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The Covid-19 Mechanical Ventilators and Health Monitoring Device

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ABSTRACT: This paper shows the construction of a Low-cost, open source mechanical ventilators. At this time of COVID-19 outbreak the demand for ventilators and health monitoring devices has increased with each passing day. So it will also be capable of monitoring our health and provide data about our health and our heartbeat and SPO₂ levels. Current pricing of commercial mechanical ventilators in low-/middle-income countries markedly restricts their availability, and consequently a considerable number of patients with acute/chronic respiratory failure cannot be adequately treated. Our aim was to design and test an affordable and easy-to-build noninvasive bilevel pressure ventilator to allow a reduction in the serious shortage of ventilators in LMICs. The healthcare monitoring systems has emerged as one of the most vital system and became technology oriented from the past decade. Humans are facing a problem of unexpected death due to various illness which is because of lack of medical care to the patients at right time. The primary goal was to develop a reliable patient monitoring system using IoT so that the healthcare professionals can monitor their patients, who are either hospitalized or at home using an IoT based integrated healthcare system with the view of ensuring patients are cared for better. A mobile device based wireless healthcare monitoring system was developed which can provide real time online information about physiological conditions of a patient mainly consists of sensors, the data acquisition unit, microcontroller (i.e., Arduino), and Wifi. The patient's temperature, heart beat rate, EEG data are monitored, displayed and stored by the system and sent to the doctor's mobile containing the application. Thus, IoT based patient monitoring system effectively monitor patient's health status and save life ontime.

KEYWORDS: Heart beat sensor, LM35, mechanical ventilation, pic controller, LCD Display

I. INTRODUCTION

Corona virus disease 2019 (COVID-19) caused by a novel coronavirus (SAR-CoV-2) is a part of so dangerous because it threatens to overwhelm our medical infrastructure at the regional level, causing spikes in mortality rates. Within the medical infrastructure there are critical technologies that are generally available but simply do not exist in a high enough density to handle the excessive volume of patients associated with pandemics. Mechanical ventilators are essential for treating both influenza and COVID-19 patients in severe acute respiratory failure. In this new model designs are developed and then shared with open source licenses freely on the Internet so that others can simply download and replicate the design on their own equipment, even at the household scale. In this study after providing a background on ventilators the academic literature will be reviewed to find the existing and already openly published vetted designs for ventilator system. This article will be analyzed to determine if the designs are open source both in licenses as well as required practical details which include possessing the design source files as well as production files. Next, the evolving area future work will be described to enable wide-spread mass distributed manufacturing of open source ventilators to fight against the current COVID-19 pandemic as well as for future pandemics and to provide the devices to low – resource regions of the world that are underserved even in normal times. The increased use of mobile technologies and smart devices in the area of health has caused great impact on the world. Health experts are increasingly taking advantage of the benefits these technologies bring, thus generating a significant improvement in health care in clinical settings. Likewise, countless ordinary users are being served from the advantages of the M-Health (Mobile Health) applications and E-Health (health care supported by ICT) to improve, help and assist their health. According to the constitutions of World Health Organization (WHO) the highest attainable standard of health is a fundamental right for an individual.

II. OBJECTIVES

One of the specific objectives of mechanical ventilators is to promote the optimization of arterial blood gases levels and acid-base balanced by providing oxygen and eliminating carbon dioxide (ventilation). Mechanical ventilator can reduce the work of breathing by taking effort from respiratory muscles and maintaining the long-term respiratory support for patients with chronic diseases. Consideration of the patients need is the basis of this decision making. The main indication for intubation and mechanical ventilation are 1) Refractory hypoxemia 2) increased respiratory effort 3) Apnea/hypopnea leading to inadequate ventilation (hypercapnia) 4) the inability for airway protection. In general we can encompass the specific objectives of mechanical ventilators in three fundamental principles that must be fulfilled in every patients by setting the goals according to the primary disease: 1) improve oxygenation (O_2) and ventilation (CO_2), 2) reduce respiratory effort 3) minimize ventilator induced lung injury (VILI).

