Ventilator Using Ardino

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Abstract- ***In response to anticipated shortages of ventilators caused by the COVID-19 pandemic, mechanical ventilation is a life-saver in the development of modern ICUs. This project provides an idea of the origin of modern mechanical ventilators. Based on the reviewed literature, a simple, easy-to-use, and easy-to-build design of low-cost portable ventilator is proposed in this project. The proposed ventilator prototype here is assumed to have better working performance than already available around. This ventilator consists of oxygen sensor and a sensitive pressure monitoring system all at a very low cost. The ventilator we here design and develop using Arduino encompasses all the requirements to develop a reliable yet affordable whilst matching all the conditions and marks of an original mechanical ventilator along with its property of portability. This ventilator will help in a situation like COVID-19 when the whole world facing difficulties related to ventilators and thereby can also be used in other critical situations or mass casualties.***

I. INTRODUCTION

According to the World Health Organization (WHO), about 80% of persons who contract Covid-19, a coronavirus-related condition, recover without the need for hospitalization. However, one out of every six people falls critically ill. The virus damages the lungs in these extreme cases, causing the body's oxygen levels to plummet and making breathing difficult. To help with this, a ventilator is used to force air into the lungs with higher oxygen levels.

There are 2 types of ventilators
1. Mechanical ventilator
2. Non- invasive ventilator

Mechanical ventilation is a life-saving therapy that catalyzed the development of modern intensive care units. The origins of modern mechanical ventilation can be traced back about five centuries to the seminal work of Andreas Vesalius. A Ventilators a machine that helps you take breaths if you can't do it on your own it mechanically helps pump oxygen into your body. The air flows through a tube that goes in your mouth and down your windpipe. The ventilator also may breathe out for you, or you may do it on your own. This report represents an Arduino based ventilator with pulse oximeter sensor and servomotor.

Mechanism of the ventilator:
A ventilator uses pressure to blow air into the lungs. This pressure is known as positive pressure. The amount of oxygen the patient receives can be controlled through a monitor connected to the ventilator. If the patient's condition is particularly fragile, the monitor will be set up to send an alarm to the caregiver, indicating an increase in air pressure.

The machine works by bringing oxygen to the lungs and taking carbon dioxide out of the lungs. This allows a patient who has trouble breathing to receive the proper amount of oxygen. It also helps the patient's body to heal, since it eliminates the extra energy of labored breathing. The machine blows air into the airway through a breathing tube. One end of the tube is inserted into patient's windpipe and the other end is attached to the ventilator. The breathing tube serves as an airway by letting air and oxygen from the ventilator flows into the lungs. Depending on the patient's medical condition, they may be able to use a respiratory mask instead of the breathing tubes.

Automatic inflated bag
Automatic inflated bag, also known as bag valve mask (BVM), ventilation is a critical skill for emergency providers. BVM ventilation is a technique that restores breathing in patients who are not spontaneously breathing. In most settings, a BVM is an emergency procedure carried to tide over until intubation is done. BVM ventilation is needed in the following conditions:

- Respiratory (lung) failure

- Failed intubation (insertion of an artificial ventilation tube into the trachea)
- Patients undergoing anaesthesia for elective surgery
- Apnoea (slowed or stopped breathing) Patients who use a breathing machine (ventilator) can also use a resuscitator bag if there is a need to disconnect from the ventilator due to a power failure or when there is a problem with the ventilator.

Mechanism of the BVM:

II. LITERATURE REVIEW

In Muhammad Jawad Ghafoor et al. titled "Prototyping of a Cost-Effective and Portable Ventilator Software Technology Park, Ferozepur Road, Lahore" [1] paper provides concise information about the functionalities and the effectiveness of the ventilator which in addition to being economical is also easy to move. The ventilator is crafted and designed in a way that makes it efficient enough to operate during times of extreme medical crisis and as a result save as many human lives as possible. This ventilator was created using wooden pieces. It weighs exactly 6 kgs and its dimensions are 14 x 7 x 9 inches. This ventilator delivers oxygen to the patient with the help of an orthodox bagvalve-mask. The energy source of the ventilator is a 12 Volts DC battery. The Ventilator very effectively takes care of the two most significant aspects of mechanical ventilation i.e., BPM (Breaths per minute) and Pressure as it is equipped with a user-friendly input board. Not only this but it also consists of an alarm flow battery indication system in addition to assist control. The cost of the Ventilator is slated at $150 but it would be available at about 100 dollars once it starts getting mass produced. These characteristics of the ventilator make it a preferred choice during a catastrophe

