conclusion

# Chapter 2
# Block Diagram/Flow Chart of A.I.R

## 2.1 Block Diagram

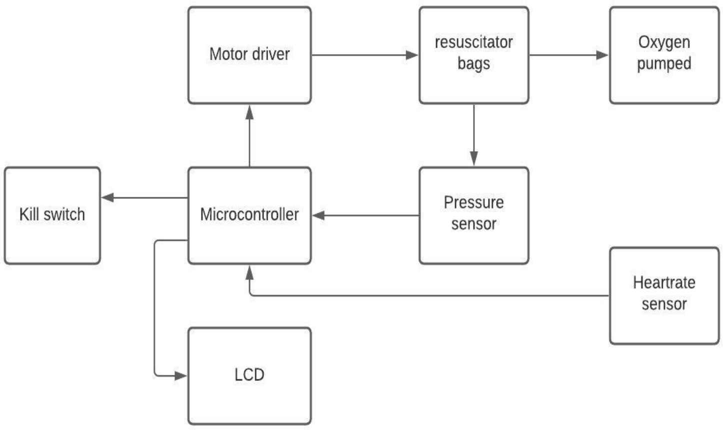


Figure 2.1: Block Diagram

The Block Diagram of A.I.R is shown in Figure 2.1. Typically, a tube is placed in a patient's mouth or windpipe, which attaches to a machine that's controlled by a doctor, nurse, or respiratory therapist. Air flows from the hospital oxygen supply into the ventilator and then into the patient's lungs through a tube or a mask. Bag valve masks are small devices that are used to deliver breathing support in case of emergencies. For the making of low-cost ventilators resuscitator bags or Ambu bags are commonly used. These are used for having several advantages like :

- Low cost
- Portable and one time use
- Bulk production is easy

The compression of the Ambu bag is automated with the help of mechanical arms. For controlling the servo motor we have 2 Potentiometers that adjust the volume and pressure of the air coming out of the Ambu bag according to the user's needs. Volume represents the angle and pressure represents the speed of compression. We use a pressure sensor to continuously monitor the pressure of air entering the lungs of the patient so that in case of high pressure which damages the lungs, an alarm can be triggered. A normal person is capable of a breath pressure of 1-2

Pound-force per square inch (PSI), so by pressure breathing it can increase lung pressure from 10.1 PSI to 11.1-12.1 PSI during each exhale, closer to the 14.7 PSI. Total Lung Capacity(TLC)is defined as the maximum volume of air the lungs can accommodate or the sum of all volume compartments or volume of air in lungs after maximum inspiration [11]. The normal value is about 6,000ml(4-6 L).

A heart rate sensor or pulse sensor is used to monitor the heartbeat of the patient in terms of BPM(beats per minute). These values are fed into the microcontroller with code made to detect pressure, volume at the outlet of the ventilator according to the BPM requirements. The LCD is used to display the volume and pressure range which is set currently and also the heart rate of the patient. In case of emergencies where the system needs to halt immediately, the kill switch is used.

# Chapter 3
# Hardware and Software Description

## 3.1 Hardware

### 3.1.1 Pulse Sensor

The Pulse sensor as shown in figure 3.1 has two sides, on one side the Light Emitting Diode (LED) is placed along with an ambient light sensor and on the other side, we have some circuitry. This circuitry is responsible for the amplification and noise cancellation work. The LED on the front side of the sensor is placed over a vein in our human body. This can either be your Fingertip or your ear tips, but it should be placed directly on top of a vein. Now the LED emits light which will fall on the vein directly. The veins will have blood flow inside them only when the heart is pumping, so if we monitor the flow of blood we can monitor the heartbeats as well. If the flow of blood is detected then the ambient light sensor will pick up more light since they will be reflected by the blood, this minor change in received light is analyzed over time to determine our heartbeats.

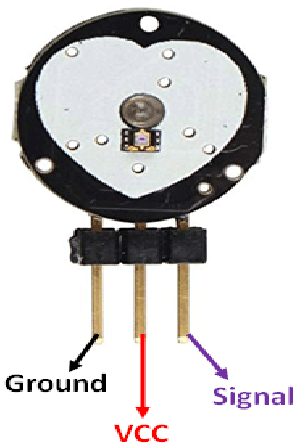


Figure 3.1: Pulse Sensor

Features :

- Bio metric Pulse Rate or Heart Rate detecting sensor
- Plug and Play type sensor
- Operating Voltage: +5V or +3.3V

- Current Consumption: 4mA
- Inbuilt Amplification and Noise cancellation circuit.
- Diameter: 0.625"
- Thickness: 0.125" Thick

### 3.1.2 MPS20N0040D-D AIR PRESSURE SENSOR

The purpose of this sensor is to measure the pressure of the air coming out from the resuscitating bag. It can be found in the automotive industry such as in tire pressure measuring sensors, MAP sensors, tire air pumps, and air braking systems found in some cars, buses, and trucks, and the health industry such as in air-pumped style blood pressure sensors, etc. MPS20N0040D-D pressure sensor is shown in the figure 3.2.

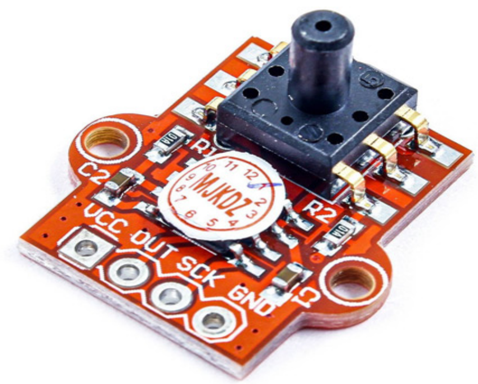


Figure 3.2: MPS20N0040D-D AIR PRESSURE SENSOR

Specification:

- Measurement range: 0 - 5.8 PSI (40kPa)
- Voltage: 5V
- Output: 0 - 50 mV
- Power supply 5 VDC
- Input impedance of 4 - 6 KΩ
- The output impedance of 4 - 6 KΩ

- Operating temperature -40 - 85 ° C -40 ° F - +185 ° F
- Storage Temperature -40 - 125 ° C -40 ° the F - +257 ° F

### 3.1.3 Atmega328P

The high-performance Microchip picoPower® 8-bit AVR® RISC-based microcontroller as shown in figure 3.3 combines 32 KB ISP Flash memory with read-while-write capabilities, 1024B EEPROM, 2 KB SRAM, 23 general purposes I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented Two-Wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughput approaching one MIPS per MHz, balancing power consumption and processing speed.


