




# Automatic Oxygen Ventilation and Monitoring System Using IoT

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**Abstract.** The difficulties faced by the country in the medical system during COVID-19 have increased tremendously. Shortage of resources to patients if generated can help them to come out of the situation and can even save their lives. The proposed system can help to provide primary resources which generates oxygen based on the heartbeat of the patient. In this paper, an oxygen generation ventilation system is designed which assist patients who are suffering from breathing problems. This system generates oxygen based on the heartbeat of a patient where the minimum and maximum values of a heartbeat are taken as threshold values and these values are processed to drive the motor through the relay driver circuit. IoT-based monitoring and alert system will send the status of the patient's health condition to a doctor at regular intervals. Additionally sensing devices like the temperature sensor and vibration sensors are also used to monitor the patients. Simulation results show that the proposed system will work efficiently and save the life of the patient.

**Keywords:** Internet of Things · Ventilation system · Oxygen generation · Sensing devices · COVID-19

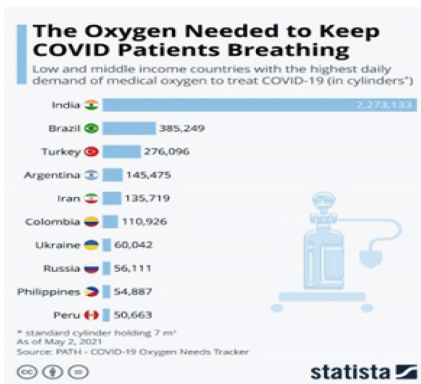
## 1 Introduction

Since December 2019, the SARS-CoV-2 virus has been spreading over the world. Coronavirus disease 2019, commonly known as COVID-19, is caused by the virus. A severe respiratory syndrome can result from these respiratory problems and critical patients frequently require a ventilator throughout their stay in an isolation unit in turn demand for ventilators has risen day by day. Figure 1 shows the statistics of the oxygen requirement during a pandemic. Mechanical ventilators provide oxygen to patients by manually raising pressure to fill the lungs with air during inspiration and manually reducing pressure to evacuate the air from the lungs during expiration as shown in Fig. 2.

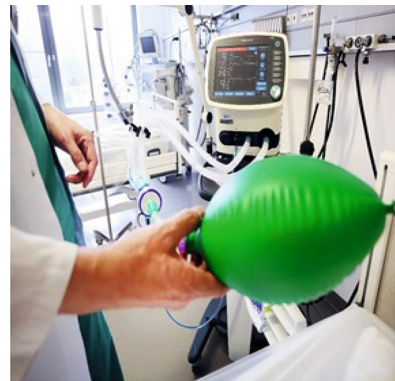
To mitigate this situation, many authors have designed different systems. A controller with adjustable gain that Adjusts gains based on the patient's flow trigger levels, which can be set to a low level to assist the patient and allow for the greatest possible outcomes [1]. The data from the interaction with the ventilation equipment is monitored and analyzed by an automated system application. As a result, a man-machine interface

controller from the system and an algorithm for controlling the valve outlet diameter were inserted into the valve and created a mechanical ventilator based on sensors [2]. The infrared sensor produced the best results and supplied more compatible values to the information provided by the reference sensor [3]. A ventilator is designed using external oxygen and a pressure sensor. The proposed sensor and alert system can help pressure-cycled emergency ventilators work better [4].

Author [5] used an orthogonal experiment to construct an analytical model of output which is a volume-controlled ventilation system with two lungs, to assess its operating characteristics and the coupling impact of two lungs. Based on DL and clinical data, the author [6] developed a prognostic model that accurately indicated which of these patients would survive. If the patient suffered considerable respiratory distress, intubation and mechanical ventilation would be necessary. The article says, "This has been a challenge to all engineering groups, particularly biomedical engineering community, to respond to the need and what can we do today to support our health care workers on the front lines of this epidemic [7]. The inbuilt scalar measuring module was calibrated and tested against two open-source ventilator compressing mechanism designs such as the scotch-yoke mechanism and the ball-screw mechanism, by the researchers. In the future, the researchers are looking at using fuzzy controllers and AI to enhance respiratory scalar measuring calibration [8].



