Efficient & Low Cost Non-Invasive Emergency Ventilator

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***Abstract*— The present outbreak of COVID-19 pandemic has resulted in the dramatic increase in the number of patients who need respiratory care. Health care systems worldwide are facing the extreme shortfall of ventilators particularly mechanical ventilators and their components. The shortage of ventilators has already been experienced by most of the countries who are extremely hit by this pandemic. One of the main reasons for the shortage of ventilators is the issues related to their global supply chain. Due to the worldwide spread of infection, the exports of the medical equipment's including ventilators have come to a halt. The situation has been become so alarming that as many as fifty-four countries have stopped exporting the goods related to medical field including ventilators. The production of medical machines such as ventilators demands more intensive capital and expertise.**

In response to these challenges, we present a ventilator with low cost, efficient and automatic air delivery ventilator with alarm and PEEP. In this system that natively supports pressure-control, spontaneous inhalation and exhalation monitoring, and key alarms specified by regulatory agencies are included. Anyone can operate it as no need to study or training of ventilation rules like ICU ventilator.

Keywords*— *Arduino board, Heart Rate and Pulse Oximeter Sensor

I. Introduction

COVID-19 pandemic is an infectious disease which is caused by novel coronavirus. It is a highly contagious disease which begun in Wuhan in China at the end of December 2019 and now has spread across the globe to around 220 countries, in a short period of three months and has affected more than 2.1 million individuals and has caused death in more than 145 thousand patients. It reaches now at 147,904,276 Coronavirus cases and 3,124,980 deaths. It can present as a mild infection (such as common cold) to a serious respiratory illness (such as pneumonia). The droplets of saliva and the discharge from the nose of the infected person while sneezing are the main sources for the spreading of coronavirus. When SARS-CoV-2, the virus that causes COVID-19, gets in the human body, it comes into contact with the mucous membranes that line our nose, mouth, and eyes, and infects the upper or lower part of respiratory tract. As a result, the respiratory tract and lungs swells, become irritated and inflamed and, in some cases, the infection can reach all the way down into alveoli, where oxygen goes into the blood and carbon dioxide comes out. For those who develop trouble breathing, medical care outside of the home is needed.

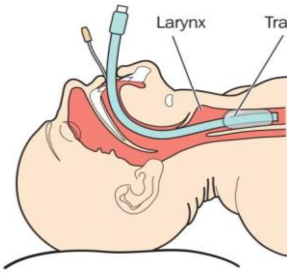
The seriously ill patients suffering from COVID-19 need respiratory support, as their lungs get damaged by the coronavirus leading to breathing difficulties. Ventilators are needed in such cases for supplying adequate oxygen (O2) into their lungs and also removing the carbon dioxide (CO2), as a lifesaving supportive measure. The ventilators are one of the most vital medical devices needed to keep these critically ill COVID-19 patients alive. There has been a drastic increase in the number of patients struck by COVID-19 pandemic in the hospitals and ICUs worldwide. However, sufficient ventilators are not available in the hospitals at present. An influential report from Imperial College London estimates that 30% of patients admitted in hospitals due to COVID-19 are expected to need the mechanical ventilation. According to the WHO, one in six COVID-19 patients has significant difficulty in breathing and may require ventilator support. However, the patients who require ventilator support have low survival rates of 20% because many of these infected patients (40%) develop acute respiratory distress syndrome (ARDS), which has a high mortality.

Ventilator and its importance in COVID-19 pandemic;

Ventilator is a medical equipment/machine which is employed to provide respiratory support to the patients whose lungs are significantly compromised due to infection (pneumonia) etc. leading to severe respiratory problems. The ventilator uses a positive pressure to supply oxygen into the lungs through the inner ways and fully regulate the breathing process of the patients. The lungs of the patients who require mechanical ventilation due to COVID-19 are so much inflamed that the oxygen is unable to reach the alveoli when a patient breathes, and the mechanical ventilator acts to force the oxygen flow under pressure to these small air passages. Medical ventilation is basically of two types:

a. Invasive mechanical ventilation
b. Non-invasive ventilation.

a. Non-Invasive ventilator



b. Invasive ventilator

The invasive mechanical ventilation uses an endotracheal tube which is inserted in to trachea for the flow of oxygen in to the lungs of the patient. The non-invasive ventilation does not employ any internal tube. Non-invasive ventilation is delivered via face mask. The present outbreak of COVID-19 pandemic has resulted in the dramatic increase in the number of patients who need respiratory care. Health care systems worldwide are facing the extreme shortfall of ventilators particularly mechanical ventilators and their components. The shortage of ventilators has already been experienced by most of the countries who are extremely hit by this pandemic. One of the main reasons for the shortage of ventilators is the issues related to their global supply chain. Due to the worldwide spread of infection, the exports of the medical equipment's including ventilators have come to a halt. The situation has been become so alarming that as many as fifty-four countries have stopped exporting the goods related to medical field including ventilators. The production of medical machines such as ventilators demands more intensive capital and expertise.

