Affordable Ventilator with Variable BPM and Oximeter

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Abstract: *This project considers a low-cost ventilator that is based on a manual resuscitator bag (Ambu bag) to pump air into the lung of a patient who is physically unable to breathe. To maintain the pressure of oxygen level to improve the patients breathing by regulating the flow of oxygen in the lungs as an intensive therapy. A contradictory motion is used by a ventilator to inflate the lungs by pumping type motion. The ventilator functions while not a human operator because it delivers breaths through the compression of an associate degree orthodox bag-valve mask. It satisfies its energy wants from an electrical motor having a battery power of three to twelve volts DC. Different functions got to be performed for the aim of ventilation i.e. pressure and needed range of breaths per minute are managed by a simple-to-use input board comprising of buttons. Adjust the time duration for inhalation to exhalation ratio. The low-cost ventilator design oxygen sensor and pressure sensor controlled by the microcontroller. This project work on a mechanical method to provide oxygen to the patient. This project gives comfortable treatment to the patient, and monitors and controls the pressure of oxygen level ,Pulse rate and also the Temperature using sensors. The sensors data is displayed on LCD Module.*

Keywords: — Ventilator bag, Oxygen sensor, Servo Motor, ATmega328 Microcontroller, LCD Display

I. INTRODUCTION

A ventilator is a machine that provides mechanical ventilation by moving breathable air into and out of the lungs, to deliver breaths to a patient who is physically unable to breathe or breathing insufficiently.Modern ventilators are awfully expensive. These ventilators are so expensive that for a country of 1.3 billion people there were only 47,000 ventilators. The few of the ventilators that are available are working overtime and are very susceptible to malfunction.

Most of the government hospital have very low budget so they cannot be equipped with ventilator. They have a very high maintenance cost. These machines look very small but are very expensive. And if they are not maintained properly, they can be more of a death sentence than a life saver. This

IOT based portable Ventilator is a concept to realize the advancement in health monitoring system of human beings due to the COVID-19 pandemic, the medical facilities have been scares and are required by a lot of people. As we all are aware of COVID-19 causes respiratory distress due to which patients face difficulty in

breathing and because of which ventilators are used, which help them breath. This paper describes a prospective solution of low cost ventilators with a wireless monitoring feature. The goals and advantages of the prospective solution are: - Fight COVID-19 in countries with poor healthcare systems - Provide low-cost and low-resource ventilation devices - Help hospital staff to monitor operational functionality and parameters of ventilators with affordable and reliable Internet of Things (IoT) technology - Support Patient Management via User Interface - Compensate lower reliability of low-cost ventilators by supporting human supervision - Reduce the need for medical staff by monitoring several ventilation devices at the same time - Save Personal Protection Equipment (PPE) such as masks by reducing patient contact..

II. LITERATURE REVIEW

The COVID-19 pandemic has brought attention to the necessity of ventilators, yet their acute shortage persists primarily due to cost constraints. This scarcity is notably apparent in countries like India, where only 47,000 ventilators serve a population of 1.3 billion. In response, MIT has pioneered an open-source ventilator project, led by a diverse team of engineers, physicians, and computer scientists. Their objective is to develop a safe, cost-effective alternative for emergency use that can be rapidly deployed worldwide.

Central to this innovative approach is the utilization of a hand-operated plastic pouch termed a bag-valve resuscitator, or Ambu bag, abundantly available in hospitals. Traditionally employed by medical professionals to manually administer breaths during emergencies like cardiac arrest, the Ambu bag forms the foundation of MIT's ventilator alternative. A tube is inserted into the patient's airway, akin to conventional ventilators, while automated mechanisms developed by the MIT team regulate the pumping of air into the lungs, ensuring precise control over air volume and pressure.

The history of mechanical ventilation traces back to earlier iterations such as the iron lung, extensively utilized during 20th-century polio outbreaks. Advancements in noninvasive ventilators, including microprocessor-controlled models, have markedly enhanced patient care in intensive care units (ICUs). Despite these strides, the persistent shortage of ventilators contributes to preventable fatalities, particularly in rural regions. Ventilators play a vital role in managing respiratory disorders like pneumonia, a leading cause of mortality, notably among children under five in India.

