

Implementation of low cost portable ventilator

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Abstract. This paper presents the implementation and prototype of low cost, portable ventilator for patients who are in a no resource places and no primary care environment. This can be achieved by a squeezing the bag valve mask (BVM) inflating and deflating the bag with respect to the servo motor with the help of mechanism. The system contains an assist-control mode are also included in the prototype. Future versions of the device will have a pressure relief valve, PEEP capabilities, and a customizable inspiration to expiration duration ratio. The cost of this prototype is determined very much less than the mass manufacturing units of ventilators. The idea of cam based bag compression is a efficient way to achieve low cost, high efficiency in this work to aid in the crisis conditions to assist the needy people who have suffocation, and using IoT Technology, we can monitor the patient's healthcare system through the specially made application to apply the required information about the patient's health state, with the help of this technology, a doctor can monitor the patient's health and giving treatments according to the information and based on the information, diagnosis will be given to the required patient.

1.Introduction

The usage of ventilators is used abundantly in the world of medical world. The awareness of ventilators has been in the people has been changed drastically after the COVID-19 pandemic. The requirement of ventilators is minimum before the pandemic and that has been gone to peak during the covid 19 situation. Before the pandemic situation, ventilators doesn't have been used extensively, but during the pandemic situation, the deadly virus directly gone to lungs of the individual and affected the whole body system, with the virus affects the lungs directly there is a trouble in natural breathing, there is trouble breathing happens in the lungs and within the specific amount of time and particular interval, the virus grows and makes the situation worse in respiration system. Thus, with respect to trouble breathing, the ventilators are used to eradicate that issue in medical industry. Due to lack of production and supply of required ventilators, the death rate has been gone to more than 20%, numerous developed countries are facing this issue in a priority basis but with no result death toll has been raised gradually. The situation are even worse in the under-developed and developing countries, due to mismatch between production and demand of ventilators are the major reason for mortality rates. The much shorter production and no prior operating knowledge should be tackled with the mass production and proper awareness to people to eradicate this issue. With the help of this prototype, we can operate this prototype in easy manner and efficient way to make the required treatment much more feasible and efficiently.

In under-developing and developing nations, illness in the respiratory system is more common public issue. Trouble breathing has been caused due to various reasons like asthma, chronic obstructive pulmonary disease and various other respiratory related diseases etc. smoke from the power stations, smoking and burning of coal are also aggregate to these problems respectively. Individuals with underlying lung illness are more likely to experience respiratory failure and can benefit from mechanical support. These are devices that mechanically help patients inhale and exhale, enabling what is known as artificial respiration—the exchange of oxygen and expiration of carbon-di-oxide and vice-versa to the lungs through the mask of bag valve mask.

The ventilators are used in the modern hospitals in the developed countries are highly functional and technologically more advance manner, but their purchasing prices are also highly expensive to purchase for required needs. Such technologically advanced mechanical are too expensive for usage in countries with limited resources due to high costs. Furthermore, these ventilators can become brittle and vulnerable with extended

usage, necessitating pricey service agreements with the manufacturer. This has resulted in activities like the inadequate amount of ventilators available in the hospitals and the purchase of equipment that is low dependable in under-developing and developing nations. Terrain and country-side has been given no-access for the required ventilators support isn't available in these regions.

In the industrialized world, where access to well-stocked medical facilities is widespread, the issue is of a different kind. While there are enough ventilators to be used on a regular basis, there is a lack of preparation for situations where there will be a lot of casualties, like pandemics of influenza, natural catastrophes, and large-scale releases of dangerous chemicals. Modern mechanical ventilators are prohibitively expensive to store and use in mass casualty situations, especially in industrialized nations. In a very worst case scenario, during the covid-19 pandemic availability of ventilators was very limited. The patients who doesn't afford a ventilators are being treated in their transport/out of the intensive care unit, they were forced to use the oxygen cylinder without the proper mechanical ventilator, due to lack of knowledge of operation of ventilation, that results in the loss of their lives. Due to these situations in mind, there is a necessity for the low cost portable ventilators has been raised and developed, their demand are also been raised and courtesy to high price of stocked ventilators available in the low numbers and high price.