In response to these challenges, we present a ventilator with low cost, more efficient and automatic air delivery ventilator with alarm and PEEP. In this system that natively supports pressure-control, spontaneous inhalation and exhalation monitoring, and key alarms specified by regulatory agencies are included. Anyone can operate it as no need to study or training of ventilation rules like ICU ventilator.

II. LITERATURE REVIEW

A. *Designing an Electro-Mechanical Ventilator Based on Double CAM Integration Mechanism*

This paper proposes a simplified structure of microcontroller based mechanical ventilator integrated with a Bag-Valve-Musk (BVM) ventilation mechanism. Here, an Ambu bag is operated with computer-aided manufacturing (CAM) arm that is commanded via a microcontroller and manual switches by sending a control signal to the mechanical system and according to this control signal, the mechanical computer-aided manufacturing (CAM) arm simultaneously compresses and decompresses the Ambu bag. It is a self-inflating bag and like a one-way valve around its inlet and outlet corner. By compressing the Ambu bag it delivers air and by relaxing, it takes air from the environment through a mechanical scavenger. The control signals are designed with three modes named adult mode, pediatric mode, and child mode based on the respiratory rate. These modes are selected according to the lung capacity and breath-rate of the subject as well as inspiration and expiration (I:E) ratio. The device is in assist controlled mode by dint of fixing the tidal volume for all unique control signals. The device is portable, compact, low weight, and efficient performable. It has some additional feature of controlling precisely with portability, battery operated, reduced size and noise removal. The automation requires a microcontroller, some mechanical switches, and two servos. Servos are positioned face to face oppositely with the 180-degree angle. The shafts of the motor are attached with a mechanical pulley that rotates according to motor direction. A nonflexible cot wire connects one arm and one pulley and same to the second one. When the motor rotates, the torque creates tension in the cot wire through the pulley that results in pulling a mechanical arm to compress an Ambu bag.

B. *Partially RepRapable automated open source bag value mask- based Ventilator.*

This paper describes a portable automated Bag valve mask (BVM) compression system, which, during acute shortage and supply chain disruptions can serve as a temporary emergency ventilator. The resuscitations system is based on the Arduino controller with a real-time operating system installed on a largely RepRap 3D printable parametric component based structure. This device provides a controlled breathing mode with tidal volume, breathing rate and inspiratory-to-expiratory ratio. The system is designed for reliability and scalability of measurement circuit through the use of the serial peripheral interface and has the ability to connect additional hardware due to the object oriented algorithmic approach. The design of the device and software was governed by ISO standards. The system implements two modes: controlled mechanical ventilation (CMV) and inverse ratio ventilation (IRV). A user can control breathing rate tidal volume and inspiratory/expiratory ratio. All the mechanical components were developed in open-source CAD system. A back up battery enables short-term patients mobility and safety protocols in software provide alarm when the monitored proximal pressure exceeds the permissible range, or the pressure sensor are disconnected.

C. *Design and Prototyping of a Low-cost Portable Mechanical Ventilator.*

This paper describes the design and prototyping of a low-cost portable mechanical ventilator for use in mass casualty cases and resource-poor environments. The ventilator delivers breaths by compressing a conventional bag-valve mask (BVM) with a pivoting cam arm, eliminating the need for a human operator for the BVM. An initial prototype was built out of acrylic, measuring 11.25 x 6.7 x 8 inches (285 x 170 x 200 mm) and weighing 9 lbs (4.1 kg). It is driven by an electric motor powered by a 14.8 VDC battery and features an adjustable tidal volume up to a maximum of 750 ml. Tidal volume and number of breaths per minute are set via user-friendly input knobs. The prototype also features an assist-control mode and an alarm to indicate over pressurization of the system. Through this prototype, the strategy of cam-actuated BVM compression is proven to be a viable option to achieve low-cost, low-power portable ventilator technology that provides essential ventilator features at a fraction of the cost of existing technology. A roller-chain concept is utilizes, roller-chains with roller diameters larger than link width. The chain wraps around the circumference of the bag, and as a result is very space efficient. A sprocket connects to the motor shaft; its clockwise/anticlockwise rotation compressing and expanding the bag for breath delivery. It has low power requirements, running for 3.5 hours on one battery charge at its most demanding setting. The air volume delivered was measured as a function of cam angle by integrating the flow rate over time.