Figure 3.3: Atmega328P-Micro-controller

Parameters:

- Program Memory Type - Flash
- Program Memory Size (KB) - 32
- CPU Speed (MIPS/DMIPS) - 20
- SRAM (B) - 2,048
- Data EEPROM/HEF (bytes) - 1024
- Digital Communication Peripherals - 1-UART, 2-SPI, 1-I2C
- Capture/Compare/PWM Peripherals - 1 Input Capture, 1 CCP, 6PWM

- Timers - 2 x 8-bit, 1 x 16-bit
- Number of Comparators - 1
- Temperature Range (°C) - -40 to 85
- Operating Voltage Range (V) - 1.8 to 5.5
- Pin Count - 32
- Low Power - Yes

### 3.1.4 Servo motor

The TowerPro MG995 High-Speed Digital Servo Motor as shown in figure 3.4 rotates 90° in each direction making it a 180° servo motor. It is a Digital Servo Motor that receives and processes PWM signals faster and better. It equips sophisticated internal circuitry that provides good torque, holding power, and faster updates in response to external forces. These TowerPro MG995 Sem-Metal Gear Servo Motors are high-speed servo motors with a mighty torque of 10 kg/cm.

Figure 3.4: TowerPro MG995 Servo motor

Specification:

- Weight: 55 gm
- Operating voltage: 4.8V 7.2V
- Servo Plug: JR

- Stall torque @4.8V : 10 kg-cm
- Stall torque @6.6V : 12 kg-cm

### 3.1.5 LCD display module

An LCD screen as shown in figure 3.5 is an electronic display module and has a wide range of applications. A 16x2 LCD display is a very basic module and is very commonly used in various devices and circuits. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. The 16 x 2 intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols. This LCD has two registers, namely, Command and Data. Command register stores various commands given to the display. The data register stores data to be displayed. The process of controlling the display involves putting the data that form the image of what you want to display into the data registers, then putting instructions in the instruction register.

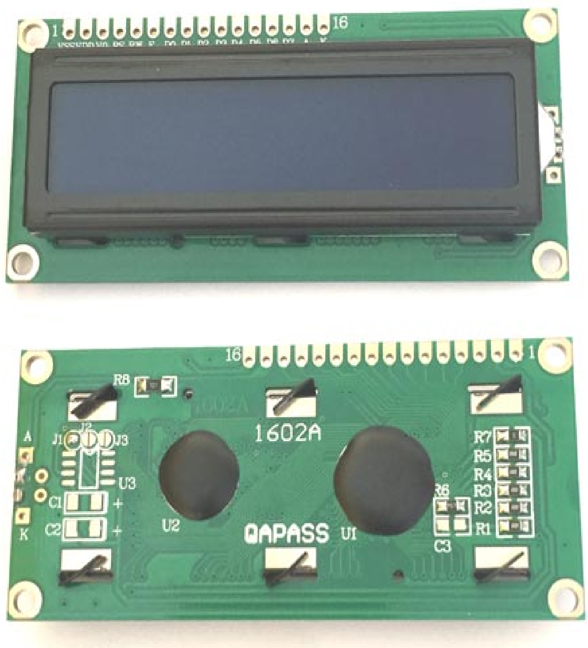


Figure 3.5: 16x2 LCD-Module

Features:

- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without back light

- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is build by a 5×8 pixel box
- Can work on both 8-bit and 4-bit mode
- It can also display any custom generated characters
- Available in Green and Blue Back light

### 3.1.6 Bag Valve Mask

Also known by the proprietary name Ambu bag or generically as a manual resuscitator or "self-inflating bag", as shown in Figure 3.6, is a hand-held device commonly used to provide positive pressure ventilation to patients who are not breathing or not breathing adequately. The device is a required part of resuscitation kits for trained professionals in out-of-hospital settings (such as ambulance crews) and is also frequently used in hospitals as part of standard equipment found on a crash cart, in emergency rooms, or other critical care settings. Manual resuscitators are also used within the hospital for temporary ventilation of patients dependent on mechanical ventilators when the mechanical ventilator needs to be examined for possible malfunction or when ventilator-dependent patients are transported within the hospital. Two principal types of manual resuscitators exist; one version is self-filling with air, although additional oxygen (O2) can be added but is not necessary for the device to function. The other principal type of manual resuscitator (flow-inflation) is heavily used in non-emergency applications in the operating room to ventilate patients during anesthesia induction and recovery.

### 3.1.7 Switch Button

A switch is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another. The most common type of switch is an electromechanical device consisting of one or more sets of movable electrical contacts connected to external circuits. When a pair of contacts are touching current can pass between them, while when the contacts are separated no current can flow. Figure 3.7 shows the Switch button.