Given the recent COVID-19 pandemic, ventilators have emerged as indispensable life-saving devices. India, among the hardest-hit countries, faces an urgent need for expanded ventilator availability to mitigate the pandemic's impact. Initiatives such as MIT's endeavor to develop affordable ventilator alternatives hold promise in saving numerous lives and addressing critical healthcare challenges posed by respiratory diseases globally.

III. BLOCK DIAGRAM

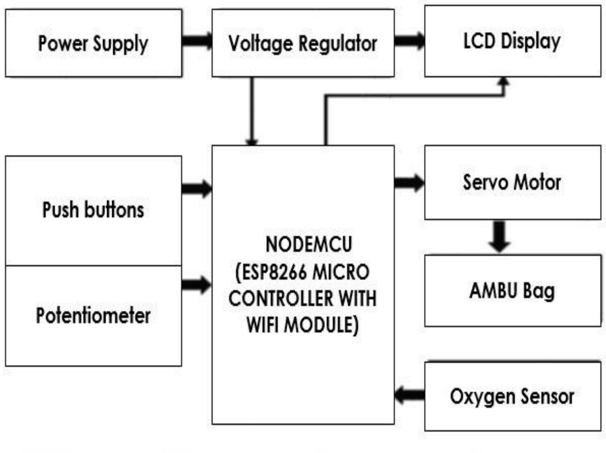

Fig.1: Block Diagram of the low-cost ventilator

IV. BLOCK DIAGRAM DESCRIPTION

A. Power Supply

The power supply consists of four stages namely transformer, rectifier, filter, and regulator. A transformer is a stepdown transformer taking an input voltage of 230V or 240V AC and giving an output voltage of 12V AC with a current rating of 500 mA. This 12V AC is rectified by a bridge rectifier consisting of four diodes, which converts the DC signal but some part of the AC signal is mixed with the output voltage, we have to use a capacitor to filter out the AC of the output signal. There are mainly three types of rectifiers Half wave, Full wave, and Bridge rectifier. Out of these three, we have used a bridge rectifier since it gives more efficiency. The regulator removes the entire ripple and gives pure DC.

B. Voltage Regulator

A voltage regulator is used after the filter capacitor to generate a constant DC voltage supply of 5V. We have used 7805 as a voltage regulator it is a three-pin IC which are namely input, ground, and output. We have to give an output of the filter capacitor to the input of the regulator, and we get 5V at the output pin of the regulator.

C. LCD Display

We are going to use a 20*4 alphanumeric Liquid Crystal Display (LCD) which means it can display alphabets along with numbers on 4 lines each containing 20 characters. It can be used to display the various options and all the readings that have been stored in the EEPROM. The LCD is an alphanumeric display which means that it can display Alphabets, Numbers, as well as special symbols thus LCD, is a user-friendly Display. It operates on a 4.7 v to 15 v power supply [14].

D. ATmega328 Microcontroller

The high-performance, low-power Atmel 8- bit AVR RISC-based microcontroller combines 32KB of programmable flash memory,2KB SRAM, IKB EEPROM. The device supports throughput of 16 MIPS at 16 MHz and operates between 4.7-5.3 volts. By executing instructions in a single clock cycle, the device achieves throughputs approaching I MIPS per MHz, balancing power consumption and processing speed[5]

E. Oxygen Sensor

The MAX30100 is an integrated pulse oximeter and heart rate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximeter and heart-rate signals. It operates on 1.8 v to 3.3 v but we supply this sensor to 3.3 v because IR_LED operates on 3.3 v and senses the signal. This oxygen sensor has 14 pins, in this 7 pins are built and 7 pins connect the output device to get the result on display [10].

F. Switch/Pushbuttons

A Push Button switch is a type of switch that consists of a simple electric mechanism or air switch mechanism to turn something on or off. Depending on the model they could operate with momentary or latching action functions. The button itself is usually constructed of a strong durable material such as metal or plastic. Pushbuttons we use to operate high-voltage operating devices and also to on or off [14].

G. Servo Motor

Servos have three wires coming out of them. Out of which two will be used for Supply (positive and negative) and one will be used for the signal that is to be sent from the MCU. An MG995 Metal Gear Servo Motor. Operating voltage is 4.8 v to 7.2 v. Revolution per minute 180 degree.

