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FABRICATION OF LOW COST IOT BASED BAG VALVE MASK OPERATING VENTILATOR

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Abstract

The number of reported instances of COVID-19 around the world skyrocketed a few years ago, the need for ventilators has skyrocketed as well. Lack of access to ventilators has claimed many lives over the past several years all across the world. Ventilators have been shown to be effective in reducing the risk of lung damage caused by inadequate oxygen supply and allowing for a sufficient infusion of oxygen-rich air. The current ventilators are both costly and hard to come by. The typical weight of about 7 to 8 kilograms (kg), making them cumbersome to transport due to their bulk dimensions. Our project's ultimate goal is to create an IoT-enabled, microcontroller-based smart ventilator system (IOT). The smart ventilator will be small and lightweight, making it easy to transport and use without any training. The high-torque motor we use allows us to adjust the pressure as needed. The LCD screen is kept up-to-date with the most recent readings from the temperature and pulse oximetry sensors.

I. Introduction

Prior to the pandemic, ventilators were mostly utilized on patients with critical lung support needs or other lung-related health conditions in a small number of countries. During the pandemic, this situation was drastically altered because to the extensive use of ventilators in the treatment of COVID-19. Patients infected with this fatal virus received subpar care due to a lack of ventilators. As this worldwide scarcity has impacted healthcare facilities, the death rate has risen by more than 25%. The medical industry has reported shortages of vital equipment in the wake of the worldwide setback caused by the coronavirus pandemic. Most people infected with COVID-19 are at a critical stage of sickness and require respiratory care due to the virus's devastating effects on their lungs. When a patient is experiencing problems breathing, ventilators can be used to force oxygen-rich air into their lungs.

Because of the problem with hospital beds, it is our duty as manufacturers to address the issue by creating a low-cost, portable ventilator that requires nothing in the way of training to use. The proposed portable, low-cost ventilator is relatively easy to operate and can do many of the same tasks as a standard ventilator. By facilitating prompt treatment, this tool lessens the likelihood of the patient experiencing respiratory distress. We help alleviate the problem of a lack of ventilators by producing new models at lower cost than the ones currently on the market. The development of a lightweight, affordable, and dependable low-cost ventilator that could replace cumbersome, expensive ventilators in hospitals [4].

There has been talk of prototyping a wooden ventilator with motors for use in underdeveloped healthcare facilities [5]. The authors of A Low-Cost Ventilator for the Use of Patients Suffering with COVID-19 [6] explore the development and validation of low-cost, portable ventilators that can be made in a short amount of time and distributed widely. When compared to current options, this uni mode uninterrupted, mandatory ventilator offers increased security and productivity.

The system configuration and implementation strategies for this cheaply made Ventilator are discussed in [7]. The technology has undergone extensive testing with ventilator testers and is

currently being developed into a product for use in low-resource settings. The suggested control framework [8] discusses the use of a highly scalable Internet of Things (IoT) based mechanical ventilator called NeT-Vent with adaptive control to lower the risk of Pulmonary Barotrauma in SARS-CoV-2 patients. Using an accelerometer and RFID technology, a fall detection system can keep tabs on the elderly and do interior and outdoor tracking utilising an embedded system and thresholds [9].

Prototype model of an electric appliance control tool via SMS by using GSM is proposed in [14], which makes use of a GSM module and an Arduino to do so. The GSM standard was chosen because it operates independently of the hardware in mobile phones. The transfer module is controlled by an Arduino and a GSM SIM 900. The smart mobile devices and the regularly used powerful hardware and beneficial functions are discussed in [15], which addresses a wireless gadget that can measure blood pressure with the help of a smart device. When the trial results were compared to the estimates obtained using a sphygmomanometer, it was demonstrated that the novel device had an average accuracy of 93.52% in weak persons and 94.53% in healthy people.

Short Message Service (SMS-based) smart house framework development using inexpensive and open-source components is discussed in an automated home based on the wireless microcontrollers [23]. The Arduino microcontroller, SIM800l GSM module, electric transfer, and several other fundamental electronic components are all included here. The improvement tenet of "object-oriented analysis and design" (OOAD) was adopted for the study. It has been proposed to create a portable CPR and Ventilation device that functions similarly to the human respiratory system [24]. In this study, we present the research and design behind a portable high-frequency ventilator for clinical use, one that can keep a patient breathing even if their natural respiratory system breaks down [27]. There has been talk of a low-cost ambu-bag based ventilator that uses a mechanical motor and a screen to display the patient's vitals in real-time [10].

Figure 1: Bag Valve Mask

II. Methodology

The MAX30100 sensor for pulse oximetry and a pressure sensor for measuring airway pressure will be used in the device's development. A high-torque motor will generate variable pressure, and an LCD panel will present sensor readings in real time.

The microcontroller was programmed using the Arduino IDE; this was done for both the Arduino Uno and the NodeMCU. Device code was written in C++ and included MAX30100 and pressure sensor library code.