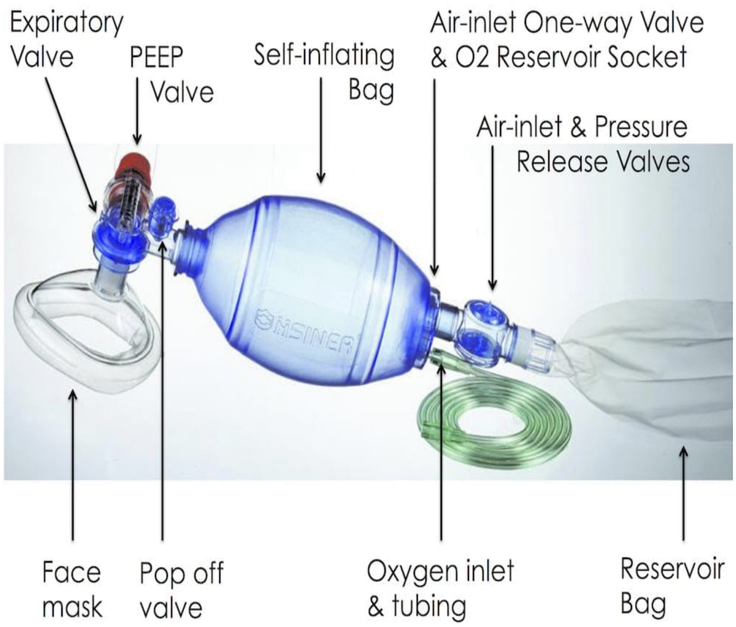


Figure 3.6: Bag Valve Mask

Figure 3.7: Switch Button

### 3.1.8 Potentiometer

A Potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat.Figure 3.8 shows 3 terminal Potentiometer.
The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name. Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers, for example, in a joystick. Potentiometers are rarely used to directly control significant power (more than a watt) since the power dissipated in the potentiometer would be comparable to the power in the controlled load.

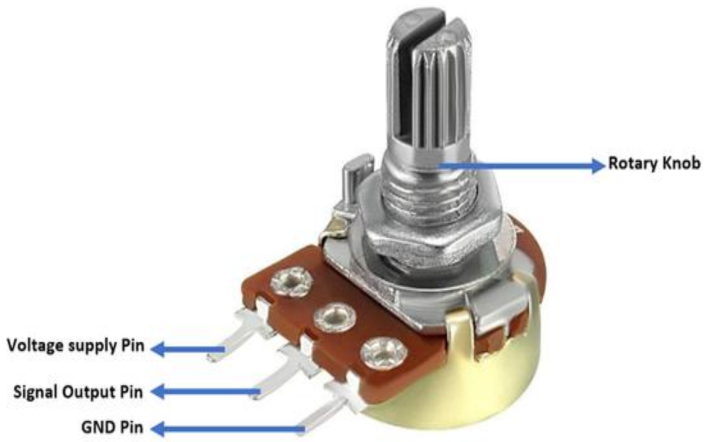


Figure 3.8: Potentiometer

## 3.2 Software

### 3.2.1 Autodesk fusion 360

Fusion 360 combines the whole process of product development into one suite. It has a sculpting work space where industrial designers can make the aesthetic design. It has the modeling and surfacing work-space which is used to make mechanical assemblies along with the simulation work-space which allows the designer to simulate a wide range of analyses ( From static stress to thermal and even impact) Fusion 360 also provides an animation work-space for making an animation of mechanisms, exploded views, etc. And it has a good Rendering work-space too. All of the functionality of the software comes at a cheap price and is available on the cloud, individuals can access designs on the phone from anywhere. It allows for better collaboration between teams. Figure 3.9 shows the commercial symbol.


Figure 3.9: Autodesk Fusion 360 Software

### 3.2.2 Proteus

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards. The Proteus Design Suite is a Windows application for schematic capture, simulation, and PCB (Printed Circuit Board) layout design. It can be purchased in many configurations, depending on the size of designs being produced and the requirements for micro-controller simulation. All PCB Design products include an auto-router and basic mixed-mode SPICE simulation capabilities.
The micro-controller simulation in Proteus works by applying either a hex file or a debug file to the micro-controller part on the schematic. It is then co-simulated along with any analog and digital electronics connected to it. This enables its use in a broad spectrum of project prototyping in areas such as motor control, temperature control, and user interface design. It also finds use in the general hobbyist community and, since no hardware is required, is convenient to use as a training or teaching tool. Figure 3.10 shows the commercial symbol.

Figure 3.10: Proteus Software

### 3.2.3 Arduino IDE

Arduino IDE is a lightweight, cross-platform application that introduces programming to novices. It has both an online editor and an on-premise application, for users to have the option whether they want to save their sketches on the cloud or locally on their computers. Arduino IDE works on the three most popular operating systems: Windows, Mac OS, and Linux. Aside from that, the application is also accessible from the cloud. These options provide programmers with the choice of creating and saving their sketches on the cloud or building their programs locally and upload them directly to the board. Arduino IDE has more than 700 libraries integrated. Users can utilize it for their projects without having to install anything. Figure 3.11 shows the commercial icon.

Figure 3.11: Arduino IDE Software

### 3.2.4 Tinkercad

Tinkercad is a free, online 3D modeling program that runs in a web browser, known for its simplicity and ease of use. It became available in 2011, it has become a popular platform for creating models for 3D printing as well as an entry-level introduction to constructive solid geometry in schools. Tinkercad is a free online collection of software tools that help people all over the world think, create and make. This 3D modeling software is user-friendly. Tinkercad has introduced an expansion to include circuits in its design capability called Tinker cad Circuits. This brings a whole new side to Tinkercad, revolving around simulating circuits with Arduino. Tinkercad Circuits allows anyone to virtually create and program Arduino projects without the need for physical hardware. Figure 3.12 shows the commercial icon.

Figure 3.12: Tinkercad Software

### 3.2.5 Atmel Studio

Atmel Studio was designed for hardware developers to help them create microcontroller applications, and also debug them. It comes as an integrated development platform that uses Microsoft Visual Studio shell. Atmel Studio 7 is the integrated development platform (IDP) for developing and debugging all AVR® and SAM microcontroller applications. The Atmel Studio 7 IDP gives you a seamless and easy-to-use environment to write, build and debug your applications written in

C/C++ or assembly code. It also connects seamlessly to the debuggers, programmers, and development kits that support AVR and SAM devices. Figure 3.13 shows the commercial icon.

Figure 3.13: Atmel Studio

# Chapter 4
# Implementation and Design

## 4.1 Hardware

### 4.1.1 Micro-controller Unit

The controller Unit is designed using Atmega328P, 16MHz Crystal Oscillator, Resistors, Capacitors,LED, and Switch. The circuit is then constructed on a PCB. the connections for the given circuit are shown in the figure 4.1. The Sensors required to perform the tasks are then connected to the PCB.

