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An IoT based Low-cost Artificial Mechanical Ventilator for Patients

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Abstract: **This paper presents the construction of a low-cost, open-source mechanicalventilator. The motto behind making this type of ventilator comes from the global shortage of ventilators to treat patients suffering with Covid-19. This paper presents a digital method to monitor the lung status of patients. This is achieved by determining pressure measurements from the inspiratory arm and alerts clinicians if the patient is in a healthy or unhealthy condition. The common symptoms of Covid-19 that can be easily identified are body temperature, blood oxygen level and heart rate that we must check to identify the virus. Hence this system can help in case a patient is unable to meet the doctor or requires frequent monitoring. These are going to develop a system which can monitor, and all the monitored data is stored in the cloud. When people suffer from breathing problems, this can be used for emergencies. The ventilator will be able to monitor the patient's blood oxygen levels and exhaled lung pressure while avoiding high pressure. Designed using Arduino, the ventilator meets all these requirements, creating an affordable ventilator to help during a pandemic. A motor mechanism is used to push the air bag. When the oxygen level counts are low, this mechanism is utilized. LCD screens are used to display oxygen levels. Whenever a patient faces a dangerous position, a buzzer sounds to notify a nearby caretaker. The entire system is driven by an Arduino microcontroller and a buzzer is fitted to detectany low levels of oxygen count.**

Index Terms**: Oxygen, Covid-19, Ventilator, Lung pressure, Air bag.**

I. Introduction

Corona virus, a dangerous disease caused by a virus which got spread two years back, made our lives upside down. Many people died because of this virus due to lack of medicinal facilities. It infects our respiratory system causing difficulty in breathing. Incase if a patient suffers from respiratory failure mechanical ventilators are needed. A ventilator is a medical device used for the breathing process.

Ventilators are needed to treat influenza and corona virus and people in Intensive Care Units (ICU). Before Covid times, people used them only in ICU, but after the heavy spread of Corona, demand for ventilators increased.Ventilator helps in pumping air into the lungs. People infected with Coronavirus need a ventilator because they have difficulty in breathing, or they do not have sufficient oxygen levels. Whereas due to the heavy spread of Corona there is a shortage of ventilators. There is a lack of ventilators for many medical units. Then came the necessity for the invention of artificial mechanical ventilators. After designing them, these models are distributed and, on the web, so that others can also use it and design their own ventilator, even at the small scale.

In recent months, the demand for ventilators to treat Covid-19 patients hassurged and there is currently a global shortage of ventilators. The outcomesof this flaw are devastating, especially in underprivileged areas. Even a well-resourced hospital has developed a protocol for two patients to share the same ventilator. This is a questionable practice since it not only spreadsthe load of bacteria and viruses among patients, but it also puts patients at risk of damage. Researchers have initiated an endeavor to manufacture cost effective open-source ventilators to combat the global shortage of ventilators.

A. Objective

A ventilator is a machine that provides mechanical ventilation by moving breathable air into and out of the lungs, to deliver breath to a patient who is physically unable to breathe or breathing insufficiently. With the current times, we need a safe and inexpensive alternative to handle a respiratory emergency.

The main objective of our system is to design a simple and inexpensive ventilator. It is an alternative to a hand-operated plastic pouch called a bag- valve resuscitator, or AMBU bag. Every hospital has in its inventory in large quantities. It is a hand-on device that means to be operated by hand, by a medical professional or emergency technician. It is to provide continuous breaths to a patient in situations like cardiac arrest until an intervention such as a ventilator becomes available.

The pumping of air into the lung is done by squeezing and releasing the flexible pouch. This is the task of a skilled person, trained in how to evaluatethe patient, and adjust the timing and pressure of the pumping accordingly. Since this is not something that a person could be expected to do for an extended period. However, it is crucial for such a system not to damage the bag and to be controllable so that the amount of air and pressure being delivered can be tailored to the patient.

In this paper, we will design and develop an IoT-based ventilator system. Itdelivers air to breathe by compressing a conventional AMBU bag with the help of a fixed arm connected to a servo motor. Tidal volume and number of breaths per minute are set via user-friendly input modes. It regulates the temperature, and the input pressure can be customized according to the real- time requirements of the patient. The safety mode initiates the backup mechanism without any delay. A built-in alerts system warns during an emergency. This system will improve the quality of life by saving time and resources.

