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Smart Portable Ventilator for Covid19 Patients

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Abstract— **On March 11 2020, the WHO designates a coronavirus disease 2019 a global pandemic. Hospitals and medical facilities now require a greater number of ventilators due to the new respiratory infection-causing virus known as COVID-19. The situation like Covid-19 not only India, the whole world is facing the shortage of ventilator. India may witness massive third wave of Covid-19, warns IMA. Here is an immediate need to Create and build a cheap portable ventilator for on-site usage by patients. This project proposes the creation of a low- cost portable ventilator that provides a breathing mechanism for a patient who is physically unable to do. The proposed Ventilator uses the Microcontroller and an OLED display to monitor the patient BPM rate and pulse wave according to the specific input of the patient. The Ventilator delivers air by using blower motor drive mechanism. This gadget may be utilised in ambulances, medical facilities, and isolated areas that are challenging to access. The user or a professional can change the primary parameters of the installed device. In this project, a portable, restricted ventilator will be designed to act as a patient's breathing system if they are literally incapable of doing so themselves.**

Index Terms— **Artificial respiration, Covid -19 Low-cost portable ventilator, pandemic, microcontroller.**

I. Introduction

The worldwide medical community currently faces a critical shortage of Ventilator to address the COVID-19 pandemic. With an exponential growth rate, COVID-19 has become a global world pandemic [1]. The virus causes little or no symptoms in most people, but it can potentially causeinfected people to develop a fast progressing and deadly pneumonia. Mechanical or artificial ventilators are a life- saving remedy for the patients with acute respiratory failure. India have approximately nineteen lakh hospitals, ninety-five thousand ICU beds and forty-eight thousand ventilators only but the population of India is approximately 135.26 crores which indicates that there is a huge shortage of Ventilator. Existing ventilators have a number of drawbacks, including the capacity to easily hyperventilate patients and a limited ability to assess tidal volumes, as well as stomach bloating, aspiration, and the danger of barotrauma. The cost of ventilator in India is more than 1.5 lakh which is very expensive and an obvious one of the reasons for not having sufficient quantity of ventilators in every hospital. In intensive care units, mechanical ventilators have a sophisticated design using pressurized air to provide optimumlung ventilation [8]. The ambulance must be equipped with proper ventilation equipment that is acceptable in terms of size, external power requirement, and average gas consumption while transporting patients who require respiratory support. Portable ventilators are small and light, with the purpose of providing mechanical ventilation depending on user-defined parameters. Artificial ventilation systems are a critical part of helping patients breathe better. Because it directly impacts pulmonary gas exchange, these devices must configure the ventilator's settings to meet the

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patient's specific situation. Ghafoor and his team produced a cheap transportable wood ventilator that is 6 kg. Utilizing a pressurized mask with a bag valve, it takes breaths. The system utilizes a keyboard to manipulate two settings (pressure and the required number of breaths per minute). A system with several variables and stochastic interactions and unexpected responses to modifications, the ventilation system as a whole. As a result, obtaining an accurate mathematical model is extremely challenging. Most ventilators employ confined control methods including PID, reactive, and optimal controllers [9]. To change the set-pointsor controller settings, these controllers use a mathematical model. For example, fuzzy reasoning controllers and expertise did not rely on the ventilator's prediction model. They came to the conclusion that this method would promotegas exchange and give the patient enough breathing. The closed-loop feedback regulation of artificial breathing while under general anesthesia has been improved using a fuzzy approach. This control system changes the ventilator frequency (f) and tidal volume automatically to maintain the end-tidal carbon dioxide fraction (CO_2) at the set level (VT).They discovered that maintaining a target CO_2 level while under anesthesia is safe and reliable with fuzzy-based ventilators control. The primary goal of this study is to provide a solution to tackle the shortage of ventilators by designing the low-cost portable ventilators. This low-cost portable ventilator is a cost-effective and dependable equipment that may be used to replace a large and costly hospital ventilator.