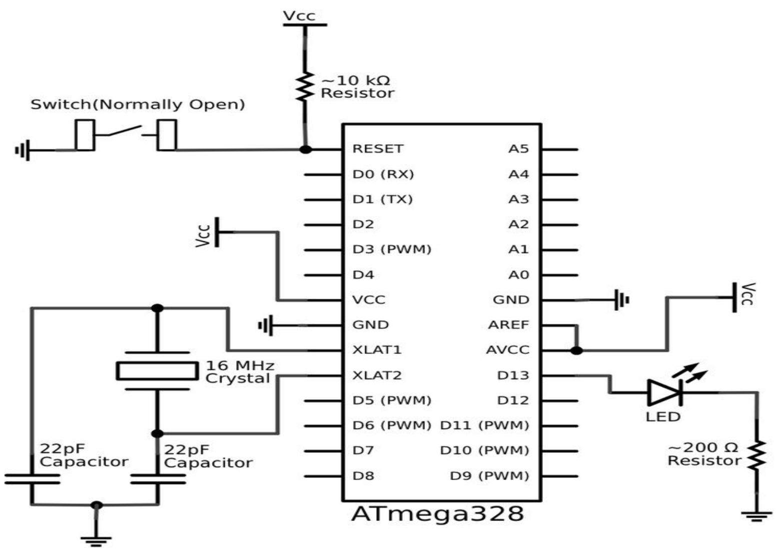


Figure 4.1: Circuit diagram

Figure 4.2: PCB construction using Proteus software

### 4.1.2 Pressure Sensor

The Pressure sensor is connected to Atmega using the Two Analog pins 24-PC1,23-PC0, a ground pin, and a 5V supply pin. Figure 4.3 shows the connection made and working of the Pressure sensor, Figure 4.4 shows the output readings of the pressure sensor, and finally Figure 4.5 shows how the graph looks at the output readings of the pressure sensor.

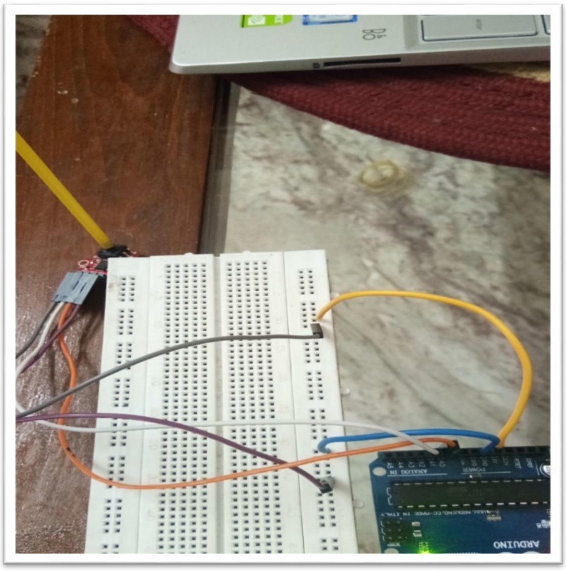

Figure 4.3: Pressure sensor circuit connection

```
Readings:
one reading:    48.9    | average:    11.8
one reading:    -0.5    | average:    59.2
one reading:    -37.5   | average:    15.9
one reading:    15.5    | average:    70.3
one reading:    -23.5   | average:    30.9
one reading:    -33.0   | average:    6.6
one reading:    149.6   | average:    209.5
one reading:    -24.5   | average:    221.3
one reading:    218.3   | average:    72.0
one reading:    126.5   | average:    115.8
one reading:    130.8   | average:
```

Figure 4.4: Output values of Pressure sensor

### 4.1.3 Pulse sensor

The Pulse Sensor is connected to Atmega using an Analog pin 27-PC4, a ground pin, and a 5V supply pin. Fig 4.6 shows the connection of Pulse sensor with Atmega328P using Proteus software. Figure 4.7 shows the pulse sensor working of simulation by varying the Active Potentiometer used as input for an artificial heartbeat in software. Figure 4.8 shows the working demo along with the output readings and graphs as shown in Figure 4.9 and Figure 4.10 respectively.