D. GlasVent—the Rapidly Deployable Emergency Ventilator.

The GlasVent, developed by University of Glasgow team, is an affordable and rapidly deployable emergency DIY ventilator which takes into consideration most of the basic requirements for ventilators. The system utilizes a crank—slider mechanism to convert the rotation motion of the motor to reciprocal linear motion. The base of the motor is able to slide toward or away from the BVM to regulate the maximum compression of the bag and provides control over the tidal volume exerted by the system. The system has three operating schemes: a) mains or supply operated, b) battery operation, and c) manual operations via a small handle attached to the rotating disc of the system. The system could also be adapted for operation by foot instead. This mode is possible because the system is designed to operate with continuous one directional rotation rather than reciprocal motion found in other emergency ventilator designs. This prototype also uses a small spring attached to a rod placed vertically to the base. The other end of the spring is attached to the connection between the disc and the link. The spring and the link form a 90° angle when the pistons fully compress the BVM. While the motor is retracting the piston, the spring extends and stores the energy. At the time of compression of the BVM the spring contracts and releases the stored energy to support the motor. The base of the motor is able to slide toward or away from the BVM. This regulates the maximum compression of the bag and provides control over the tidal volume exerted by the system. GlasVent can be operated in three ways: The first scheme, i.e., manual operation, does not require any electronic component and accordingly the cost of the system is reduced to minimum. The second operation scheme (i.e., mains or battery operated) is the scheme with the most features. The heart of the system is the stepper motor driver printed circuit board (PCB) module (DRV8825 Stepper Motor Driver Carrier, High Current, Pololu electronics). All inputs and outputs of the DRV8825 are connected to the brain of the GlasVent system, i.e., Arduino Due.

III. EFFICIENT & LOW COST NON-INVASIVE EMERGENCY VENTILATOR

The lungs of the patients who require mechanical ventilation due to COVID-19 are so much inflamed that the oxygen is unable to reach the alveoli when a patient breathes, and the mechanical ventilator acts to force the oxygen flow under pressure to these small air passages. The main aim of the project is to propose a ventilator system with low cost, more efficient and automatic air delivery ventilator with alarm and PEEP. We are developing a ventilator system equipped with a pressure sensor, alarm relay and a pulse oximeter. The whole system consists of components like microcontroller, pulse oximeter, pressure sensor, safety valve, stepper motor, buzzer, LCD display, potentiometers and LEDs. The man controller of the ventilator is Arduino board and a pulse oximeter. Max30102 sensor is a pulse oximeter that used to measure the patient's heart rate (HR) and blood oxygen rate (SpO2). A pressure sensor and Alarm buzzer is also connected to the Arduino board. Pressure sensor helps to measure the pressure in airway and ventilator standards are controlled by alarm, these appropriate actions take when an alert condition is detected. Here we use the ventilator standards such as Frequency and PEEP. Frequency is a parameter that used to the time period for inhalation and exhalation.

A. Time period for inhalation from frequency

Inhalation is the flow of air into an organism that is due to a pressure difference between the atmosphere and alveolus. Inspiration begins with the contraction of the diaphragm, which results in expansion of the thoracic cavity and the pleural cavity. The pleural cavity normally has a lower pressure compared to ambient air (–3 mmHg normally and typically –6 mmHg during inspiration), so when it expands, the pressure inside the lungs drops. Pressure and volume are inversely related to each other, so the drop in pressure inside the lung increases the volume of air inside the lung by drawing outside air into the lung. As the volume of air inside the lung increases, the lung pushes back against the expanded pleural cavity as a result of the drop in intrapleural pressure (pressure inside the pleural cavity). The force of the intrapleural pressure is even enough to hold the lungs open during inspiration despite the natural elastic recoil of the lung. The alveolar sacs also expand as a result of being filled with air during inspiration, which contributes to the expansion inside the lung. Eventually, the pressure inside the lung becomes less negative as the volume inside the lung increases and, when pressure and volume stabilize, air movement stops, inspiration ends, and expiration (exhalation) will begin. Deeper breaths have higher tidal volumes and require a greater drop in intrapleural pressure compared to shallower breaths.

