STUDY OF VENTILATOR SYSTEM FOR COVID-19 PATIENT

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CERTIFICATION OF APPROVAL

The thesis titled " STUDY OF VENTILATOR SYSTEM FOR COVID-19 PATIENT ", Safa Tus Selahin, Md.Shamsul Islam Shovon, Md. Shohan Sheikh, Md. Tanvir Ahamed, Asraful Islam Shakib, Session: September-December (Fall), Batch: 016 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Mechanical Engineering on 16 May 2022.

Signature

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DECLARATION OF THE CANDIDATE

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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ABSTRACT

The recent pandemic of Covid-19 has diffused and become concerned to the world. Covid-19 has infected more than 100 million of reported cases according to the WHO with more than 2 million deaths. Shortness of breath is found in 18.6% of Covid-19 infected people. The people suffered from acute difficulty in breathing need a help from ventilator for breathing. The ventilator plays important role in saving the Covid-19 patients and other patients suffering from acute breathing difficulty. Ventilator can aid the patient to breathe easily and supporting the lungs by letting in the sufficient air. It's hard to find a ventilator while the demand gets increased in a pandemic like Covid-19.

Our goal is to design and construct a low-cost and straightforward ventilator system, test the performance and implement the ventilator system.

To achieve our goal, we divided our works in 5 stages. They are study, design, component collection, assembling and completion of project. Before starting the product designing, we have studied regarding journals and thesis papers and taken information from it (reference) to determine the design of the product. we decided to make the Ventilator System using Bag Valve Mask (BVM), Servo Motor, Relay, Arduino Nano, SMPS, Oxygen Cylinder, LCD Display, Regulator and switches. Our designed ventilation system worked beautifully and as we expected. our Ventilator System is still under development. The model can be improved by making some changes in the program written by Arduino Software IDE and components.

LIST OF FIGURE

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

Mechanical ventilation is a necessary tool in every modern intensive care unit (ICU). The type and intensity of ventilation support required by a patient varies over the course of treatment. Modern mechanical ventilators are versatile and adapt to patient needs. Commercially available devices control volume, pressure, or gas flow and the breathing cycle timing. They support patients who cannot breathe, and who can still trigger a mechanical cycle by a spontaneous inspiratory effort1 .Present-day mechanical ventilators are complex machines, consisting of many specialized components and featuring several ventilation modes.[1-3] The exponential growth of COVID-19 in 2020 put ICUs all over the world under unprecedented pressure. The drastic increase in demand of these devices exceeded the capacity of the existing supply chains, especially in regions where cross-border supply has been disrupted. This created the need for a simpler, but technically suitable machine that could be mass-produced on a very large scale and in a short time frame.

The MVM collaboration has responded to this need by developing the Mechanical Ventilator Milano (MVM), a reliable, fail-safe, and easy to operate mechanical ventilator, built from a small number of readily available parts. The design is inspired by the idea proposed by Manley[4] back in 1961, i.e. *the possibility of using the pressure of the gases from the anesthetic machine as the motive power for a simple apparatus to ventilate the lungs of the patients in the operating theatre* [5] , but using a completely different design, i.e. in particular, replacing all moving mechanical parts with electro-mechanical components, allowing better parameter control and improving robustness and reliability in the long-term operation, often needed by COVID-19 patients.

The MVM was designed in a collaboration between healthcare professionals and experimental physicists, benefiting from the medical expertise of the former and the latter's technical expertise in designing gas handling systems, with industrial partners (Elemaster, Italy and Vexos, Canada) who provided access to laboratories and production lines for both R&D and prototype construction. The MVM was certified by the Center for Devices and Radiological Health, U.S. Food and Drug Administration (FDA) for Emergency Use Authorization in May

2020, *in response to concerns relating to insufficient supply and availability of FDA-cleared ventilators for use in healthcare settings to treat patients during the COVID-19 pandemic*, and received Health Canada Medical Device Directorate Authorization *for Importation or Sale, under Interim Order for Use in Relation to COVID-19* in September 2020. A production run of 6000 units was recently performed in Canada (Vexos and JMP Solutions).

The cost of a single unit turned out to be about 10000 US$, about five times less than commercially available mechanical ventilators for ICUs. The MVM is a mechanical ventilator for adult patients assisted with tracheal tubes, designed to control pressure, while the resulting delivered volume is measured. Pressure control is widely used for COVID-19 patients, who are susceptible to further lung damage from too high a pressure or volume. The MVM can be operated in two modes, pressure-controlled ventilation (PCV), and pressure-support ventilation (PSV). In PCV mode, the ventilator controls the timing of the breathing cycle and regulates the pressure applied to the patient. PCV mode is used in the acute phase of the disease when patients are deeply sedated or paralyzed. By delivering the mechanical breath with an exponentially decelerating flow pattern, PCV allows pressures to balance across the lung units during a preset time, resulting in significantly reduced pressures and in improved distribution of ventilation. This lowers the risk of barotrauma attributable to the high pressures often required to ventilate these patients.[6]

PSV is an assisted ventilatory mode that is patient triggered, pressure-limited, and flow-cycled. The main use of this mode is for the weaning of the patient from mechanical ventilation, because it unloads the work of breathing and allows a gradual decrease of ventilator support until extubation. Invasive mechanical ventilation exposes the patient to risks arising from infections, pneumothorax, ventilator-associated lung injury, and oxygen toxicity, as well as from operator error. Therefore, the MVM has a sophisticated integrated alarm system, in accordance with EN 60601- 1-8:2007, that monitors the various aspects of the breathing cycle and alerts the operator when any anomaly arises. The hardware and software are designed to be as straightforward as possible to mitigate the risk of operator error. In addition, the MVM must be used in association with an oximeter and a manometer.

1.2 MEDICAL CONSIDERATION

According to current studies, approximately 5 % of patients hospitalized with COVID-19 develop severe lung damage.[7,8] This condition reflects the pathophysiology of severe acute respi- ratory distress syndrome (ARDS). ARDS is a disease characterized by reduced lung compliance due to the loss of surfactant function, collapsed lung areas, and accumulation of interstitial/alveolar plasma leakage. Computerized Tomographic (CT) scans demonstrate uneven distributions of aerated areas, and dense, consolidated regions of the lung; the remaining alveolar surface for gas exchange is greatly reduced in adult patients, a condition termed baby lung. It has been suggested that the clinical management of COVID-19 patients with severe lung damage should follow the established guidelines for ARDS subjects. This opinion has been confirmed by a recent study comparing COVID-19 subjects to patients affected by ARDS due to other causes; the physiological differences between ARDS from COVID-19 and other causes were found to be small. The principal supportive treatment for ARDS patients is mechanical ventilation with supplemental oxygen, currently deemed most appropriate, following a discussion that has been ongoing since the syndrome was first described in 1967. The tidal volume (Vtidal) is a key parameter, with potentially unfavorable effects if incorrectly set, such as ventilator-induced lung injury. Starting in the 1970s, a Vtidal of 12–15 mL per kg of predicted body weight (PBW) was recommended by clinicians until, in 2000, the Acute Respiratory Distress Syndrome Network reported that the length of hospital stay and mortality could be significantly reduced using a lung-protection strategy.

1.3 OBJECTIVE

The objectives of this project are:

a) To study the **Ventilator System for Covid-19 Patient**.
b) To design and construct of the Ventilator System.
c) To test the performance of the ventilator system for covid-19 patient.
d) To implement the ventilator system.

CHAPTER 2

LIRERATURE REVIEW

2.1 INTRODUCTION

This chapter is arranged on Literature Review. Here's a look at some of last year's literature, like our project. By reading them, we can overcome the mistakes of the previous project and make a more effective project.

2.2 ABOUT BVM BOX (BAG VALVE MASK)

A bag valve mask (BVM), sometimes known by the proprietary name Ambu bag or generically as a manual resuscitator or "self-inflating bag", is a hand-held device commonly used to provide positive pressure ventilation to patients who are not breathing or not breathing adequately. The device is a required part of resuscitation kits for trained professionals in out-of-hospital settings (such as ambulance crews) and is also frequently used in hospitals as part of standard equipment found on a crash cart, in emergency rooms or other critical care settings. Underscoring the frequency and prominence of BVM use in the United States, the American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiac Care recommend that "all healthcare providers should be familiar with the use of the bag-mask device. Manual resuscitators are also used within the hospital for temporary ventilation of patients dependent on mechanical ventilators when the mechanical ventilator needs to be examined for possible malfunction or when ventilator-dependent patients are transported within the hospital. Two principal types of manual resuscitators exist; one version is self-filling with air, although additional oxygen (O_2) can be added but is not necessary for the device to function. The other principal type of manual resuscitator (flow-inflation) is heavily used in non-emergency applications in the operating room to ventilate patients during anesthesia induction and recovery.

