

DESIGNING OF VENTILATOR USING PIC MICROCONTROLLER WITH BLOOD OXYGEN SENSOR

Submitted in partial fulfillment of the requirements for the award of Bachelor of

Technology Degree in Biomedical Engineering

by

BLESSY. NS (38240007)

SIVAGAMI. K (38240036)



**DEPARTMENT OF BIOMEDICAL ENGINEERING
SCHOOL OF BIO AND CHEMICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **BLESSY N.S(38240007),SIVAGAMI.K(38240036)** who carried out the project entitled **"Designing of Ventilator using pic micro controller with blood oxygen sensor"** under our supervision from **September 2021 to March 2022.**

Ms.SINDHU DIVAKARAN.,M.E., (Ph.D.,)

Assistant Professor

Guide

Dr. T. SUDHAKAR .,M.SC.,PH.D.,

Head of the Department

Submitted for Viva-voce Examination held on 02-05-2022

Internal Examiner

External Examiner

DECLARATION

We **BLESSY.NS(38240007) AND SIVAGAMI.K(38240036)** hereby declare that the Project Report entitled “**Designing of Ventilator using pic micro controller with blood oxygen sensor**” done by us under the guidance of **Ms. Sindu Divakaran, ME., (Ph.D.), Department of Biomedical Engineering** at submitted in partial fulfillment of the requirements for the award of **Bachelor of Technology Degree in Biomedical Engineering.**

DATE:

1.



2.



PLACE: CHENNAI

SIGNATURE OF THE CANDIDATES

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ABSTRACT

Human lungs use the reverse pressure generated by contraction motion of the diaphragm to suck in air for breathing. A contradictory motion is used by a ventilator to inflate the lungs by pumping type motion. A ventilator mechanism must be able to deliver in the range of 10 – 30 breaths per minute, with the ability to adjust rising increments in sets of 2. Along with this the ventilator must have the ability to adjust the air volume pushed into lungs in each breath. The last but not the least is the setting to adjust the time duration for inhalation to exhalation ratio. Apart from this the ventilator must be able to monitor the patient's blood oxygen level and exhaled lung pressure to avoid over/under air pressure simultaneously. Our system makes use of blood oxygen sensor along with sensitive heart Beat sensor to monitor the necessary vitals of the patient and display on a webpage using IoT. To adjust the time duration for inhalation the option command given in the IoT application to set. The entire system is driven by PIC controller to achieve desired results and to assist patients in COVID pandemic and other emergency situations.

Key Words: Ventilator, Pic Micro-controller, IOT application, Heart beat sensor, Blood oxygen level, COVID Pandemic.

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LIST OF ABBREVIATION

ABBREVIATION	EXPANSION
AC	ALTERNATING CURRENT
ACV	ASSIST CONTROVENTILATION
ALU	ARITHMETIC LOGIC UNIT
BVM	BAG VALVE MASK
CPU	CENTRAL PROCESSING UNIT
CU	CONTROL UNIT
DC	DIRECT CURRENT
GPR	GENERAL PURPOSE REGISTER
IOT	INTERNET OF THINGS
LED	LIGHT EMITTING DIODE
MU	MEMORY UNIT
PS	PRESSURE SUPPORT
RR	RESPIRATORY RATE
SFR	SPECIAL FUNCTION REGISTER

CHAPTER 1

INTRODUCTION

The Corona-virus pandemic is a major health emergency, as of 15 July, the World Health Organization (WHO) has reported over 1.3 Million of confirmed Corona-virus cases all over the world (shaik M, et al 2020). According to data provided by WHO, 80% of confirmed Corona-virus cases will be able to recover without the need for hospitalization (Catho G, et al 2020). However, 1 in 6 patients could have significant aggravated symptoms, causing damage to the lungs and therefore decreasing the levels of oxygen in the body.

In this sense for patients with severe effects of the infection, an artificial ventilator may offer the best chance of survival.

A DIY ventilator may not be effective as that of a medical grade ventilator yet it can go about as a decent substitute in the event that it has authority over the accompanying key boundaries. It is also combined with robust blood oxygen measuring sensor.

Pulse oximetry might be utilized in both inpatient and outpatient settings. In some cases, your doctor may recommend that you have a pulse oximeter for home use. During a pulse oximetry perusing, a little clamp like device is set on a finger, earlobe, or toe. Little light emissions go through the blood in the finger, estimating the measure of oxygen. It does this by estimating changes of light absorption in oxygenated or de-oxygenated blood (Radogna AV,et al 2020). This is a painless process.

Yet this reliable and affordable DIY ventilator during Covid pandemic times. After designing this model these models are distributed and, on the web (kerachanin CW,et al 2004), so that others can also use it and design their own ventilator, even at the small scale.

Patient management during COVID-19 faces serious issues of lung damage, and the ventilators must be able to handle situations of rapidly changing lung compliance, and potential collapse and consolidation. Thus as a general concern for any ventilator design the driving pressure of the ventilator is a crucial factor for patient comforts. In particular, when a low tidal volume is used, the driving pressure is an

important variable to be monitored to assess the risk of loss of the patient breaths . In light of the extreme importance of the pressure monitoring, the ventilator will target pressure-controlled modes. This will include: PRVC (Pressure Regulated Volume Control) mode, SIMV-PC (Intermittent Mandatory Ventilation); and in addition, a basic mode of operation: CPAP (Continuous Positive Airway Pressure).

Synchronized intermittent mandatory ventilation (SIMV) is a type of volume control mode of ventilation. With this mode, the ventilator will deliver a mandatory (set) number of breaths with a set volume while at the same time allowing spontaneous breaths. Spontaneous breaths are delivered when the airway pressure drops below the end-expiratory pressure (trigger).

The ventilator attempts to synchronize the delivery of mandatory breaths with the spontaneous efforts of the patient. In contrast, to assist control ventilation (ACV), SIMV will deliver spontaneous volumes that are 100% driven by patient effort.

Pressure support (PS) may be added to enhance the volumes of spontaneous breaths. SIMV was initially developed in the 1970s as a method to wean patients who are dependent on mechanical ventilation (Zuckerberg J, et al 2020). SIMV gained popularity and was the most widely used ventilatory mode for weaning, with 90.2% of hospitals preferring SIMV in a survey conducted in the 1980s.

The last few months have seen an increased demand for ventilators in the treatment of patients with COVID-19, a fact that led to a ventilator shortage worldwide. The consequence of this shortage is calamitous, especially in deprived areas. Even well-equipped hospitals have developed protocols for sharing the same ventilator between two patients, a dubious practice e.g. because it opens up the possibility of not only sharing bacterial and viral load among patients, but also provoking untoward harm. As an attempt to face the worldwide problem of ventilator shortage, researchers have started an initiative of producing low-cost, open-source ventilators . This paper contributes to this initiative.

Researchers agree that mechanical ventilation can harm lungs, provoking a condition known as ventilation-induced lung injury. The two most common types of damage are Volutrauma and Atelectrauma . Volutrauma appears when the ventilation in excess distends the airways and alveoli, causing over-stretching of the

corresponding lung parenchyma (Grifols J, et al 2016). Volutrauma causes an inflammatory reaction, which eventually leads to the rupture of the alveolar walls and edema. Atelectrauma, in contrast, seems to be caused by insufficient ventilation; poor ventilation allows alveolar units to collapse and reopen, in a repetitive, sequential movement, which may lead to injury as well. To avoid atelectrauma, most researchers recommend clinicians doing mechanical ventilation with positive end-expiratory pressure (PEEP). PEEP has become a ubiquitous tool to prevent atelectrauma, gaining evidence after the seminal results in . However, using PEEP to reduce lung injury is debatable since recent findings suggest that PEEP causes other harm like lung inflammation and edema formation. These investigations together indicate that the full understanding of the mechanical ventilation process requires more research (e.g.—yet mechanical ventilators undoubtedly help patients suffering from acute respiratory problems). Since mechanical ventilators potentially expose the patient's lungs to damage, all initiatives of constructing low-cost mechanical ventilators must provide the regulation of not only the lung's pressure but also the positive end-expiratory pressure (PEEP)—two points for concern. The first point involves regulating the machine to prevent excessive pressure, which is a side effect of the surplus of energy from the ventilator machinery.

We developed a novel method that monitors the patient pulmonary condition to mitigate the chance of occurring those undesired spikes in the lung's pressure. The sensor of pressure, which is attached in the inspiratory limb, feeds a carefully-designed algorithm.

