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IoT CONTROLLED PORTABLE VENTILATOR WITH DUAL OPERATION MECHANISM

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Abstract: This paper unfolds the design of a low cost portable IoT controlled electro-mechanical ventilator. The specialty of this system is we can provide artificial respiration for single or dual ways to the patients at a time through this single system. The designed system consist of a microprocessor which is the main part of our system, OLED screen, battery pack for power back up, pressure controller, I-E controller(Inspiration and expiration controller),alarm, stepper motor, motor driver, dual and single selection mode feature selection through mode selection mechanism**.**

Keywords **- Ventilator, breathing, Ambu bag, IoT, dual mechanism, portable, stepper motor.**

I. INTRODUCTION

The need of the low-cost ventilator design arises in the year 2019. In 2019 we seen a great disaster that happened in our world around, which kills many of the life and their dreams. And we call it as a name corona virus disease. Corona virus is acute respiratory syndrome which originates from a family of corona virus that ranges from the common cold to the MERS. The major problem that arises from this is shortness of breath. When it widely spread on the whole world pushes to get more ventilator to get the corona virus patients.

A ventilator research paper of Alvin et al[1], Anup et al[2], Jandre et al[3] proposes that ventilator is a machine which is designed to giving artificial breathing air into and out of lungs, to the patient who are not having the ability to breathe sufficiently. When a machine helps a patient to breath air it becomes the mechanical ventilator which was referred from Chatburn et al[4], Mushin et al[5], Backer et al[6] . In 1928 we use the Negative pressure ventilator (iron lungs). In this it applies the outside sub atmospheric pressure on to the chest to inflate the lungs and when a negative pressure removes it allows passive exhalation. The limitation of a non-negative ventilators is the patient's body was enclosed by an iron cylinder and then generated a negative pressure. This mechanism is restricted in the clinical practice, but they limit positioning and movements. Then this limitation is overcome by introducing positive ventilator by John Haven Emerson an American engineer.

The research work of Sykes et al[7], Ponn et al[8] leads to the problem of the negative ventilator is overcome by using the positive pressure ventilator which performs effectively for unloading the respiratory muscles. In positive pressure ventilator the air forcefully flows to the lungs by exerting the positive pressure on the alveoli. But it is compact and costly. The work of Bernstein et al[9], Chatburn et al[10] gave reference to the need of ventilator become worst, it effects very badly on the economic system and society.

So here introduced a model "IoT Controlled Portable Ventilator with Dual Operation Mechanism" for defeating such crisis and this will help us any situation that will comes in future. The main advantage of this system is we can give a dual and single selection mode features through the selection mode mechanism. And the other one is we can control the devices like pressure controller, Inspiration and expiration controller, air volume controller, motor torque in anywhere through mobile, pc, laptop etc with the help of internet of things.

The designed system consists of a microprocessor which is the controller part of our system. It controls the devices like I-E Controller (Inspiration and expiration controller), Pressure controller, and stepper motor. An OLED display is used in this system which is used to display various parameters like air pump pressure, air flow velocity etc. Then whole system is controlled by a DC power supply and it is protected by from the power failure by using Lithium polymer battery pack. The system also consists of an alarm system which is supposed to get an alert in case of power failure, low/high pressure in the Ambu bag and other abnormalities.

In Section II it explains how the process of inhalation and exhalation. Section III Modal establishment provides a detailed explanation of components used in the respiration system. Section IV explains the working principle of the designed model, the whole system is controlled by a processor and its functions.

II. RESPIRATION PROCESS

Respiration is the process of movement of the oxygen molecules from the outside environment to the inside body through nose and transport of carbon dioxide in the opposite direction.