2. Literature Survey

Authors in [1] analysed the low cost, gas-efficient ventilators which are tested in different rate settings. The prototype had been used for adults who have tidal volume ranges between 500-700ml. Authors of [2] described the ventilator prototype that had been used for compressing the bag valve mask with the roller chain mechanism with the computer aided design(CAD) and maximum cam shaft angle was enough to deliver the sufficient air volume at a 6-8 ml/kg. Authors of paper [4] designed a ventilator that could be used to supply oxygen at frequent intervals and it used fraction of oxygen of inhaled gas at an efficiency of atleast 0.42% higher than contemporary ventilator devices. [6] described the design called ServoU(Siemens Co) which had a magnitude of more than 118 components in its own structure thereby reducing the total cost of its contemporary devices to enhance the prototype of the ventilator. [7] presented a ventilator with low cost, automatic air delivery with alarm and PEEP(positive end expiratory pressure).It was also supported buzzer as well as the other safety practices. [8] described the Raspberry-Pi based system. An Arduino uno board was used to collect information from the pressure sensor, and send to the Pi, and Raspberry pi in turn send commands to the actuator.

3. Software Implementation

In this implementation of the software implementation, we can access the information from the internet which has been stored in the real time scenario of diagnosis of the patients individual, which is the effective and useful ways to diagnosis of the healthcare professional to analyse and give treatment in the basis of information from the application. Thus, the specially made application has been made as IOT Healthcare ventilator. The application works smoothly on android & IOT. The webpage which is designed to show the four important parameters to determine the human health condition. Thus, they are heart beat (72 beats/min is considered as normal, which either more/less are considered as abnormal state of condition), SpO2 level (which are above than 95 is considered as normal, which less than 90 which is considered as the abnormal condition), Temperature (which is used to sense the temperature of the atmosphere), pressure (which is given to patients in a specific amount which ranges from 5-30 pa).

An Web application titled as "IOT Healthcare Ventilator" is used to monitor. The values displayed in this application has been updated at a particular interval and updated values help the healthcare professional to give treatments in the real time case scenario. Application has received certain data from connecting the Node micro-controller unit, the WIFI module to show the data in page/app. The Node micro-controller unit and Arduino are inter-connected and connected via a set of user name and password to get the proper working of the application and in particular frequency.

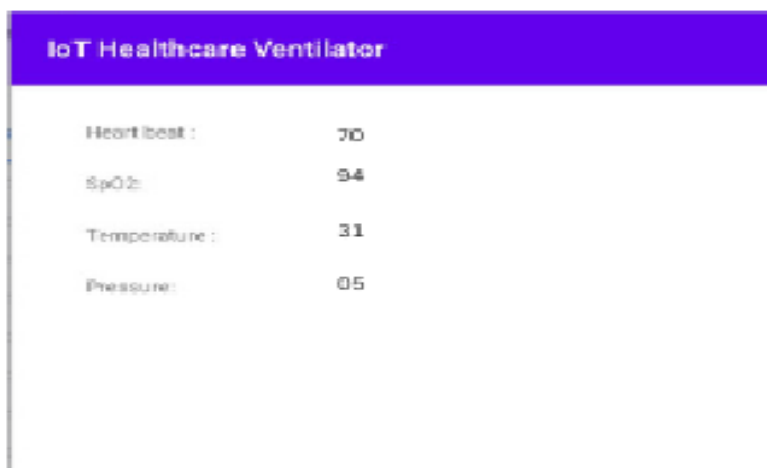


Fig.1 Picture of our IOT Application.

4. Specifications

Table 4.1 Specifications of ambu bag

Stroke Volumes	450ml
Patient weight	10-30kg
Total bag volume	635ml
Dimensions	1400x900ml
Oxygen reservoir volume	600ml

The bag valve mask is used in this prototype has an total stroke volume of 450 ml and has an dimensions of 14cm length and 9cm diameter. Thus, with a presence of oxygen tubing inlet and pressure valve and face mask with an oxygen reservoir bag has a total volume of 650 ml as alike respondents of the function of the lung.