This algorithm combines the Clegg-integrator system with a low-pass filter in discrete-time. This algorithm applied in a mechanical ventilator represents a novelty. Experimental data support the usefulness of this algorithm. The second point for concern on the ventilator's design is that of assuring PEEP.

A limitation of the mechanical ventilator shown here is that it does not account for PEEP. Yet PEEP valves are commercially available and can be readily adapted in the inspiratory limb. For this reason, the no-PEEP-monitoring condition does not prevent the use of this low-cost ventilator in clinical trials. This paper's main contribution is to describe the construction of a low-cost, open-source mechanical ventilator for patients with COVID-19.

Recall that technology can be considered at low cost if the corresponding deployment can be produced by using inexpensive spare parts. An electronic device that has been largely used in these low-cost initiatives is the Raspberry-Pi, a versatile small-size single-board computer. The Raspberry-Pi is a critique tool in this paper since it acts as the “brain” of the machinery, as detailed in the sequel. In summary, this paper presents two main findings: (i) construction of a low-cost, open-source mechanical ventilator for patients with COVID-19, and (ii) deployment of a method that monitors the pressure in the patient’s lungs and acts on the machinery accordingly. Experimental data support the potential of these findings, as detailed in the sequence.

To be used in intensive care units, mechanical ventilators must comply with the following three guidelines (Brown et al 2019). (e.g they should allow users to set (i) the respiratory frequency (FR); (ii) the ratio of inspiration-to-expiration at each respiratory cycle (I:E); and (iii) the air volume supplied to the patient (V_t). Those guidelines were fulfilled by the mechanical ventilator described in this paper, as indicated in the schematic. As can be seen, the ventilation apparatus hinges upon the parameters FR, I:E, and V_t , which should be set by the clinician. The air/oxygen supply flows through the corresponding limb and reach the patient’s lungs. Remark. When clinicians increase the I:E ratio in mechanical ventilators (Radogna et al 2020), they indeed increase the inspiratory time within the respiratory cycle, which means that the lung receives more oxygen. Prolonged high levels of oxygen can cause alveolar overstretching, which triggers volutrauma. depicts the electronics and mechanical actuators elements. They are connected with the parts shown in the scheme.

Our proposed ventilator is also capable of Advanced Synchronized intermittent mandatory ventilation (SIMV) mode and a basic non-invasive operation mode where a fixed pressure is made available to the patient. Our design also provides PEEP (Positive End-Expiratory Pressure), which is not a ventilatory mode in itself but is designed to support steady low positive pressure to the lungs.

Respiratory diseases and injury-induced respiratory failure constitute a major public health problem in both developed and less developed countries. Asthma, chronic obstructive pulmonary disease and other chronic respiratory conditions are widespread (Zhang et al 2020). These conditions are exacerbated by air pollution,

smoking, and burning of biomass for fuel, all of which are on the rise in developing countries^{1,2} Patients with underlying lung disease may develop respiratory failure under a variety of challenges and can be supported mechanical ventilation.

These are machines which mechanically assist patients inspire and exhale, allowing the exchange of oxygen and carbon dioxide to occur in the lungs, a process referred to as artificial respiration³. While the ventilators used in modern hospitals in the United States are highly functionally and technologically sophisticated, their acquisition costs are correspondingly high (as much as \$30,000).

High costs render such technologically sophisticated mechanical prohibitively expensive for use in resource-poor countries. Additionally, these ventilators are often fragile and vulnerable during continued use, requiring costly service contracts from the manufacturer. In developing countries, this has led to practices such as sharing of ventilators among hospitals and purchasing of less reliable refurbished units.

Since medical resources in these countries are concentrated in major urban centers, in some cases rural and outlying areas have no access at all to mechanical ventilators. The need for an inexpensive transport ventilator is therefore paramount. In the developed world, where well-stocked medical centers are widely available, the problem is of a different nature. While there are enough ventilators for regular use, there is a lack of preparedness for cases of mass casualty such as influenza pandemics (Huttner B, et al 2020), natural disasters and massive toxic chemical releases.

The costs of stockpiling and deployment of state-of-the-art mechanical ventilators for mass casualty settings in developed countries are prohibitive. According to the national preparedness plan issued by President Bush in November 2005, the United States would need as many as 742,500 ventilators in a worst-case pandemic. When compared to the 100,000 presently in use, it is clear that the system is lacking⁴ One example of this shortage occurred during Hurricane Katrina, when there were insufficient numbers of ventilators⁵, and personnel were forced to resort to manual BVM ventilation⁶.

Measures to improve preparedness have since been enacted; most notably the Center for Disease Control and Prevention (CDC) recently purchased 4,500 portable emergency ventilators for the strategic national stockpile (Catho G, et al 2020)

However, considering the low number of stocked ventilators and their currently high cost, there is a need for an inexpensive portable ventilator for which production can be scaled up on demand.

1.1. PRIOR ART

While many emergency and portable ventilators are on the market, an adequate low-cost ventilator is lacking as shown in fig 1.1. A cost-performance distribution is depicted in FIG 1 with manually operated BVMs on the low end of cost and performance (Deshmukh AD, et al 2020), and full-featured hospital ventilators on the other extreme. The middle section of the chart includes the existing portable ventilators which can be broadly categorized as pneumatic and electric. Pneumatic ventilators are actuated using the energy of compressed gas, often a standard 50 psi (345 kPa) pressure source normally available in hospitals.

These ventilators have prices ranging from \$700-1000. This category includes products such as the VORTRAN Automatic Resuscitator (VAR™), a single patient, disposable resuscitator, and the reusable Lifesaving Systems Inc.'s Oxylator, OTwo CAREvent® Handheld Resuscitators and Ambu® Matic. However, these systems cost an order of magnitude more than our target price and depend on external pressurized air, a resource to which our target market may not have access.

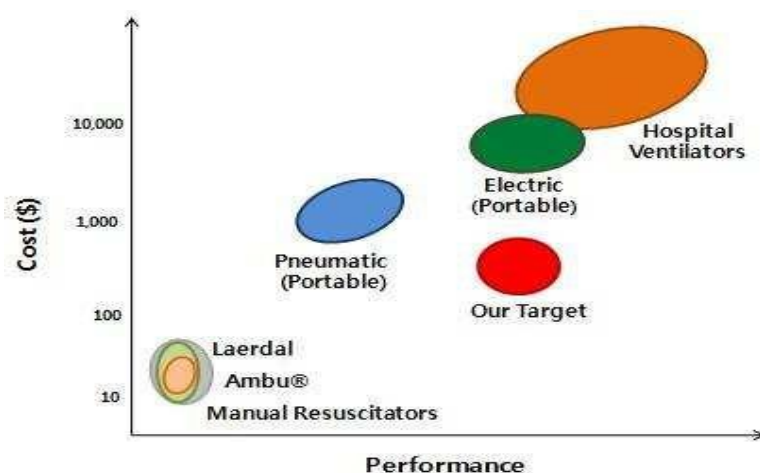


Fig 1.1: Cost-Performance Distribution of Ventilator

CHAPTER 2

LITERATURE REVIEW

Leonardo Acho, Alessandro N.,(2020) developed a successful Low-Cost, Open Source Mechanical Ventilator with Pulmonary Monitoring for COVID-19 Patients. This article shows that construction of low-cost, open-source mechanical ventilator. This article also shows that numerical method for monitoring patients pulmonary condition. With the help of pressure sensor, we can classify the patients are healthy or unhealthy lungs. An Arduino board collects the information from pressure sensor and sends them to raspberry pi. The raspberry pi commands the actuator and breathing bag compress accordingly. According to manufacture the pressure sensor can measure differentially pressure of up to 70 cm H₂O. the gear was attached to the servo motor rod. The rod was made by plexi glass bar. The radius of this gear is 2.5cm.

Aliaksei Petsiuk, Nagendra G. Tanikella,(2020) applied a technique of Partially Replicable automated open source bag valve mask-based ventilator. This article shows that development of simple and easy to build portable automated mask valve bag. This handles with Arduino controller with real time operating system installed on largely rep rap 3d printable parameter component based structure. For Arduino extensively grows the conceivable outcomes of the controller. A real-time operating system gives fundamental capacities to software tasks, like planning, dispatching, inter-task communication, and synchronization.