Ventilation is the mechanical process whereby air is taken into and out of the lungs. Situations in which patients might require ventilatory support range from apnea to patients experiencing depressed respiratory function. If the patient's rate of breathing decreases significantly it can lead to hypercarbia, hypoxia, a lowered ph level and a decreased in respiratory minute volume. This can result in cardiac or respiratory arrest if it isn't corrected. Expired air ventilation has been the accepted as the technique of choice since the late 1950's. It has been shown to be an effective practice for both professionals and laypersons including young children over 5 years of age. Ventilation using the expired air of the rescuer can be applied to mouth or nose of the adult victim and mouth-to-nose ventilation of the infant.

Mouth-to-Mouth ventilation and Mouth-to-Nose ventilation can provide effective ventilatory support to a patient. A Major advantage of these methods of ventilation is that no equipment is required to effectively offer ventilatory support to the patient. However, the disadvantage of these methods of ventilatory support are that both methods only offer a limited oxygen supply due to the fact that oxygen expired from the rescuer will only contain 17 percent oxygen. Mouth-to-mask Ventilation or Pocket Mask Ventilation. A clear plastic, molded facemask similar to that used in anesthesia maybe used to provide mouth to mask ventilation. A unidirectional valve diverts the patient's expired air away from the rescuer and traps any macroscopic particles emerging from the patient. This valve improves the aesthetics arid reduces risk of cross infection or contamination. The mouth to mask method is a two handed technique which produces a better seal than Bag-valve Ventilation or Bag-valve-mask (BVM) is a self-inflating bag can be connected to a facemask, a tracheal tube, a laryngeal mask, or a combitube. The bag consists of a transparent facemask, one-way valve, oblong self-inflating silicone or rubber bag, and oxygen reservoir.

It comes available in infant, child and adult sizes. Depending on make or model of BVM they may or may not have a pop-off release valve. A Pop off release valve allows excess pressure of air being forced into the mask from the bag to be released under certain centimeter of water pressure with allows air to escape. Thereby reducing potential volume Higgins and Yared (1993) and Todres (1993). In most cases the pop off valve should be disabled. Failure to do so could result in inadequate artificial ventilation. The oxygen inlet and reservoir allow for high concentration of inspired oxygen (80% to 100%). The BVM device should be used in conjunction with high-flow oxygen. These devices have a one-way or non-rebreather valve to maintain.high concentrations of inspired oxygen.

The volume of most adult BVM is approximately 1600 milliliters (mL). Despite what appears to be large volume for ventilation, the BVM provides less volume than the mouth-to-mask ventilation, if an airtight seal is not obtained between the mask and the face. An airtight seal is difficult to maintain unless a second rescuer squeezes the bag to deliver ventilations. Because of the difficulty of maintaining an airtight seal while squeezing the bag, a single rescuer may wish to perform mouth to mask ventilation instead of using the BVM alone as delineated by Circulation. (2000).

When used by one person, a considerable degree of skill is required to maintain a patent airway and airtight seal with one hand, while squeezing the bag with the other. This is only likely to be achieved by someone who regularly uses a BVM device. Too much air leakage will result in hypoventilation, while excessive tidal volumes may result in gastric insufflation and increase risk of regurgitation. If ventilation has to continue with a BVM, then a two-person technique is preferable; one person holds the facemask in place using both hands and an assistant squeezes the bag. In this way a better seal is achieved, the jaw thrust maneuver is more easily maintained and the patient's lungs can be ventilated more effectively. It has been noted by the 2000 Guidelines on Cardiac Care (2001) that when two rescuers are available the BVM can be very effective device.

Todres (1993) studied the effectiveness of mask ventilation performed by 112 physicians with clinical responsibilities at a tertiary referral teaching hospital in Ireland. Participants' physicians were asked to perform mask ventilation for three minutes on a Resaca Anne using a facemask and a two-liter self-inflating bag. The tidal volumes generated were quantified using a Laerdal skill meter computer. The effectiveness of mask ventilation was greater for anesthetists than for non-anesthetist. Physicians who had attended one or more resuscitation course where no more effective at mask ventilation than their colleagues who had not undertaken such courses. It is likely that first responders to in hospital cardiac arrests are commonly unable to perform adequate mask ventilation. Whereas in research by Elling and Politis (1983) Three hundred and twenty Emergency Medical Technicians (238 males and 82 females) were tested for the ability to ventilate a pre-calibrated Laerdal Recording Resusci-Anne using both a BVM and pocket mask ventilator.

Efficacy of cricoid pressure-in preventing gastric inflation during Bag-Mask Ventilation in pediatric patients a study done by Salem, Wong, Mani, and Sellick (1974) had ten patients between the ages of 3 months and 5 years, undergoing elective surgical procedures were studied under anesthesia and muscle paralysis. In most patients, bag-mask ventilation for a two-minute period, without cricoid pressure, resulted in appreciable accumulation of gases in the stomach. The investigation indicates that the simple maneuver of gentle cricoid pressure using the middle or little finger of the hand holding the mask is effective in reducing gastric distension during bag-mask ventilation without interfering with its adequacy. Exhaled volumes were greater during Intermitted Positive Pressure Ventilation with cricoid pressure because gases were prevented from entering the esophagus and escaping into the stomach. [9]