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B. Motivation

IoT based ventilator provides a continuous breathing process to the patient whose lung capacity has decreased to a point where inhalation and exhalationis not possible on their own. In normal situations, a ventilator is considered asa last alternative for saving a person's life but when the covid-19 hit the globe,the demand for ventilators increased drastically as the virus decreased the lungcapacity of an infected person.

With the integration of IoT, the ventilator will be able to send real-time data of the vital levels of the patient to the doctor. Covid-19 pandemic made us realize that ventilators are far more important than we think. Most of the patients who lost their lives during the pandemic were due to the unavailability of a ventilator. So, this situation has motivated us in developing a system where we need a budget-friendly, portable, and easy to make system.

Because Covid-19 attacks the respiratory system and causes breathing difficulties that ultimately result in mortality, we have chosen this specific system to help combat this global catastrophe. Mechanical ventilation systems are considered as basic systems of life. By enabling remote ventilator control, this technology attempts to create a physical barrier between medical personnel and patients, thereby limiting the spread of this illness.

The history of mechanical ventilation begins with various versions of what was eventually called the iron lung, a form of non-invasive negative-pressure ventilator widely used during the polio epidemics of the twentieth century after the introduction of the "Drinker respirator" in 1928. Most recently, Covid-19 saw a widespread that it has been categorized as a pandemic, and India is the second most affected county in the world. The Covid-19pandemic has cast a spotlight on ventilators but is in acute shortage mainly due to the cost of it. Not everyone can afford it. So, this motivated us to develop the artificial mechanical ventilator.

II. Literature Review

[1] proposed a system in August 2020 which can be monitored anytime and all the data can be stored at a cloud. Also, this system can be used at the entrance of various shops, marts, clinics to monitor customers' health conditions and store their records. The result shows that the proposed system can be more efficient than the normal manualsystem.

[3] proposed a numerical method for monitoring the patient's pulmonary condition. The method considers pressure measurements from the inspiratory limb and alerts physicians in real-time whether the patient is in a healthy or unhealthy situation. Experiments are carried out in the laboratory that have emulated healthy and unhealthy patients to determine the benefits of the mechanical ventilator.

[5] this paper displays the research where it shows the development of a low-cost, open- source mechanical ventilator. Constructing a low-cost, open-source mechanical ventilator aims to mitigate the consequences of this shortage on those regions.

[7] discussed about the Covid-19 global health emergency to accept suggestions for using robots to boost ventilator productivity. Based on what was summarized from the analysis of the academic literature to arrive at the fundamental designs for the manufacture of ventilators that were already investigated, and the practical specifics required, they discussed ventilators at the beginning of this literature review.

III. Implementation

In this system, we are developing an automatic system to monitor patient's body temperature, and blood oxygen levels. Further we extend the existing system to Predict if the patient is suffering from any chronic disorder or Disease using the various health parameter and various other Symptoms that are obtained by the system. A general ventilator just controls oxygen, we monitor oxygen, heart beats, temperature, humidity etc. Then they can be all sent to cloud and then doctor will monitor patient remotely.

In our system we are measuring patient's parameters (temperature, oxygen level concentration in blood) using different available sensors. These sensors collected data i.e., biometric information is given to Arduino and then it is transferred to server. The data stored in a database and can be displayed in a website that can be accessed only by authorized person. The doctors, RMOs, patient or his family members can be given authorization. The system even facilitates the doctor to view the patient's previous history from the data in memory.