In [2], We are a witness to the times and the rapid advancement in the automation sector and almost all aspects of our lives are dependent upon it. Also, we are aware that the ongoing development in Automation will usher us into a future that we can predict might be literally ahead of its times. This global pandemic, the Covid-19 is catapulting us into that very future of smart automation. The covid-19 and its various variants have forced Scientists and Researchers all over the world to find a way to tackle it and it has thereby paved a way for great technological development. This has led to overwhelming demand in the automation sector in the Biomedical field. One of the results of this is the Industrial grade programmable logic controller which aims to control the mechanical ventilation process of a bag-valve mask-based emergency ventilator. The conclusions and the Mechanisms have been concisely documented. In [3], In 2021, The second wave of the Covid-19 struck the entire globe which proved to be extremely contagious and dangerous because of which an unimaginable, overwhelming number of people had to be admitted to the hospital. This resulted in the shortage of ventilators, oxygen beds due to which a lot many people lost their lives. This situation forced medical and technological institutions and universities all over the world to work upon various designs for mechanical ventilators. These designs are concerned with the automation of the BagValve-Mask. The Bag Valve mask (also known as an Ambu Bag) is a resuscitator device used during emergency situations mostly when the patient isn't able to breathe normally. This paper discusses how we could automate the manual operation of the big-valve-mask and how this BVM-based ventilator could be turned into a sophisticated and reliable device that can be used by a pulmonologist and other medical practitioners.

In [4], The paper deals with the construction of an economical ventilator that can effectively and efficiently deal with the shortage of ventilators which was experienced by an overwhelming number of people who were struck by Covid-19 and this resulted in the loss of many lives. In this paper, a numerical method to monitor the respiratory condition of the Patient is also cited. As per the method, a track is kept of Pressure measurements from the inspiratory limbs and the doctor or the clinician is alerted if something goes wrong. From the paper, we also come to know that the equipment was made using only commercial parts. The experiments conducted using this ventilator are testimony about the effectiveness and the other related benefits of the ventilator.

III. METHODOLOGY

In this block diagram first, the Oximeter is connected to the Arduino with analog input signals, and Whenever the Oximeter reads the pulse lower than the prescribed value then the Buzzer will ring and the information is sent to the Relay Model to operate the motor, as the motor is connected to the oxygen cylinder when the motor-operated the oxygen cylinder get started, and the patient is supplied with the given amount of oxygen. Hence the patient's pulse rate, blood oxygen, and heart rate are sent to the cloud with the help of either an Ethernet shield or Wi-Fi model, from the cloud the data is pushed to thing speed, where the doctor or other hospital staff can monitor the patient condition and do the necessary actions.

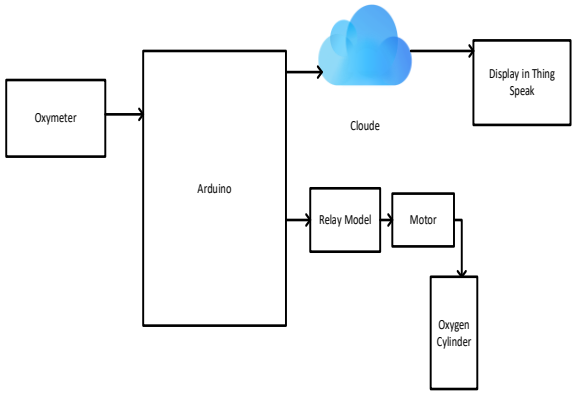


Figure: Complete Block diagram of Automatic Controller Ventilator using Arduino

IV. HARDWARE DISCREPTION

1. Arduino Mega2560

Arduino board is an open-source microcontroller board which is based on Atmega 2560 microcontroller. The growth environment of this board executes the processing or wiring language. These boards have recharged the automation industry with their simple to utilize platform wherever everybody with small otherwise no technical backdrop can start by discovering some necessary skills to program as well as run the Arduino board. These boards are used to extend separate interactive objects otherwise we can connect to software on your PC like MaxMSP, Processing, and Flash. This article discusses an introduction to Arduino mega 2560 board, pin diagram and its specifications.