III. LITERATURE REVIEW

1. S. J. Jung and W. Y. Chung studied the Flexible and scalable patient's health monitoring system in 6LoWPAN. The main advantage of this enabling factor is the combination of some technologies and communications solution. The results of Internet of Things are synergetic activities gathered in various fields of knowledge like telecommunications, informatics and electronics. 2. K. S. Shin and M. J. Mao Kaiver studied a cell phone based health monitoring system with self analysis which incorporates IoT [13] a new paradigm that uses smart objects which are not only capable of collecting the information from the environment and interacting the physical world, but also to be interconnected with each other through internet to exchange data as well as information.

3. Gennaro tartarisco and Tabilo Paniclo had studied a Maintaining sensing coverage and connectivity in large sensor networks mainly includes the information about how to build or develop a new computational technology based on clinical decision support systems, information processing, wireless communication and also data mining kept in new premises in the field of personal health care. 4. Cristina Elena Turcu studied Health care applications a solution based on the Internet of Things survey aims to present a detailed information about how radio frequency identification, multi-agent and Internet of Things technologies can be used to develop and improve people's access to quality and health care services and to optimize the health care process.



5. L. Kalju developed a system, which is capable of measuring different physiological parameters and are used to design a system for heart rate reconstruction for rate adaptive pacing. 6. Loren Schwiebert, Sandeep K.S. Gupta and Jennifer Weinmann studied the strength of smart sensors which are developed from the combination of sensing materials along with combined circuitry for other bio medical applications. 7. Gentili G.B proposed a simple microwave technique to monitor the cardiac activity. This technique is dependent on changes in modulation envelope of amplitude modulated waves passing through the body. It explained the use of wireless microsensors networks for medical monitoring and environmental sensing.

8. Reza S. Dilmaghani (2016) in their study found the design of Wi-Fi sensor network that is capable of monitoring patient's chronic diseases at their home itself via a remote monitoring system. So immersing of wireless sensor technology individual test like only blood pressure, heart rate, temperature etc. can be measured but this research project enables all this parameter together to be measured under single system, and also thus all can be worn by patient and processed data send toward internet through internet of things (IOT). 9. Rouf - ul - Alam was Design of efficient low cost ventilator for emergency COVID-19 patients and its used and The local shortage of this medical equipment and

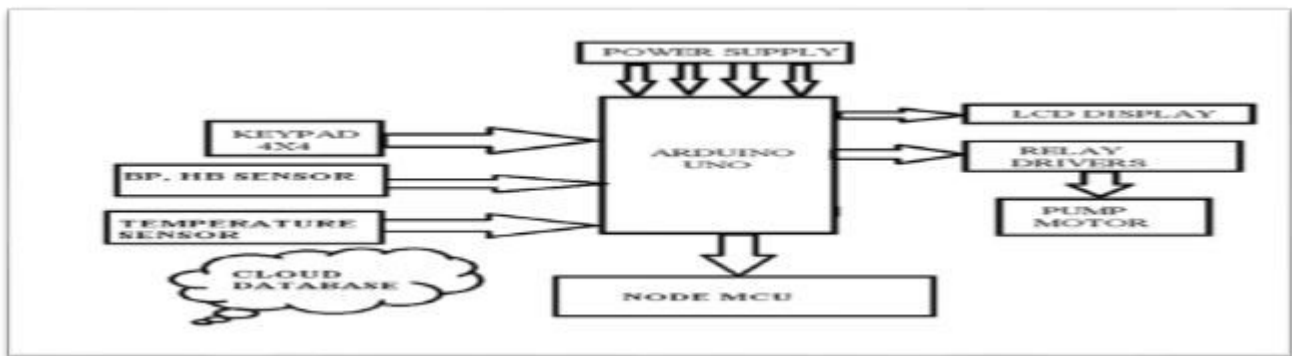


develop a somewhat semi-automatic mechanical ventilator that could be used in emergency medical units in hospitals as well as mobile medical units such as ambulance to provide emergency ventilation using an ambu bag.