**Fig. 1.** Oxygen requirement statistics



**Fig. 2.** Mechanical Ventilations

Author uses MATLAB to simulate respiratory activities in both regular and pathological circumstances, such as inhalation and exhalation of the PCV (packed cell volume). After using the anomalous instances of the PCV signal, output of pressure (P), volume (V), and flow (F) sensors create patient-connected medical equipment to monitor the patient [9]. The proposed low-cost portable ventilator is a cost-effective alternative to high-priced hospital ventilators. The proposed ventilator has a tidal capacity of 500-600ml and may work continuously [10]. Author [11] describes the dispersion of mechanical stress-strain and the predominance of stress raisers and measures lung inhomogeneity to reduce the negative effects of lung disease and respiration setting. If a ventilator configuration cannot be established to reduce the risk of ventilator-induced lung problems, other alternatives such as replacement lungs (artificial lungs) must be examined. All of the examined ventilators had variances in airway occlusion pressure and

occlusion pressure at a hundred milliseconds, which might restrict the use of universal airway occlusion pressure threshold levels to determine clinical choices [12].

As the COVID-19 virus grows throughout the globe, healthcare providers face the arduous issue of procuring ventilators to assist patients. To produce additional ventilation systems for the pandemic situation, all steps of the ventilator distribution network are being expedited [13]. The laminar flow meter is simple to manufacture and only requires a few sensors, such as a sensing element like pressure to determine air velocity and a temperature probe to turn on the heater, that adjusts for condensing of humidity, especially in the exhaling airways. A laminar flowmeter measures the volumetric airflow rate and differential pressure in a linear relationship [14]. The researchers have found a link i.e., Supply scarcity is linked to psychological suffering, both of which have been associated with the prevalence of COVID-19 and panic. Fear-reduction techniques for pandemic situations have the ability to change the link between shortages and suffering [15]. A summary of the existing work is shown in Table 1. Till now the research on ventilator systems is based on oxygen supplied to patients externally, but due to oxygen scarcity, patient life may end. To solve this, the proposed system is designed which generate oxygen based on the heartbeat of the patient and the pressure sensor will supply the required amount of generated oxygen to the patient.

**Table 1.** Summary of the Existing work.

Ref no	Similar Work Compared to Proposed Work	Technology Used	Benefits	Drawbacks
[1]	Ventilation is set according to the patient's condition	The system uses a blower, hose, leakage, and pressure measurement which are used to build a mechanical ventilator	A required amount of oxygen is supplied to the patient	It is very costly, and it can only be operated by medical staff
[2]	Monitoring of patient condition and recording the data	Splitting Ventilator Valve Concept	Ventilation, as well as patient condition, is monitored	All the parameters used here is very difficult to understand
[3]	Ventilation is supplied based on different sensor values	The system volume sensor, pitot tube, venturi tube, infrared sensor, and mechanical ventilator to provide oxygen to the patient based on different sensors	It is low-cost and very effective	Comparing the values of different sensors is time taking

(continued)

**Table 1.** (continued)

Ref no	Similar Work Compared to Proposed Work	Technology Used	Benefits	Drawbacks
[4]	If there is any emergency alarm it will indicate	external oxygen and a pressure sensor, alarm for emergency	This system has a number of advantages, including the ability to give oxygen based on various sensors and provide an alarm in the event of an emergency	Oxygen is supplied externally nowadays its scarcity increased
[5]	It provides ventilation based on the patient's condition	VCV (volume-controlled ventilation), secretion clearance method, the coupling effect	It is an alternative of the mechanical ventilator and works very effectively	It is very complex to build and costly
[6]	This model analyses the covid-19 patients using the latest technologies such as IoT and AI	AI-based nomogram (CIAIN), CT scans, routinely available blood parameters	It gives an accurate technique to classify individuals' risk levels after they've been detected with COVID-19	It is very difficult to understand and should have minimum knowledge to use this model
[7]	It provides ventilation in the cheapest way	Bilevel positive airway pressure machine (BIPAP) into an invasive ventilator	It is a Low-Cost Ventilator	The conversion is very risky and time taking
[8]	It improves the ventilation process through the automation	programmable logic controller, scotch-yoke mechanism and the ball-screw mechanism, A rescue respiratory system with a bag, valve, and mask	By using these methods, it will give accurate values, so that ventilation is done very effective	Understanding these mechanisms is very difficult
[9]	Provides the ventilation based on the parameters used	Pressure pulse, respiratory rate, tidal capacity, MATLAB or Simulink, and Simscape are all terms used to describe PEEP	It depends on blood oxygen saturation so it will be very effective in providing the ventilation	Building this setup is very costly
[10]	The status is displayed on a computer screen	Mechanical ventilator, bag-valve-mask (BVM) with a pivoting cam arm	It is low-cost, portable also, an alternative to high-priced hospital ventilators	Power consumption is very high
[11]	It overcomes the drawbacks of mechanical ventilation	Mechanical ventilation, Mechanical power, Extracorporeal membrane oxygenation	The ventilator has fewer negative consequences in patients with acute respiratory distress syndrome (ARDS)	It involves negative ventilation which is very risky