CHAPTER 3

THEORY & WORKING PRINCIPLE

3.1 WORK FLOW DIAGRAM

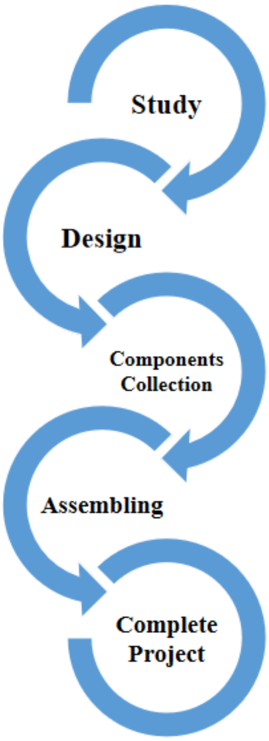

Figure 3.1: Working Flow Diagram

3.2 BLOCK DIAGRAM:

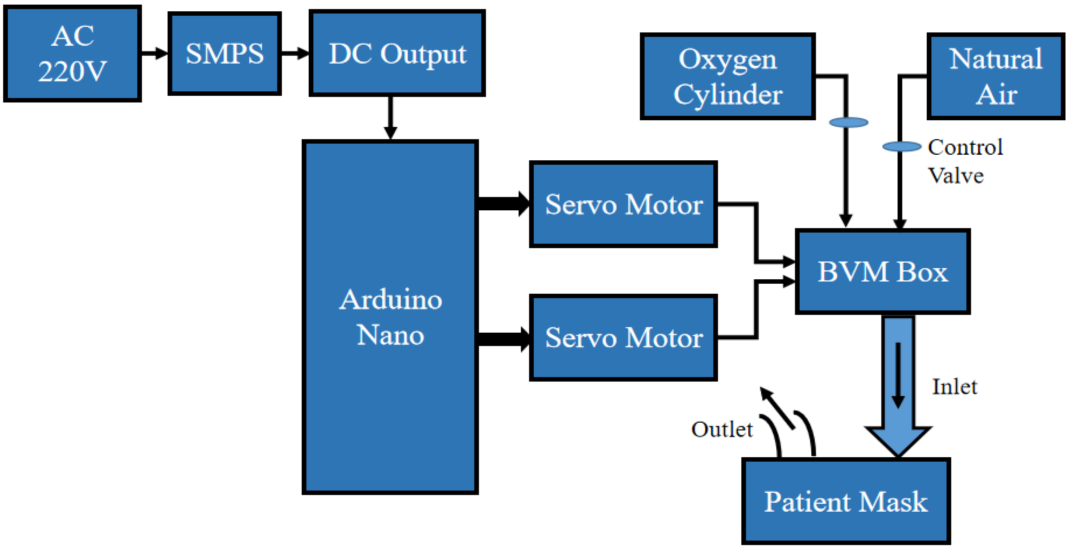

Figure 3.2: Block Diagram of **Ventilator System for Covid-19 Patient.**

3.3 CIRCUIT DIAGRAM

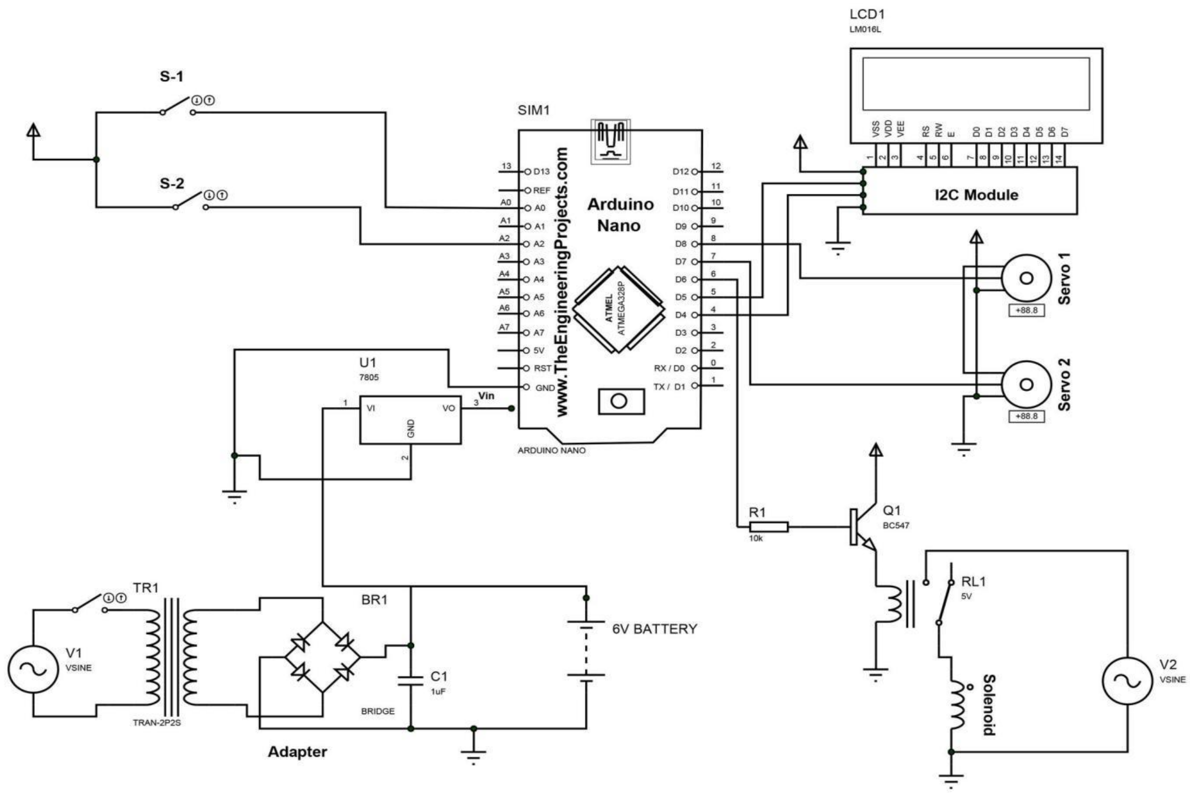

Figure 3.3: Circuit Diagram of **Ventilator System for Covid-19 Patient.**

3.4 PROJECT DESIGN

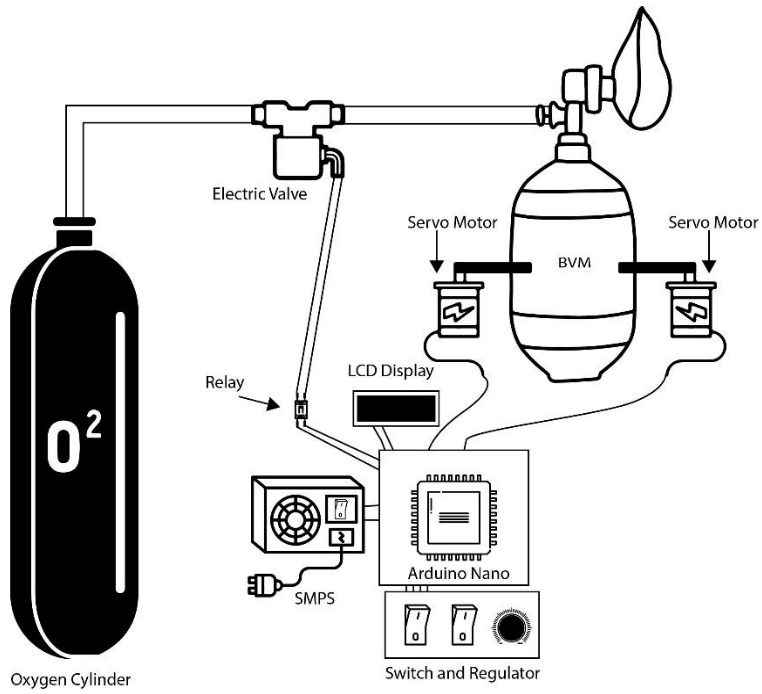

Figure 3.4: Project Design**.**

3.5 WORKING PRINCIPLE

SMPS will be the main power supply of our system. Converting supply voltage from 220 volts to SMPS 5 volts DC. Here our instruments work at 5 volt DC. Two servo motors are connected to the output of the micro-controller. These servo motors will put a certain amount of pressure on the BVM box. This BVM box will be attached to the face mask of COVID-19 patient. This will reduce the problem of breathing of COVID-19 patients. By doing this, the problem of breathing administration of COVID-19 patient will be reduced.

3.6 METHODOLOGY

Collecting all components/materials to construct the system. Set up the BVM box according to the design. Then two servo motors on either side of the BVM box according to the design. Then connect an electrical valve to the BVM box with a pipe. Attach an oxygen cylinder with the electrical valve by a pipe. Attach a relay to the electrical valve. Then connect servo motors, LCD display, controlling regulator, switches, and power supply with the ARDUINO NANO microcontroller. Then input the program into the microcontroller. Finally, we made this system & checked it finally that working very well.