IV. PROPOSED SYSTEM

These devices support breathing by getting oxygen into the lungs and removing carbon dioxide. The flow rate oxygen can be monitored through LCD display. The ventilator is connected to the patient through a tube that is placed into the mouth or nose. A pump is electronically controlled by a micro controller. They are classified as life-critical systems, and high precautions must be taken to ensure that they are reliable. And also the temperature, blood pressure, heart beat are monitored by the sensors. The data's are updated over a IOT server to monitor the patient continuously. In our project design a low-cost, open source mechanical ventilator using Arduino. So, we have decided to make a small prototype ventilator and it will also capable of monitoring our health and provide data about our heartbeat and SPO.

V. BLOCK DIAGRAM



A. POWER SUPPLY

Voltage sources in a circuit may have fluctuations resulting in not providing fixed voltage outputs. A voltage regulator IC maintains the output voltage at a constant value. 7805 IC, a member of 78xx series of fixed linear voltage regulators used to maintain such fluctuations, is a popular voltage regulator integrated circuit (IC). The xx in 78xx indicates the output voltage it provides. 7805 IC provides +5 volts regulated power supply with provisions to add a heat sink. All voltage sources cannot give fixed output due to fluctuations in the circuit. For getting constant and steady output, the voltage regulators are implemented. The integrated circuits which are used for the regulation of voltage are termed as voltage regulator ICs. Here, we can discuss about IC 7805. The **voltage regulator IC 7805** is actually a member of 78xx series of voltage regulator ICs. It is a fixed linear voltage regulator. The xx present in 78xx represents the value of the fixed output voltage that the particular IC provides. For 7805 IC, it is +5V DC regulated power supply. This regulator IC also adds a provision for a heat sink. The input voltage to this voltage regulator can be up to 35V, and this IC can give a constant 5V for any value of input less than or equal to 35V which is the threshold limit.

B. RELAY DRIVER

A relay driver circuit is a circuit which can drive, or operate, a relay so that it can function appropriately in a circuit. The driven relay can then operate as a switch in the circuit which can open or close, according to the needs of the circuit and its operation. In this project, we will build a relay driver for both DC and AC relays. Since DC and AC voltages operate differently, to build relay drivers for them requires slightly different setup. We will also go over a generic relay driver which can operate from either AC or DC voltage and operate both AC and DC relays.

C. PIC CONTROLLER

PIC is a family of modified Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Peripheral Interface Controller" now it is "PIC" only. PICs are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes,



availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.

D.PRESSURE SENSOR

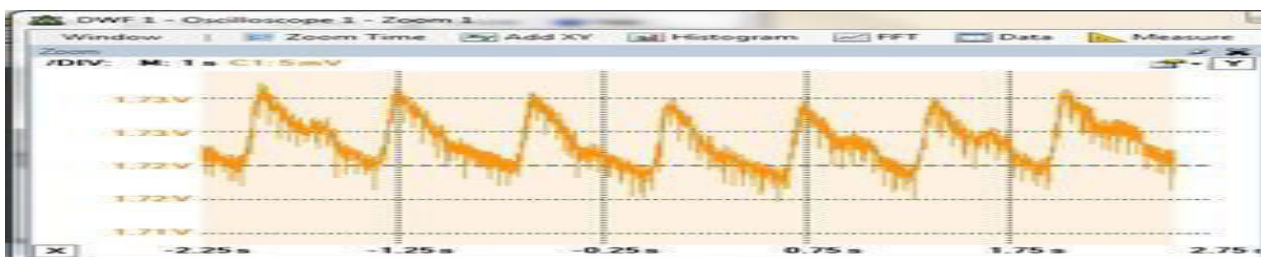
The MPS-2000 features silicon pressure sensors in 6-pin dual in-line packages. All parts in these series are uncompensated high-performance die mounted on a substrate with a plastic cap. Pins are designed for through-board assembly. The MPS-2000 is ideal for applications requiring low hysteresis, high reliability and stability. With constant voltage excitation, the MPS-2000 produces a voltage output that is linearly proportional to the input pressure. The user can provide MPS-2000 with signal conditioning circuitry to amplify the output signal or to maximize OEM value added. The MPS-2000 is compatible with most noncorrosive gases and dry air.