Couchman, B.A. et al. (2006) applied successfully a Nurses role in prevention and management of mechanical ventilation related complications. In their article titled, nursing care of the mechanically ventilated patient: What does the evidence say? summarized as nursing care and management of mechanically ventilated patient is challenging and requires nursing expertise for knowing the technological issues underlying the patient centered approach. Mechanical ventilation precipitates several actual and potential complications for the critically ill clients. Use of ventilator care is

effective in mechanically ventilated patients producing positive outcomes which consists of four interventions, those are; elevation of head of the bed, sedation vacation, peptic ulcer prophylaxis and deep vein thrombosis prophylaxis. The nursing care practice lacks in supportive significant evidence for proving one care approach is better than the other. In the care of mechanically ventilated patient the best nursing care practice is the use of evidence-based practice conjunction with comprehensive and systematic patient.

VikkyBhakre*,AjayPathrabe,(2021) developed a succesfull ventilator using Arduino with blood oxygen sensing for covid pandemic. ventilator bag driven by Direct Current motors, 2 side push mechanism to push the air bag. Toggle for switching, variable pot to check the breath length ,BPM levels of the patient. There is a lot of Future work to be upgraded to make it medical grade hardward. The team of engineers and clinicians designed and tested an emergency ventilator that uses a single limb portable ventilator circuit. Ventilator performance was assessed using an IngMar ASL 5000 breathing simulator, and it was compared with a commercially available mechanical ventilator. The emergency ventilator provides volume control mode, intermittent mandatory ventilation and continuous positive airway pressure.

Balamurugan C.R., Kasthuri A., Malathi E. (2021) applied a technique in ventilator that made with push mechanism in each breath. This ventilator is very cheap and affordable. Motor mechanism is used push the air bag. When oxygen level count is low this mechanism is performed. Small screen is used to display the oxygen level at real time. The entire system is controlled with Arduino. If the oxygen level is low the buzzer is ring. Toggle are switching and variable pot to check the breath length and BPM level of patients.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

Coronavirus, 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. In case if a patient suffers from respiratory failure mechanical ventilators are needed.

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.

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

3.2. EXISTING SYSTEM

The most pressing shortages facing hospitals during the COVID-19 emergency is a lack of ventilators. These machines can keep patients breathing when they no longer can on their own and they can cost around \$30,000 each. Design and development of a low-cost portable ventilator could be a possible way, that can help pneumonia cases of COVID-19 patient

3.3 PROPOSED SYSTEM

Proposed low-cost ventilator delivers breaths by compressing a conventional Bag Valve Mask (BVM) or Ambu bag with a pivoting motor drive mechanism, eliminating the need for a human operator

Proposed low-cost ventilator delivers breaths by compressing a conventional Bag Valve Mask (BVM) or Ambu bag with a pivoting motor drive mechanism, eliminating the need for a human operator.

Among other features, the machine should have invasive and non-invasive feature, and supports 500-600 mL tidal volume, with a continuous working capability for several days. Based on calculation, 12 Respiratory rate (RR)/min can provide required amount of tidal volume to the pneumonia patient.

Strategy of automatic arm actuated BVM compression is proven to be a viable option to achieve low-cost, low-power and portable ventilator technology that provides essential ventilator features at a fraction of the cost of existing models.

3.3.1 ADVANTAGES

The overall system efficiency with regard's to:

1. Speed
2. Easy to Use

3.3.2 DISADVANTAGES

1. High cost
2. No portable
3. Human's need to regularly monitor the entire system.

3.4 SCOPE AND APPLICATION

3.4.1 FUTURE SCOPE

1. If the blood oxygen level low, then it automatically calls the doctor or ambulance.
2. And the particular location will be shared through GSM using GPS unit.

3.4.2 APPLICATIONS

Hospitals & Home, Medical sector's, Hospitals, clinics, First Aid Centres, Emergency Situation

CHAPTER 4

MATERIAL AND METHODOLOGY

4.1 HARDWARE COMPONENT

4.1.1 BAG VALVE MASK (BVM) OR AMBU BAG:

Used for resuscitation in emergency situations, available at local chemists. Compressible self-refilling ventilation bag with non-re breathing patient valve with pressure limitation valve to minimize the risk of over inflating. 100% latex free as shown in fig 4.1.

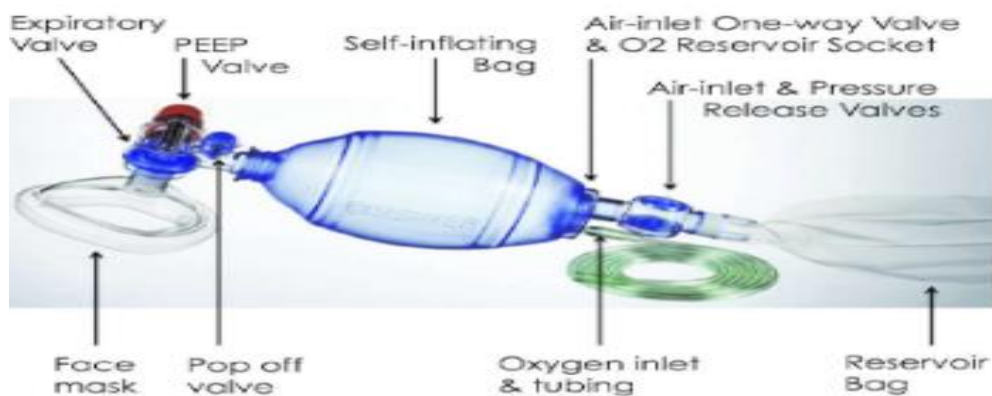


Fig 4.1 : Bag Valve Mask (BVM) OR Ambu Bag

4.1.2 PIC MICROCONTROLLER:

PIC micro controllers can be used in CAN bus-based projects. In general, any type of PIC micro controller can be used, but some PIC micro controllers (e.g. PIC18F258) have built-in CAN modules that simplify the design of CAN bus-based systems. Micro-controllers with no built-in CAN modules can also be used in CAN bus applications, but additional hardware and software are required, making the design costly and also more complex.