H. AMBU Bag

This is an Ambulatory Manual Breathing Unit bag, which means if you bring this device you go outside of the city or village it will operate in an emergency. It consists of a self- inflating bag, a one-way valve, a mask, and an oxygen reservoir. When we switch the motor it rotating then the mechanical rod pushes the Ambu bag. When the mechanical rod pushes the Ambu bag then air comes outside and oxygen is reserved in the reservoir bag. In this device, we provide 100% oxygen to the patient using an oxygen tube this tubeinlet only oxygen from the air to the reservoir bag and reserves it. This Ambu bag has various sizes to requirements of patients like 240 ml, 500 ml, and 1600 ml bag sizes for infants, children, and adults. This device help in emergency time to breathe patient [1-3].

I. Toggle/Potentiometer

This device is operates and adjusts the input signal to the output signal. This adjustable or Variable resistor is PCB mountable and has 3 terminals. The voltage between the terminal varies as the preset is rotated. The Variable resistors are used for variable voltage as per the need in the circuit. The device operates low voltage also high voltage to adjust how much output they need [14]..

J. NodeMCU ESP8266 Microcontroller

The NodeMCU ESP8266 is a low-cost, high- performance microcontroller with built-in Wi-Fi capabilities, making it ideal for Internet of Things (IoT) applications. The core of the NodeMCU is the ESP8266 Wi-Fi SoC (System on Chip) from Espressif Systems, which integrates a Tensilica L106 32-bit RISC processor, offering up to 160 MHz clock speed.

By combining robust processing capabilities with integrated Wi-Fi, the NodeMCU ESP8266 microcontroller offers a versatile solution for IoT projects, enabling the development of smart devices and automation systems with minimal effort and cost.

V. METHODOLOGY

Mechanical ventilators need to manage (i) the respiratory frequency, (ii) the inspiration-to-expiration ratio for each respiratory cycle, and (iii) the volume of air supplied to the patient. The ventilator described in this paper directs the flow of air and oxygen through designated pathways to reach the patient's lungs. Numerous designs have received FDA Emergency Use Authorization (EUA), though many may not be broadly adopted. Our design is intended to be viable beyond the EUA phase, necessitating thoughtful consideration for its long-term functionality. An Arduino microcontroller is employed to control this device.

We performed a cost analysis on the transfer of patients from various ICUs to the CVDU between 1993 and 1998, establishing cost values for the same period. This analysis included evaluating the cost-effectiveness of transferring patients from high-cost ICUs to the lower-cost CVDU, as well as examining ventilator weaning and mortality rates

A comprehensive review of MEDLINE (January 1966- April 2007) and bibliographies of retrieved articles was conducted to identify observational interventional studies focused on the incidence, microbiology, outcomes, and prevention of ventilator-associated pneumonia (VAP) in ventilated adults in developing countries. We assessed VAP rates using National Healthcare Safety Network (NHSN)

Our ventilator system incorporates a passive valve breath ventilator and a high-efficiency particulate air (HEPA) filter, along with actuators and sensors for its operation. The system features two gas inlets: one for hospital-supplied oxygen and another for ambient air delivered via a blower assembly. It also includes a mixing tank with safety valves, pressure sensors, a humidity exchanger, filters, and standard inhalation and exhalation components. A versatile printed circuit board (PCB) was designed to integrate the necessary electronic components. Various boards are being developed for mechanical ventilators, equipped with electronic sensors to measure flow in the inhalation and expiratory lines, airway pressure, and oxygen levels delivered to the patient.

We utilized the net benefit regression approach to conduct a cost-effectiveness analysis comparing nasal oxygen and BCPAP interventions for treating neonates with respiratory difficulty, reporting outcomes using the incremental cost-effectiveness ratio (ICER) and incremental net benefit (INB).