(continued)

**Table 1.** (continued)

Ref no	Similar Work Compared to Proposed Work	Technology Used	Benefits	Drawbacks
[12]	It helps to provide ventilation in an effective way	Tested ventilator, active humidifier, pressure and flow transducers, tow chamber test lung, driver ventilator	It compares the different ventilation systems in different situations	Usage of different ventilation leads to becoming costly
[14]	By this flow meter, ventilation is done very effectively	laminar flowmeter, pressure sensor, temperature sensor	Easy to build it and it works very effectively	Sensors are very sensitive and industrial grade so readings are taken with a delay

## 2 Methodology

### 2.1 Block Diagram

An automatic ventilator system using IoT is shown in Fig. 3. It contains a PIC controller which takes the inputs from sensors like heartbeat, vibration, and temperature sensor. To provide output to the patients through a silicone oxygen bag and to the doctors through a Wi-Fi module using Node MCU. The connection diagram is shown in Fig. 4.

#### PIC Microcontroller

The full form of PIC is a peripheral interface controller as shown in Fig. 5. It does all the arithmetic and logical calculations and uses a crystal oscillator to run the program in this microcontroller. It is controlled by software and is configured to do various jobs. The RISC (reduced instruction set computer) architecture is used in the PIC microcontroller. Its storage architecture is based on the Harvard model, which utilizes distinct memories for programs and data, along with separate buses [16].

#### Heartbeat Sensor

The job of the heartbeat sensor as shown in Fig. 6 is to check for the heart rate pulses which are transferred to the controller to take necessary action based on variation in the heart rate. Heartbeat sensors are designed to give a digital output when a finger is placed on it. The light-emitting detector blinks for every heartbeat when the heartbeat detector is turned on [17].

#### Silicon Oxygen Bag

It is inflating bag as shown in Fig. 7 that provides ventilation to patients who are feeling hard to breath. It is made up of high-quality silicone rubber and comes in a variety of colours, including green, white, and blue. The silicone artificial resuscitator comes with a pouch that includes a face mask, an oxygen tube, and a reservoir bag. It contains features such as reusability [18].