5. Methodology

1.1 5.1 Traditional Ventilator system

The most important demerit of traditional ventilator system is to a healthcare professional/worker is to take the bag valve mask or ambu bag for a long time and compressing for a long time. Thus, after the particular interval of time, they were used to be tired to compress or squeeze the bag valve mask, it will lead to major risk to patient/individual which would lead to serious loss.

Limitations of Existing System:

- 1) When the existing system has the major demerit of misbalance happen between the supply and demand are happen in the disaster/pandemic/epidemic conditions.
- 2) Even with increased resource management, many countries are only able to meet the minimum of 30% admission rate, so, it will be the major reason for death of people due to poor health-care structure.

1.2 5.2 Proposed System

For the ventilator’s air delivery system, two choices are used. While one method sporadically supplies air using a steady pressure source, on the other hand, steadily deliver breaths by compression. The latter strategy was

chosen since it does not require a positive pressure source to be running constantly. This lowers the need for expensive, tricky-to-repair pneumatic components and lowers power consumption.

We have chosen to adapt the affordable bag valve mask in this prototype to enhance the performance of proposed system. Thus, without the existing technology, we are using the entirely different BVM to increase respiration to the required patient/individual.

Simple structure and straightforward design will help in mass production and thereby will make it available in the under-developing and developing nations. They satisfy the basic needs of the ventilator by presenting oxygen reservoir and full valve system.

1.3 5.3 Mechanism

Worm gear mechanism is made comprising of worm and wheel. The worm that has a screw which is readily attached to the wheel. When required input power given to the worm, it starts act against its counterpart wheel to rotate the action to its full extension ex. With an expansion of 180 degree, it will enhance the rotation in the form of 60 degree/rotation or full rotation based on the required resources. The internal friction between the worm and wheel has keeps the worm in rightful place. This mechanism used most widely in automobile industry and has given most accurate results than its counterpart mechanisms and provide the higher level of reduction of speed. Its gears are made to be used to gradually rising shaft torque or significantly in the reduction of speed. They are also the most sought and smoothest gear systems, provided they are fitted and lubricated properly. Worm gears, also referred to as worm drives, are a particular kind of gear composition. A screwworm engages a spur gear-like gear or wheel. The configuration gives the machine operator control over rotational speed. A greater force can also be transmitted thanks to the configuration.