There are two phases of Respiration process

1. Inhalation process
2. Exhalation process finance.

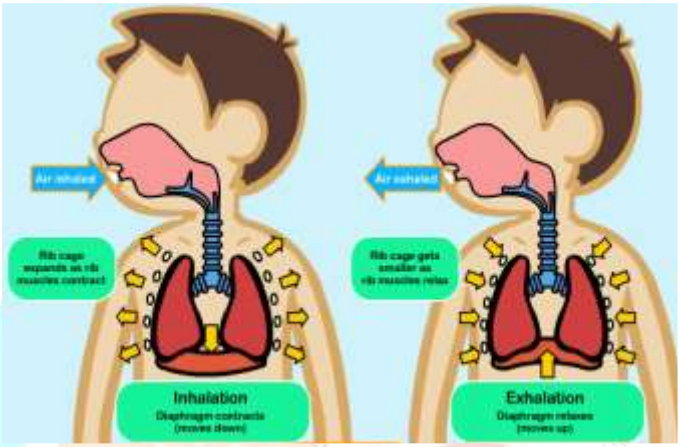

Fig.1 Respiration Process

Breathing is a part of respiration. The process that taken apart of respiration are Nasal cavity, pharynx, Larynx, Trachea, Bronchi, Lungs, Alveoli. The Nasal is the opening of nose, the nasal cavity is lined with cilia, mucus membrane and blood capillaries. The air is filtered by cilia moisture and by the mucous membranes and warmed by the blood. The warmed and clean air from the nasal passage through the trachea and bronchi to reach the lungs. The lungs are spongy tissues with alveoli and blood capillaries. The breathing occurs due to the expansion and the contraction of lungs, in each lungs the bronchi divides into thinner tubes called as bronchioles at the end of the each bronchial are alveolar sacs which are surrounded by the blood capillaries and contains the millions of single layer alveoli cells where the gas exchange takes place. The oxygen from the nose goes to the pharynx, trachea, bronchus, and the alveoli by the process of the diffusion oxygen red spores, air moves into the alveoli to the capillaries. Then carbon dioxide that moves into the capillaries to the alveoli and is exhaled, this is how the respiration take place in the human beings.

Table 1 Respiration Rate

BODY TYPE	**REST**	**LIGHT WORK**
ADULT	**16**	**23.6**
MALE	**16**	**23.6**
FEMALE	**16**	**23.6**
CHILD	**22**	**33.6**
ELDERLY	**20**	**38.2**

When a man needs to breathe in and out, the muscles will expand and contract. When the man is breath in the rib pulls upwards and pull downward when the man breathes downwards. For a normal resting person can take 30% to 40%. Respiration rate is the rate in which a person has taken the number of breaths per minute. If a man who is unable to breathe sufficiently then we use a mechanical ventilator that deliver breathing air into and out of the lungs.

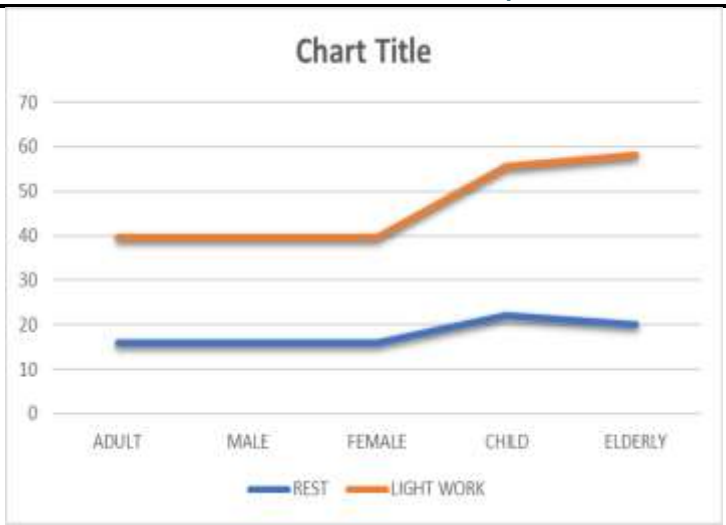

Fig. 2 Respiration Rate (breaths/min)