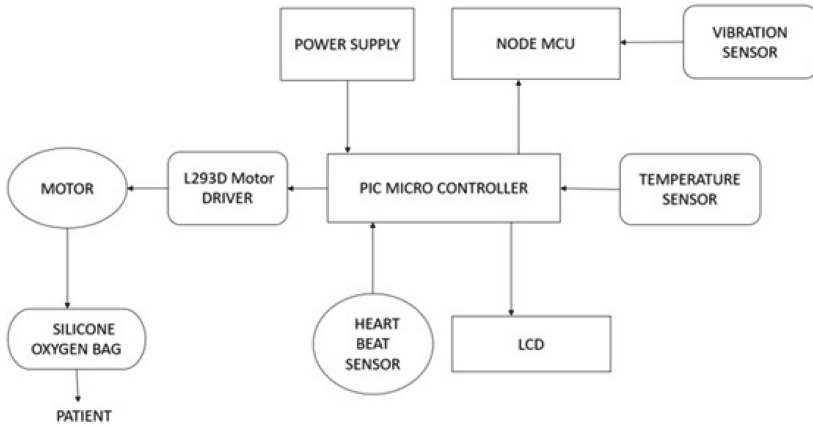


Fig. 3. Block diagram of the proposed system

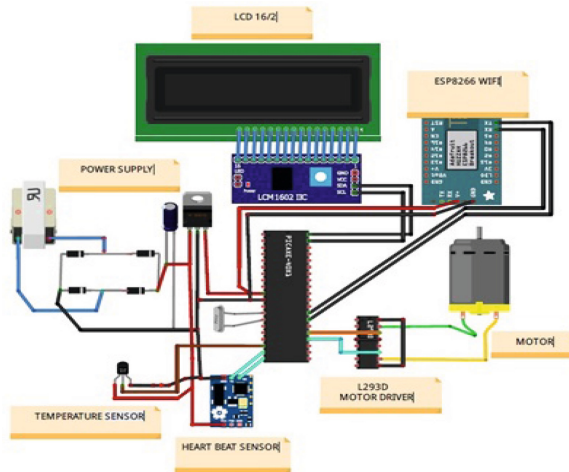


Fig. 4. Connection diagram of the proposed system



Fig. 5. PIC Microcontroller



Fig. 6. Heartbeat sensor



Fig. 7. Silicon Oxygen bag

### L293D Motor Driver

It is available in the form of an integrated circuit as shown in Fig. 8 that takes low voltage from the controller/processor and controls the motor which requires high input voltage. A motor driver IC, in basic terms, regulates the direction of the motor in response to orders or instructions received from the controller [19].

### DC Motor

The direct current motor as shown in Fig. 9 is an electric machine that transforms electrical sources into mechanical sources. Despite the fact that the motor produces 60 RPM at 12V, it operates smoothly from 4V to 12V and produces a wide range of RPM and torque. This 12v motor is driven by the relay driver according to the threshold values of the heartbeat.

### Node MCU

Node MCU is an open-source IoT platform with reasonable costs which has an inbuilt ESP8266 Wi-Fi module as shown in Fig. 10 that can link items and allow data to be sent via Wi-Fi. Furthermore, it may address many of the project's demands on its own by providing some of the most significant functionalities of microcontrollers such as GPIO, PWM, ADC, and so on [20].

### Temperature Sensor

The temperature sensor as shown in Fig. 11 is used to measure temperature. There are different types of temperature sensors available, and each uses different technologies, and principles to take the temperature measurement. This sensor is utilized in a variety of applications such as ovens, refrigerators, air conditioners, and in this model, a contact-type sensor is employed to provide precise readings [21].



Fig. 8. L293D Motor driver



Fig. 9. DC Motor

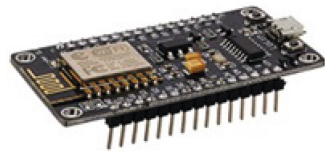


Fig. 10. NODE MCU

### Vibration Sensor

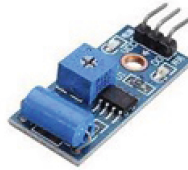
The vibration sensor as shown in Fig. 12 is a sensor that employs a variety of optical/mechanical concepts to identify observable system vibrations. It is piezoelectric accelerometers that sense vibration and are used for measuring fluctuations [22].

### Power Supply

The adaptor as shown in Fig. 13 is a device that converts one form of source to another form of source (dc energy). This adaptor is a replacement for the transformer and other electricals components to avoid electrical shocks.



**Fig. 11.** Temperature sensor



**Fig. 12.** Vibration sensor



**Fig. 13.** Adopter

## 2.2 Arduino IDE Software

The Arduino ide Software makes it easy to write code and upload it to the board. This software is used to dump code in node MUC with all of the necessary credentials for the Thing Speak platform [23].

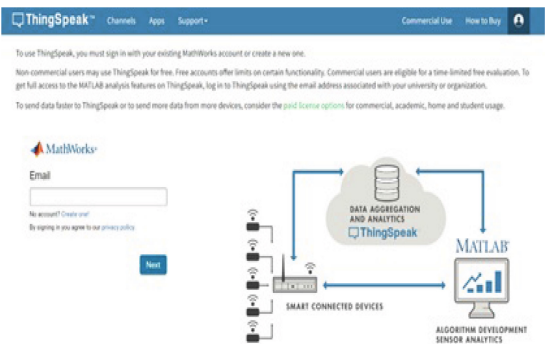
- Firstly, open the ide software
- Click on the new file and write the code as shown in Fig. 14.
- Save the code and verify the code
- Then upload the code using the USB cable.