The microcontroller board like "Arduino Mega" depends on the ATmega2560 microcontroller. It includes digital input/output pins-54, where 16 pins are analog inputs, 14 are used like PWM outputs hardware serial ports (UARTs) – 4, a crystal oscillator-16 MHz, an ICSP header, a power jack, a USB connection, as well as an RST button. This board mainly includes everything which is essential for supporting the microcontroller. So, the power supply of this board can be done by connecting it to a PC using a USB cable, or battery or an AC-DC adapter. This board can be protected from the unexpected electrical discharge by placing a base plate.

The SCL & SDA pins of Mega 2560 R3 board connects to beside the AREF pin. Additionally, there are two latest pins located near the RST pin. One pin is the IOREF that permit the shields to adjust the voltage offered from the Arduino board. Another pin is not associated & it is kept for upcoming purposes. These boards work with every existing shield although can adjust to latest shields which utilize these extra pins.

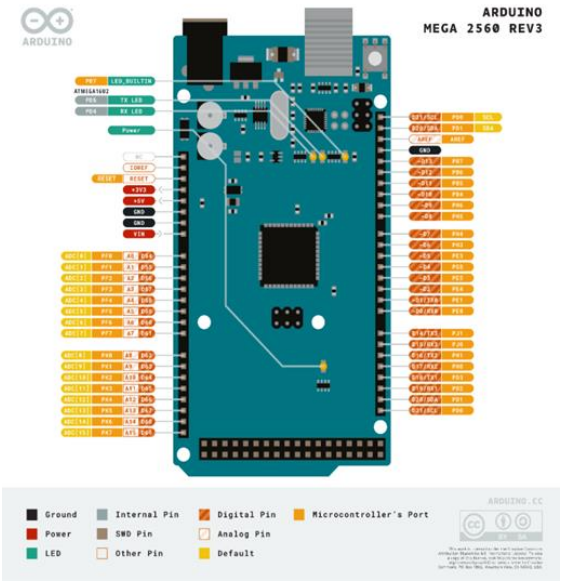


Fig: Pin diagram of Arduino mega 2560
Source: Mega 2560 Rev3 | Arduino Documentation | Arduino Documentation

The pin configuration of this Arduino mega 2560 board is shown below. Every pin of this board comes by a particular function which is allied with it. All analog pins of this board can be used as digital I/O

pins. By using this board, the Arduino mega projected can be designed. These boards offer flexible work memory space is the more & processing power that permits to work with different types of sensors without delay. When we compare with other types of Arduino boards, these boards are physically superior.

Pin 3.3V & 5V
These pins are used for providing o/p regulated voltage approximately 5V. This RPS (regulated power supply) provides the power to the microcontroller as well as other components which are used over the Arduino mega board. It can be attained from Vin-pin of the board or one more regulated voltage supply-5V otherwise USB cable, whereas another voltage regulation can be offered by 3.3V0-pin. The max power can be drawn by this is 50mA.

GND Pin
The Arduino mega board includes 5-GND pins where one of these pins can be used whenever the project requires.

Reset (RST) PinThe RST pin of this board can be used for rearranging the board. The board can be rearranged by setting this pin to low.

Vin Pin
The range of supplied input voltage to the board ranges from 7volts to 20volts. The voltage provided by the power jack can be accessed through this pin. However, the output voltage through this pin to the board will be automatically set up to 5V.

Serial Communication
The serial pins of this board like TXD and RXD are used to transmit & receive the serial data. Tx indicates the transmission of information whereas the RX indicates receive data. The serial pins of this board have four combinations. For serial 0, it includes Tx (1) and Rx (0), for serial 1, it includes Tx(18) & Rx(19), for serial 2 it includes Tx(16) & Rx(17), and finally for serial 3, it includes Tx(14) & Rx(15).