Therefore,

Time period for inhalation = [(1/frequency)* (VT)] * [inhale time in I:E]

Where VT is the Tidal volume and I:E is ratio of inhalation and exhalation.

B. Tidal Volume

Tidal volume is the air volume entering and exiting the lungs each breath or Tidal volume is the amount of air that moves in or out of the lungs with each respiratory cycle. Excessive volumes can overinflate and stretch lung tissue causing injury. It is therefore chosen by the clinician, usually using predicted body weight. It measures around 500 mL in an average healthy adult male and approximately 400 mL in a healthy female.

C. Inspiratory: Expiratory Ratio

Inspiratory: Expiratory ratio refers to the ratio of inspiratory time: expiratory time. In normal spontaneous

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breathing, the expiratory time is about twice as long as the inspiratory time. This gives an I:E ratio of 1:2 and is read "one to two". The total time of a respiratory cycle is determined by dividing 60 seconds by the respiratory rate. Inspiratory time and expiratory time are then determined by portioning the respiratory cycle based on the set ratio. For instance, a patient with a respiratory rate of 10 breaths per minute will have a breath cycle lasting 3 seconds. That means for inspiration and expiration the patient have 3 seconds, Then,

I:time (Inspiratory Time) = 1 second _ (1/3) E:time (Expiratory Time) = 2 second _ (2/3) second)

(Since 3 seconds total cycle time minus 1 second inspiratory time then left is 2

I:E Ratio= 1:2"

D. Time period for exhalation from frequency

Exhalation (or expiration) is the flow of the respiratory current out of the organism. Expiration, also called exhalation, is the flow of the respiratory current out of the organism. The purpose of exhalation is to remove metabolic waste, primarily carbon dioxide from the body from gas exchange. The pathway for exhalation is the movement of air out of the conducting zone, to the external environment during breathing. Expiration is typically a passive process that happens from the relaxation of the diaphragm muscle (that contracted during inspiration). The primary reason that expiration is passive is due to the elastic recoil of the lungs. The elasticity of the lungs is due to molecules called elastin in the extracellular matrix of lung tissues and is maintained by surfactant, a chemical that prevents the elasticity of the lungs from becoming too great by reducing surface tension from water. Without surfactant the lungs would collapse at the end of expiration, making it much more difficult to inhale again. Because the lung is elastic, it will automatically return to its smaller size as air leaves the lung. Exhalation begins when inhalation ends. Just as the pleural cavity's increased negative pressure leads to air uptake during inhalation, the pleural cavity will contract during the exhalation (due to relaxation of the diaphragm),which exerts pressure on the lungs and causes the pressure inside the cavity to be less negative. An increase in pressure leads to a decrease in volume inside the lung, and air is pushed out into the airways as the lung returns to its smaller size. The pleural cavity is so important to breathing because itspressure changes the volume of the lungs, and it provides a friction-less space for the lung to expand and contract against during breathing. Therefore,

Time period for exhalation = [(1/frequency)* (VT)]* [exhale time in I:E] Where VT is the Tidal volume and I:E is ratio of inhalation and exhalation.

E. Tidal volume

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That means for inspiration and expiration the patient have 3 seconds, then,
I:time (Inspiratory Time) = 1 second _ (1/3) E:time (Expiratory Time) = 2 second _ (2/3)
(Since 3 seconds total cycle time minus 1 second inspiratory time then left is 2 second) I:E Ratio= 1:2
Here we assume that,
VT = 600 ml
I:time =(1/3)
E:time = (2/3) There for the equation becomes,
Time period for exhalation = [(1/frequency)* (600)]*[2/3]
Time period for inhalation = [(1/frequency)* (600)]*[1/3]
From these time periods, total time period will calculate and through this determine whether the patient is inhale or exhale.
Time period = ON time + OFF time

(Whether the patient is inhale then ON time is equal to Time period for inhalation and OFF time is equal to Time period of exhalation, vice versa).

G. Positive end expiratory pressure

There are two basic methods for maintain a successfully gas exchange between the respiratory system components and atmospheric environment using a mechanical ventilator.