## 2.3 Thingspeak

Thing Speak is an open-source Internet of Things platform that enables users to communicate with internet-connected gadgets. This cloud-based platform solution allows you to gather, display, and analyze real-time data streams. You can submit data from your devices to Thing Speak, generate real-time visualizations of live data, and send alerts. To use the thing speak platform in a login window as shown in Fig. 15 [24].



**Fig. 14.** Overview of IDE software



**Fig. 15.** Thingspeak

## 2.4 MPLAB IDE Software

Make programs like a boss (MPLAB) is a software platform as shown in Fig. 16 is used to program the PIC microcontroller according to the goal of the proposed system. A burner, such as pickit2 or pickit3, is used to load the programs into the PIC microcontroller. Microchip technologies created the MPLAB IDE program, which is utilized for a variety of embedded applications using the PIC microcontroller [25].

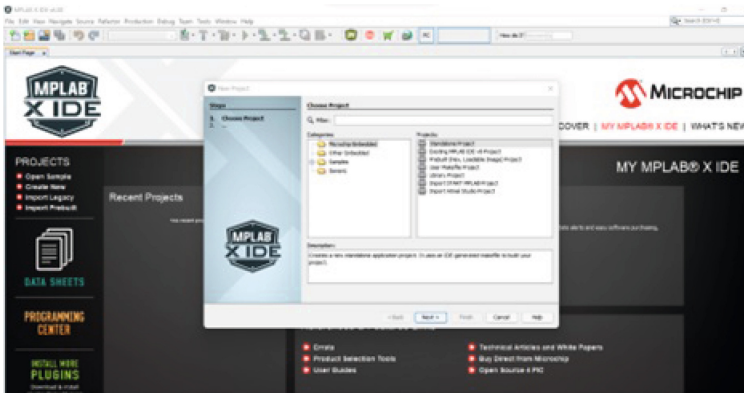


Fig. 16. MPLAB IDE software

## 2.5 Flowchart

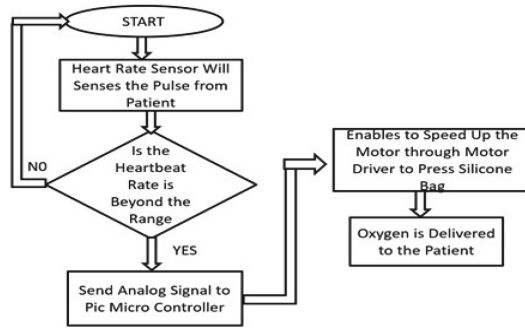
The execution flow of the proposed system is described in two steps:

### Step 1: Execution Flow of Ventilation

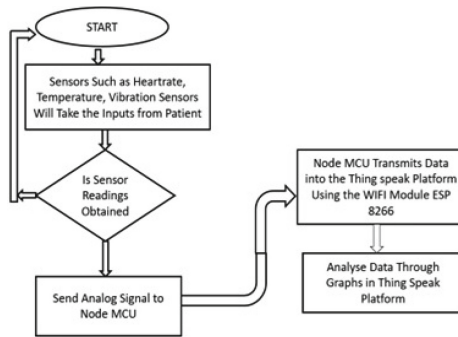
The heartbeat sensor is used to take heart rate pulses of the patient which are transferred to the controller to take necessary action based on variation in the heart rate. Heartbeat sensors are designed to give a digital output heartbeat when a finger is placed on it. The light-emitting detector blinks for every heartbeat when the heartbeat detector is turned on. The input is taken from the heartbeat sensor and the output is providing oxygen through a silicone oxygen bag as shown in Fig. 17.

### Step 2: Execution Flow of Monitoring

The system provides a backup called monitoring system which takes input from the heart rate sensor, temperature sensor, and vibration sensor and sent data to the thinkspeak platform via node MCU. The thing speak platform is a cloud that takes the input readings from the sensors and analyze the data based on the requirement of the patient as shown in Fig. 18. The heartbeat sensor is employed in both the execution flow such as heart rate readings are taken to speed up the motor to provide oxygen to the patient and heart rate readings are taken to monitor the patient.