To address the shortcomings of existing ventilator systems, we developed a straightforward and practical device suitable for emergency use. Our device uses two sensors: an oxygen sensor to measure and display oxygen levels on an LCD, and a pressure sensor to monitor the oxygen pressure delivered to the patient. The device is adaptable for both adults and children, ensuring appropriate BPM and BPL are provided. A PIC microcontroller is used to manage the entire circuit, reducing hardware requirements and overall cost. The device is programmed with embedded C language to ensure reliable operation. Additionally, we included a feature for remote monitoring of patient parameters using Blynk software on mobile devices, facilitated by the NodeMCU microcontroller with its built-in Wi-Fi module. This feature allows for remote data access and monitoring, significantly enhancing the utility and effectiveness of the ventilator in various settings..

VI. RESULT AND DISCUSSION

The creation of a low-cost ventilator using a manual resuscitator bag (Ambu bag) has effectively provided a practical solution for patients who are unable to breathe on their own. This ventilator successfully maintains appropriate oxygen pressure and regulates the flow of oxygen into the lungs via a controlled pumping mechanism. It functions autonomously without requiring constant human intervention by delivering breaths through the compression of a standard bag-valve mask, powered by a battery ranging from 3 to 12 volts DC. Essential functions such as pressure management and breath rate control are easily managed through a user friendly input board, which allows for adjustments in the inhalation to exhalation ratio. The incorporation of oxygen and pressure sensors, overseen by a microcontroller, ensures precise and reliable ventilator performance, providing consistent and effective patient care.

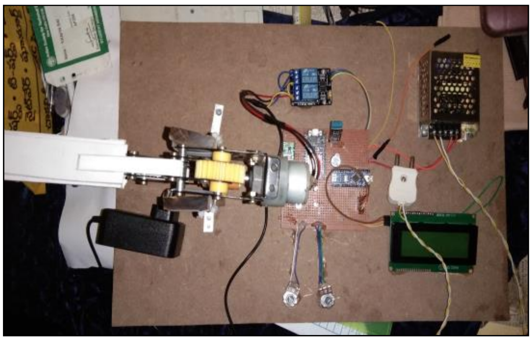

Fig hardware Kit

This project effectively tackles the need for affordable ventilators, especially in developing countries and during health emergencies like pandemics. By using a manual resuscitator bag, the project significantly lowers costs while utilizing commonly available medical supplies. The inclusion of an electric motor to automate the compression process ensures steady breath delivery, reducing the reliance on manual operation and minimizing the chance of human error. The battery-powered feature enhances the ventilator's portability, making it ideal for use in various healthcare environments, including emergency and field hospitals.

Fig LCD display

The simple input board allows healthcare providers to easily adjust critical parameters, accommodating different patient needs. The sensors offer real-time feedback for precise monitoring and control. While these accomplishments are significant, further refinement in mechanical durability, energy efficiency, and the range of adjustable parameters is necessary. Additionally, clinical trials are essential to thoroughly validate the ventilator's effectiveness and safety. In summary, this low-cost ventilator presents a promising solution for providing necessary respiratory support, improving healthcare accessibility and patient outcomes in underserved areas, with continued development required to fully realize its potential in critical care settings.

VII. CONCLUSION

We anticipate that this project will fulfill its intended purpose and save numerous lives. Designed to function as artificial lungs for individuals with respiratory issues, this project replicates the conditions of both healthy and unhealthy patients to demonstrate the potential benefits of the developed mechanical ventilator. The device is user friendly and does not require the oversight of medical specialists, making it suitable for home use and emergency situations.

The project includes a mechanism to determine the necessary oxygen levels for the patient, facilitating easy monitoring and control of oxygen pressure. The prototype is designed to aid patients who can partially breathe independently, featuring a straightforward and reliable structure that is well-tolerated by users. The primary goal of this project is to reduce the number of components while enhancing the device's efficiency, ensuring that patients experience comfort comparable to that of a standard ventilator.

Furthermore, we have incorporated a feature to monitor various patient parameters, such as pulse rate, oxygen levels, temperature, and humidity. Utilizing the NodeMCU ESP8266 microcontroller, we can collect and transmit this data to the Blynk app software. This integration allows for real-time monitoring and easy access to critical patient information, further enhancing the functionality and user friendliness of the device

Table No. 1 parameter conditions

Sr. No.	Age	Health Condition	SPO2(In MedicalDevice)
1	Child	Healthy	95-100
2	Adult	Healthy	95-100
3	Child-Adult	Unhealthy	< 90

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