6. Block Diagram

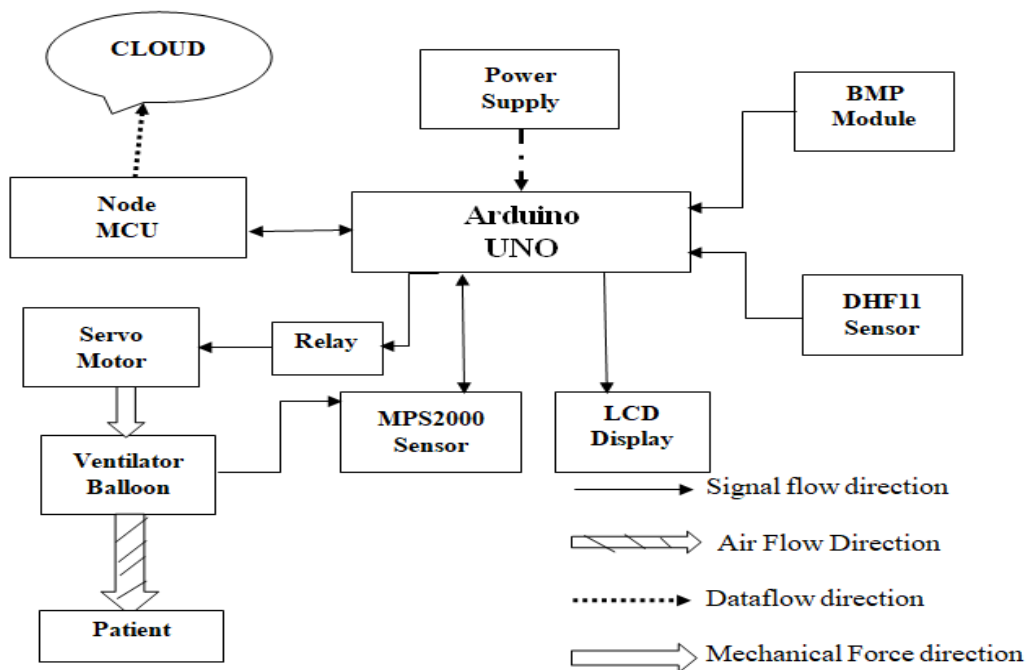


Fig 2 Block Diagram of ventilator

This proposed ventilator is made to give assured tidal volumes using the mode of assist-control mode other than the full ventilation mode. Operating personnel must choose the rightful tidal volumes for the patient/individual. For the tidal volume calculation, in medical terms they are calculating typically 5ml/kg in most cases to give proper ventilation. For the adults, we are assuming the 7ml/kg, to give proper ventilation to the required patient. This is entirely depends on the ideal body weight and minimum respiratory rate. When the troubled breathing

has been controlled the ventilator compression via the blood oxygen level, automatically stops its operation.

Within this assist control mode, the required individual/patient will get guaranteed ventilation for a minute to meet the minimum requirements for minute ventilation. Tachypneic or rapid-breathing patients run the risk of developing respiratory alkalosis, or who are having several respiratory illness has a risk of developing negative effects. Reduced respiration rate and, if necessary, sedation are typically used to treat these problems. The major part of clinical diseases is managed in this AC Mode, which is the one of most sought modes of ventilators. This, ventilator can be used as non-invasive mode of ventilator to ensure that no tubes/parts are injected to the body, that was conveyed through the mask, that is seek used for positive pressure.

7. Control Implementation

7.1 Controller

Our device will be controlled using a commercial Arduinoduemilanove microcontroller board. The microcontroller runs a set prescribed tidal volume to needed individual in an emergency manner. This controller has been controls the DC Servo motor to inflating and deflating the ambu bag which has a range of 450ml. It has been using to get the Minimum Pressure of 5 pa that has been prescribed by respiration specialists.

7.2 Motor

The MG995 Servo Motor has been selected for the prototype due to operating speed and shall torque. Ranges of above mentioned parameters are 0.20sec/60* at 5v and 0.16sec/60* at 6.6V. Torque has been ranging from 10-13 kg-cm. Despite the lower torque value measured in our experiment, we found that this motor did not provide quite enough torque to effectively drive the cam at the slower inhalation cycle rates prescribed to some patients. While a larger motor will be necessary to achieve better speed control, this motor function acceptably at the proof-of-concept phase.

7.3 Pressure Sensor

The MPS 2000 sensor used to sense the airflow pressure that's flowing the external valve of the bag valve mask. It is connected to the sensor port. Therefore, with the serial interface it sends the data's to the Arduino and then it is displayed in the LCD.

7.4 User Interface

The Four user inputs (pressure, SpO2, heart rate, Temperature) are made visible through the LCD Display made through with the help of Micro-controller. So, these have been a vital source of information for patients in sense of diagnosis. The 16x2 LCD Screen has been made to display all the required information to the user and a healthcare professional.

7.5 Relay

The 5V Relay is used to execute the operation of opening and closing which is done on the basis of determining of blood oxygen level. Based on particular oxygen level of individual/patient's data, it will either go on open or close the operation of operation.

7.6 Node MCU Unit

The Usage of Node MCU unit is deliver the information in the specially made application. It will enhance the treatment of patients in a needy way. With the help of this unit, a health care professional will go-through this information and give treatment accordingly to the information. The ESP8266 Wireless information module has been made interconnected with the Arduino. We can access the information via the required set of passwords and name in the specially made application.

8. Results and Discussions

The prototype developed has an assured minute compressions of 30 compressions per minute and for that compressions, it will give a required ventilation of up to 100ml. We are achieve in this pressure of the 5-10 pa. With the usage of CAM actuated compression of the BVM will provide necessary and assured breathing or ventilation in the very possible manner. Thus, by we are satisfying the tidal volume configuration to ensure the patients are getting the assured minute ventilation.