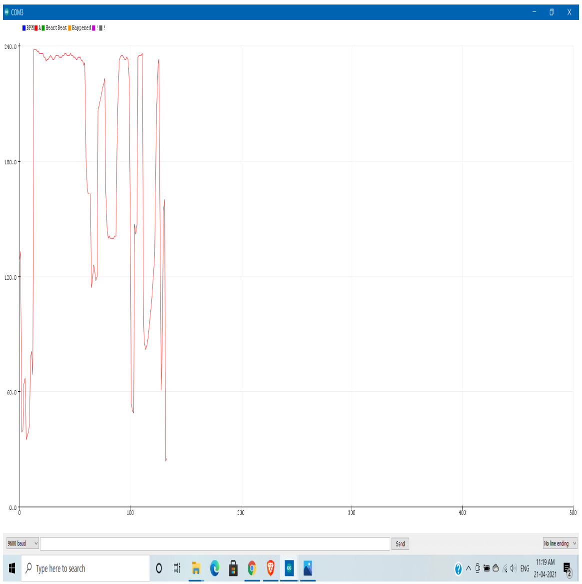

Figure 4.5: Output Graph of Pressure sensor

Figure 4.6: Pulse sensor circuit using Proteus software

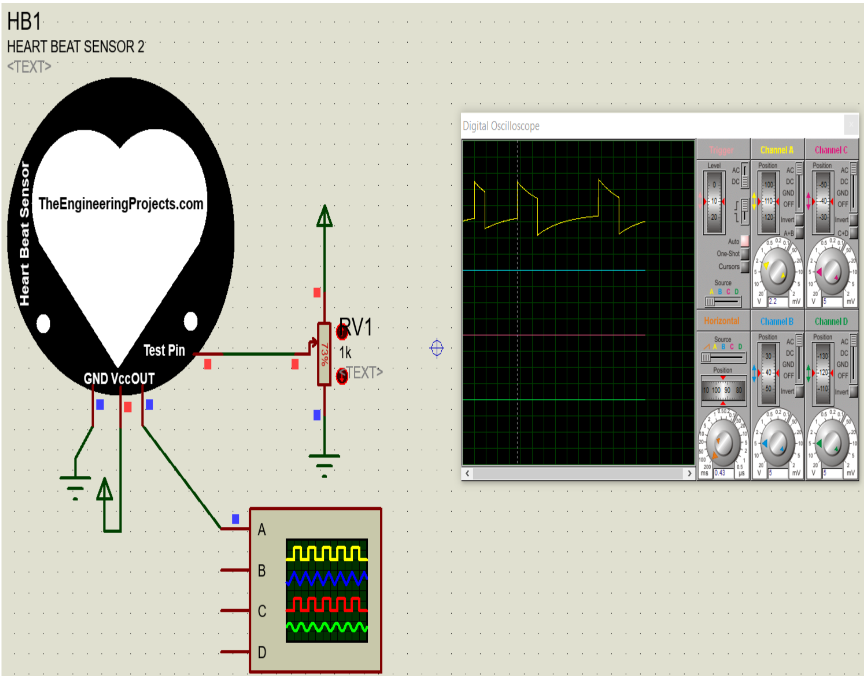


Figure 4.7: Simulation of Pulse sensor using Proteus software

### 4.1.4 Servo motor

Servo motor requires to be connected to a PWM pin for its working. We connected the servo motor to a PWM pin 13-PD7, a ground pin, and a 5V supply pin. To control the Volume and Pressure of the air coming out of the Ambu bag, we use a Two Potentiometer which controls the speed of the motor and the Angle of the Servo motor to control Pressure and Volume respectively. The Potentiometer pins

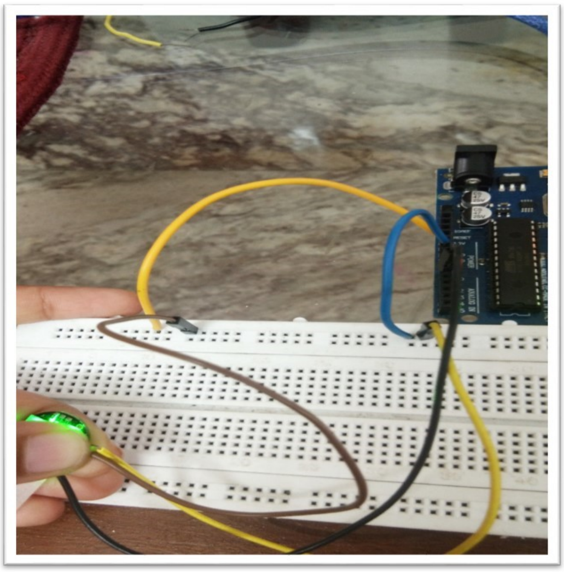

Figure 4.8: Pulse sensor circuit connection

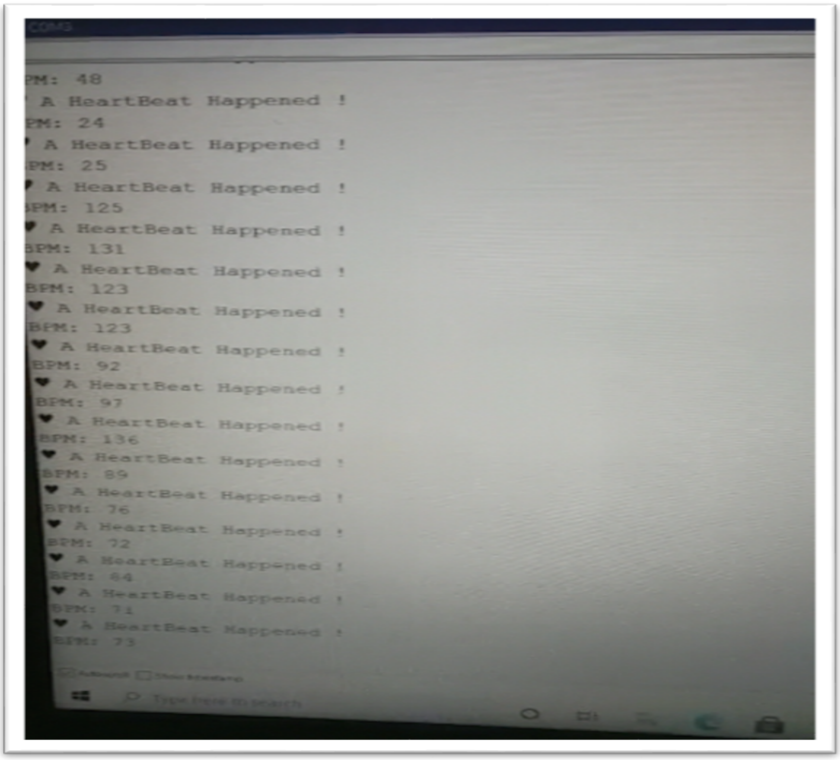


Figure 4.9: Output values of Pulse sensor

are connected to Two Analog Pins 25-PC2 and 26-PC3, ground pins and 5V pins. Figure 4.11 shows the connection and working of the system. And Figure 4.12 shows the circuit connection implemented using Proteus software.