PDIP

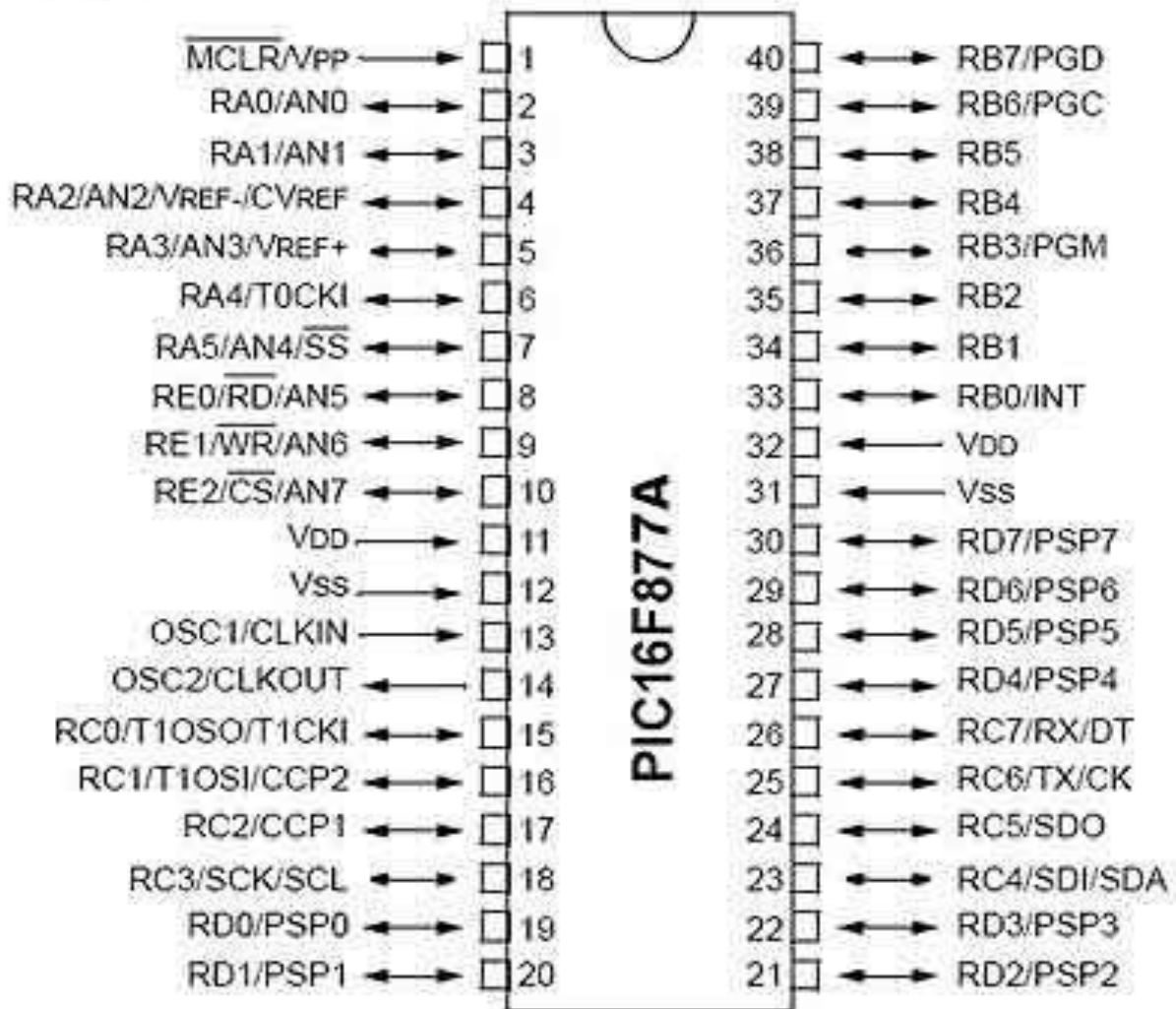


Fig 4.2: PIC Microcontroller

4.2 PIC ARCHITECTURE

PIC Micro-controller architecture is based on Harvard architecture and supports RISC architecture (Reduced Instruction Set Computer). PIC micro controller architecture consists of memory organization (ram, rom, stack), CPU, timers, counter, ADC, DAC, serial communication, CCP module and I/O ports. PIC micro controller also supports the protocols like CAN, SPI, UART for interfacing with other peripherals.

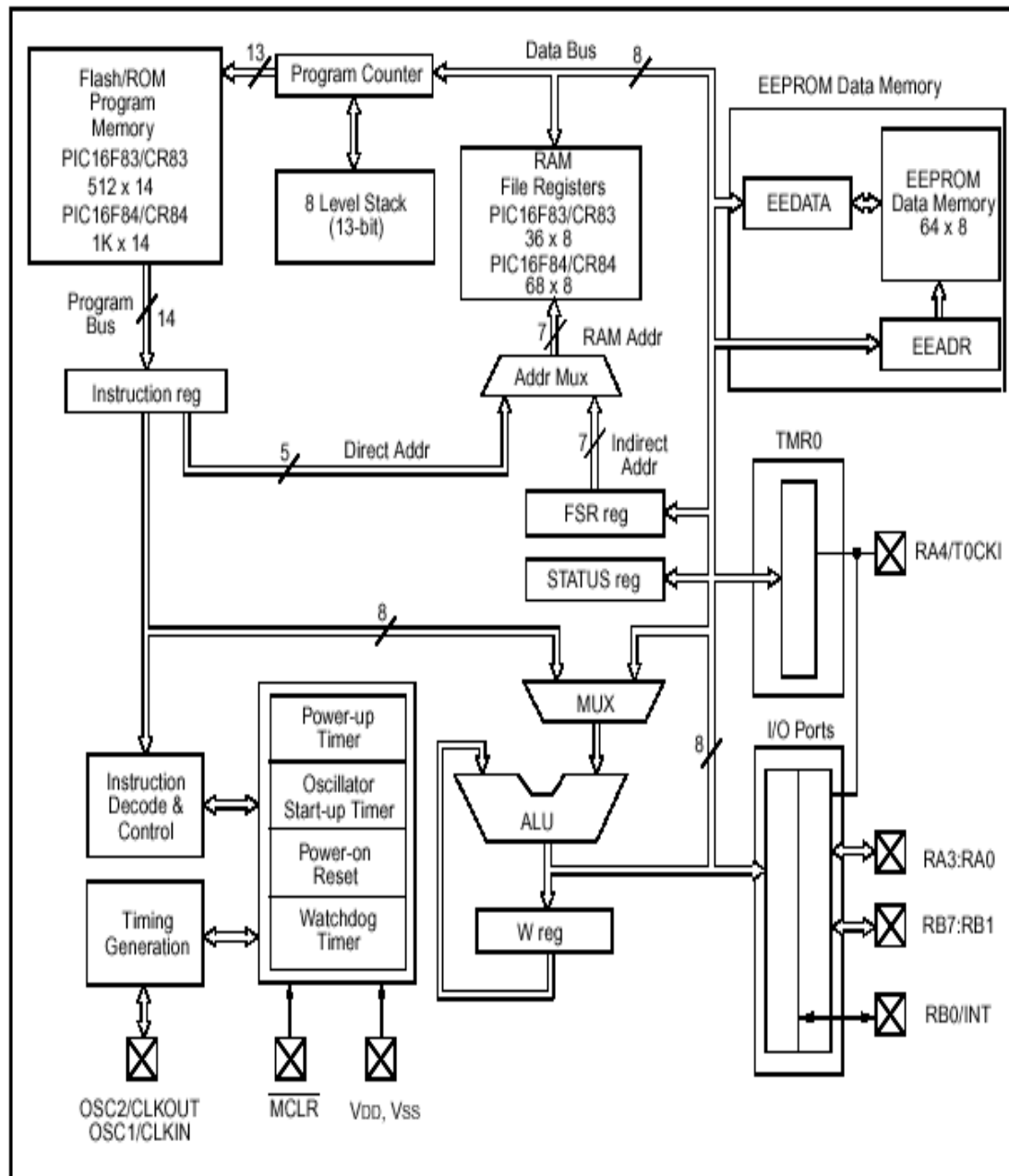


Fig 4.3 PIC Architecture

4.2.1 CPU (Central Processing Unit):

PIC micro controller's CPU consists of

- Arithmetic logic unit (ALU)
- Memory unit (MU)
- Control unit (CU)
- Accumulator

ALU is used for arithmetic operations and for logical decisions. Memory is used for storing the instructions after processing. Control unit is used to control the internal and external peripherals which are connected to the CPU and accumulator is used for storing the results.

4.2.2 MEMORY ORGANIZATION:

PIC micro controller memory module consists of mainly 3 types of memories:

- **PROGRAM MEMORY:**

It contains the written program after we burned it in micro controller. Program Counter executes commands stored in the program memory, one after the other. Pic micro controller can have 8K words x 14 bits of Flash program memory that can be electrically erased and reprogrammed. Whenever we burn program into the micro, we erase an old program and write a new one.

- **DATA MEMORY:**

It is a RAM type which is used to store the data temporarily in its registers. The RAM memory is classified into banks. Each bank extends up to 7Fh (128 bytes). Number of banks may vary depending on the micro controller. PIC16F84 has only two banks. Banks contain Special Function Registers (SFR) and General Purpose Registers (GPR). The lower locations of each bank are reserved for the Special Function Registers and upper locations are for General Purpose Registers.

GENERAL PURPOSE REGISTER(GPR):

These registers don't have any special function. These are used for general purpose for multiplying, addition or subtraction and then storing the results in other registers. CPU can easily access the data in these registers.

SPECIAL FUNCTION REGISTER (SFR):

These registers are used for special purposes and they cannot be used as normal registers. Their function is set at the time of manufacturing. They perform the function assigned to them and user cannot change the function of SFR. Three important SFR's for programming are:

STATUS register: It changes the bank

PORT registers: It assigns logic values 0 or 1 to the ports

TRIS registers: It is a data direction register for input and output

DATA EEPROM:

This memory allows storing the variables as a result of burning the written program. It is readable and writable during normal operation (over the full VDD range). This memory is not directly mapped in the register file. It is indirectly addressed through the SFRs. There are six SFRs which are used to read and write to this memory (EECON1, EECON2, EEDATA, EEDATH, EEADR, EEADRH).

SERIAL COMMUNICATION:

The transfer of one bit of data at time consecutively over a communication channel is called Serial Communication. There are three protocols of serial communication:

- **USART:** It stands for Universal synchronous and Asynchronous Receiver and Transmitter which provides a serial communication in two devices. In this protocol data is transmitted and received bit by bit through a single wire according to the clock pulses. To send and receive data serially the PIC micro controller has two pins TXD and RXD.

4.2.3 SPI PROTOCOLS:

SPI stands for Serial Peripheral Interface. It is used to send data between PIC micro controllers and other peripherals like sensors, shift registers and SD cards. Three wire SPI communications is supported in PIC micro controller between two devices on a common clock source. SPI protocol has greater data handling capability than that of the USART as shown in fig 4.4 .I2C Protocol: I2C stands for Inter Integrated Circuit, and this protocol is used to connect low speed devices like micro controllers, EEPROMS and A/D converters. PIC micro controller support two wire Interface or I2C communication between two devices which can work as both Master and Slave device.