E.LCD DISPLAY

LCD is a type of display used in digital watches and many portable computers. LCD displays utilize to sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. LCD technology has advanced very rapidly since its initial inception over a decade ago for use in lap top computers. Technical achievements has resulted in brighter display, higher resolutions, reduce response times and cheaper manufacturing process. The liquid crystals can be manipulated through an applied electric voltage so that light is allowed to pass or is blocked. By carefully controlling where and what wavelength (color) of light is allowed to pass, the LCD monitor is able to display images. A backlight provides LCD monitor's brightness. One of the latest such advancement is applied to glass during acts as switch allowing control of light at the pixel level, greatly improving LCD's ability to display small-sized fonts and image clearly. Other advances have allowed LCD's to greatly reduce liquid crystal cell response times. Response time is basically the amount of time it takes for a pixel to "change colors", in reality response time is the amount of time it takes a liquid crystal cell to go from being active to inactive.

F.HEARTBEAT SENSOR

This project is based on the principle of photoplethysmography (PPG) which is a non-invasive method of measuring the variation in blood volume in tissues using a light source and a detector. Since the change in blood volume is synchronous to the heart beat, this technique can be used to calculate the heart rate. Transmittance and reflectance are two basic types of photoplethysmography. For the transmittance PPG, a light source is emitted in to the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. Because of the limited penetration depth of the light through organ tissue, the transmittance PPG is applicable to a restricted body part, such as the finger or the ear lobe. However, in the reflectance PPG, the light source and the light detector are both placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the detector.



VI. METHODOLOGY

To be used in intensive care units, mechanical ventilators must comply with the following three guidelines they should allow users to set (1) the respiratory frequency (FR);(2) the ratio of inspiration-to-expiration at each respiratory cycle (I:E); and (3)the air volume supplied to the patient(Vt).Those guidelines were fulfilled by the mechanical ventilator described in this paper, as indicated in it. The system depends on the signals I:E, Vt, and FR, provided by the clinician. The device adjusts the airflow to the patient's lungs accordingly. An Arduino boards collects data from the pressure sensor. According to the manufacturer, this pressure sensor can maximum differential pressure of up to 70cm H₂O.This sensor produced measurements that were proportional to voltage according to this equation.

$$\text{Measured_Pressure[cmH}_2\text{O]}=21.8(\text{Output_Pressure_Sensor_Voltage[Volts]}-0.4)$$



The pressure sensor was connected in the circuitry in such a way that it sent measurements to an Arduino Uno board, which processes them and transmits the processed data to the device. The device takes these measurements and feeds the pulmonary monitoring algorithm, as described in the sequence. The servomotor used in a high – precision mechanical – rotary position system that works by controlling an internal DC-motor.

VII. CONCLUSION

So it will also be capable of monitoring our health and provide data about our health and our heartbeat and SPO₂ levels. Current pricing of commercial mechanical ventilators in low-/middle-income countries markedly restricts their availability, and consequently a considerable number of patients with acute/chronic respiratory failure cannot be adequately treated. Our aim was to design and test an affordable and easy-to-build noninvasive bilevel pressure ventilator to allow a reduction in the serious shortage of ventilators. Thus, IoT based patient monitoring system effectively monitor patient's health status and save life on time.

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