3.7 COMPLETE PROJECT PROTOTYPE IMAGE

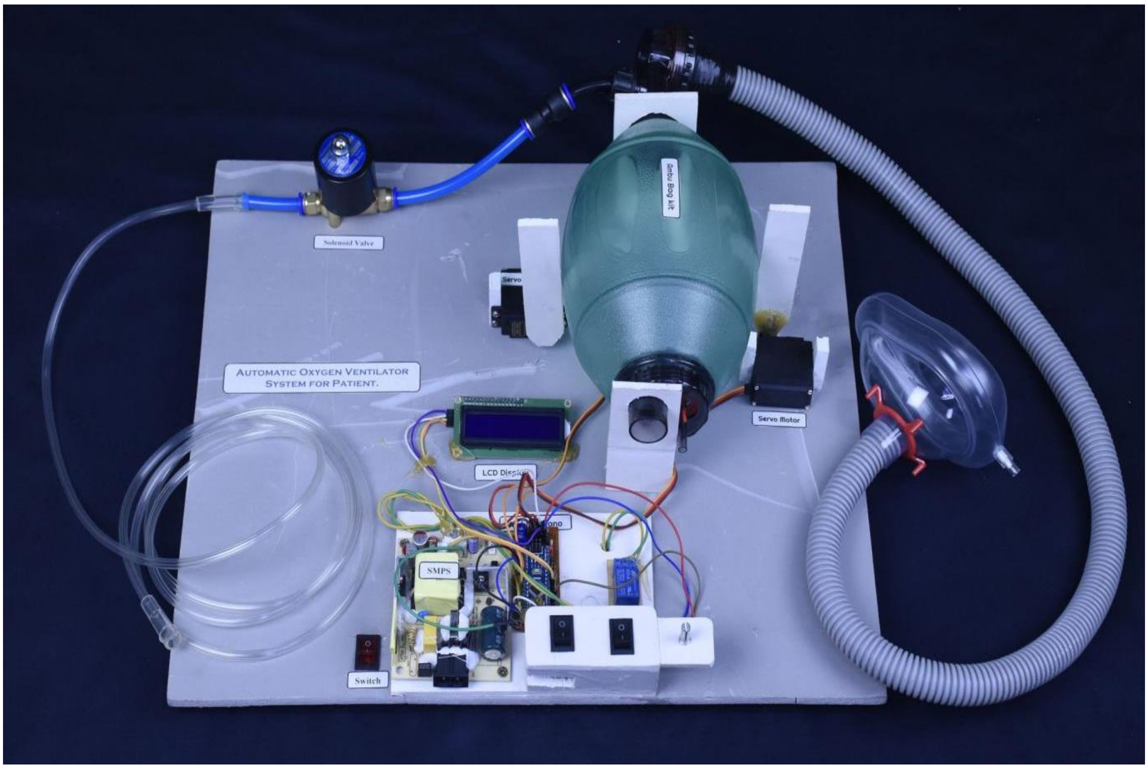

Figure 3.5: Project Prototype Image

3.8 COMPONENTS LIST:

1. Arduino Nano
2. SMPS
3. Oxygen Cylinder
4. Servo Motor
5. Relay
6. BVM Mask
7. Patient Mask
8. LCD Display
9. Regulator and switches

3.9 ARDUINO NANO

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling Lights, motors, and other actuators.

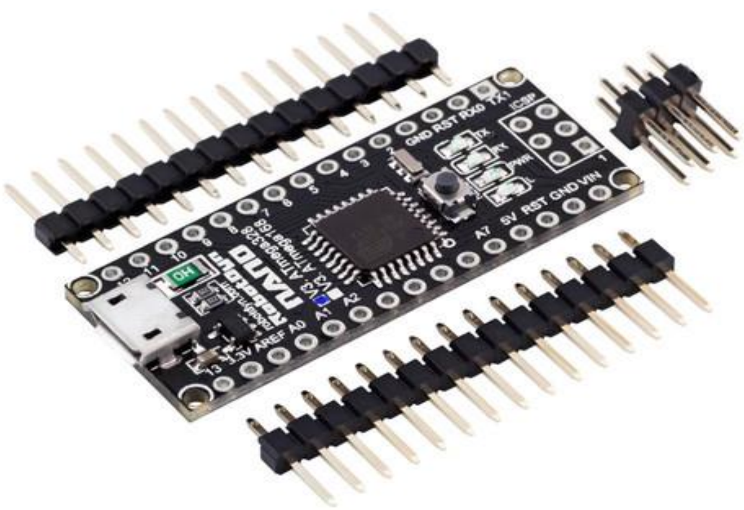

Figure 3.6 : Arduino Nano

The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

Arduino Nano is a surface mount breadboard embedded version with integrated USB. It is a smallest, complete, and breadboard friendly. It has everything that Diecimila / Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano is automatically sense and switch to the higher potential source of power.

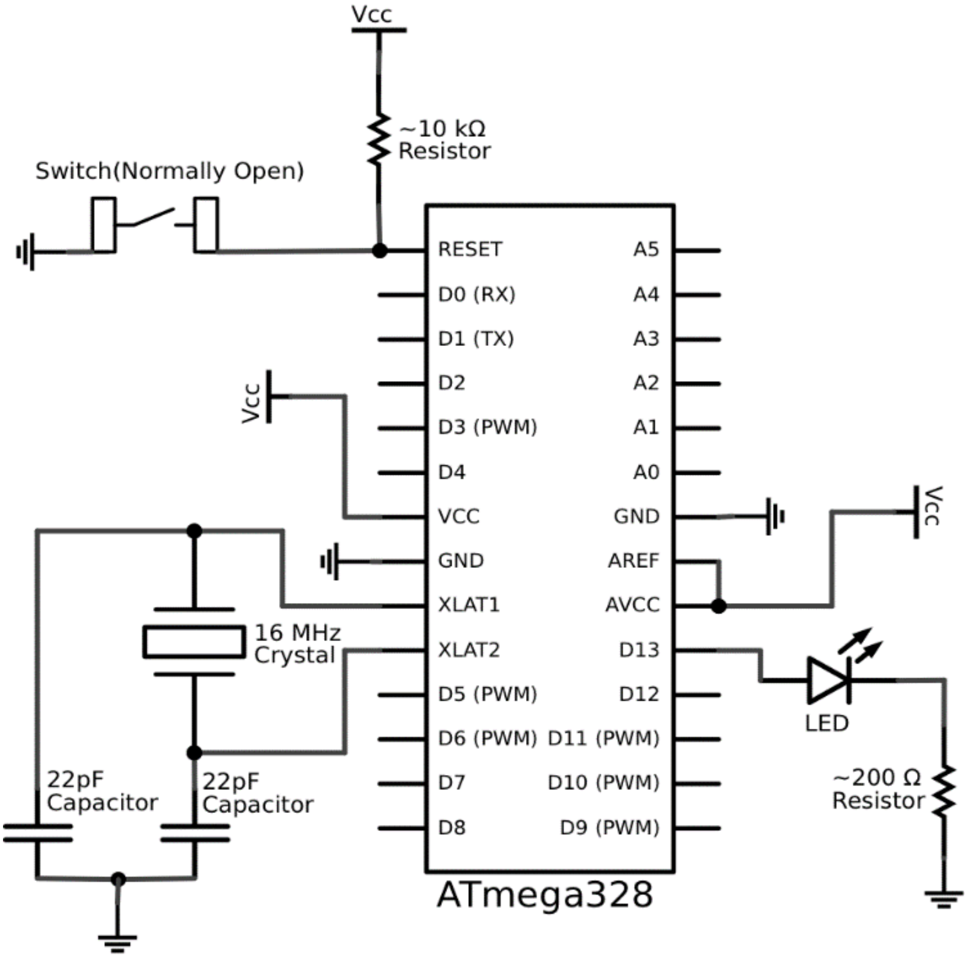

Figure 3.7: Arduino schematic diagram

Nano's got the breadboard-ability of the Boarduino and the Mini+USB with smaller footprint than either, so users have more breadboard space. It's got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, GND on one top, power and ground on the other). This new version 3.0 comes with ATMEGA328 which offer more programming and data memory space. It is two layers. That make it easier to hack and more affordable.[10]

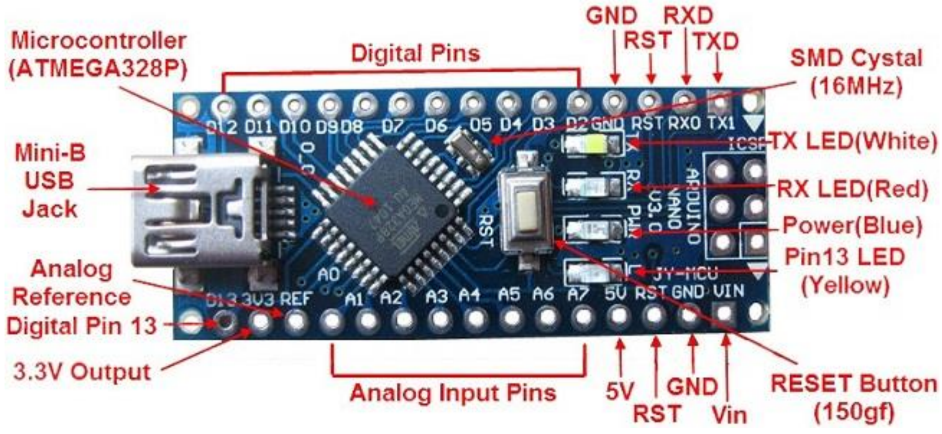

Figure 3.8: Section of Arduino Nano.

SPECIFICATIONS:

- Microcontroller: Atmel ATmega328
- Operating Voltage (logic level):5 V
- Input Voltage (recommended):7-12 V
- Input Voltage (limits):6-20 V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 8
- DC Current per I/O Pin: 40 mA
- Flash Memory: 32 KB (of which 2KB used by boot loader)
- SRAM : 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Dimensions: 0.70” x 1.70”

FEATURES:

- Automatic reset during program download
- Power OK blue LED
- Green (TX), red (RX) and orange (L) LED
- Auto sensing/switching power input

- Small mini-B USB for programming and serial monitor
- ICSP header for direct program download
- Standard 0.1 spacing DIP (breadboard friendly)
- Manual reset switch

Micro-controller IC ATmega328p:

Figure 3.9: Microcontroller IC AT mega 328p.