The MAX30100 sensor was calibrated with an off-the-shelf pulse oximeter. The MAX30100 sensor was calibrated using the patient's pulse oximeter measurements, after being placed on the patient's finger. Using the pressure gauge's measurements, the device's pressure sensor was adjusted for accuracy.

Our invention is based on the wiper motor principle, and its optimal functioning and increased precision necessitate the use of a belt that moves in a synchronous fashion. In this case, the silicon ventilator bag is propelled by DC motors via a belt arrangement. The patient's breathing rate and heart rate can be customised using a toggle switch and a rotary pot. Our device employs a blood oxygen sensor and a sensitive pressure sensor to track the patient's vitals and present them on a small

screen. Also, the system is equipped with an emergency buzzer alert that will sound if something goes wrong. To accomplish its goals and aid patients during the COVID pandemic and other emergency scenarios, the entire system is driven by a node controller. A battery operates both of the major motors. The healthcare provider must enter data into the system by hand.

Advantages

- Because of its small size and light weight, the gadget can be easily transported to and used even in outlying places.
- The device's intuitive design and lack of technical requirements make it ideal for usage by non-specialist healthcare personnel.
- The gadget provides continuous monitoring of a patient's vitals, including pulse oximetry and blood pressure, to guarantee that they are receiving the correct level of ventilation at all times.
- Pressure settings can be adjusted to meet the needs of individual patients thanks to the device's high-torque motor.
- The device's Internet of Things (IoT) connectivity enables remote monitoring and control, cutting down on the requirement for onsite checks and balances.

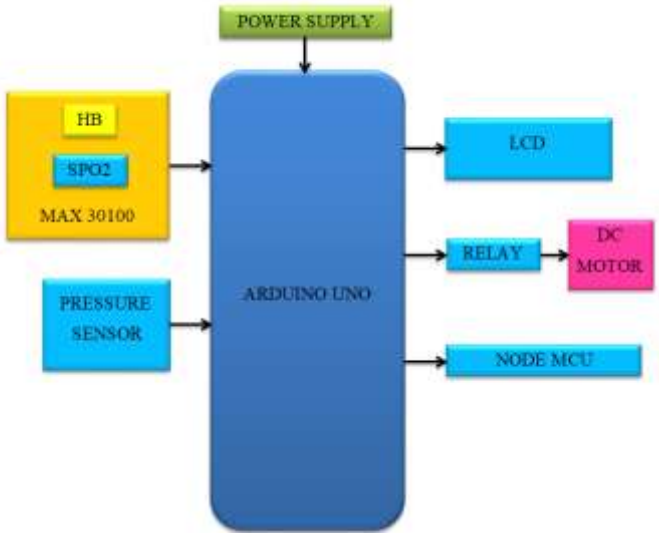

Figure 2: Block diagram

III. System Description

A. Arduino Uno

The ATmega328P is the foundation of the Arduino Uno, a free and open-source microcontroller board. Its simplicity, flexibility, and ease of use have made it a popular choice for the creation of electronic projects. The board's many input/output pins allow it to interface with a wide variety of sensors, actuators, and other electrical devices. The Arduino Integrated Development Environment (IDE) is a user-friendly coding environment that can be used to code the board by anyone, from novices to seasoned pros.

When compared to other microcontroller boards, the Arduino Uno has many benefits:

Hardware and software for the Arduino Uno platform are both open source, making them freely accessible to the public for the purposes of modification and customization.

To get started with programming, all you need is an internet connection and the Arduino IDE, which is a simple and user-friendly environment.

B. Node MCU

Using the ESP8266 WiFi module as its foundation, NodeMCU is a free and open-source development board. It's a suitable platform for Internet of Things (IoT) applications due to its similarity to Arduino in terms of functionality and its built-in WiFi connectivity. There is a wide variety of sensors, actuators, and other electronic components that can be connected to NodeMCU via its many input/output pins.

Here are a few of NodeMCU's many benefits:

NodeMCU has built-in WiFi connectivity, making it a great platform for creating Internet of Things projects that rely on wireless networking.

The Lua programming language, which is used to create the code for NodeMCU, is a simple and lightweight language.

C. Max30100

Based on the MAX30100 microprocessor, the Max30100 is a pulse oximeter and heart rate sensor. The MAX30100 is a comprehensive solution for pulse oximetry and heart rate sensors in wearable and medical devices.

These capabilities are available on the MAX30100 module:

Measurement of Blood Oxygen Saturation (SpO2) Levels without Invasive Procedures: The percentage of hemoglobin in the blood that is fully saturated with oxygen can be calculated using this method.

It is able to detect the pulsating nature of blood and use that information to calculate the user's heart rate.

High-intensity red and infrared LEDs are used to shine through the skin and measure the amount of light absorbed by the blood, and these LEDs are integrated into the device.

D. Relay

Electrical relays are switches that allow a low-power signal to regulate a high-power circuit. A little electrical signal can regulate a huge electrical load by means of an electromagnet that manually switches a set of contacts.