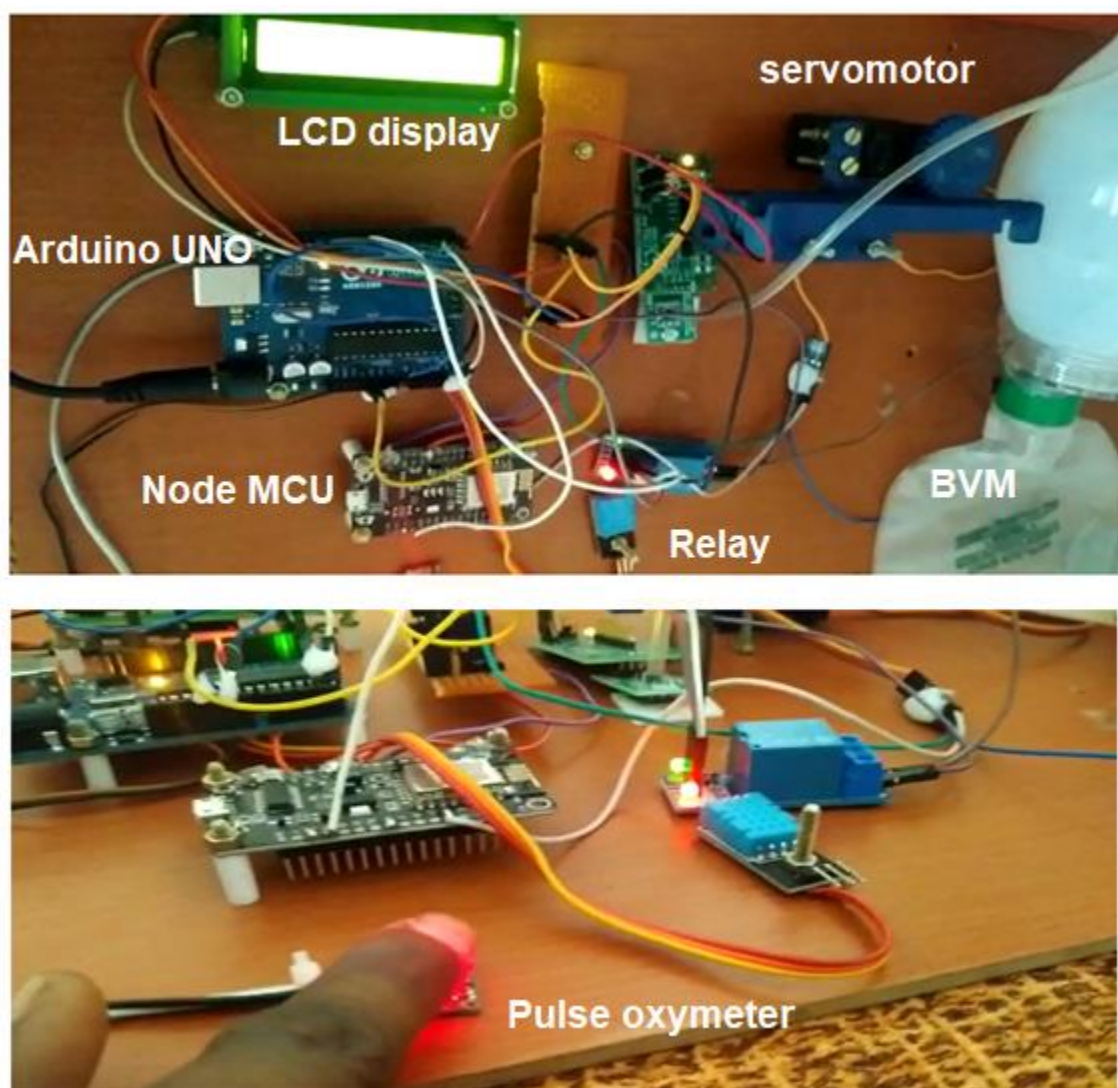


Fig 3 Hardware Implementation

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