1. Positive Pressure Ventilation: Respiratory support via effective pressure applied to the patient's airway opening.
2. Negative Pressure Ventilation: Respiratory support is performed with help of vacuum pressure around the chest wall.

As inspiration occurs (1) the alveoli expands to allow the air in. Gas exchange can then take place as the blood supply moves past the wall of the alveoli. During expiration the alveoli contracts down (2). It does not completely collapse, partly due to the presence of a substance called surfactant (3). This decreases the surface tension within the alveoli ensuring that complete collapse cannot take place. Unfortunately, ventilation of a patient tends to inactivate the pulmonary surfactant which then leads to collapse of the alveoli (4), making gas exchange more difficult as the surface area of the lung is now reduced. The ventilator also causes an increase in alveolar capillary permeability and causes the activation of inflammatory cells and the release of cytokines. The consequence of this is that the alveoli are opening and collapsing much more than they would

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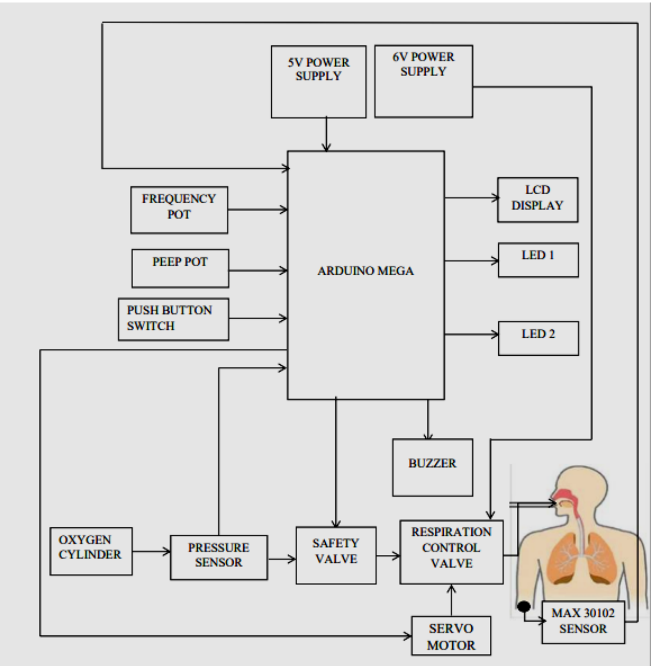
normally and will also be subject to higher pressures in order to reopen them with each breath. This combination will damage the alveoli further. Positive end expiratory pressure (PEEP), is a pressure applied by the ventilator at the end of each breath to ensure that the alveoli are not so prone to collapse. This 'recruits' the closed alveoli in the sick lung and improves oxygenation.

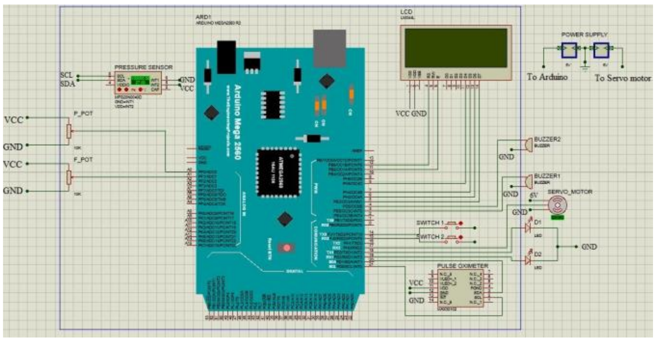
IV. BLOCK DIAGRAM.

In this system all processes are controlled by the arduino microcontroller. Here we use 2 separate power supplies, one (5v) for power up the arduino board and other (6V) for power up the servo motor (Respiration control valve). A max30102 sensor is connected from the patient to the arduino board. It is used to measure the heart rate and blood oxygen rate of the patient. Frequency and PEEP potentiometers are used to change or vary those values with respect to the requirement of the patient. Ventilation is provided through an oxygen cylinder and ventilation is controlled by a safety valve that is attached on a servomotor. Pressure sensor is used to measure the pressure of airway. Alarm is also provided that helps to know the condition of the patient.



Block Diagram

CIRCUIT DIAGRAM



Circuit Diagram

Transmitter and receiver pins of the Arduino mega is connected to the other interfacing devices.