Fig 4.4 : SPI Protocols

4.3 SERIAL COMMUNICATION

4.3.1. INTERRUPTS:

There are 20 internal interrupts and three external interrupt sources in PIC micro controllers which are related with different peripherals like ADC, USART, Timers, and CCP etc.

4.3.2 I/O PORTS:

Let us take PIC16 series, it consists of five ports, such as Port A, Port B, Port C, Port D and Port E.

- **Port A:** This port is 7-bit wide and can be used for both input and output. The status of TRISA register decided whether it is used as input or output port.
- **Port B:** It is an 8-bit port. This port also can be used as input and output. More over in input mode four of its bits are variable according to the interrupt signals.
- **Port C:** It is also an 8-bit port and can be used as both input and output port which is determined by the status of the TRISC register.
- **Port D:** This 8-bit port, unlike Port A, B and C is not an input/output port, but is used as acts as a slave port for the connection to the micro processor . When in I/O mode Port D all pins should have Schmitt Trigger buffers.
- **Port E:** It is a 3-bit port which is used as the additional feature of the control signals to the A/D converter.

4.3.3 CCP MODULE:

A CCP module works in the following three modes:

- **Capture Mode:** In this mode time is captured when a signal is arrived, or we can say that, when the CCP pin goes high it captures the value of the Timer1.
- **Compare Mode:** It works same as an analog comparator, which means that

when timer 1's value reaches some reference value it will give an output signal.

- **PWM Mode:** This mode provides a 10 bit resolution pulse and duty cycle that is programmed.

Timers:

Timers and counters are important as timers can tell the time and count. PIC micro controller can have up to four timers (depending upon the family) Timer0, Timer1, Timer2 and Timer3. Timer0 and Timer2 are of 8-bits while the Timer1 and Timer3 are of 16-bits, which can also be used as a counter. These timers work according to the selected modes.

4.3.4 D/A CONVERTER:

There are no analog outputs in PIC Micro-controller. To get analog output we have to use external Digital-to-Analog Converter (DAC) as shown in fig 4.5. It can convert 8 bits of digital number from the eight digital outputs of PIC micro controller.



Fig 4.5 : D/A Converter

4.3.5 A/D CONVERTER

It converts the analog voltage levels to digital voltage values. In PIC Micro-controller, ADC has 8-channels and has resolution of 10-bit, which means that if we have to convert an analog voltage between 0V to 5V the converter will divide it to 2^{10} levels (1024 levels). The special function registers ADCON0 and ADCON1 control the operation of ADC. The converter stores the lower 8 bits in ADRESL register and the upper bits in the ADRESH register. Reference voltage of 5V is required for the operation of the converter.

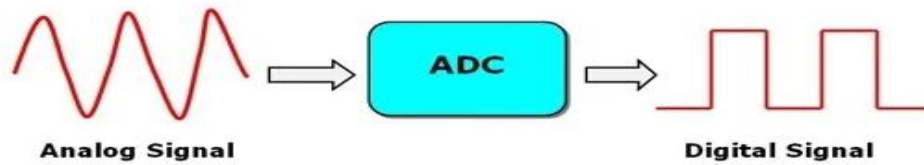


Fig 4.6 : A/D Converter

4.3.6 MOTOR CONTROLLER L298:

Motor Controller is used to control the direction of DC motor.

- It consists of an L298 motor driver IC which is capable of rotating the motor in both clockwise and anti-clockwise directions by switching its pins from HIGH to LOW and vice versa.
- Required +12V, GND and +5V in order to power it up. So, we will design a voltage regulator which will stepdown 12V to 5V.
- Using L298 micro controller, 2 DC motors can easily operate. So simply by adding another DC motor with ambu bag setup can operate 2 ventilation system at the same time.

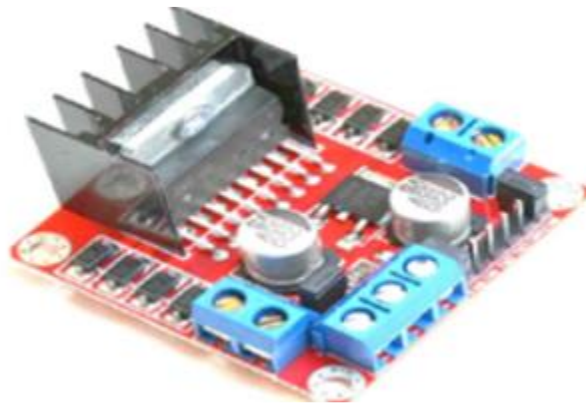


Fig 4.7 : Motor Controller L298

4.3.7 DC Gear Motor:

For this prototype used 12V DC gear motor of 7 kg/cm torque capacity.

- Speed(RPM): 7-600RPM and 0.15A is suitable for proposed design



Fig 4.8: DC Gear Motor

4.4 ARDUINO UNO

Arduino Uno is a micro controller board based on the ATmega328. It has 14 digital input / output pins (of which 6 can be used as PWM outputs), 6 analog inputs, 16 MHz ceramic resonator, USB connection, power jack, ICSP plug, and a reset button. It contains everything needed to support the micro controller as shown in fig 4.9; simply use the USB cable or power it with a AC-to-DC adapter or battery is connected to a computer begins.



Fig 4.9 : Arduino Uno

4.4.1 I2C LCD DISPLAY

- At the heart of the adapter is an 8-Bit I/O Expander chip – PCF8574. This chip converts the I2C data from an Arduino into the parallel data required by the LCD display.
- The board also comes with a small trimpot to make fine adjustments to the contrast of the display.
- In addition, there is a jumper on the board that supplies power to the backlight as shown in fig 4.10. To control the intensity of the backlight, you can remove the jumper and apply an external voltage to the header pin that is marked as

'LED'.



Fig 4.10 : I2C LCD Display

4.4.2 PRESSURE SENSOR

- The MPL3115A2 is a compact, piezoresistive, absolute pressure sensor with an I2C digital interface. MPL3115A2 has a wide operating range of 20 kPa to 110 kPa, a range that covers all surface elevations on earth. The MEMS is temperature compensated utilizing an on-chip temperature sensor.
- The pressure and temperature data is fed into a high resolution ADC to provide fully compensated and digitized outputs for pressure in Pascals and temperature in °C
- MPL3115A2's advanced ASIC has multiple user programmable modes such as power saving, interrupt and autonomous data acquisition modes, including programmed acquisition cycle timing, and poll-only modes. Typical active supply current is 40 μ A per measurement-second for a stable 10 cm output resolution.

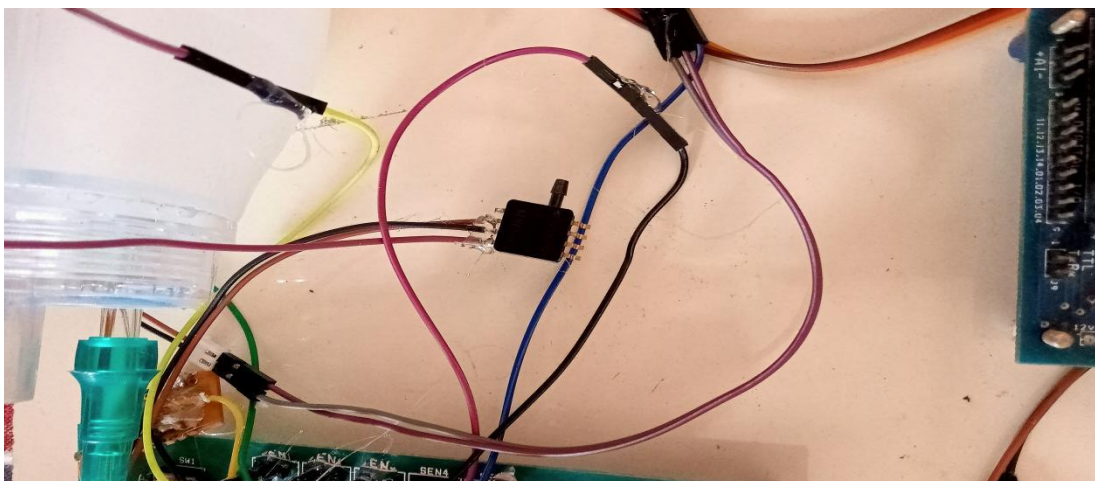


Fig 4.11 : Pressure Sensor

4.4.3 HEART RATE SENSOR

- Pulse Sensor is a low cost, very small size a plug-and-play heart rate sensor for Arduino and Arduino compatible boards. It can be used by students, artists, athletes, makers, and game & mobile developers who want to easily incorporate live heart-rate data into their projects as shown in fig 4.12.
- Pulse Sensor Amped adds amplification and noise cancellation circuitry to the hardware. It's noticeably faster and easier to get reliable pulse readings. Pulse Sensor works with either a 3V or 5V Arduino.
- A Color-Coded Cable, with a standard male header connectors. Plug it straight into an Arduino or a Breadboard. No soldering is required.
- An Ear Clip, perfectly sized to the sensor. It can be hot-glued or epoxied to the back of the sensor to get reading from an ear lobe.