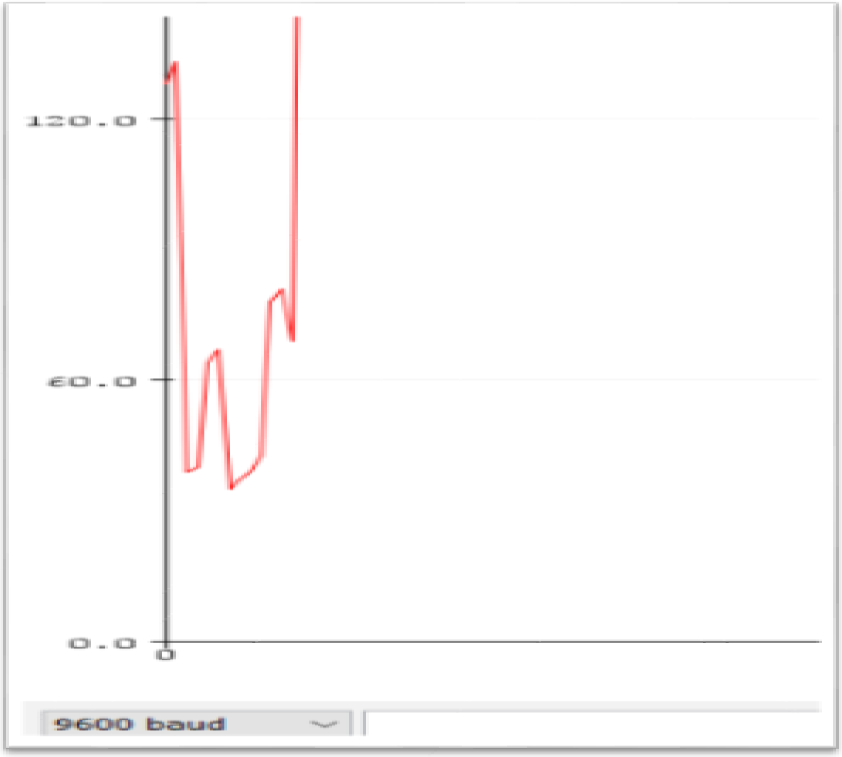


Figure 4.10: Output graph of Pulse sensor

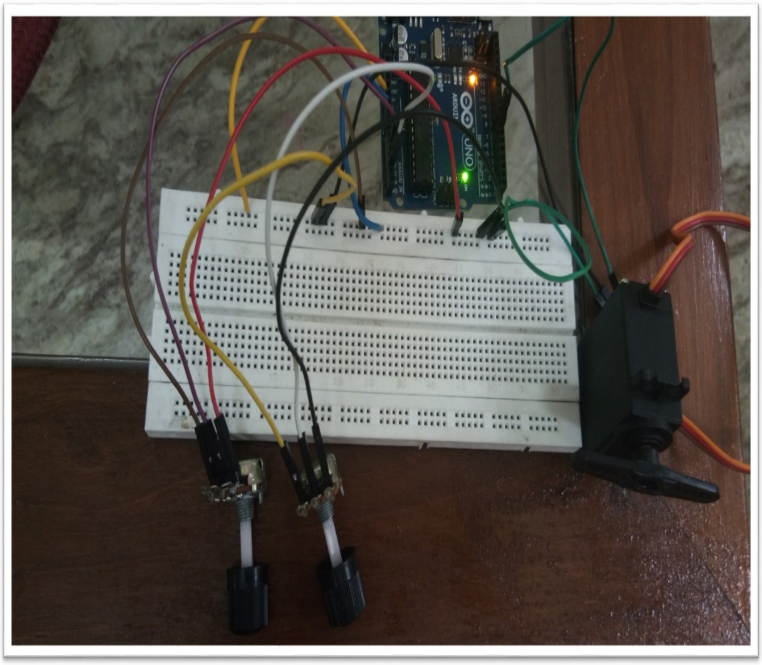

Figure 4.11: Volume and Pressure control system using Potentiometer and Servo motor

### 4.1.5 3D Model of the Ventilator

The 3D model for the structure of the ventilator is constructed with the help of the Auto-desk Fusion 360 Software tool. The model consists of Four individual parts

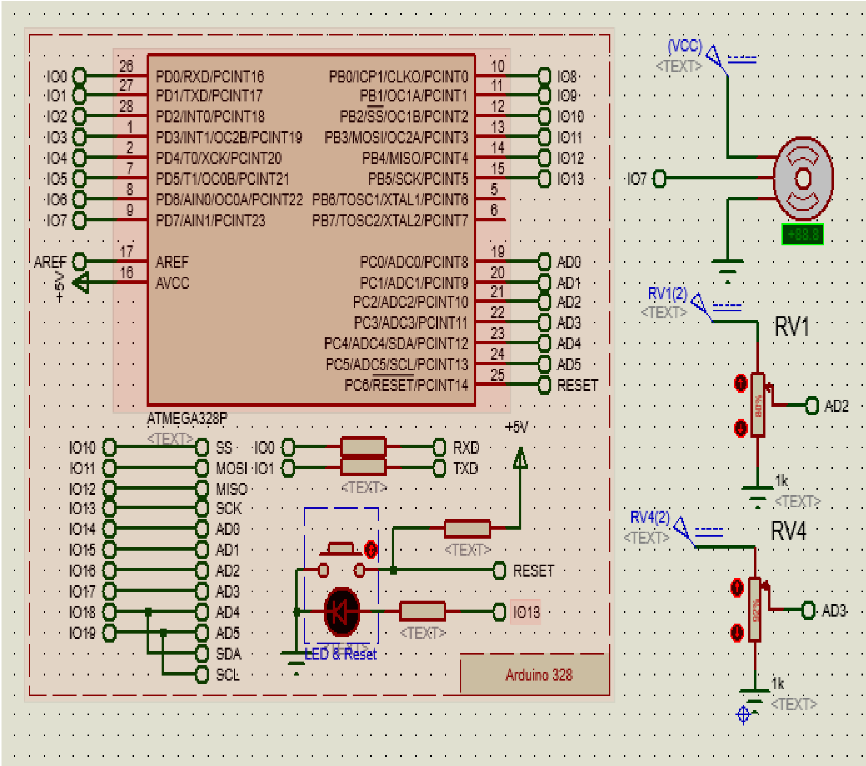

Figure 4.12: Servo motor and Potentiometer Circuit connection using Proteus software

which are, set of claws to compress the Ambu bag, two stands to hold the Ambu bag in a fixed position one of which has an amount to hold the servo motor, and rods connecting the claws with the servo motor.