External Interrupts
The external interrupts can be formed by using 6-pins like interrupt 0(0), interrupt 1(3), interrupt 2(21), interrupt 3(20), interrupt 4(19), interrupt 5(18). These pins produce interrupts by a number of ways i.e. Providing LOW value, rising or falling edge or changing the value to the interrupt pins.

LED
This Arduino board includes a LED and that is allied to pin-13 which is named as digital pin 13. This LED can be operated based on the high and low values of the pin. This will give you to modify the programming skills in real time.

AREF
The term AREF stands for Analog Reference Voltage which is a reference voltage for analog inputs

Analog Pins
There are 16-analog pins included on the board which is marked as A0-A15. It is very important to know that all the analog pins on this board can be utilized like digital I/O pins. Every analog pin is accessible with the 10-bit resolution which can gauge from GND to 5 volts. But the higher value can be altered using AREF pin as well as the function of analog Reference ().

I2C
The I2C communication can be supported by two pins namely 20 & 21 where 20-pin signifies Serial Data Line (SDA) which is used for holding the data & 21-pin signifies Serial Clock Line (SCL) mostly utilized for offering data synchronization among the devices

SPI Communication
The term SPI is a serial peripheral interface which is used to transmit the data among the controller & other components. Four pins like MISO (50), MOSI (51), SCK (52), and SS (53) are utilized for the communication of SPI.

Dimensions
The dimension of Arduino Mega 2560 board mainly includes the length as well as widths like 101.6mm or 4-inch X 53.34 mm or 2.1 inches. It is comparatively superior to other types of boards which are accessible in the marketplace. But the power jack and USB port are somewhat expanded from the specified measurements.

Shield Compatibility
Arduino Mega is well-suited for most of the guards used in other Arduino boards. Before you propose to

utilize a guard, confirm the operating voltage of the guard is well-suited with the voltage of the board. The operating voltage of most of the guards will be 3.3V otherwise 5V. But, guards with high operating voltage can injure the board.

In addition, the distribution header of the shield should vibrate with the distribution pin of the Arduino board. For that, one can connect the shield simply with the Arduino board & make it within a running state.

Relay:

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations. A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays"

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured). The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB.

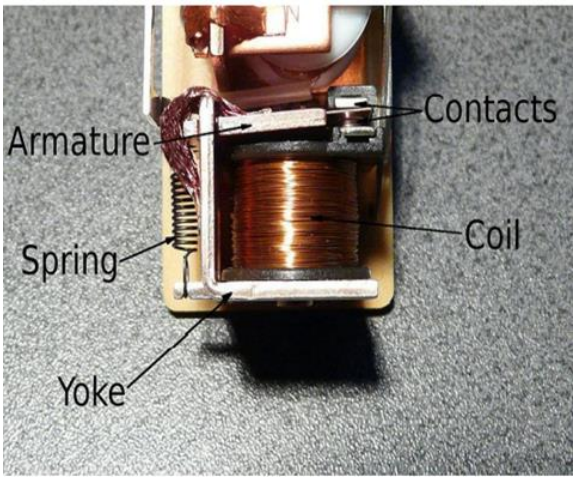


Figure. Internal Relay Circuit

When an electric current is passed through the coil it generates a magnetic field that activates the armature and the consequent movement of the movable contacts either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing

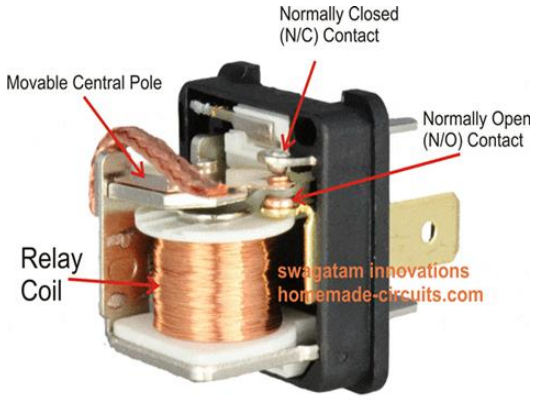


Figure. Schematic Circuit of Relay

When the coil is energized with direct current, a diode is often placed across the coil to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components

Pulse Oximeter Sensor:
The MAX30100 is a Pulse Oximetry and heart rate monitor sensor solution. The sensor combines a pulse oximetry and heart-rate monitor sensor in one package. It detects pulse and heart rate signals using two LEDs, a photo detector, optimized optics, and low-noise analog signal processing. It runs on 1.8V and 3.3V power sources and can be turned off by software with very little standby current, allowing the power supply to be connected at all times.