II. RELATED WORKS

The development of an inexpensive, simple-to- manufacture, serviceable, and rapidly scaled invasive mechanical ventilator is now a major global technical challenge. In general, mechanical ventilation controls how much air and other gases flow into a patient's lungs and at what pressure. The manner of breathing is represented by via artificial ventilation of the lungs (ALV). The respiratory aid allows a gas to flow via a breathing system. ALV is given to individuals with severe respiratory system injury for either short- or long-term assistance. ALV is associated with possible dangers and consequences, which must be understood in order to achieve appropriate therapeutic outcomes. According to a study published in 2013, about 1.5 million people in the United States receive ALV each year [12]. As stated in [15] individuals getting ventilation during severe illness had a 31-37 percent fatality rate. The decision to employ ALV is influenced by a number of circumstances and should be carefully considered. The main factors are the assessment of oxygenation, ventilation, pulmonary mechanics, and the condition of the ill person. However, assessing the patient's historical health as well as the patient's alleged progress is crucial. Rather than only evaluating the border values of tangible indicators, this idea appears to be more appropriate. Because each patient is different and their conditions might vary, the patient's lung mechanics should inform the appropriate ALV. It's worth noting that current mechanical ventilators have gone through at least five generations in the previous 40 years. First- generation ventilators had uncalibrated dials, just one mode of ventilation, rudimentary electrical or pneumatic control circuits, and no warnings. The second generation of devices had several ventilation modes, basic alarms, and straightforward analogue electrical or fluidic control circuits. In third generation machines, digital electronics (microprocessors) are employed for both control and operator interaction. Utilizing computerised operator interfaces to the fullest extent, fourth generation ventilators (CRT and LCD displays). Waveform monitoring, computed lung mechanics, and whole system diagnostics were made possible by advances in software. In order to provide a "global machine" that can ventilate newborn, adolescent, and grownup patients, the current fifth-generation mechanical ventilator uses a "virtual instrument" operator interface design in conjunction with more potent control software. The electronics architecture appears to have reached a point of stability, and updates are currently limited to control software and display improvements. One of the most serious consequences of the COVID-19 pandemic is the worldwide lack of ventilators, particularly for those with severe sickness. There aren't enough of them to match the enormous increase in demand worldwide, despite the fact that they are essential for maintaining COVID-19 sufferers' lives. Around the world, many individuals are attempting to design and produce an emergency ventilator that might be portable and simple to use. These easily built, locally sourced devices have the potential to save many lives. The scientific community has focused on this topic due to the lack of an appropriate ventilator design in many places, notably in developing countries. While the bag-valve-mask (BVM) system is still often employed in emergency settings, mouth to mouth and mouth to nose are two mechanical breathing techniques. The use of this portable ventilator becomes important when the number of high-level ventilators accessible in a hospital is more than the number of critically ill patients. The authors of [8] created a micro controllable mechanical ventilator that is based on the BVM. Using the CAM principle, the arm moves the ambu bag. The system may be used in a number of modes, including child, pediatric, and adult modes. [7] Talks about an open-source mechanical ventilator that is low-cost. The notion was sparked by a worldwide lack of mechanical ventilators for COVID-19 treatment. This solution uses a Raspberry Pi-based device to push an ambu bag. In the ventilator, a pressure sensor is employed to monitor a maximum pressure of 70 cmH20. Another low-cost portable mechanical ventilator is described in [12], which is based on a compressed BVM with a rotating CAM arm. Arduino is used to control the ventilator. In the prototype, the user was in charge of the residual volume and breathing rate. The current system will provide the needed motion for the arm movement to sustain air flow with a regulated volume and pressure rate using an Arduino uno based clockwise motor drive. The ventilator works by compressing the Ambu bag, also known as a bag that self- inflates or a manual technician, with the use of a motor drive system, which allows it to operate without the need for a person. The existing ventilator equipment can support 500- 600ml tidal volume and can function continuously for several days. It can also deliver 12 respiratory rates per minute (RR/min), which may supply the appropriate quantity of tidal volume for pneumonia patients.

Based on the literature reviews, most of the mechanical ventilators are fixed, bulky and expensive. Thus, all these issues were eradicated by using this portable ventilator which measure and monitor the patient input and delivers the air according to the patient condition.

III. PROPOSED APPROACH

The prototype of a portable low-cost ventilator model is proposed in this paper. With the help of this device, artificial breathing might be possible. The primary goal of this project is to create a portable ventilator that is affordable essential for oxygenating patients who cannot breathe on their own and to tackle the solution for shortage of ventilator in pandemic situation. The system mainly consists of ESP32 microcontroller, blower motor, driver, Max30100 pulse oximetry sensor, Humidity sensor and gas sensor and accelerometer sensor. For an artificial ventilator the ventilator requires the patient BPM rate and pulse oximetry rate according to that amount of air is supplied to the patient.so that max30100 sensor is connected to the Esp32 MCU. When patient finger is touching the max30100 sensor their BPM and pulse rate is monitored and it can be displayed in OLED Display. Both the max30100 and OLED Display is connected to the same pin in microcontroller. Accelerometer sensor is also connected to the max30100 and microcontroller to monitor the patient position of Physical state. Because this project is considered as an IOT based, when patient in critical stage this sensor sense and monitor the patient movement and report to the specialist or an operator. Here, Atmosphere oxygen is supplied to the patient to breathe the air, so Air gas sensor is also connected to the Microcontroller, it senses the oxygen level in the atmosphere.