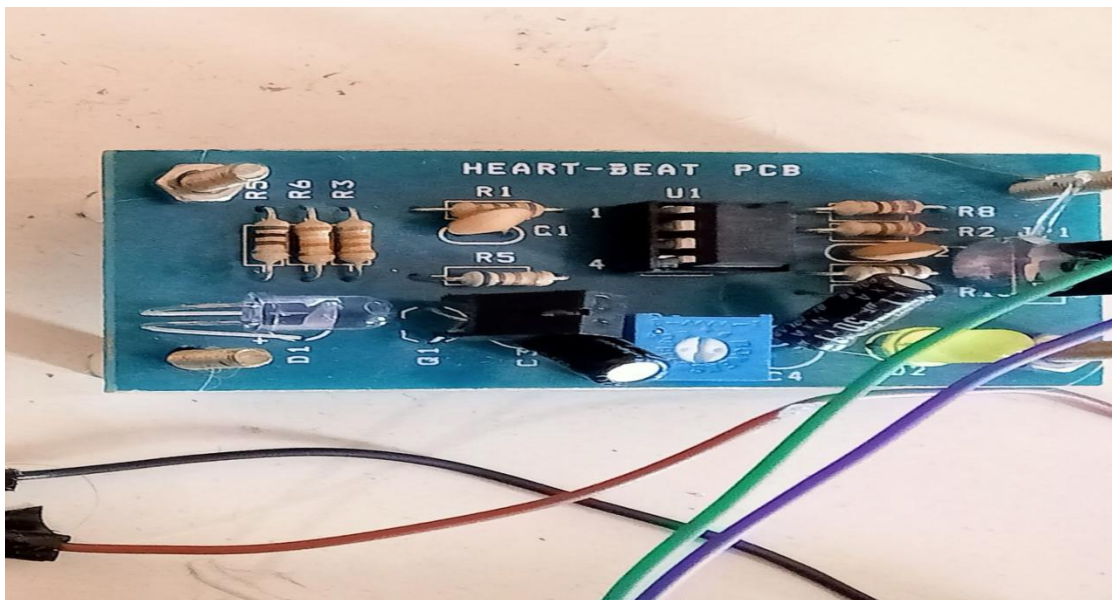


Fig 4.12 : Heart Rate Ssensor

4.4.4 DHT11 SENSOR

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). Its fairly simple to use, but requires careful timing to grab data.

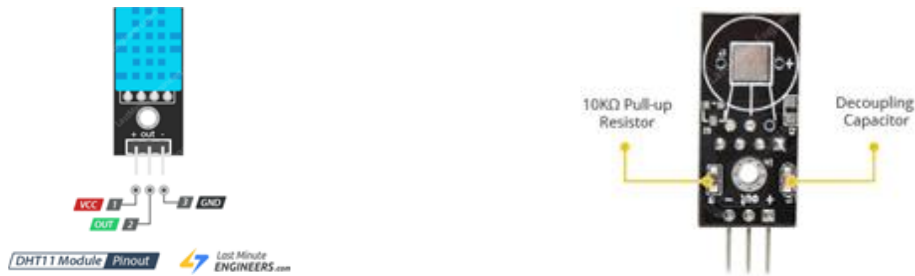


FIG 4.13 : DHT11 SENSOR

4.4.5 TRANSFORMER

0-12 5Amp Step Down Transformer is a general purpose chassis mounting mains transformer. Transformer has 230V primary winding and non-center tapped secondary winding. The transformer has flying colored insulated connecting leads (Approx 100 mm long). The Transformer act as step down transformer reducing AC - 230V to AC - 12V.

The Transformer gives outputs of 12V and 0V. The Transformer's construction is written below with details of Solid Core and Winding. The transformer is a static electrical device that transfers energy by inductive coupling between its winding circuits. A varying current in the primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic flux through the secondary winding.

This varying magnetic flux induces a varying electromotive force (E.M.F) or voltage in the secondary winding. The transformer has cores made of high permeability silicon steel.

The steel has a permeability many times that of free space and the core thus serves to greatly reduce the magnetizing current and confine the flux to a path which closely couples the winding.

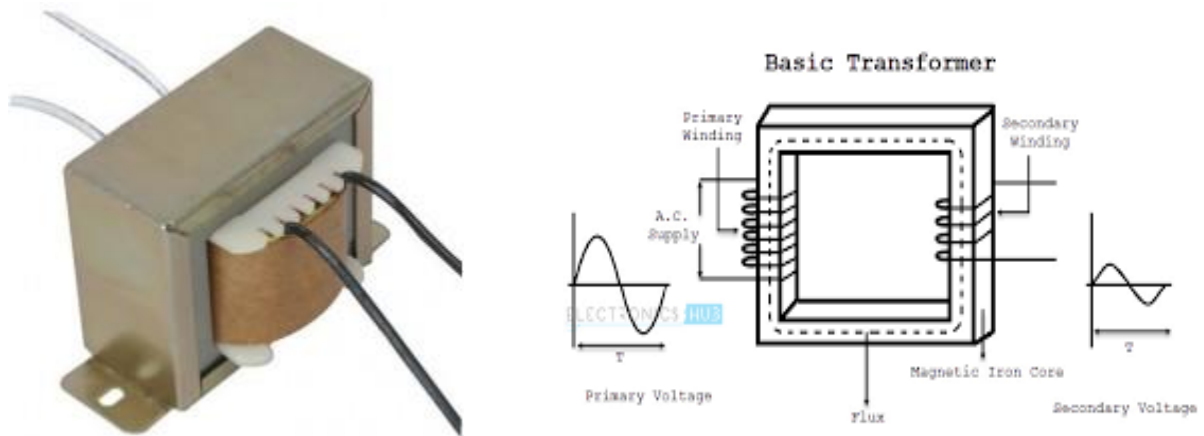


FIG 4.14 : TRANSFORMER

A Bridge rectifier is an Alternating Current (AC) to Direct Current (DC) converter that rectifies mains AC input to DC output. Bridge Rectifiers are widely used in power supplies that provide necessary DC voltage for the electronic components or devices. They can be constructed with four or more diodes or any other controlled solid-state switches. We can find this rectifier in a wide variety of electronic AC power devices like home appliances, motor controllers, modulation process, welding applications, etc.