The high-performance Microchip pico Power 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

3.10 SWITCH MODE POWER SUPPLY (SMPS):

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.

Fig 3.10 : SMPS

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.

12V 5A Industrial SMPS Power Supply – 60W – DC Metal Power Supply – Good Quality – Non Waterproof with Aluminum casing.

- Input Voltage: AC 100 – 264V 50 / 60Hz
- Output Voltage: 12V DC, 0-5A

- Output voltage: Adjustment Range: ±20%
- Protections: Overload / Over Voltage / Short Circuit
- Auto-Recovery After Protection
- Universal AC input / Full range
- 100% Full Load Burn-in Test
- Cooling by Free Air Convection
- High Quality and High Performance
- LED power supply with a metal body for hidden installation for LED lighting
- Design with Built-in EMI Filter, improve signal precision.
- Certifications: CE & RoHs
- No Minimum Load.
- Compact Size Light Weight.
- High Efficiency, Reliabiltiy & low energy consumption
- Category – Switch Mode Power Adaptor (SMPS)

Switched-mode power supplies are classified according to the type of input and output voltages. The four major categories are:

- AC to DC
- DC to DC
- DC to AC
- AC to AC

A basic isolated AC to DC switched-mode power supply consists of:

- Input rectifier and filter
- Inverter consisting of switching devices such as MOSFETs
- Transformer
- Output rectifier and filter
- Feedback and control circuit

The input DC supply from a rectifier or battery is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.[11]

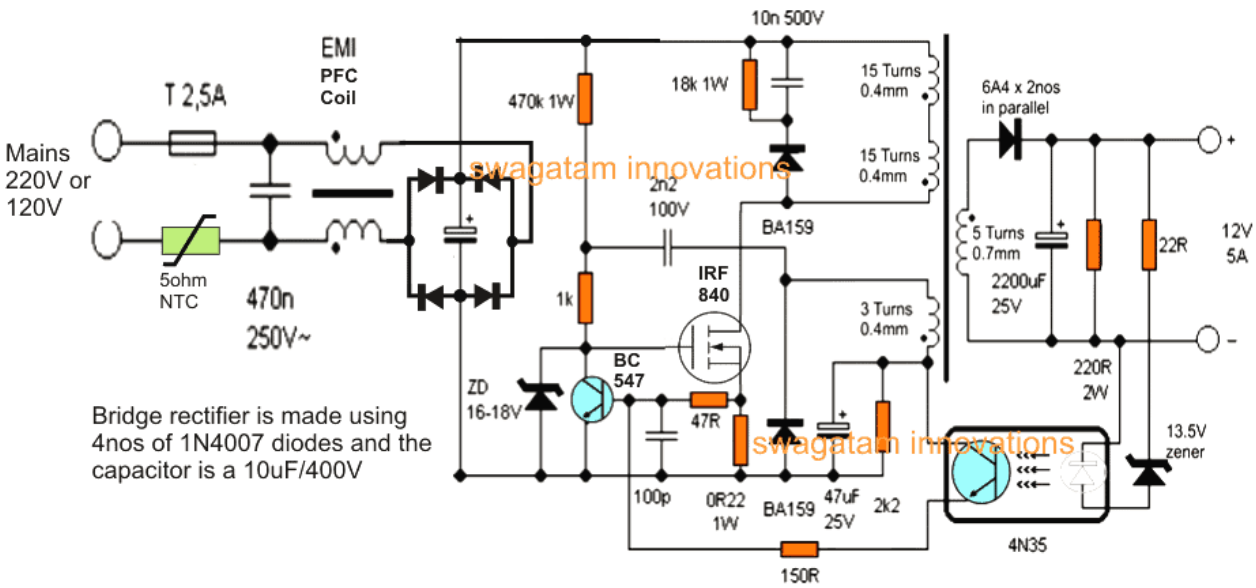

Fig 3.11: SMPS Circuit Design

BASIC WORKING CONCEPT OF AN SMPS

A switching regulator does the regulation in the SMPS. A series switching element turns the current supply to a smoothing capacitor on and off. The voltage on the capacitor controls the time the series element is turned. The continuous switching of the capacitor maintains the voltage at the required level.

DESIGN BASICS

AC power first passes through fuses and a line filter. Then it is rectified by a full-wave bridge rectifier. The rectified voltage is next applied to the power factor correction (PFC) pre-regulator followed by the downstream DC-DC converter(s). Most computers and small appliances use the International Electro technical Commission (IEC) style input connector. As for output connectors and pin outs, except for some industries, such as PC and compact PCI, in general, they are not standardized and are left up o the manufacturer.

There are different circuit configurations known as topologies, each having unique characteristics, advantages and modes of operation, which determines how the input power is transferred to the output. Most of the commonly used topologies such as flyback, push-pull, half bridge and full bridge, consist of a transformer to provide isolation, voltage scaling, and multiple output voltages. The non-isolated configurations do not have a transformer and the power conversion is provided by the inductive energy transfer.

ADVANTAGES OF SWITCHED-MODE POWER SUPPLIES:

- Higher efficiency of 68% to 90%
- Regulated and reliable outputs regardless of variations in input supply voltage
- Small size and lighter
- Flexible technology
- High power density

DISADVANTAGES:

- Generates electromagnetic interference
- Complex circuit design
- Expensive compared to linear supplies

Switched-mode power supplies are used to power a wide variety of equipment such as computers, sensitive electronics, battery-operated devices and other equipment requiring high efficiency.

SWITCH MODE POWER SUPPLY

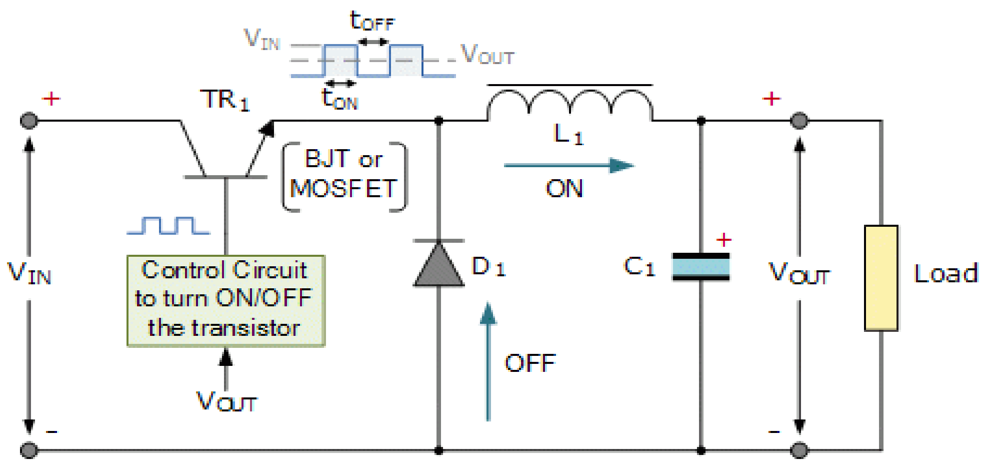

Fig 3.12: Power Supply Connection

Linear voltage IC regulators have been the basis of power supply designs for many years as they are very good at supplying a continuous fixed voltage output. Linear voltage regulators are generally much more efficient and easier to use than equivalent voltage regulator circuits made from discrete components such a zener diode and a resistor, or transistors and even op-amps.The most popular linear and fixed output voltage regulator types are by far the positive output voltage series, and the negative output voltage series. These two types of complementary voltage regulators produce a precise and stable voltage output ranging from about 5 volts up to about 24 volts for use in many electronic circuits. There is a wide range of these three-terminal fixed voltage regulators available each with its own built-in voltage regulation and current limiting circuits. This allows us to create a whole host of different power supply rails and outputs, either single or dual supply, suitable for most electronic circuits and applications. There are even variable voltage linear regulators available as well providing an output voltage which is continually variable from just above zero to a few volts below its maximum voltage output.