A. Block Diagram

The block diagram of the system is shown in figure 1. It consists of an Arduino microcontroller connected with a power supply. The main component of the ventilator is the DC motor. The DC motor is connected to a mechanical arm which will inflate and deflate the AMBU bag. It is used to pump air in and out to a patient who has lost the capacity to breathe on their own. The Arduino is connected to 2 sensors, namely DHT11 temperature sensor, MAX30100 SpO2 sensor. These sensorscollect the readings from the finger of the human body and these values are processed by the Arduino board which further displays them on the LCD module. If the oxygen saturation level falls below 95% and the temperature level falls below 36.5°C, then the microcontroller first activates the buzzer alarm to indicate caution and instructs the dual motor driver to rotate which further rotates the arm fixed to it making the AMBU bag expand & contract so that the oxygen is sent to the mouthpiece of the human being. Apart from this, Arduino is also connected to ESP8266 Wi-Fi module which is used to send the data received from the sensors to the ThingSpeak website.

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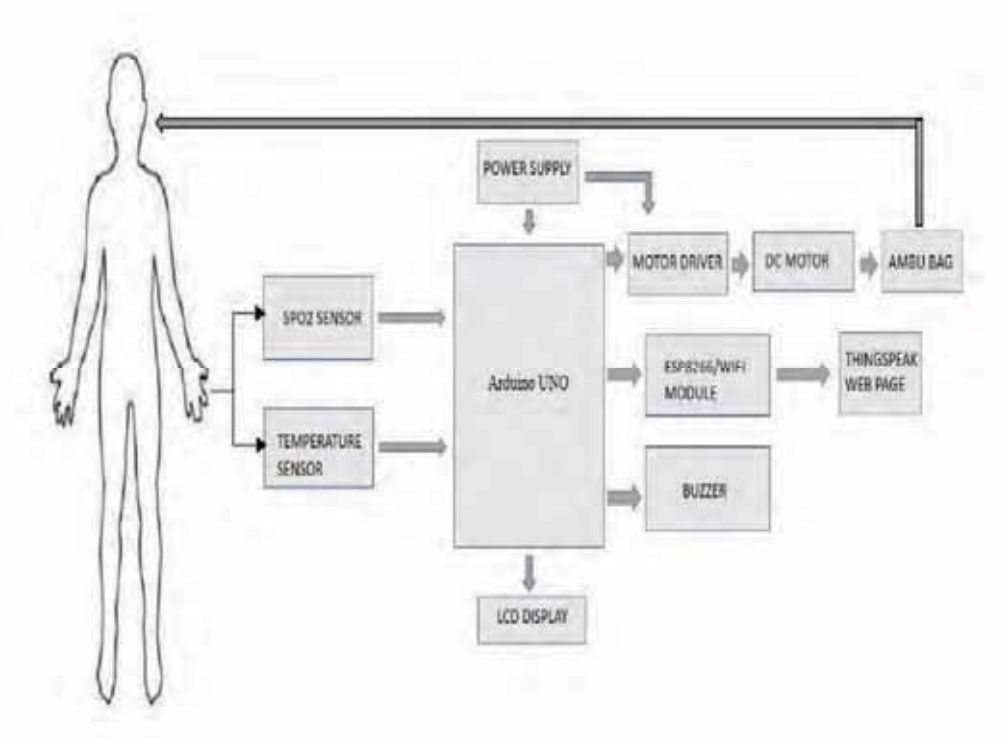