IV. System Implementation

A. Software for Arduino Boards - Arduino IDE

Programming Arduino boards can be done with the help of the Arduino IDE. It works with a wide variety of OSes and allows for both manual and automatic setup procedures. The Arduino website hosts the ide.exe file, which can be downloaded for use. The Arduino board can be connected to a computer when the Arduino Software Development Environment (IDE) has been installed. Data analysis tools like the Serial monitor and Serial Plotter are incorporated right into the Arduino IDE.

B. IoT Framework: Blynk App

You may control your Arduino, Raspberry Pi, or NodeMCU devices from afar using the Blynk app on your iOS or Android mobile. By assembling and delivering the required addresses on the accessible widgets, this programme enables users to create a graphical interface or Human Machine Interface (HMI).

V. Results and Discussion

The proposed technology may help solve problems with ventilator accessibility and pricing. It is portable and lightweight so that it can be used in a variety of medical situations. Patients in

respiratory distress will have better access to effective ventilation thanks to this device, lowering the likelihood that their lungs may suffer damage from a lack of air. The device's inexpensive price makes it a potentially useful alternative in areas with limited access to ventilators.

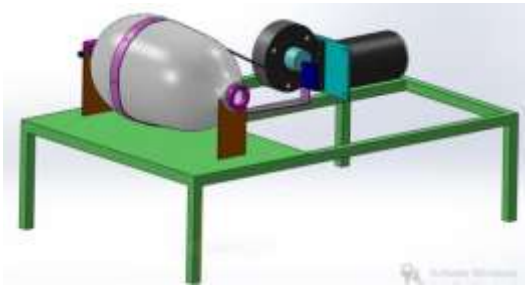

Figure 3: Low Cost IoT Based Bag Valve Mask Operating Ventilator

There are a number of benefits to using an Internet of Things–based bag valve mask operating device instead of a conventional ventilator. To begin with, it is portable and lightweight, allowing for application in a variety of medical settings. In places with few resources and a shortage of medical supplies, this function is crucial. Second, the device's low price makes it an attractive option for solving issues with ventilator accessibility and affordability. Third, the device needs nothing in the way of training for healthcare professionals to begin using it effectively.

One of the greatest benefits of this gadget is that it can track the patient's oxygen levels and airway pressure in real time. By letting doctors tweak ventilation settings as needed, this system lessens the likelihood that a patient may suffer lung damage from insufficient airflow. Adjustable airway pressure, which is crucial for effectively ventilating patients in respiratory distress, is made possible by the device's high-torque motor.

However, the gadget has a few restrictions. To begin, this gadget is not meant to change the function of a regular ventilator. Its intended use is as a stopgap measure when regular ventilators are unavailable, such as during an emergency. Second, patients in acute respiratory distress or those with complex medical issues may not benefit as much from the device. Last but not least, more testing and validation are required before the device may be widely employed in clinical settings.

To sum up, the Internet of Things-based bag valve mask operating device shows promise as a means of resolving issues related to the accessibility and affordability of ventilators. It's a great option for places with limited resources because of its portability, affordability, and simplicity of usage. Before the device can be widely implemented in clinical settings, its efficacy and safety must be verified through more development and testing.

VI. Conclusion

We conclude that ventilation is a crucial process and that a Bag valve mask based mechanical ventilator can be a reliable alternative to standard ventilators in the event of an emergency based on our in-depth analysis of various automatic bag valve mask operating devices for low-cost mechanical ventilators. Although there are many mechanical ventilators that provide similar output to that of a standard mechanical ventilator and also fulfil the requirement which is stated in Medical norms stated by the Ministry of Health and Family Welfare and HLL Life Care Ltd., this Automatic ambu bag operating device for low cost ventilator can still provide a basic level of medical assistance to a patient. Low-cost, portable, and user-friendly ventilator systems that can produce their own oxygen from ambient air and provide patients with basic medical support are feasible.

VII. Future scope

The ventilator system may be monitored and controlled from afar thanks to the Internet of Things technology embedded in the device. This is especially helpful in areas where medical

personnel are few yet where resources are limited. The application of AI and ML algorithms may one day allow for even more automation and optimisation of the ventilator's functioning.

Smart Sensors: New developments in sensor technology may allow for the creation of smart sensors that deliver more precise and dependable readings of vital factors like oxygen levels, airflow, and pressure. Better patient outcomes may result from finer-grained regulation of the ventilator system.

With the use of wireless communication, lightweight and portable ventilator devices might be created for usage in a wider variety of locations, such as ambulances and outlying clinics. More effective data transfer and real-time monitoring of the ventilator's operation may also be possible with the help of wireless communication.

Connectivity to Other Systems: The Internet of Things ventilator system can be linked to other medical systems, such as telemedicine portals, EHRs, and wearables. The treatment and monitoring of patients might become more streamlined and effective as a result.

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