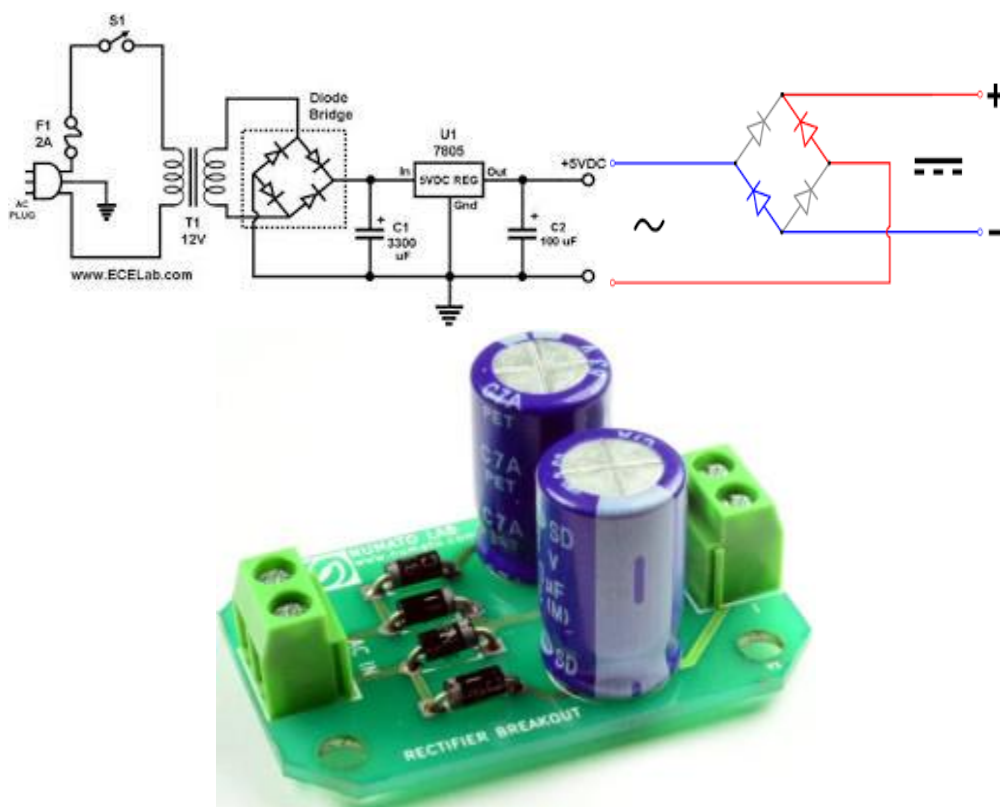


FIG 4.15 : TRANSFORMER

4.4.6 IC 7805 VOLTAGE REGULATOR

- It is a three-pin IC; input pin for accepting incoming DC voltage, ground pin for establishing ground for the regulator, and output pin that supplies the positive 5 volts.
- Input Voltage: Minimum 7V, Maximum 25V Output Current: 1.5A Operating Virtual Junction Temperature: Minimum 0, Maximum 125°C Possible High Temperatures
- If differences between the input and output voltages are not well managed, LM7805 can overheat, which may result in malfunctioning. Solutions Include: Limiting input voltage to 2-3 volts above the output regulated

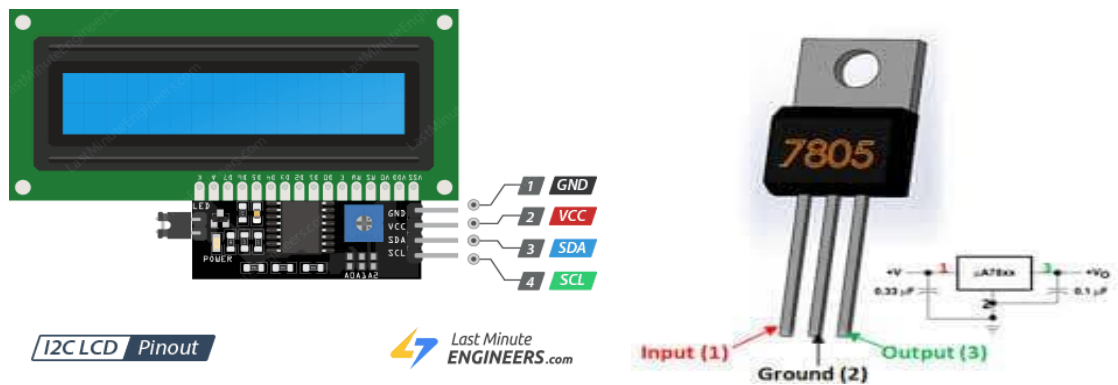


FIG 4.16 : IC 7805 VOLTAGE REGULATOR

4.4.7 IC 7812 VOLTAGE REGULATOR

LM7812 is a TO-220 packaged positive voltage regulator IC of LM78xx series that is manufactured by many different electronic components manufacturers. The IC provides fixed 12V output voltage no matter if the input voltage is fluctuating or changing continuously or it is higher than 12V but the input voltage should not be more than 35V which is the maximum input voltage limit this IC is capable to handle. Moreover the input voltage should not be less than 14V that is the minimum input voltage requirement of the IC to provide fixed 12V output. During usage when the IC performing voltage regulation or stepping down the input voltage all the voltage difference between the input voltage and the output is converted to heat due to which a suitable heatsink is mandatory for proper working of the IC. The IC can handle maximum load of 1A to 1.5A but the input current should be 2A to get 1A

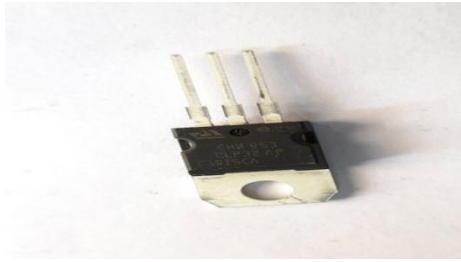


FIG 4.17 : IC 7812 VOLTAGE REGULATOR

4.5 ARDUINO IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards. The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring.

The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub `main()` into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution.



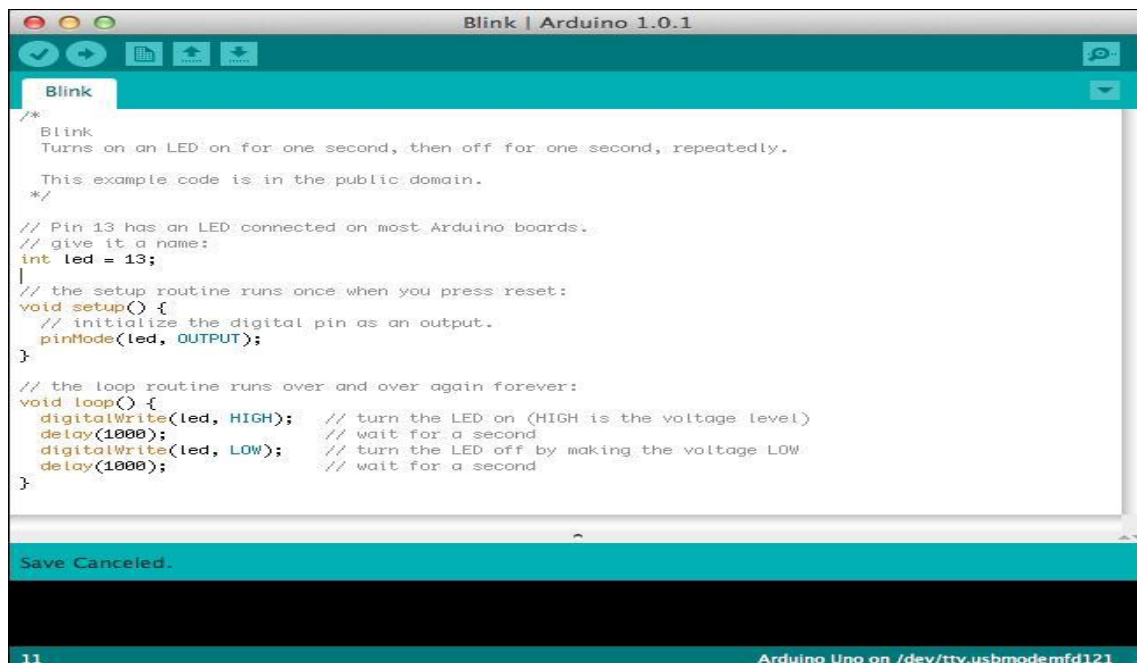


FIG 4.18 : ARDUINO IDE

4.6 IOT PAGE

- The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data.
- Thanks to the arrival of super-cheap computer chips and the ubiquity of wireless networks, it's possible to turn anything, from something as small as a pill to something as big as an aero plane, into a part of the IoT.
- Connecting up all these different objects and adding sensors to them adds a level of digital intelligence to devices that would be otherwise dumb, enabling them to communicate real-time data without involving a human being.
- The Internet of Things is making the fabric of the world around us more smarter and more responsive, merging the digital and physical universes.



FIG 4.19 : IOT PAGE

4.7 BLOCK DIAGRAM

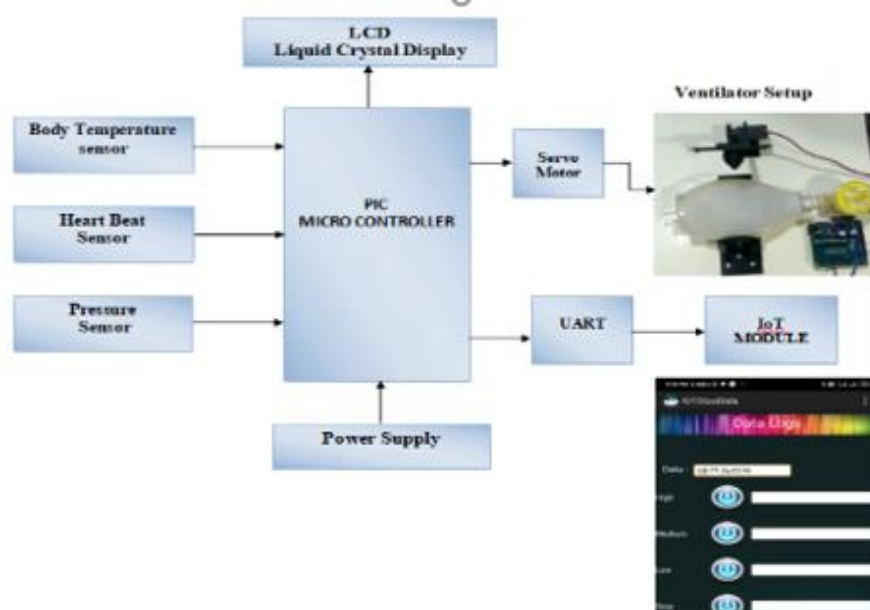


FIG 4.20 :BLOCK DIAGRAM

An IoT based motor drive of clockwise and counter clockwise will provide the required motion for the arm movement to maintain an automatic air flow with a controlled pressure rate.