**Fig. 17.** Execution flow of Ventilation



**Fig. 18.** Execution flow of Monitoring

### 3 Results and Discussion

The proposed system generates oxygen automatically to provide the required oxygen to the patient. It contains a PIC microcontroller, heartbeat sensor, temperature sensor, DC motor, motor driver, silicone bag, wi-fi module ESP32, vibration sensor, and adaptor for ventilation and monitoring. The main controlling device is a PIC microcontroller, which is programmed with embedded C language and the software used is MPLAB IDE software. The PIC microcontroller is capable of communicating with input and output modules. The heartbeat sensor is the key input for the PIC microcontroller to provide oxygen to the patients, it provides the input from the patient to the microcontroller and based on the threshold values of the patient the microcontroller drives the DC motor through a relay driver. A direct current motor is an electrical device that runs on a direct current supply, it requires a supply between 9-15v DC. To drive the motor a relay driver is used as an interface between the motor and controller.

The sensing parameter such as temperature sensor, heart rate sensor, and vibration sensor have determinants to analyze the health of the patient as shown in Table 2. The output of the system is shown in the think speak platform and the steps involved in think speak is as follows:

- Sign up using e-mail.
- Login with credentials to visit the user account.
- Click on my channel to see the created channels as shown in Fig. 19.

Then, in order to monitor the patient, we must pick a channel in either private or public mode. The pulse and temperature data are delivered to an IoT platform, such as the thing speaks platform, via the node MCU. The monitoring parameter such as heart rate readings are shown in Fig. 20. The data of the heartbeat is analyzed into a graph, and the graph can be modified to represent the data of the heartbeat in day-wise.

The temperature sensor will collect the patient’s input and transfer it to a node MCU capable of transmitting data to the thing speak platform, as shown in Fig. 21. The data sent to the thing speak platform is modified day by day to reflect temperature data in day wise.

In an emergency, the movement of the patient is captured by vibration sensor as shown in Fig. 22. The vibration readings are sent to the thing speak platform via the node MCU which is analyzed and turned into a graph that is subsequently modified in day wise graph.

**Table 2.** Sensing parameters

S.no	Parameter	Units	Determinants
1	Temperature sensor	C <sup>0</sup>	< 35C <sup>0</sup>
2	Heartrate sensor	BPM	< 60 bpm & > 90bpm
3	Vibration sensor	m/s <sup>2</sup>	> 0 m/s <sup>2</sup>

To analyze the status of a patient’s health condition, graphs of three sensors such as heart rate sensor, temperature sensor, and vibration sensor readings are taken in form of a table as shown in Table 3. The data can be customized hour-wise on a day to analyze the current health condition of a patient. The heartbeat data of the patient is sent to the thing speak platform through node MCU and can be monitored hour-wise during the day by modifying chart options as shown in Fig. 23 and respective reading is shown on LCD as shown in Fig. 24.

The temperature data of the patient is sent to thing speak platform through node MCU, the data can be shown in hour wise in a day by modifying chart options as shown in Fig. 25. By changing the graph from day wise to hours in a particular day, It is helpful to analyze the health condition of a patient on a particular day and respective value is shown on LCD as shown in Fig. 26.