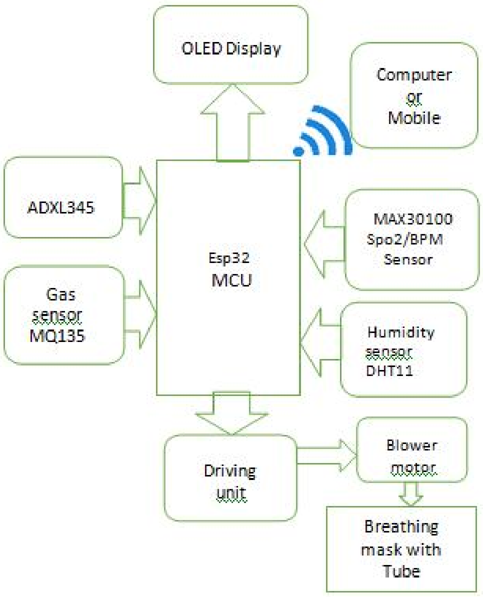

Figure 1. Block Diagram of Portable Ventilator

Blower motor is connected to the flyover diode with transistor and the buzzer. When switch on the power supply the blower motor rotates and inlet the atmosphere oxygen. The blower motor is attached with the tube and mask for supplying oxygen to the patient. When patient inlet the air through the mask the buzzer rang the alarm and they outlet the air the buzzer stops the alarm. The Buzzer sounds goes higher according to the patient inlet oxygen level is high and slow vice versa. Along with this, a buck converter is connected to step down the DC-DC voltage from power supply to the components.

IV. HARDWARE COMPONENETS

A. ESP32 Microcontroller

Dual-mode Bluetooth and built-in Wi-Fi are features of a series of restricted, low-power system-on-a-chip microcontrollers known as the ESP32. The major benefit of utilising ESP32 is that it can connect to other systems through its SPI/SDIO or I2C/UART interfaces to enable wifi and Bluetooth capability. In this ventilator system Wi-Fi and Bluetooth functionality is given through I2C / UART interfaces. In this system both MAX30100 sensor and OLED display connected to same pin D21 and D22. The Best part of this project is that you can connect this device to a mobile or computer which will upload data for both pulse rate and BPM on a regular basis. As data are uploaded to servers, anybody may view the data from anywhere in the globe.database.

B. MAX30100

The MAX30100 is a sensor that combines pulse oximetry with a heart rate monitor. It calculates the BPM and SPO2 levels. The I2C bus is used by the MAX30100 Oximeter Sensor. As a result, connect the oximeter modules' I2C pins (SCL&SDA) to the ESP32's GPIO 22 and GPIO 21 pins. Connect the INT pin to the GPIO 19 pin on the Node MCU, power the VCC pin with 3.3 volts, and ground the GND pin. The MAX30100 uses two LEDs, a photodetecor, better optics, low-noise analogue signal processing, and pulse oximetry and heart rate signals to identify them. Two LEDs are present in the device, one of which generates red light and the other infrared light. The only light needed to calculate pulse rate is infrared light. Red and infrared light are used to test the blood's oxygen content. The more blood that is pumped by the heart means that there is more oxygen-rich blood in the blood. When the heart relaxes, less blood is infused with oxygen. The pulse rate is calculated as the time between the rise and fall of oxygenated blood. Deoxygenated blood transmits more infrared light in comparison to oxygenated blood, which absorbs red light and transmits more infrared light. This is what the MAX30100's principal function is. It reads both light sources' absorption levels and stores them in a buffer that may be accessed through I2C.

C. Blower mototr

A blower motor is a part of the HVAC system of a home. In this ventilator system we supply atmosphere oxygen for the patients to breath. Blower motor is used to inlet the atmosphere air and it be supply to the patient. It is attached with breathing mask with tube through its oxygen is supplied. It is also attached with Buzzer. When patient inlet the oxygen the buzzer rang the alarm. Blower motor is connected to the flyover diode with transistor and the buzzer. When switch on the power supply the blower motor rotates and inlet the atmosphere oxygen. When patient inlet the air through the mask the buzzer rang the alarm and outlet of the air the buzzer stops the alarm. The Buzzer sounds higher according to the patient oxygen level whether it is high or slow vice versa.