Figure 1. Block diagram of the System

B. Schematic Diagram

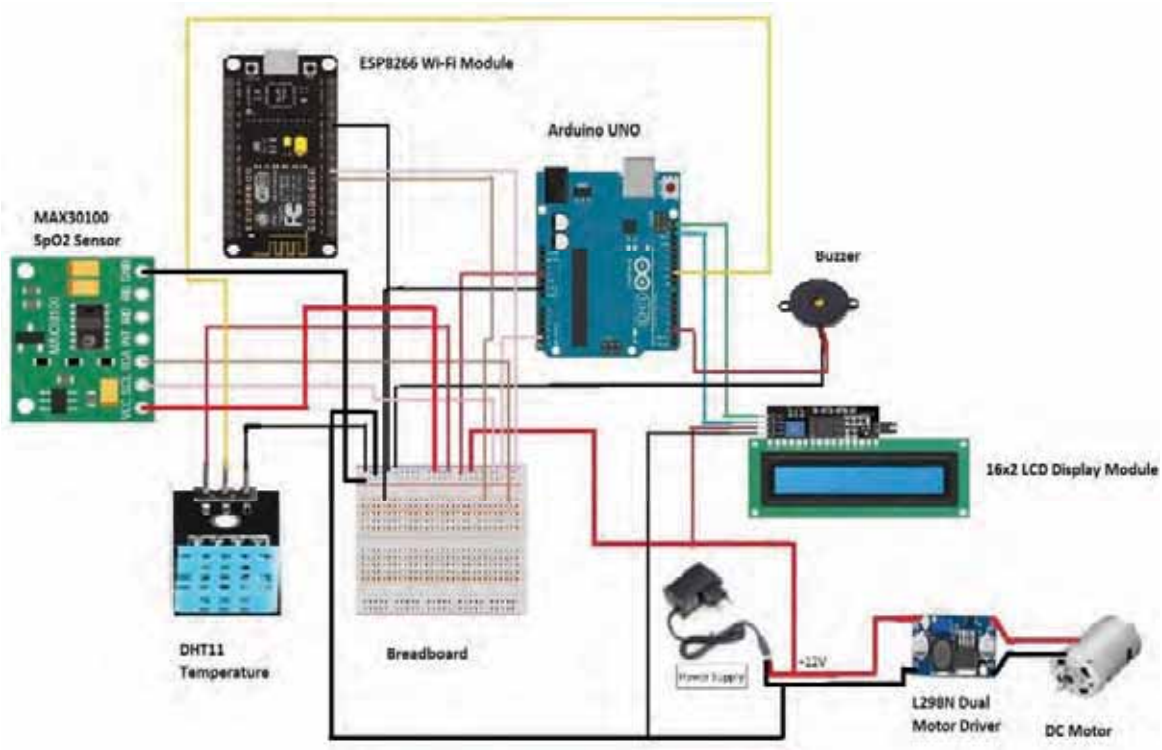

Figure 2. Schematic diagram of the System

The schematic diagram of the system is shown in figure 2. The first and foremost thing is the power supply. Power supply is given tothe kit through a 2A adapter i.e., usually 12 volts. The adapter is plugged into the socket, and the pin is fitted into Arduino board so that it receives power supply. The same 12V power supply is divided to L298N

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dual motor driver through printed circuit board. 5V and GND connections are taken from Arduino through jumper wires, and they are fixed on the breadboard for all other sensors & components to be provided with a reference. MAX30100 Sensor, Serial clock, serial data pins are connected to A4, A5 pins of Arduino respectively and 5V, GND pins are connected to Arduino through bread board. DHT11 Sensor, VCC, GND, 5V are connected to the Arduino consisting of the same pins through the bread board. ESP8266 Wi-Fi Module, GPIO02, GPIO03, GND pins are connected to A2, A3, GND pins of the Arduino respectively.

The power supply for LCD is taken from the 5V, GND pins of Arduino through breadboard and LCD is interfaced to Arduino with I2C serial adapter by connecting the SDA, SCL pins to A0, A1 pins of the Arduino respectively. The 5V and GND pins of DC motor are connected to the output pins of motor driver. The 5V, GND pins of buzzer are connected to the same 5V, GND pins of Arduino respectively through the bread board.