ThingSpeak™ Channels Apps Devices Support

## My Channels

New Channel Search by tag

Name	Created	Updated
HEALTH Monitoring	2022-03-04	2022-03-04 03:05

Private Public Settings Sharing API Keys Data Import / Export

Fig. 19. Channels created

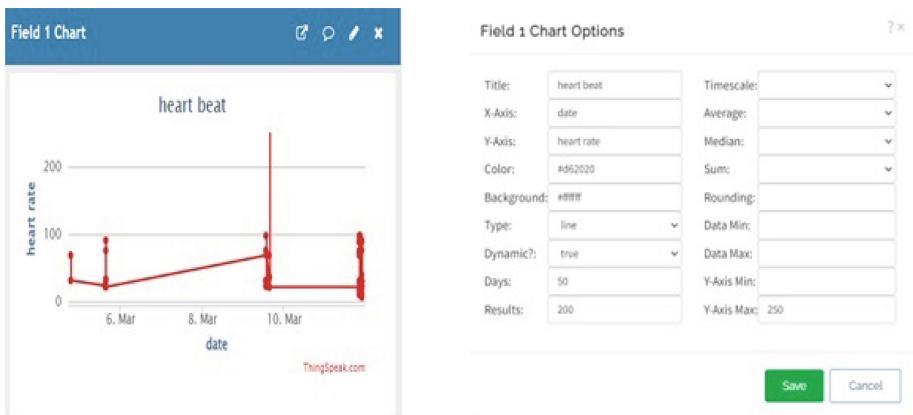


Fig. 20. Day wise Heartbeat readings



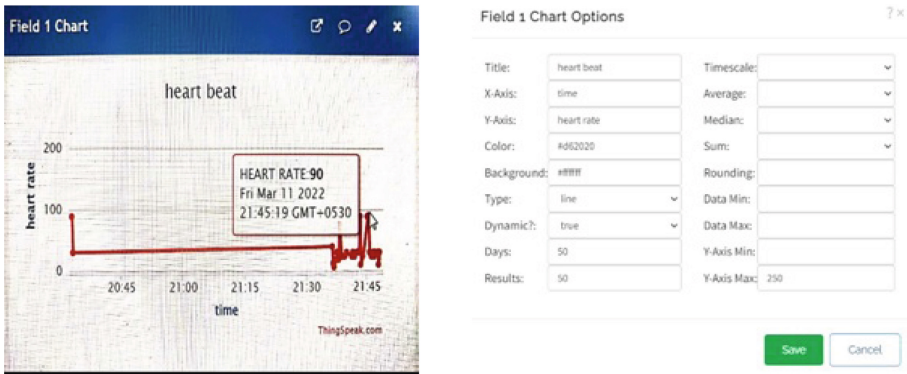
Fig. 21. Day wise Temperature readings



**Fig. 22.** Day wise Vibration readings

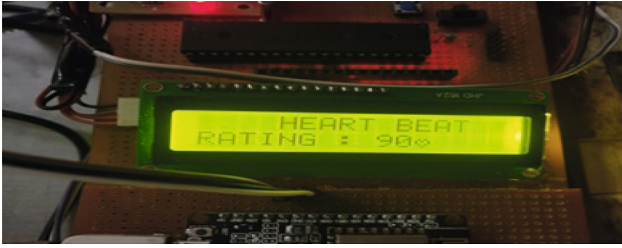
**Table 3.** Day wise readings

Date	C <sup>0</sup>	BPM	m/s <sup>2</sup>
06/03/2022	36.6	79 bpm	100
07/03/2022	35.5	56 bpm	0
08/03/2022	34.5	68 bpm	0
09/03/2022	35	72 bpm	0
10/03/2022	39	88 bpm	100



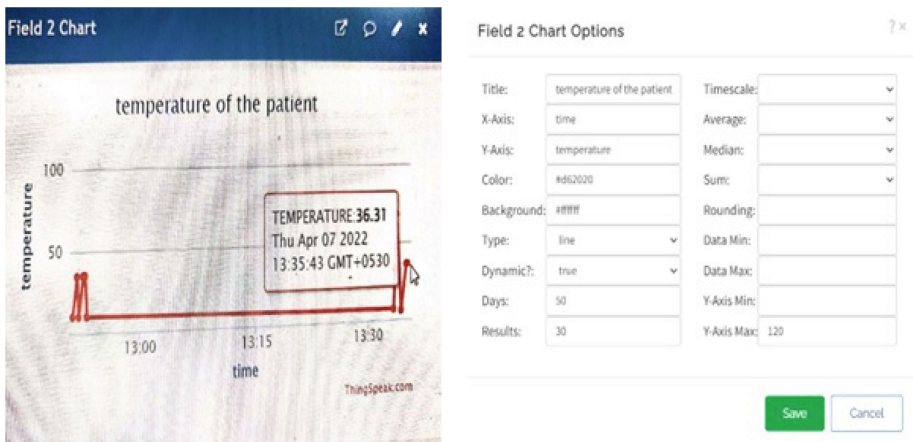
**Fig. 23.** Hour wise Heartbeat readings

The vibration readings on a graph can be viewed as either 0 or 100, where the value 0 indicates no vibration so that the patient is not in emergency and the value 100 indicates vibration and the patient is in emergency. The vibration readings sent to the Thing speak



**Fig. 24.** Heartbeat status on LCD

is analyzed and turned into a graph, which is subsequently modified in hour wise graph as shown in Fig. 27.