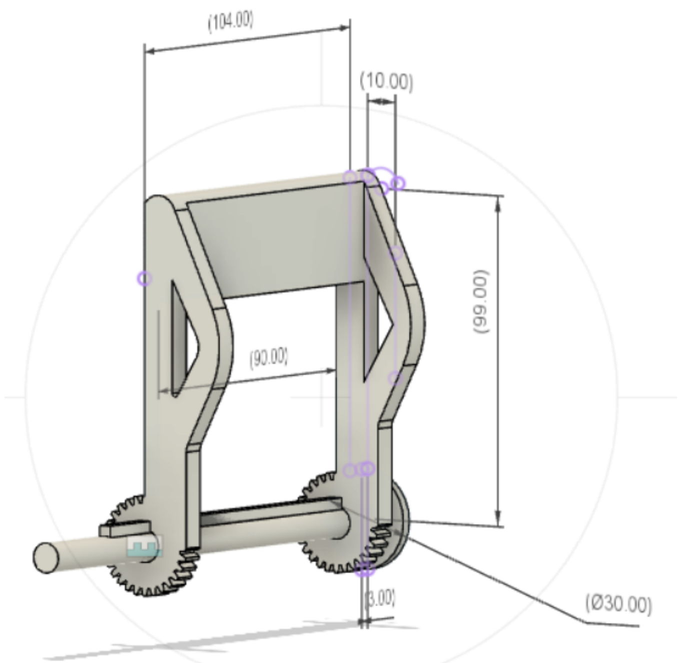


Figure 4.13: 3D model of Claw with dimension

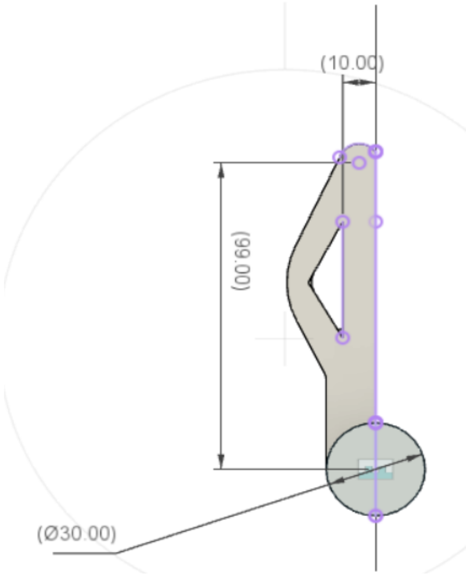


Figure 4.14: Side view of Claw with dimension

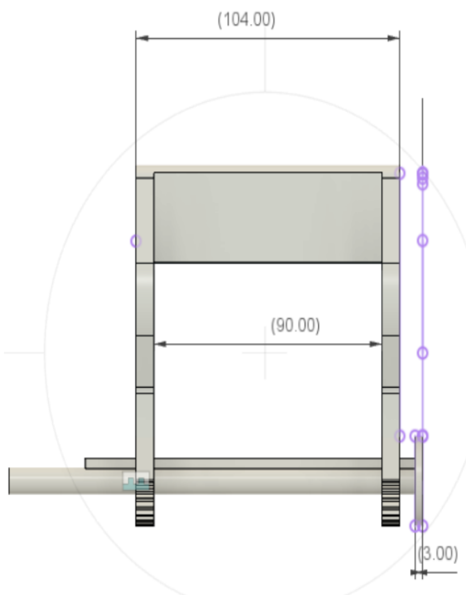


Figure 4.15: Back view of Claw with dimension

The structure of the claw is shown in Figure 4.13 with proper dimensions. Figure 4.14 and Figure 4.15 show the side view and back view of the claw with dimensions.

Figure 4.16 and Figure 4.17 shows back view and side view respectively of the stand which holds the Ambu bag. Figure 4.18 and Figure **??** shows the 3D model of back view and side view of the stand which will mount servo motor and hold Ambu bag.

Figure 4.20 shows the 3D model of the rod which connects the Servo Motor to the Claw. Figure 4.21 shows the Complete assembled structure of the Ventilator.