C. Flow Chart

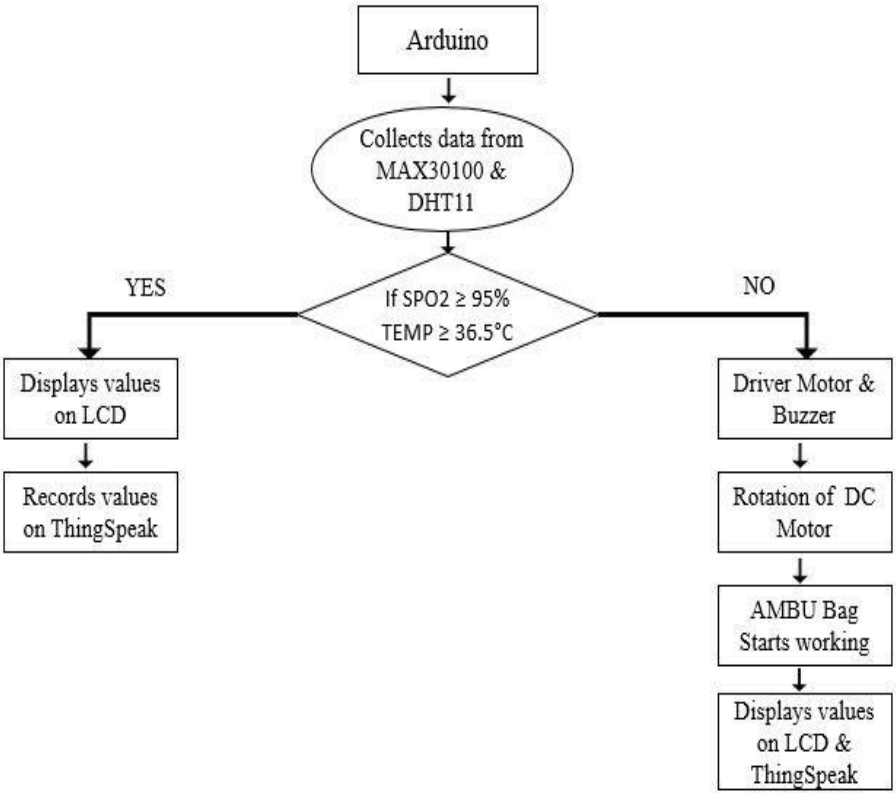

Figure 3. Flow chart of the system

IV. Results

The hardware setup of the system is shown in figure 4. The AMBU bag connected to the ventilator is the most important part of the ventilator. Air from the AMBU bag will be inhaled and exhaled by the patient.A mechanical arm controlled by high-speed DC Motor will inflate and deflatethe AMBU bag with its force. This DC motor will be controlled by the ArduinoUno board. The respected values will be displayed on the 16x2 LCD display.AMBU bag will consist of a mask that will fit the patient's nasal part for inhalation and exhalation.

Our system will be an easy to use, efficient and cost-friendly alternative to theones in use. This can be used separately or with the ventilator depending uponthe need and emergency.

Finally, the important aspect of this system is the integration of data obtained from the hardware with the software part. Connectivity between the ESP 8266 Wi-Fi module and cloud server using authentication tokens and libraries. As a result, the doctor will receive notifications about the health of the patient, be it a ventilator or health monitoring system on his/her PC/phone via the website.The website will have separate logins for patients and doctors and will be connected in the backend by a database. The AMBU bag along with motor and arm, the complete set of the ventilator is shown in figure 5 and 6 respectively.

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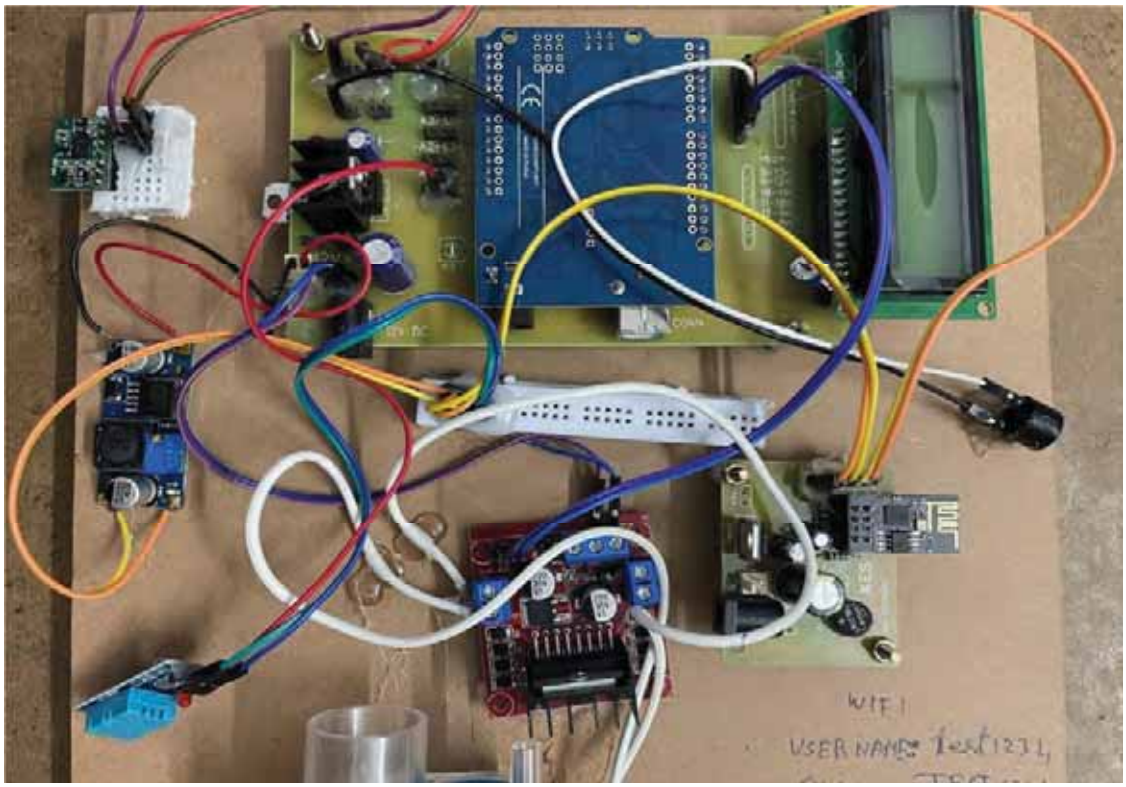