Arduino- LCD interface:

LCD is an output device, which helps to displays all the measured reading and warning alerts. LCD is connected to the Digital I/O pins (D0 to D21) of the Arduino. Here we connect D2, D3, D4, D5, D6 and D7 pins of Arduino to 12, 11, 8, 7, 6 and 5 pins of LCD

Arduino- MAX30102 Pulse Oximeter interface:

Pulse oximeter and heart rate sensor or MAX30102 is an input device, which is used to measure the oxygen rate and heart rate of the patient. Pulse oximeter is connected to the SCL and SDA of Arduino board to the SCL and SDA of pulse oximeter. And also provide VCC and ground.

Arduino-Servomotor interface:

Servomotor is an input device, which is used to provide the control of respiratory control valve. Servomotor is connected to the digital pin of the Arduino. Here we connect center of the Servo motor to the 17^{th} pin of the Arduino. And also provide the ground and a 6V power supply to the servomotor.

Arduino-Pressure sensor interface:

Pressure sensor is an output device, which is used to measure the pressure of air in the airway. Pressure sensor is connected to the SCL and SDA of Arduino to the SCL and SDA of Pressure sensor. And also provide the ground and VCC.

Arduino and Buzzer interface:

Buzzer is an output device, which provides the alarm that indicates the condition of the patient. Here we use two buzzer module one indicate the power failure or connection errors and the other indicate the breathing condition of the patient. Buzzer is connected to the digital pin of the Arduino. Here we connect the buzzer to D3 and D4 of Arduino. And also provide the ground.

Arduino and LED interface:

LED is an output pin, which is used to indicate the inhalation and exhalation of the patient's breath cycle. Here we use two LEDs one indicate the inhalation and other for exhalation. LED is connected to the digital pin of the Ardunio. Here we connect LED1 to D18 of the Arduino and LED2 is connected to the D19 of the Arduino. And also provide the ground.

Arduino and Pot interface:

Pot or potentiometer is an input pin, which is used to adjust or control the value of peep and frequency. Here we use mainly two type of pot one is for control the value of frequency (F_pot) and other is to control the peep value (P_pot). Pot is connected to the analog pins of the Arduino. Here we connect the F_pot to A0 and P_pot to A1 of the Arduino. And also provide the ground and VCC.

International Journal of Engineering Research & Technology (IJERT)
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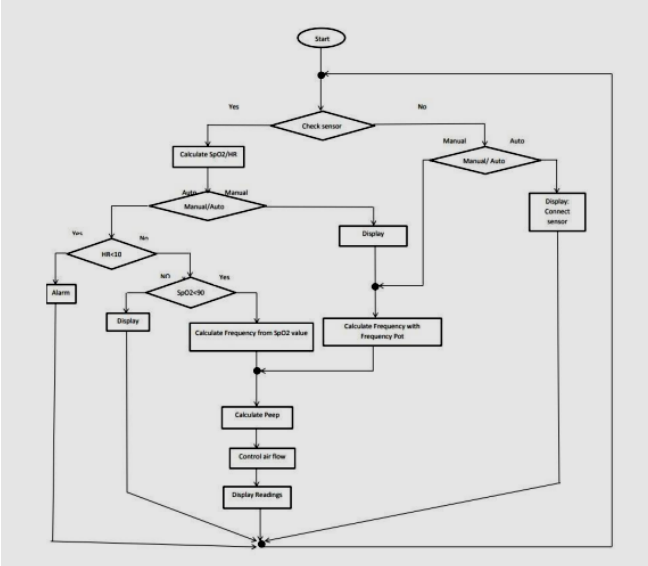
V. THE FLOW CHART



Flowchart

Ventilator system is initiated by turning on two power supplies. Here we use 5V and 6V supplies. 5V supply is given to aurdino that power up the arduino board and 6V supply is given to servo motor, which helps to the opening and closing of safety valve to patient.

Initially the system checks whether the max30102 sensor (pulse oximeter and heart rate sensor) is connected or not. Or it ensures the patient's finger is placed correctly inside the oximeter.

If max30102 (pulse oximeter and heart rate sensor) is connected or patient's finger is correctly placed, then the Ventilator (more efficient low cost non-invasive emergency ventilator) works in two modes; they are

1. Auto mode
2. Manual mode

AUTOMODE:

Ventilator works in automode when max30102 (pulse oximeter and heart rate sensor) is connected to patient.