Most d.c. power supplies comprise of a large and heavy step-down mains transformer, diode rectification, either full-wave or half-wave, a filter circuit to remove any ripple content from the rectified d.c. producing a suitably smooth d.c. voltage, and some form of voltage regulator or stabilizer circuit, either linear or switching to ensure the correct regulation of the power supplies output voltage under varying load conditions. Then a typical d.c. power supply would look something like this:

Typical DC Power Supply

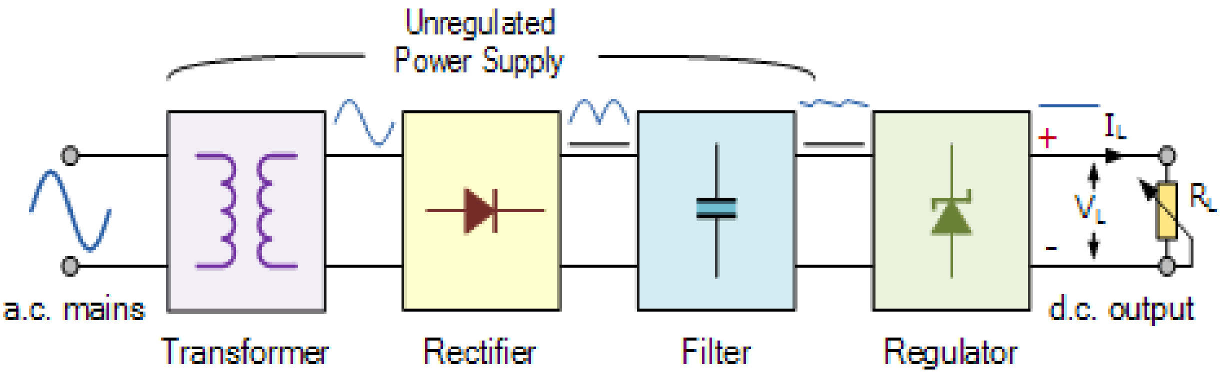

Fig 3.13 : DC Power Supply Step

These typical power supply designs contain a large mains transformer (which also provides isolation between the input and output) and a dissipative series regulator circuit. The regulator circuit could consist of a single zener diode or a three-terminal linear series regulator to produce the required output voltage. The advantage of a linear regulator is that the power supply circuit only needs an input capacitor, output capacitor and some feedback resistors to set the output voltage.

3.11 RELAY

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

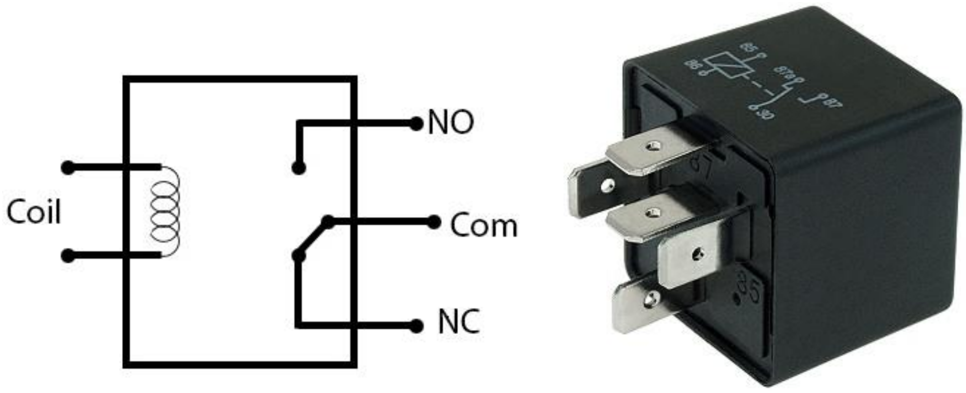

Figure 3.14: Relay

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".[12]

Magnetic latching relays require one pulse of coil power to move their contacts in one direction, and another, redirected pulse to move them back. Repeated pulses from the same input have no effect. Magnetic latching relays are useful in applications where interrupted power should not be able to transition the contacts.

Magnetic latching relays can have either single or dual coils. On a single coil device, the relay will operate in one direction when power is applied with one polarity, and will reset when the polarity is reversed. On a dual coil device, when polarized voltage is applied to the reset coil the contacts will transition. AC controlled magnetic latch relays have single coils that employ steering diodes to differentiate between operate and reset commands.

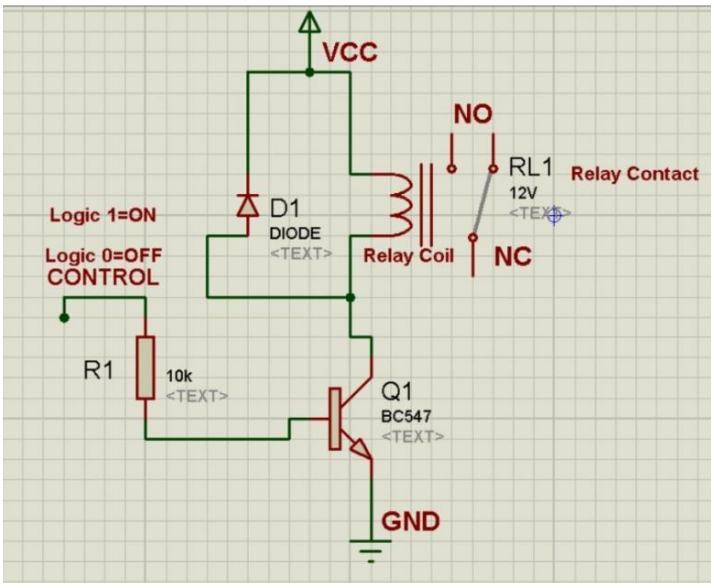

Figure 3.15: Transistor Switching Circuit.

The circuit above is called a low-side switch, because the switch – our transistor – is on the low (ground) side of the circuit. Alternatively, we can use a PNP transistor to create a high-side switch: Similar to the NPN circuit, the base is our input, and the emitter is tied to a constant voltage. A relay is an electrically operated switch of mains voltage. It means that it can be turned on or off, letting the current go through or not. Controlling a relay with the Arduino is as simple as controlling an output such as an LED. The relay module is the one in the figure below.

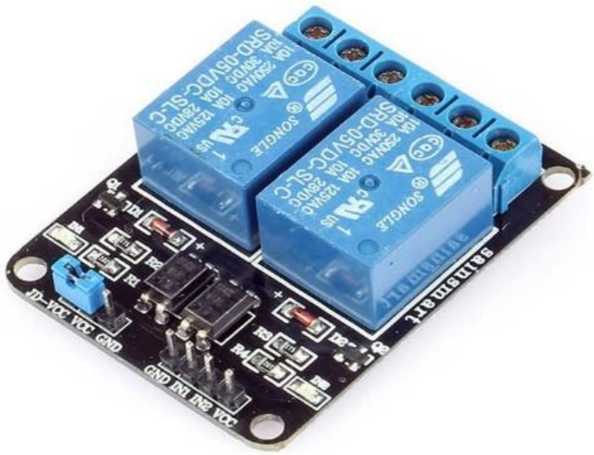

Figure 3.16 : Relay Module.

This module has two channels (those blue cubes). There are other varieties with one, four and eight channels.

MAINS VOLTAGE CONNECTIONS:

In relation to mains voltage, relays have 3 possible connections:

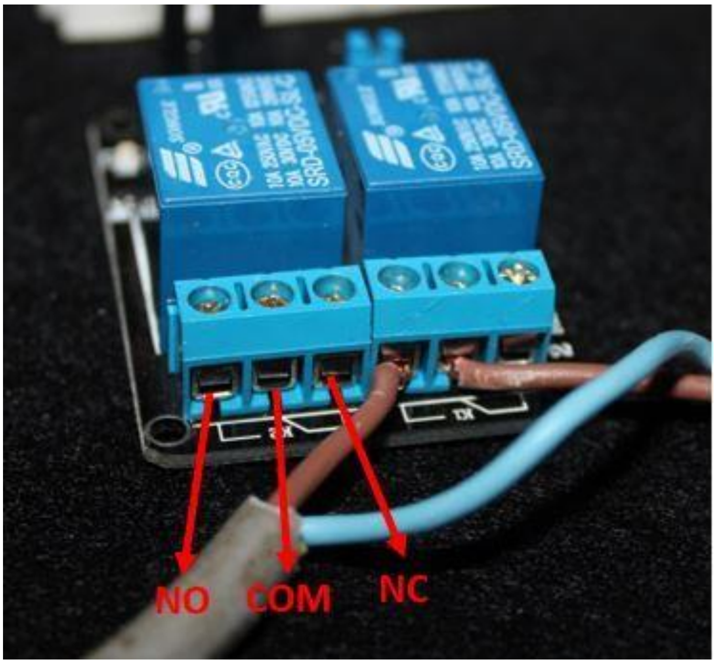

Figure 3.17: Pin diagram of Relay Module

COM: common pin

NO (Normally Open): there is no contact between the common pin and the normally open pin. So, when you trigger the relay, it connects to the COM pin and supply is provided to a load

NC (Normally Closed): there is contact between the common pin and the normally closed pin. There is always connection between the COM and NC pins, even when the relay is turned off. When you trigger the relay, the circuit is opened and there is no supply provided to a load.