Mechanical Ventilator uses only for pneumonia cases where this type of continuous ventilation machine able to generate a plate pressure (P plat) for lung.

Among other features, the machine should have invasive and non-invasive feature, and supports 500 mL tidal volume, with a continuous working capability. Based on calculation, 12 Respiratory rate (RR)/min can provide required amount of tidal

volume to the pneumonia patient. Pressure, Volume and Flow control curve.

Among other features, the machine should have invasive and non-invasive feature, and supports 500 mL tidal volume, with a continuous working capability. Based on calculation, 12 Respiratory rate(RR)/min can provide required amount of tidal volume to the pneumonia patient. Pressure, Volume and Flow control curve.

Human lungs use the reverse pressure generated by contraction motion of the diaphragm to suck in air for breathing.

A contradictory motion is used by a ventilator to inflate the lungs by pumping type motion.

A ventilator mechanism must be able to deliver in the range of 10 – 30 breaths per minute, with the ability to adjust rising increments in sets of 2.

Along with this the ventilator must have the ability to adjust the air volume pushed into lungs in each breath.

The last but not the least is the setting to adjust the time duration for inhalation to exhalation ratio.

Apart from this the ventilator must be able to monitor the patient's blood oxygen level and exhaled lung pressure to avoid over/under air pressure simultaneously.

The ventilator we here design and develop using Arduino encompasses all these requirements to develop a reliable yet affordable ventilator to help in times of pandemic.

We here use a silicon ventilator bag coupled driven by servo motor with one side push mechanism to push the ventilator bag.

Our system makes use of blood oxygen sensor along with sensitive heart Beat sensor to monitor the necessary vitals of the patient and display on a webpage using IoT.

To adjust the time duration for inhalation the option command given in the IoT application to set.

The entire system is driven by Arduino controller to achieve desired results and to assist patients in COVID pandemic and other emergency situations.

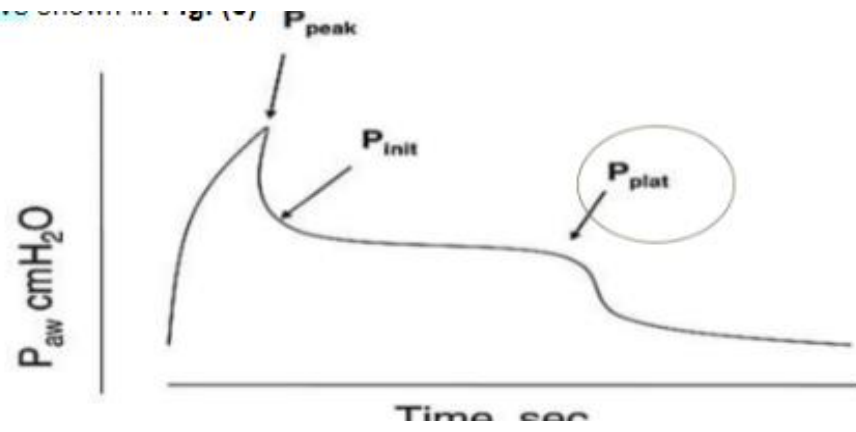


FIG 4.21 : MECHANICAL VENTILATOR PLOT PRESSURE

CHAPTER 5

RESULTS AND DISCUSSION

5.1 RESULT

The ventilator's operating and alarm capabilities were tested on a real-time after its design and fabrication as described in the Methods and Supporting Information. Under pressure-control ventilation, the high-volume, low-volume and high-pressure alarms were all successfully triggered when their alarm set points were crossed. The hardware on the system allows for a volume-driven approach to ventilation in addition to pressure-controlled ventilation with continuous feedback. Tests were conducted to characterize the system operating in this mode, but a proper continuous feedback volume-control system would require an in-line flow sensor, adding to the cost and complexity of the system and increasing reliance on an intact supply chain. However, we did test the system as a volume-driven ventilator.

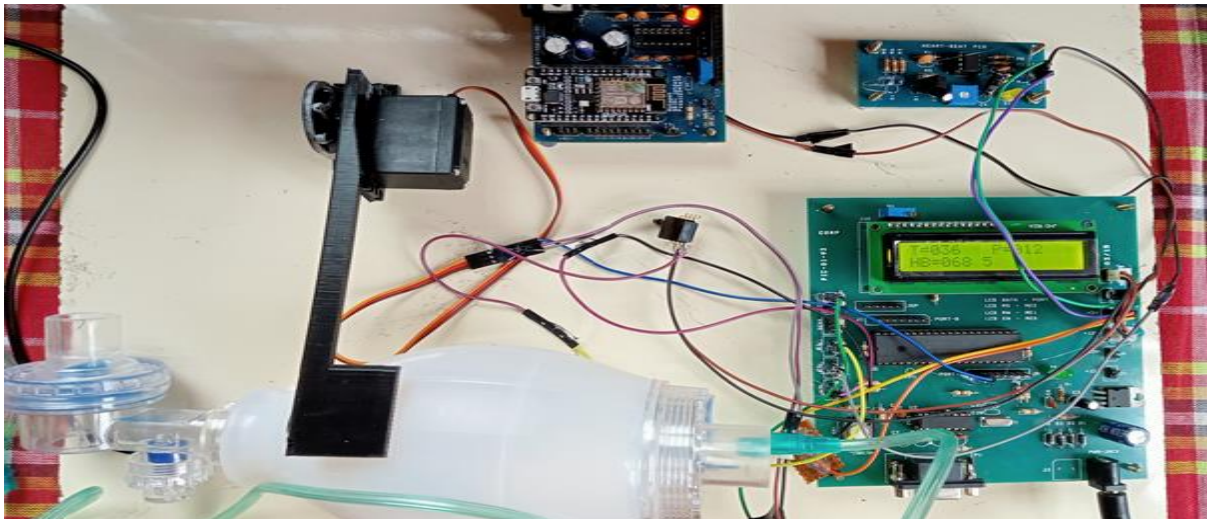
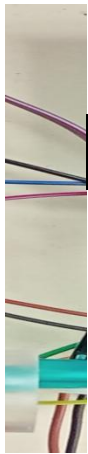


FIG 5.1: PROTOTYPE MODEL



Log ID	Data	Log Date	Log Time
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FIG 5.2: LCD DISPLAY

5.2 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 500-600 mL tidal volume. It features assist control and provide a constant air flow to the lungs.
- Power requirement is very low and running for 3.5 hours on one battery charge at its most demanding setting. Battery backup also need to be checked.
- It is low cost, portable, light weight and able to run 2 DC motors at the same time.
- Further development includes pressure sensor, air flow meter, over pressure alarm and other safety features to make it more user friendly

TA BL E 5.1 : IO T DA TA	1	TEMP30	01/22/2022	16:53:32
	2	TEMP:30_HB_68_PX:22	01/22/2022	16:54:32
	3	TEMP:30_HB_68_PX:22	01/22/2022	17:15:28
	4	TEMP:30_HB_68_PX:30	01/22/2022	17:15:35
	5	TEMP:30_HB_00_PX:30	01/22/2022	17:15:43
	6	TEMP31	03/16/2022	15:52:28
	7	TEMP:31_HB_69_PX:22	03/16/2022	15:52:28
	8	TEMP:31_HB_69_PX:22	03/16/2022	16:11:20
	9	TEMP:31_HB_69_PX:30	03/06/2022	16:12:14
	10	TEMP:31_HB_10_PX:30	03/06/2022	16:21:32

CHAPTER 6

SUMMARY AND CONCLUSION

6.1.1 SUMMARY

The People's Ventilator Project is an open-source, low-cost pressure-control ventilator designed for minimal reliance on specialized medical parts to better adapt to supply chain shortages. The designed ventilator largely follows established design conventions, most importantly active and controlled inhalation, together with passive exhalation. It supports pressure-controlled ventilation, combined with standard-features like breath detection, and the suite of minimal required alarms.

6.1.2 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.

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