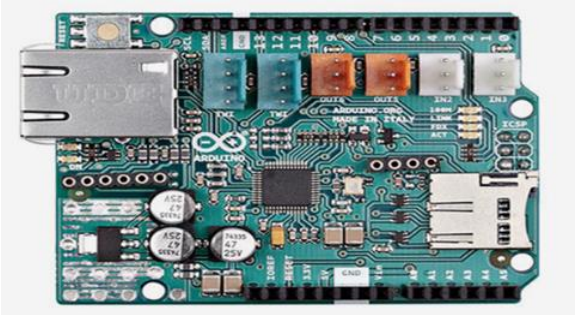
Pulse Oximeter

Motor
An aquarium pump is a type of pump that is completely submerged in the water. The aquarium pump is also known as a fish tank pump. The aquarium pumps are used in saltwater aquariums to transfer water or air between the tank and around the tank.

These are mainly utilized to drive a protein skimmer and to provide water circulation in the aquarium system. Therefore, an aquarium pump is also known as a fish tank pump. They improve the water circulation in the aquarium system.

Ethernet Shield

The Arduino Ethernet Shield 2 connects your Arduino to the internet in mere minutes. Just plug this module onto your Arduino Board, connect it to your network with an RJ45 cable (not included) and follow a few simple steps to start controlling your world through the internet. As always with Arduino, every element of the platform – hardware, software and documentation – is freely available and open-source.

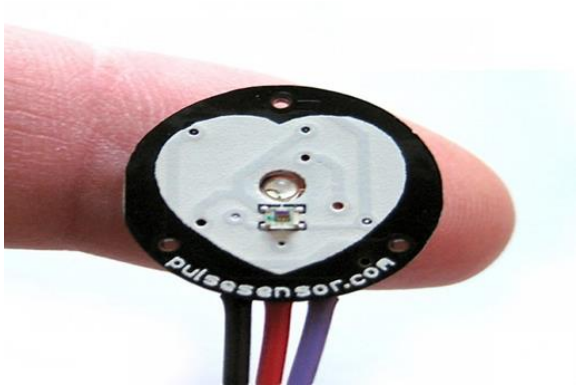


Ethernet Shield

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. 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.

Heart Rate Sensor:

Heartbeat Sensor is an electronic device that is used to measure the heart rate i.e. speed of the heartbeat. Monitoring body temperature, heart rate and blood pressure are the basic things that we do in order to keep us healthy. Heart Rate can be monitored in two ways: one way is to manually check the pulse either at wrists or neck and the other way is to use a Heartbeat Sensor.



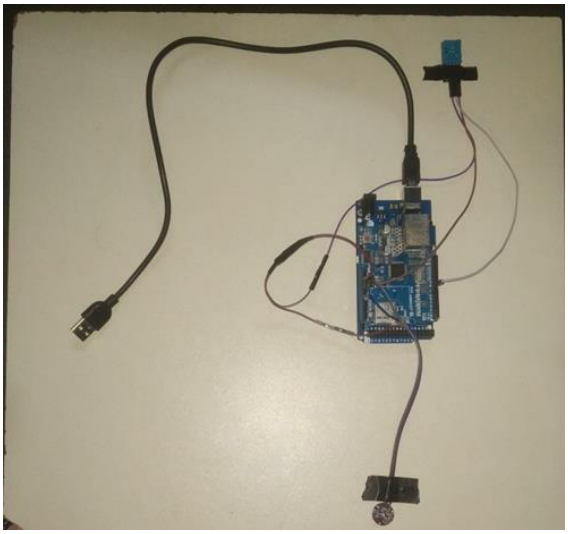
Working

The working principle of this heartbeat rate sensor is very simple. If we talk about heartbeat rate, then heartbeat rate is the ratio of time between two consecutive heartbeats. Similarly, when the human blood is circulated in human body then this blood is squeezed in capillary tissues. As a result, the volume of capillary tissues is increased but this volume is decreased after each heartbeat. This change in volume of capillary tissues affects the LED light of heart rate pulse sensor, which transmits light after each heartbeat. This change in light is very small but this can be measured by connecting any controller with this pulse sensor. This means the LED light which has every pulse sensor helps for measuring pulse rate.

