Global Journal of Engineering and Technology Advances
eISSN: 2582-5003
Cross Ref DOI: 10.30574/gjeta
Journal homepage: https://gjeta.com/

(REVIEW ARTICLE)

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Design of IOT enabled robust control of an artificial ventilator

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Global Journal of Engineering and Technology Advances, 2023, 15(01), 019–022

Publication history: Received on 21 February 2023; revised on 07 April 2023; accepted on 10 April 2023

Article DOI: https://doi.org/10.30574/gjeta.2023.15.1.0064

Abstract

To breathe, the human lungs use the reverse pressure generated by the diaphragm's contraction motion to suck in air. A ventilator uses a contradictory motion to inflate the lungs via a pumping motion. A ventilator mechanism must be capable of delivering between 10 and 30 breaths per minute, with the ability to adjust rising increments in sets of two. In addition, the ventilator must be able to adjust the amount of air pushed into the lungs with each breath. The last but not least option is to change the time duration for the inhalation to exhalation ratio. Emergency situations aside from that, the ventilator must be able to monitor the patient's blood oxygen level and exhaled lung pressure in order to avoid complications. To adjust the time duration for inhalation, an option command given in the IoT application. The entire system is driven by PIC controller to achieve desired results and to assist patients.

Keywords: Contradictory Motion; Diaphragm; Exhalation; Inhalation; Ventilator

1. Introduction

The corona virus pandemic is a major public health emergency, with the World Health Organization (WHO) reporting over 1.3 million confirmed corona virus cases worldwide as of 15 July. According to WHO data, 80% of confirmed corona virus cases will be able to recover without hospitalisation. However, 1 in 6 patients may have significantly aggravated symptoms, causing lung damage and thus lowering oxygen levels in the body. In this regard, for patients suffering from severe infection symptoms, an artificial ventilator may offer the best chance of survival. [1,2] A DIY ventilator may not be as effective as a medical grade ventilator, but it can serve as a good substitute in the meantime.

1.1. Proposed Artificial Ventilator

Corona virus, a dangerous disease caused by a virus which got spread two years back, made our lives up and down. Many people died because of this virus due to lack of medicinal facilities. It infects our respiratory system also. It is very difficult to breathe. Incase if a patient suffers from respiratory failure mechanical ventilators are needed[3].

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 only people in intensive care units used ventilators but after a heavy spread of corona demand for ventilators increased. Ventilator helps in pumping air into the lungs. People with corona virus need a ventilator because they feel 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. This is not necessary. Some countries developed ventilators which are dangerous for human lives which are small in volume [5]. Yet this reliable and affordable DIY ventilator during Covid pandemic times. After designing this model 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.

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1.2. Existing System

A lack of ventilators is one of the most pressing shortages confronting hospitals during the COVID-19 emergency. These machines, which can keep patients breathing when they can no longer do so on their own, can cost around $30,000 each. Designing and developing a low-cost portable ventilator could be one way to help COVID-19 patients with pneumonia.

1.3. Proposed System

The proposed low-cost ventilator works by compressing a standard Bag Valve Mask (BVM) or Ambu bag with a pivoting motor drive mechanism, eliminating the need for a human operator. The proposed low-cost ventilator works by compressing a standard Bag Valve Mask (BVM) or Ambu bag with a pivoting motor drive mechanism, eliminating the need for a human operator. The machine should have invasive and non-invasive features, as well as a tidal volume of 500-600 mL and the ability to work continuously for several days. According to the calculation, 12 Respiratory rate (RR)/min can provide the necessary amount of tidal volume to the pneumonia patient. The strategy of automatic arm actuated BVM compression has been shown to be a viable option for achieving low-cost, low-power, and portable ventilator technology.