Max30102 (pulse oximeter and heart rate sensor) measures heart rate and blood oxygen rate. If heart rate is less than 10, the patient is in critical condition, so the doctor cant 'do anything to the patient while placing the ventilator. At this condition the Alarm gets activated and notifies the doctor that the heart rate is less than 10 by displaying that heart rate is very low.

If heart rate is greater than 10, then it checks the value of blood oxygen rate (SpO2). If blood oxygen rate is greater than 90, then the patient is in normal condition so the display just displays the measured value. At this condition the ventilator may remove or keep it such as by the instruction of doctor.

If blood oxygen rate is less than 90, alarm gets activated and also notifies that oxygen rate is very low. For normalizing the oxygen rate of the patient the system calculate frequency from this reading. Using frequency pot we adjust the frequency to normal level delivered to patient through this we can adjust the oxygen rate. If we change the value of frequency by using frequency pot, it changes the airflow through safety valve by adjusting the angle of servo motor.

This process continues till the patient get normal level of oxygen. Normally the doctor suggests that the patient is kept under a high oxygen rate until the patient can breathe himself normally.

MANUAL MODE:

In manual mode of operation the system directly read the frequency of the patient's air flow through the frequency pot. For normalizing the oxygen rate of the patient the system adjust the frequency from this reading. Using frequency pot we adjust the frequency to normal level

delivered to patient through this we can adjust the oxygen rate. If we change the value of frequency by using frequency pot, it changes the airflow through safety valve by adjusting the angle of servo motor.

If max30102 (pulse oximeter and heart rate sensor) is not connected or patient's finger is not correctly placed, then the Ventilator (more efficient low cost non-invasive emergency ventilator) works only in manual mode. If the system is not in the manual condition then the display notifies that please connect sensor

RESULT

An efficient and low-cost emergency non-invasive ventilator is designed after an in-depth literature reviews. And we developed a block diagram for the same. The main components of our project are the micro-controller, pulse oximeter, pressure sensor, servo motor and buzzer. Since our project needs a lot of memory for the operation, we chose Arduino Mega as micro controller. The pulse oximeter is used to monitor heart rate and blood oxygen level. Here we use the pressure sensor for recognizing the pressure condition of the air in the airway. And this pressure is controlled by using the safety valve. Servo motor controls the rotation of mechanical respiratory control valve. Mechanical respiratory control valve is used to supply the inhaling and exhaling air with controlled PEEP. For the alert notification we use two buzzers with different frequency. One is for indicating the power losses or for indicating the incorrect placing of finger of the patient. And the other indicate the low level of heart rate or the blood oxygen rate.in addition, software part of this system is completed and tested in Arduino IDE. And we also developed a schematic diagram on the proteus design tool. This is an efficient system that allows the patient to get enough oxygen and remove carbon dioxide. If also maintain the stability of the respiratory track and prevent injuries caused by aspiration. Finally, we developed an efficient system using all the above- mentioned components.