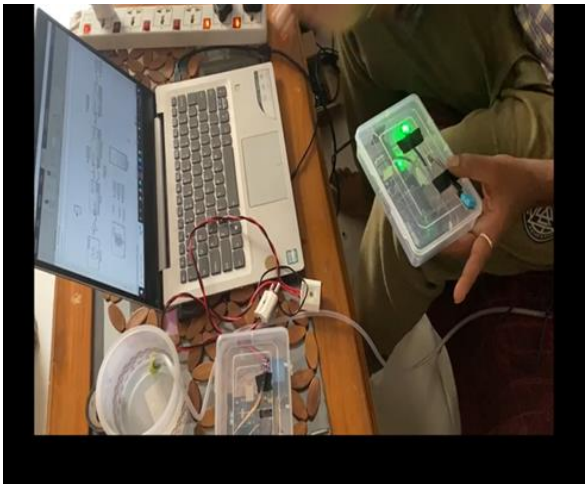
The working of this sensor could be checked by placing a human finger in front of this pulse sensor. When a finger is placed in front of this pulse sensor then the reflection of LED light is changed based on the volume of blood change inside capillary vessels. This means during the heartbeat the volume of blood in capillary vessels will be high and then will be low after each heartbeat. So, by changing this volume the LED light is changed. This change in of LED light measures the heartbeat rate of a finger. This phenomenon is known as “Photoplethysmogram.”

V. RESULT

The below figure shows the Hardware connection of Patient health monitoring system with various sensor networks, to monitor the patient temperature, Heart rate, Pulse and SPO2



The process of sending Analyzed data is using the Ethernet or Wifi Shield, here the analyzed data is sent to the web portal which is connected to the Arduino through internet, or else it can be sent to the cloud and store in Thinker speak portal, from the thinker speak portal we can sent Twitter notifications to the doctor.



Practical Setup of Automatic Ventilator

Whenever the oxygen levels of a patient is modified with respect to the potential meter, then the SPO2 calculated will become less than 95% of the Oxygen

level, then the relays will detect the signals to motor and The DC Motor will get started, when DC Motor get started the Oxygen enrichment motor will also get started and the oxygen supply to the patient can be observed in the whater with the help of bubbles in the water, whenever the oxygen level is adjusted to a normal value i.e more than 95%, automatically the DC otor will switch off with the help of same relay, and the oxygen supply to the patient will be off position.

CONCLUSION

There is clear technical potential for alleviating ventilator shortages during this and future pandemics using open-source ventilator designs that can be rapidly fabricated using distributed manufacturing. With the considerably larger motivation of an ongoing pandemic, it is assumed these projects will garner greater attention and resources to make significant progress to reach a functional and easily replicated open-source ventilator system. There is a large amount of technical future work needed to move open-source ventilators up to the level considered adequate for scientific grade equipment and further work still to reach medical-grade hardware. Future work is needed to achieve the potential of this approach not only on the technical side, but also by developing policies, updating regulations and securing funding mechanisms for the development and testing of open-source ventilators for both the current COVID19 pandemic, as well as for future pandemics and for everyday use in low-resource settings. As the reliability of the sensors are very less the estimation of oxygen requirement is not so accurate, but this project is very much needed and useful in the present Pandamic.

REFERENCES

[1] Muhammad Jawad Ghafoor, Mustafa Naseem, Fahad I1yas, Muhammad SulemanSarfaraz, Muhammad Irfan Ali, Ahsan Ejaz; Prototyping of a Cost-Effective and Portable Ventilator Software Technology Park, Ferozepur Road, Lahore

[2] Ryan RhayVicerra, *Edwin Calilung, Jason Española, Elmer Dadios, Alvin Culaba, Edwin Sybingco, ArgelBandala, Alma Bella Madrazo, Laurence Gan Lim, Robert KerwinBillones, Siegfred Lopez, Dino Dominic Ligutan, Julius Palingcod, and Carl John Patrick Castillo

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