Figure 4. Hardware Setup of the system

Figure 5. AMBU Bag along with motor and arm

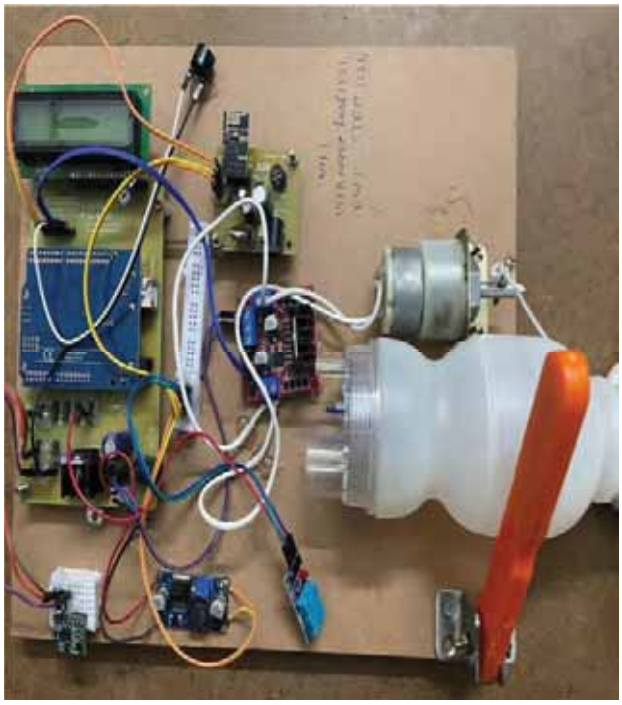

Figure 6. Complete Set-up of Ventilator

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V. Conclusions

In this proposed system, a prototype device to assist patients who can partiallybreathe on their own is developed. The motivation comes from the world-wide shortage of mechanical ventilators in the treatment of covid-19 patients. This device is provided with a very basic design and reliable structure that is easilyaccepted by the patient. The focus in this model is to minimize the components and increase its efficiency, so that while using this device to the patient, they should feel as comfortable as the normal ventilator. The biggest advantage ofour system is that it includes a health monitoring system where it measures body temperature, heart rate, oxygen level in blood. Through IoT it ensures the patient is under control and adequate action can be taken. Thus, during pandemics doctors can monitor patients via online in real time.

The future enhancement of the proposed system is, the IoT based ventilator can be embedded with PWM controlling system with the main control chip using ESP32. The use of ESP32 chip aims to control IoTbased ventilator with Bluetooth communication so that distance can be maintained. In addition to the IoT based monitoring and controlling functions.The ventilator can also be adjusted with several control buttons provided nearthe system. An alternator power source can be embedded so that when powergoes down the back up battery automatically kicks in.

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