III. MODEL ESTABLISHMENT

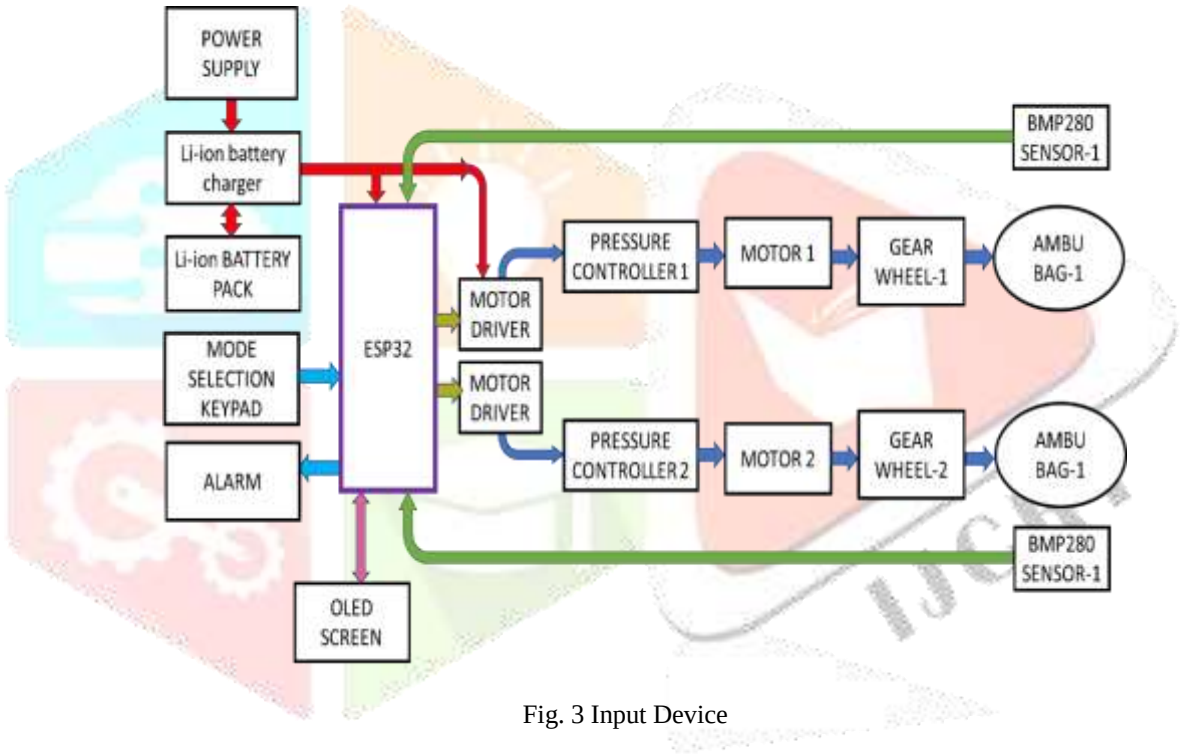

Fig. 3 Input Device

A. Input Phase

The whole system is powered with the DC power supply. The whole system is also protected from the power failure by using Li-ion battery pack. Whenever a power failure occurs, the system automatically switches to the battery-operated mode. The system also consists of OLED Screen, switching pad, alarming system which is used to warn in case of power failure, low/high pressure and other abnormalities occurs. The system designed here is portable, compact, and efficient. It can be carried over to anywhere and can use without the power supply.

B. Middle Phase

Here we use the latest technology Xtensa 32-bit microprocessor. The advantage of this system we can control other devices wirelessly like motor. The Motor used here is a stepper motor and a Motor driver also attached to this for turning the low-controlled current signal to high-controlled current signal. Stepper motor consist of an electromagnet around a center gear shape piece of iron. The electromagnets are energized by an external controller that is our microprocessor. To make the motor shaft turn, first, one electromagnet is given power which makes the gear's teeth magnetically attract to the electromagnet's teeth.

By changing the motor step by step position, we can change the inspiration and expiration time. Generally, the inspiration goes to long time when compare to the expiration. This mechanism helps in the mechanical ventilator for volume of air flowing to and from the lungs. Then the speed of the motor is controlled using a pressure controller. The function of the gear wheel is to convert the rotary motion of the stepper motor to the linear push pull motion.