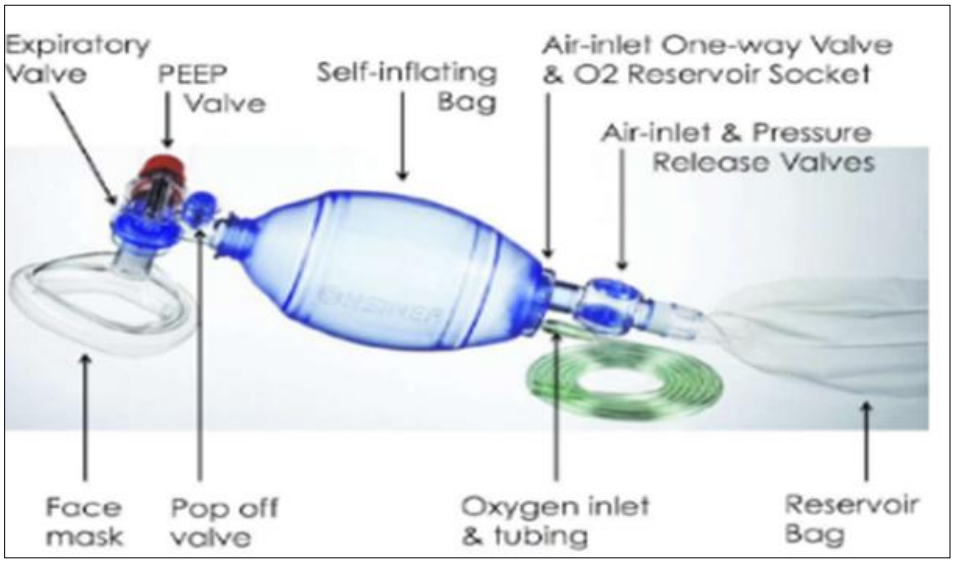

Figure 1 Bag Valve Mask (BVM) or Ambu Bag

An IoT-based motor drive with clockwise and anticlockwise rotation will provide the required motion for the arm movement to maintain an automatic air flow with a controlled pressure rate. Mechanical ventilation is only used in cases of pneumonia where this type of continuous ventilation machine can generate a plate pressure (P plat) for the lung. Among other things, the machine should support 500 mL tidal volume and work continuously [6]. According to the calculation, 12 Respiratory rate(RR)/min can provide the required amount of tidal volume to the pneumonia patient. Pressure, Volume, and Flow Control Curve Among other things, the machine should support 500 mL tidal volume and work continuously. 12 Respiratory rate (RR)/min.Control curve for pressure, volume, and flow. To breathe, the human lungs use the reverse pressure generated by the diaphragm's contraction motion to suck in air. A ventilator uses a contradictory motion to inflate the lungs via a pumping motion. A ventilator mechanism must be capable of delivering between 10 and 30 breaths per minute, with the ability to adjust rising increments in sets of two. In addition, the ventilator must be able to adjust the amount of air pushed into the lungs with each breath. The last but not least option is to change the time duration for the inhalation to exhalation ratio. Aside from that, the ventilator must be capable of monitoring the patient's blood oxygen level and exhaled carbon dioxide. To push the ventilator bag, we use a silicon ventilator bag coupled to a servo motor and a one-side push mechanism. Our system employs a blood oxygen sensor as well as a sensitive heart Beat sensor to monitor the patient's vitals and display them on a webpage via IoT [7, 8]. To change the duration of inhalation, use the option command in the IoT application. To achieve the desired results and to assist patients in COVID pandemic and other emergency situations, the entire system is driven by an Arduino controller.