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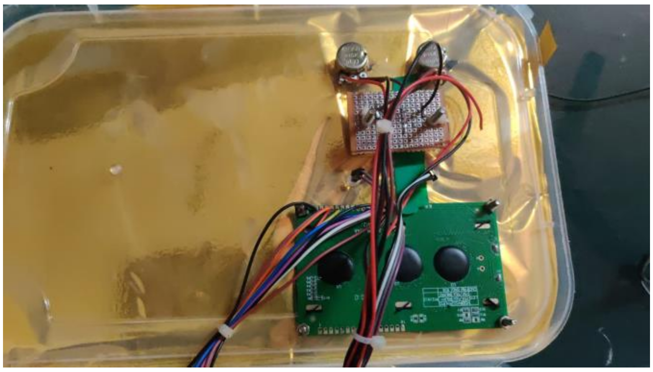
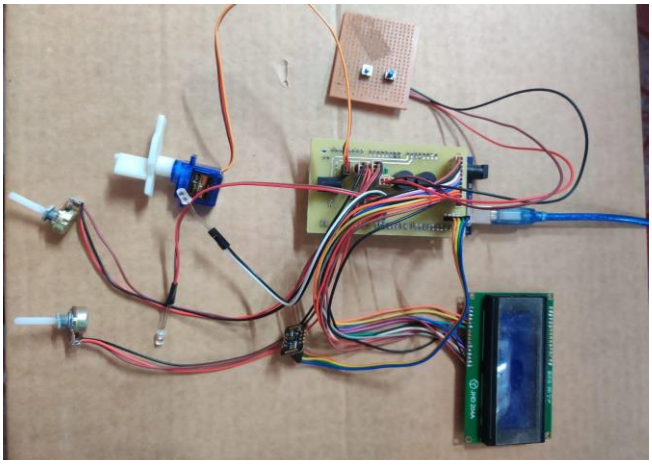
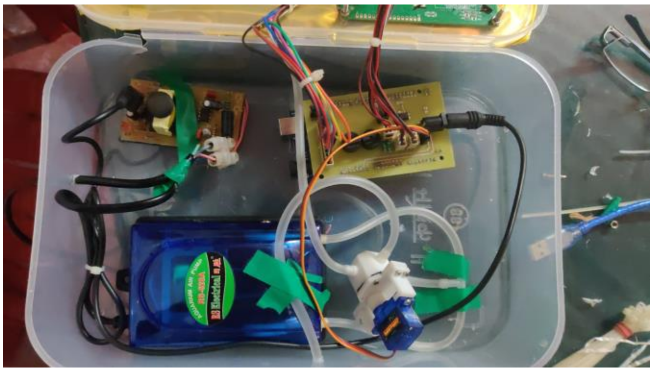
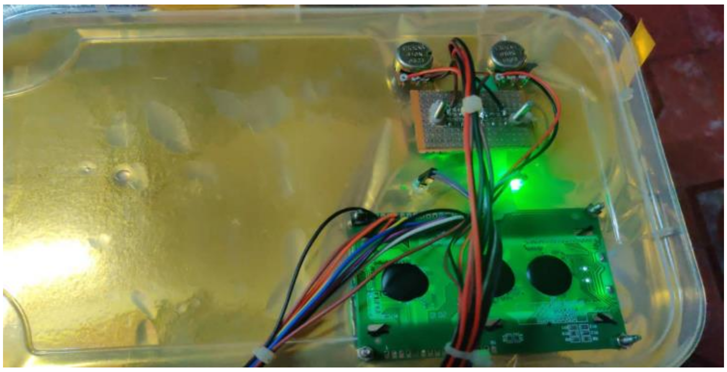


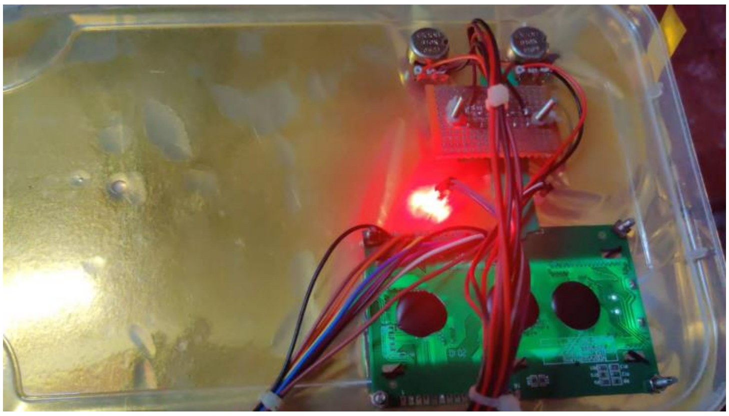




In our system we use an LCD display, which displays the information of the patient's condition. It shows the readings like blood oxygen rate, heart rate value, PEEP value and also the frequency value of the air passed in the airway. And also, the LCD display shows the working mode that the ventilator works. That is, it may work either the Auto mode or the Manual mode.

Here we use two color LEDs that shows the breathing condition of the patient. The green LED is for the indication of inhalation. And the red LED is for the indication of the exhalation of the patient.





CONCLUSIONS

The need for ventilators has increased rapidly due to recent worldwide spread of coronavirus. As a result, many established manufactures of ventilators are reallocating resources to increase production. We are also witnessing a wave of initiatives focusing on producing low-cost emergency ventilators suitable for fast deployment to meet short-term needs gaps. In response to these challenges, we present a Non-invasive ventilator with low cost, more efficient and automatic air delivery ventilator with alarm and PEEP. In this system that natively supports pressure-control, spontaneous inhalation and exhalation monitoring, and key alarms specified by regulatory agencies are included. It also displays Blood oxygen rate (SpO2) and heart rate of the patient. Anyone can operate it as no need to study or training of ventilation rules like ICU ventilator.

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