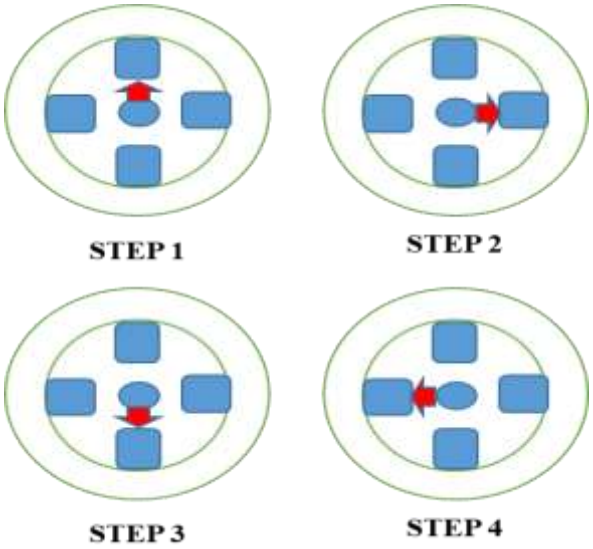

Fig. 4 Position of Stepper Motor

C. Output Phase

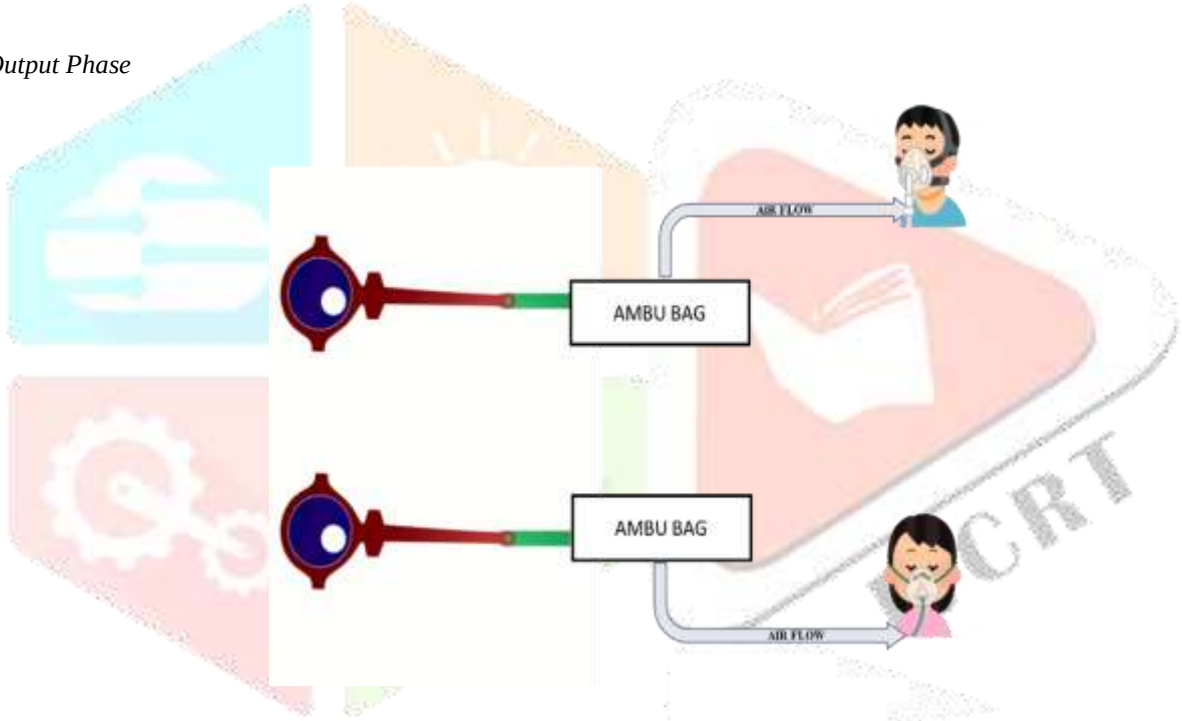

Fig. 5 Output Phase

The pumping action of the Ambu bag system is done by the stepper motors attached with a scotch yoke like mechanism connected to a stepper motor. The function of the scotch yoke mechanism is to convert the rotatory motion of the stepper motor into the linear push pull motion. The stepper motor is connected to the motor driver, the motor driver delivers enough power to the motor to rotate. In this system two motor are used so that the dual ventilation is possible at a time. The pressure of the pumping is controlled using a pressure varying knob (potentiometer). By varying knob, we can control the speed of the motion of the motor and thus by the speed of the pressure exerted by the scotch yoke mechanism. A pressure sensor BMP280 is also used here in the Ambu bag to measure the pressure of Ambu bag.

When a patient is not breathing, the Ambu bag is used in place of mouth-to-mouth resuscitation. This might happen in situations such as drowning, cardiac arrest, or a drug overdose. Its use requires training, typically to make sure the patient is getting enough oxygen when it is being used. Other problems which may result in further injury or even death can occur when using the resuscitator, such as damage to the throat, forcing of air into the stomach, etc. So, the use of mechanical portable ventilator is highly technical and complicated. It should not be attempted by anyone who is not fully trained. This training is only provided to first responders and medical professionals.

IV. WORKING PRINCIPLE

The designed system consists of a microprocessor, it plays a main role in this system. It controls all other devices like motor driver, stepper motor, OLED screen etc. The pumping action of the Ambu bag is done by the stepper motor attached with a gear wheel. This mechanism is called as the scotch yoke mechanism. The function of the scotch yoke mechanism is to convert the rotary motion to the linear motion. The stepper motor relates to a motor driver, it delivers enough power to the motor to rotate. The pressure of the pumping is controlled

using a pressure varying knob (potentiometer). By varying knob, we can control the speed of the motion of the motor and thus by the speed of the pressure exerted by the scotch yoke mechanism. A keypad (switch pad) is provided for mode selection. This system offers 3 types of modes, by pressing the key 1 of keypad to select mode 1. In mode 1, the first Ambu bag pump will only work. On selecting mode 2, the second Ambu bag pump only works. On selecting mode 3, both the ventilator pump will work simultaneously. An OLED display is used to display various parameters like air pump pressure, air flow velocity, etc. and then values is displayed in the OLED screen. It also displays the current selected mode. A pressure sensor BMP280 is used to measure the pressure of Ambu bag.