If you want to control a lamp for example, it is better to use a normally-open circuit, because we just want to light up the lamp occasionally.

Pin wiring:

The connections between the relay module and the Arduino are really simple:

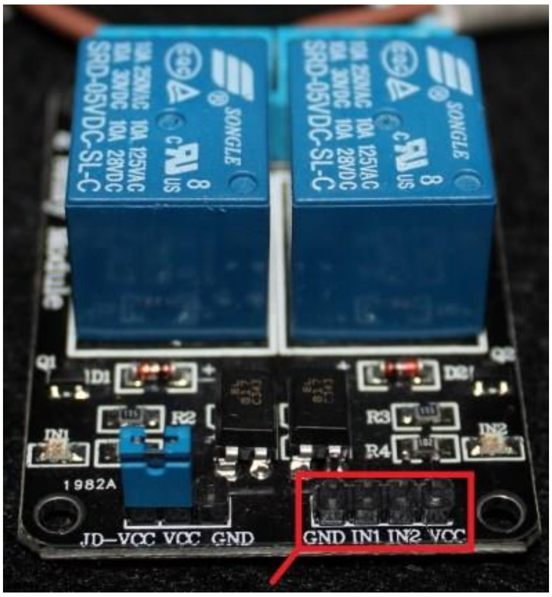

Figure 3.18: Main Voltage Connection

GND: goes to ground

IN1: controls the first relay (it will be connected to an Arduino digital pin)

IN2: controls the second relay (it should be connected to an Arduino digital pin if you are using this second relay. Otherwise, you don’t need to connect it) **VCC**: goes to 5V

3.12 SERVO MOTOR

A **servo motor** is an electrical device which can push or rotate an object with great precision. If you want to rotate and object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which run through **servo mechanism**. If motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. We can get a very high torque servo motor in a small and light weight packages. Doe to these features they are being used in many applications like toy car, RC helicopters and planes, Robotics, Machine etc.

Figure 3.19 : Servo Motor

Servo motors are rated in kg/cm (kilogram per centimeter) most hobby servo motors are rated at 3kg/cm or 6kg/cm or 12kg/cm. This kg/cm tells you how much weight your servo motor can lift at a particular distance. For example: A 6kg/cm Servo motor should be able to lift 6kg if the load is suspended 1cm away from the motors shaft, the greater the distance the lesser the weight carrying capacity.

The position of a servo motor is decided by electrical pulse and its circuitry is placed beside the motor.[13]

Servo Mechanism

It consists of three parts:

1. Controlled device
2. Output sensor
3. Feedback system

All motors have three wires coming out of them. Out of which two will be used for Supply (positive and negative) and one will be used for the signal that is to be sent from the MCU. Servo motor is controlled by PWM (Pulse with Modulation) which is provided by the control wires. There is a minimum pulse, a maximum pulse and a repetition rate. Servo motor can turn 90 degree from either direction form its neutral position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position, such as if pulse is shorter than 1.5ms shaft moves to 0° and if it is longer than 1.5ms than it will turn the servo to 180°.

Servo motor works on **PWM (Pulse width modulation)** principle, means its angle of rotation is controlled by the duration of applied pulse to its Control PIN. Basically servo motor is made up of **DC motor which is controlled by a variable resistor (potentiometer) and some gears**. High speed force of DC motor is converted into torque by Gears. We know that WORK= FORCE X DISTANCE, in DC motor Force is less and distance (speed) is high and in Servo, force is High and distance is less. Potentiometer is connected to the output shaft of the Servo, to calculate the angle and stop the DC motor on required angle.

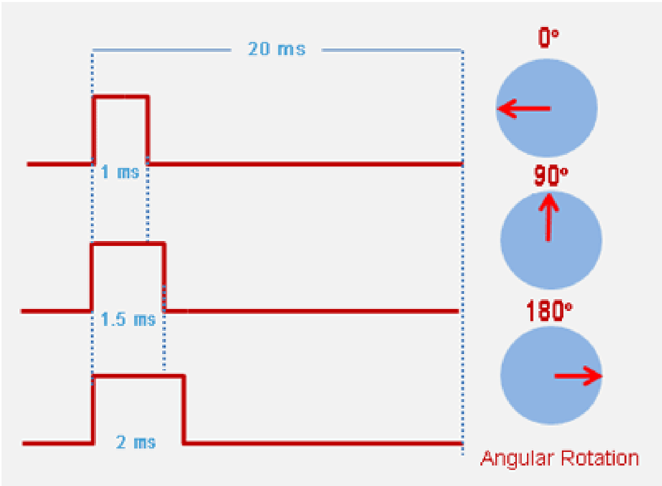

Figure 3.20 : Schema Diagram of servo motor

Servo motor can be rotated from 0 to 180 degree, but it can go up to 210 degree, depending on the manufacturing. This degree of rotation can be controlled by applying the **Electrical Pulse** of proper width, to its Control pin. Servo checks the pulse in every 20 milliseconds. Pulse of 1 ms (1 millisecond) width can rotate servo to 0 degree, 1.5ms can rotate to 90 degree (neutral position) and 2 ms pulse can rotate it to 180 degree.

All servo motors work directly with your +5V supply rails but we have to be careful on the amount of current the motor would consume, if you are planning to use more than two servo motors a proper servo shield should be designed.

3.13 BVM BOX

A bag valve mask (BVM), sometimes known by the proprietary name Ambu bag or generically as a manual resuscitator or "self-inflating bag", is a hand-held device commonly used to provide positive pressure ventilation to patients who are not breathing or not breathing adequately. The device is a required part of resuscitation kits for trained professionals in out-of-hospital settings (such as ambulance crews) and is also frequently used in hospitals as part of standard equipment found on a crash cart, in emergency rooms or other critical care settings. Underscoring the frequency and prominence of BVM use in the United States, the American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiac Care recommend that "all healthcare providers should be familiar with the use of the bag-mask device."[1] Manual resuscitators are also used within the hospital for temporary ventilation of patients dependent on mechanical ventilators when the mechanical ventilator needs to be examined for possible malfunction or when ventilator-dependent patients are transported within the hospital. Two principal types of manual resuscitators exist; one version is self-filling with air, although additional oxygen (O_2) can be added but is not necessary for the device to function. The other principal type of manual resuscitator (flow-inflation) is heavily used in non-emergency applications in the operating room to ventilate patients during anesthesia induction and recovery.[14]

Figure 3.21: BVM Box

METHOD OF OPERATION

Manual resuscitators cause the gas inside the inflatable bag portion to be force-fed to the patient via a one-way valve when compressed by the rescuer; the gas is then ideally delivered through a mask and into the patient's trachea, bronchus and into the lungs. In order to be effective, a bag valve mask must deliver between 500 and 600 milliliters of air to a normal male adult patient's lungs, but if supplemental oxygen is provided 400 ml may still be adequate. Squeezing the bag once every 5 to 6 seconds for an adult or once every 3 seconds for an infant or child provides an adequate respiratory rate.

Professional rescuers are taught to ensure that the mask portion of the BVM is properly sealed around the patient's face (that is, to ensure proper "mask seal"); otherwise, pressure needed to force-inflate the lungs is released to the environment. This is difficult when a single rescuer attempts to maintain a face mask seal with one hand while squeezing the bag with other. Therefore, common protocol uses two rescuers: one rescuer to hold the mask to the patient's face with both hands and focus entirely on maintaining a leak-proof mask seal, while the other rescuer squeezes the bag and focuses on breath (or tidal volume) and timing.