**Fig. 25.** Temperature readings in a day



**Fig. 26.** Temperature status on LCD

To analyze the health of patients, graphs of three sensors such as heart rate sensor, temperature sensor, and vibration sensor readings are taken in form of a table as shown in Table 4. Which is useful to analyze the health of patients in hour-wise. A snapshot of the proposed system is shown in Fig. 28.

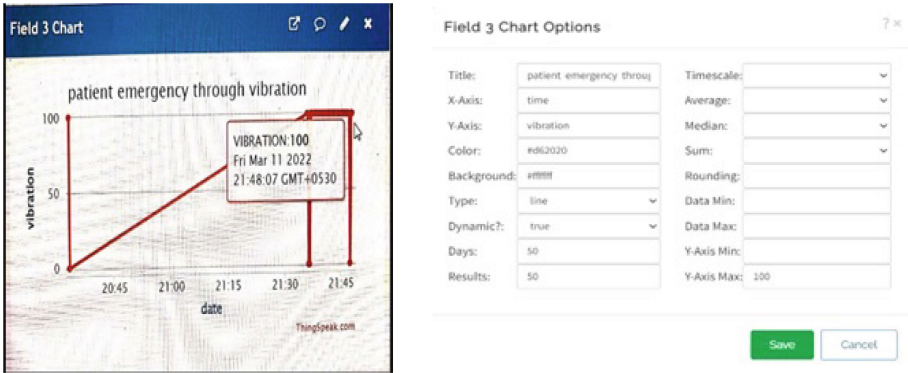


Fig. 27. Vibration readings in a day

Table 4. Particular day results

Time	C <sup>0</sup>	BPM	m/s <sup>2</sup>
20:45	35.6	88 bpm	100
21:00	36.5	66 bpm	0
21:15	32.6	69 bpm	0
21:30	37.6	69 bpm	100
21:45	29.56	90 bpm	100

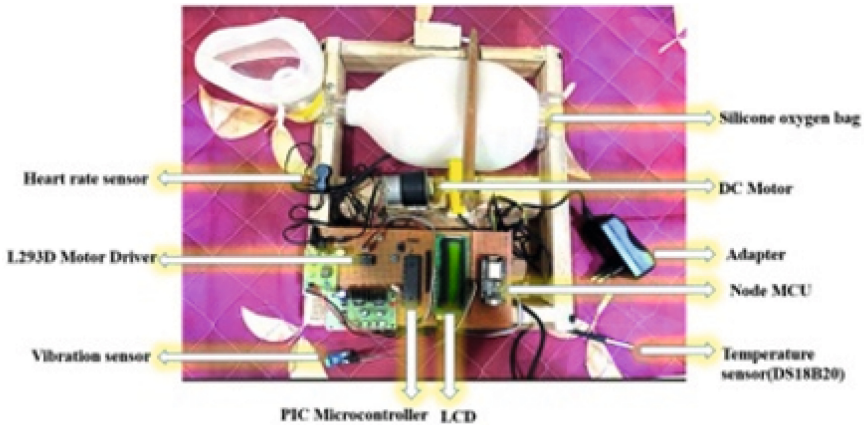


Fig. 28. Prototype of the proposed system

## 4 Conclusion and Future Scope

During COVID-19, country has faced so many problems in the medical. Due to shortage of ventilators, many lives have ended and if the oxygen was generated by some other means can help them to come out of the situation. The proposed system will improve the ventilation system by produces oxygen based on patients' heartbeat and can be monitored the status of health condition by authorized person. It also has various sensors to monitor temperature, heartbeat and vibration of a patient. The status of a patient health condition can be monitored on LCD and also through cloud. In future, the proposed system can be extended by using solar power to store energy and offer backup power and further can use satellite communication instead of Node MCU to relay data.

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