This system gives a dual mechanical operation for 2 patients at a time for that we have two motor, ambu bag and motor drivers are used and it is controlled by a microprocessor which has an IoT facility. Whenever the push is occurred, the Ambu bag air is forced into the lungs by squeezing the bag through air carrying tubes. These tubes are attached over the patient's airway. After the push, scotch yoke mechanism moves backward, and this movement allows the Ambu bag to fill the air again. Thus, whenever the motor rotates, the Ambu bag gets squeezed and the air forcefully entered the patient's lungs. Thus, the system helps the patient for the artificial respiration. The air pressure can be controlled through the pressure controlling knob. Also, the inspiration and expiration rate can be varied using the I-E controller (potentiometer). The advantage of the system is we can monitor and control devices through any system like computer or mobile

The whole system is powered with the DC power supply. The whole system is also protected from the power failure by using Lipo battery pack. Whenever a power failure occurs, the system automatically switches to the battery-operated mode. The system also consists of alarming system which is used to warn others in case of power failure, low/high pressure and other abnormalities occurs. The system designed here is portable, compact, and efficient. It can be carried over to anywhere and can use without the power supply.

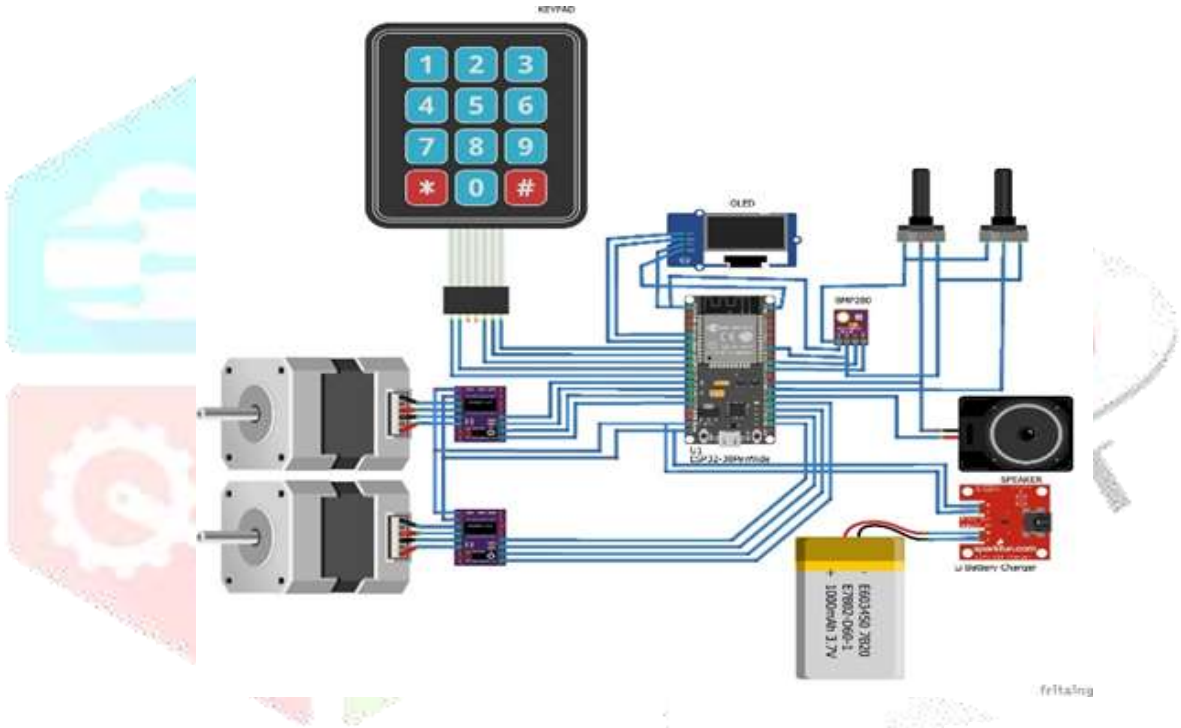

Fig. 6 Circuit Diagram

V. CONCLUSION

Surely, this system makes a good challenge in the medical system. The current ventilation system is expensive, and this problem is overcome by using an "IoT CONTROLLED PORTABLE VENTILATOR WITH DUAL OPERATION MECHANISM". The speciality of this system is less cost, dual mechanism so that we can provide air to two patients at a time. It is an IoT controlled device so that if the technician is cannot reach the patient pass, but he can control and monitor the device if any failure in the device operation with help internet connected devices like computer, mobile, tab etc.

VI. ACKNOWLEDGMENT

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