D.MQ135

It senses the atmosphere's presence or concentration of gases. In this system it is used to sense the concentration of atmosphere oxygen level. Connect the MQ135 Vcc pin to the 5V of the ESP32 board And the ground pin of the MQ135 to the ESP32 ground. And Analog pin of the MQ135 to the A0 pin of the ESP32 via a 1K resistor. It also be monitor and display in the OLED display.

E. DHT11

Use either SI Electrical devices called humidity sensors are used to measure and record the humidity and air temperature in a given space. The DHT11 is a straightforward, incredibly cheap digital temperature and moisture sensor. It is used to determine the temperature and humidity of a room. If the patient is within the room. As a result, we'll need to keep track of the room temperature and humidity. To maintain a pleasant temperature in a room by maintaining a specific temperature and moisture level. So DHT11 Temperature & Humidity sensor is used.

F.ADXL345

Having a high resolution (13-bit), 3-axis accelerometer, the ADXL345 is a compact, thin, ultralow power device up to 16 g of measurement. Anybody or object's acceleration in its immediate rest frame is measured. The I2C bus is used with the ADXL345 sensor. Connect the ESP32's GPIO 22 and GPIO 21 pins to the accelerometer modules'

I2C pins (SCL and SDA). The ADXL345's GND pin has to be connected to one of the ESP32 development board's GND pins in order to read accelerometer information from that board. Connecting the 3v3 pin of the ADXL345 to a 3v3 pin on the ESP32 development board. So that we can monitor the patient Physical state.

G.MP1584 DC-DC

The Buck converter is a common DC-DC converter that effectively and quickly converts a high voltage to a low voltage. Efficiency in power conversion extends battery life, lowers heat generation, and enables the creation of more compact gadgets. The integrated components in this system get 3.3 v and 5 v from a 12-volt DC source.

H.OLED Display

Organic Light Emitting Diode, or OLED. A device that generates light in response to an electric current passing through an emissive electroluminescent layer is referred to as an organic light-emitting diode (OLED or organic LED), also known as an organic electroluminescent (organic EL) diode. Digital displays on televisions, computer monitors, portable phones, and handheld gaming consoles are made with OLEDs. The development of white OLED components for use in solid-state lighting systems is a significant field of study. The I2C bus is used by the OLED Display. So, connect the oximeter modules' I2C pins (SCL&SDA) to the ESP32's GPIO 22 and GPIO 21 pins. Connect the INT pin to the Node MCU GPIO 19 pin, then power the VCC and GND pins with volts. For connecting the OLED display to the ESP32, there are several libraries available. SSD library from the tool and OLED interface in Arduino IDE software.

V. Results And Discussion

The prototype of a low-cost portable ventilator designed to provide a cost-effective solution for assisting patients with their breathing. It achieves this by utilizing a common bag valve mask to deliver breaths to the patient, reducing the dependency on human assistance. This approach aims to make ventilation more accessible and affordable, particularly in resource-constrained settings. One important aspect of the portable ventilator is its support system, which plays a critical role in facilitating the patients' breathing. The settings and parameters of the ventilator directly impact pulmonary gas exchange, which is essential for maintaining adequate oxygenation and carbon dioxide removal in the patient's lungs. Additionally, this prototype incorporates an alert mode to indicate instances of over-compression within the system. This feature ensures the safety and well-being of the patient by alerting healthcare providers to potential issues related to excessive pressure during ventilation.

Figure 2. Portable Ventilator

V. Conclusion

COVID-19 situation involves us to create atransportable ventilator that will act as a patient's breathing device if they are physically unable to breath. Several methods have been implemented to ensure proper therapy, including routine temperature, humidity, air quality, and patient posture monitoring, SpO2, and pulse rate. On the other hand, a COVID-19 patient's oxygen level declinesover time, and if prompt treatment is not taken, the patient could pass away rather fast. An IOT-based smart healthmonitoring system was developed for COVID-19 patients The system is controlled by a mobile IOT application, and during crises, both the patient and the doctor can receive notifications from this system. This device can be used by people with COVID-19 and many other infections, including as asthma and chronic obstructive pulmonary disease (COPD). In conclusion, this technology is crucial forthe medical field since it has the potential to extend people's lives all around the world. In future by adding oxygen gas cylinder, breathing mask with tube, the device can be act as a portable ventilator and the technology might be improved to track chronic obstructive pulmonary disease and cardiac resuscitation in real time.

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