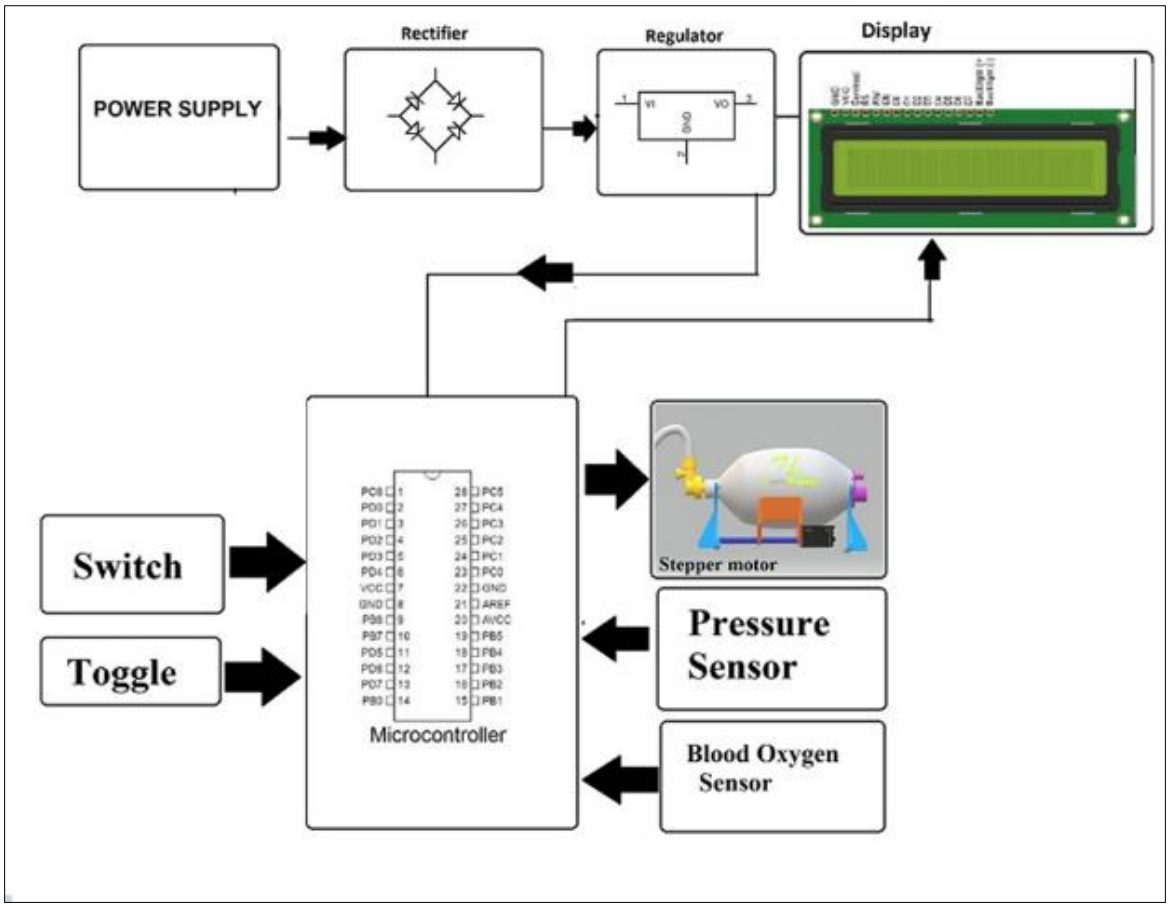

Figure 2 Proposed system Block Diagram

2. Results and Discussion

Designed and developed a prototype of automatic ventilator to support pneumonia cases for COVID-19 patients.

- It has a controlled breath rate of 12 RR/min and a tidal volume of 500-600 mL. It has assist control and maintains a consistent air flow to the lungs.
- It has a very low power requirement and can run for 3.5 hours on a single battery charge at its most demanding setting. Battery backup should also be checked.
- It is low-cost, portable, light-weight, and capable of running two DC motors at the same time. • Future development will include a pressure sensor, an air flow metre, an overpressure alarm, and other safety features to make it more user-friendly.

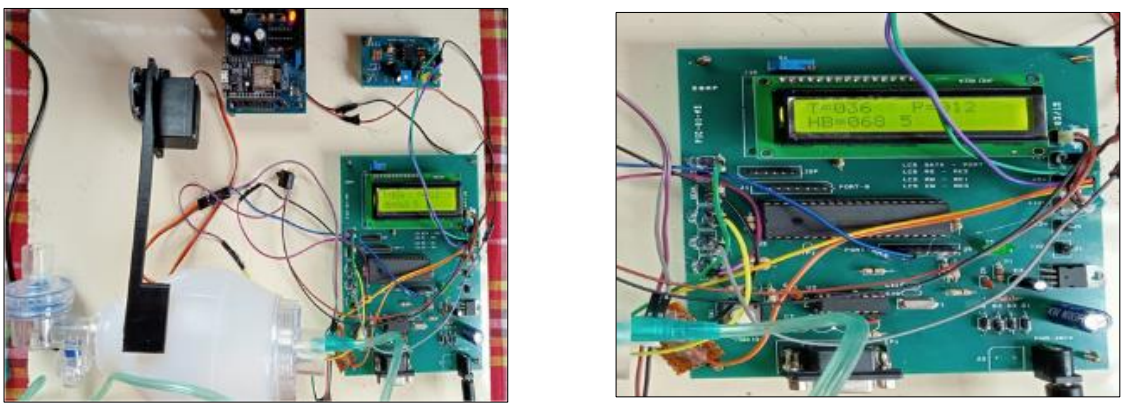

Figure 3 Developed prototype model

Figure 4 IOT interfacing method

3. Conclusion

In this project, a prototype device to assist the patients who can partially breathe by their own is developed. This device is provided with very basic design and reliable structure that is easily acceptable by the patient. Main focus in this project is to minimize the components and increase the efficiency of the device, so that while using this device to the patient, they should feel as comfortable as the normal ventilator. In this project needle valve is used along with the potentiometer for replacing the flow analyzer so that the entire setup is cost effective. Arduino UNO board is used because it is easy to program. This research has led to the development of lab model ventilator.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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