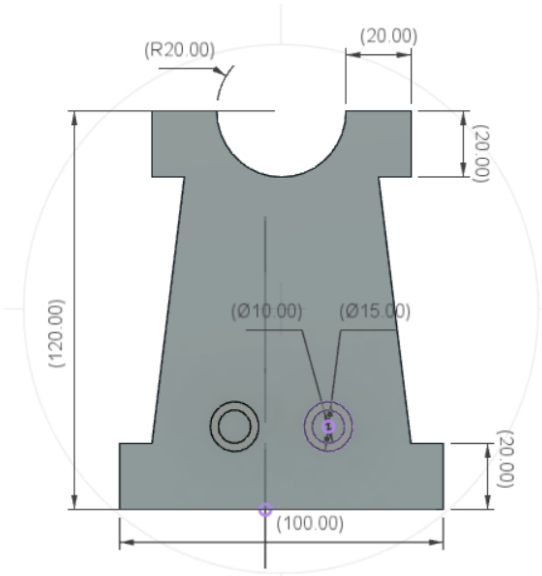


Figure 4.16: 3D Model of Stand v1 - back view

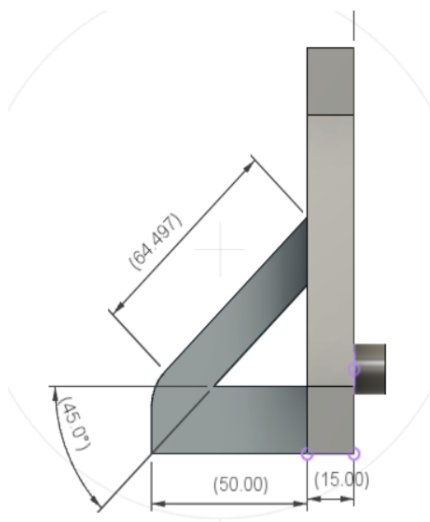


Figure 4.17: 3D Model of Stand v1 - side view

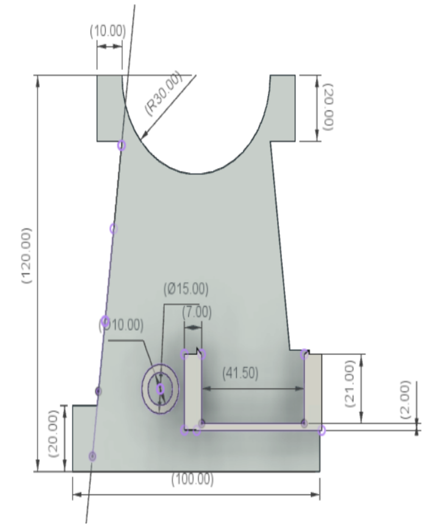


Figure 4.18: 3D Model of Stand v2 - back view

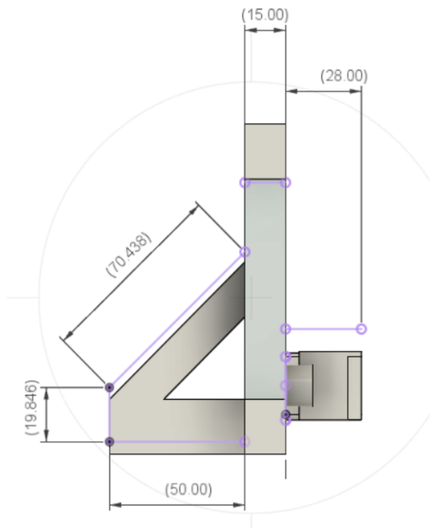


Figure 4.19: 3D Model of Stand v2 - side view

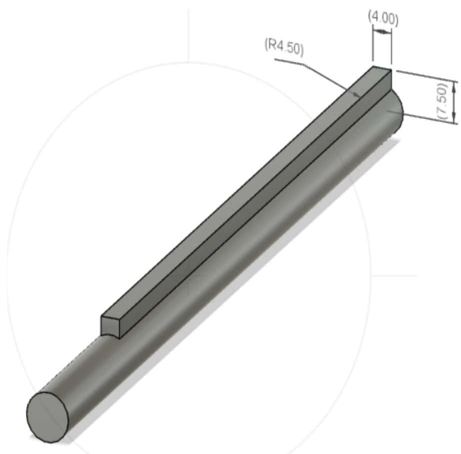


Figure 4.20: 3D Model of Rod

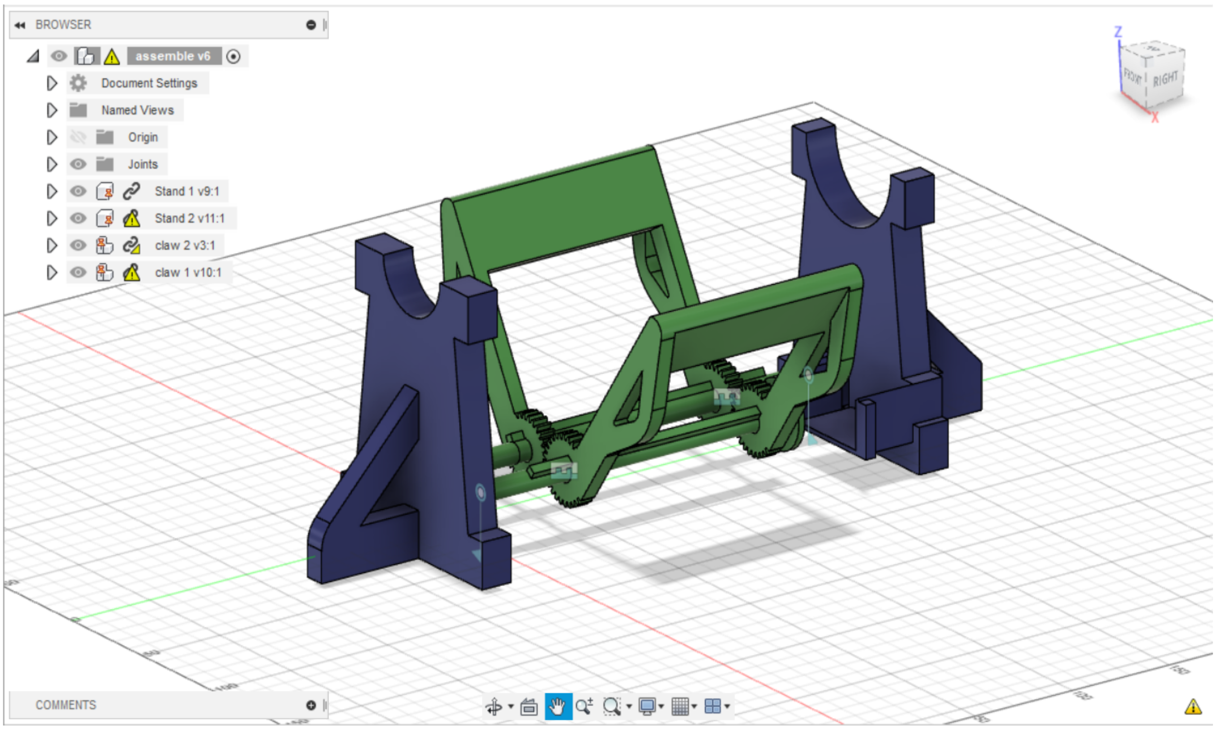


Figure 4.21: Assembled structure of Ventilator

# Chapter 5
# Conclusion and Future Work

## 5.1 Conclusion

The project A.I.R is constructed by integration of Pulse sensor, Pressure sensor, Servo motor, Ambu bag, and the support structure together. All sensors provide accurate output values. When constructed it is used as a Low-cost emergency ventilator that anyone can afford and operate easily.

## 5.2 Future Working

In the future, the A.I.R can be improved by adding more features and modifying the design of the ventilator. Features such as SPO2 level, Air purification unit and an online server to store the data and making it available to access over devices connected to the internet can be made available. Apart from this the physical design of the ventilator can be improved such that the motor can be able to compress 2 Ambu bags simultaneously increasing its efficiency.

## 5.3 Effect of Pandemic on the completion of Project

The COVID-19 pandemic compelled the global and abrupt conversion of conventional face-to-face instruction to the online format in many educational institutions. The pandemic made working on the project harder than it should be. The lockdown caused the unavailability of product delivery on many online shopping sites. Due to limited resources and less time spent on making the project in college we were unable to complete the project as planned in the initial stage. We completed the testing and working of all individual components of the ventilator and were able to design a proper body structure of the Ventilator.

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