An endotracheal tube (ET) can be inserted by an advanced practitioner and can substitute for the mask portion of the manual resuscitator. This provides more secure air passage between the resuscitator and the patient, since the ET tube is sealed with an inflatable cuff within the trachea (or windpipe), so any regurgitation is less likely to enter the lungs, and so that forced inflation pressure can only go into the lungs and not inadvertently go to the stomach (see "complications", below). The ET tube also maintains an open and secure airway at all times, even during CPR compressions; as opposed to when a manual resuscitator is used with a mask when a face mask seal can be difficult to maintain during compressions

3.14 LCD DISPLAY

LCD (Liquid Crystal Display) screen is an electronics display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being LCDs are economical; easily programmable, have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc.

Features of LCD Display:

Built-in controller (KS 0066 or Equivalent) + 5V power supply (Also available for + 3V) 1/16 duty cycle B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED) N.V. optional for + 3V power supply.

Figure 3.22: 16*2 LCD Display

3.15 ARDUINO IDE

The digital micro controller unit named as Arduino Nano can be programmed with the Arduino software IDE. There is no any requirement for installing other software rather than Arduino. Firstly, Select "Arduino Nano from the Tools, Board menu (according to the micro controller on our board). The IC used named as ATmega328 on the Arduino Nano comes pre burned with a boot loader that allows us to upload new code to it without the use of an external hardware programmer.

Communication is using the original STK500 protocol (reference, C header files). We can also bypass the boot loader and programs the micro controller through the ICSP (In Circuit Serial Programming) header. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

The Arduino Nano is one of the latest digital microcontroller units and has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The

ATmega328 provides UART TTL at (5V) with serial communication, which is available on digital pins 0 -(RX) for receive the data and pin no.1 (TX) for transmit the data. An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .in file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board.

The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial Communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus. Arduino programs are written in C or C++ and the program code written for Arduino is called sketch. The Arduino IDE uses the GNU tool chain and AVR Lab to compile programs, and for uploading the programs it uses argued. As the Arduino platform uses Atmel microcontrollers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino.

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Figure 3.23: Arduino Software Interface IDE

WRITING SKETCHES

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

UPLOADING

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx , /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

When you upload a sketch, you're using the Arduino bootloader, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The bootloader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The bootloader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

LIBRARIES

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code.

There is a list of libraries in the reference. Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources or through the Library Manager. Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch. See these instructions for installing a third-party library.

THIRD-PARTY HARDWARE

Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, bootloaders, and programmer definitions. To install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "arduino" as the sub-directory name or you'll override the built-in Arduino platform.) To uninstall, simply delete its directory.

SERIAL MONITOR

This displays serial sent from the Arduino or Genuino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial.begin in your sketch. Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board. You can also talk to the board from Processing, Flash, MaxMSP, etc (see the interfacing page for details).

3.16 PROTEUS SOFTWARE

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronics design engineers and technicians to create schematics and electronics prints for manufacturing printed circuit boards.

The first version of what is now the Proteus Design Suite was called PC-B and was written by the company chairman, John Jameson, for DOS in 1988. Schematic Capture support followed in 1990 with a port to the Windows environment shortly thereafter. Mixed mode SPICE Simulation was first integrated into Proteus in 1996 and microcontroller simulation then arrived in Proteus in 1998. Shape based auto routing was added in 2002 and 2006 saw another major product update with 3D Board Visualization. More recently, a dedicated IDE for simulation was added in 2011 and MCAD import/export was included in 2015. Support for high speed design was added in 2017. Feature led product releases are typically biannual, while maintenance-based service packs are released as required.

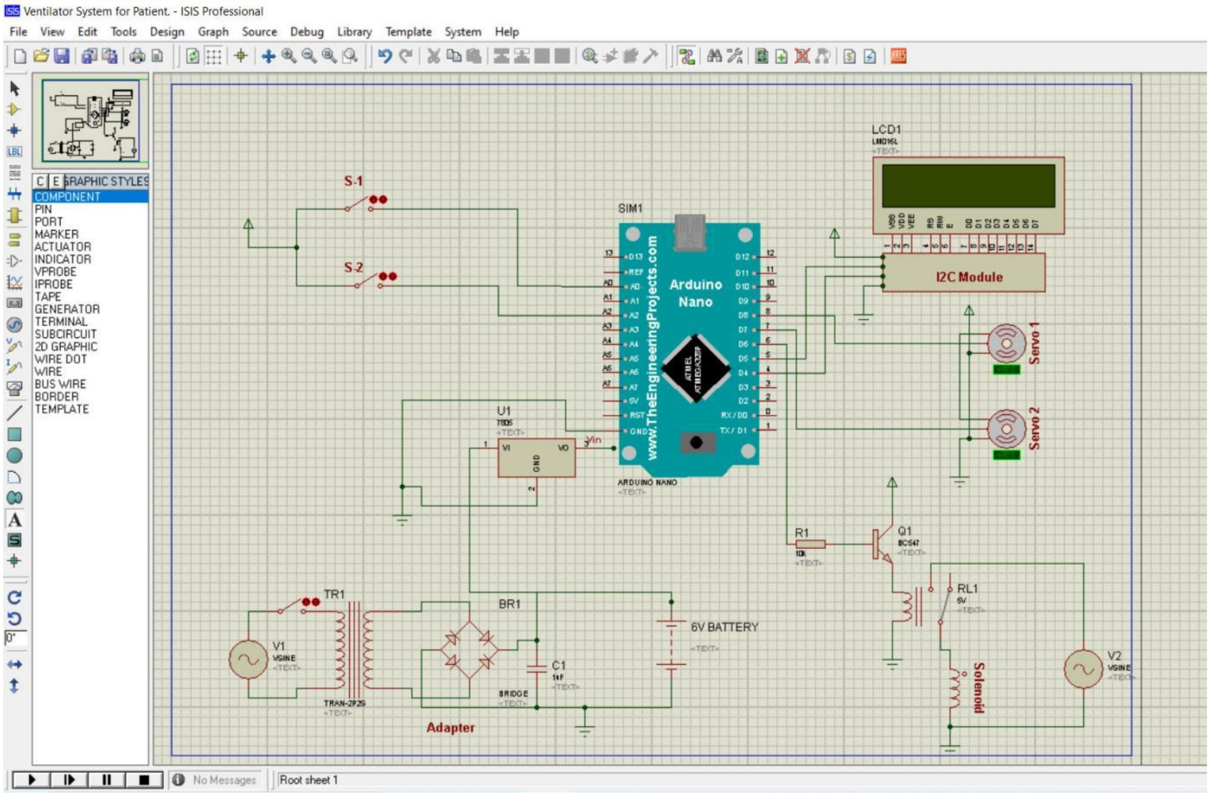

Figure 3.24: Our Project Design in Proteus Software

CHAPTER 4
RESULT & DISCUSSION

4.1 RESULT

a) We have been study about ventilation system and its mechanism how its work.

b) We have been able to design and construct a simple and inexpensive ventilation system.

c) Our ventilation system works very well as expected. Its variable Breathing speed function is working very well.

d) We have been able to build our system by following all the objects and methodologies. At first we have set up the all components well for our system. Here the BVM bag will be filled by the oxygen and servo motor will be compress the bag to supply the gas in patient breath. The efficiency of this project is very good. It is capable of working for a long time. We are satisfied its performance.

4.2 DISCUSSION

This kind of project already many of student study before, but they control it PLC system. We control with servo motor and micro-controller mechanism. When we made this project then we face some of problem. We did not run it smoothly. After hard work and team work we did it .

4.3 ADVANTAGE

- Easy of Use
- Cost Effective
- Maintenance is easy and cheap.
- Very effectively work for covid-19 patient
- The project is compact, cheap and user friendly.
- The whole system consumes very little energy.

- Less skill technicians are sufficient to operate.
- Simple construction

4.4 APPLICATION

This project has applications in many fields due its necessity. We have selected a few of them and they are given below:

- Hospital
- Pharmacy

4.5 LIMITATION

It is a demo project so we found some limitation. In future we will work for reduce this kind of limitation. These limitations are –

- It is a demo project so its accuracy is 85%.
- Our project may delay in work.

CHAPTER 5
CONCLUSION

5.1 CONCLUSION

In this technical note, a highly innovative ventilator design is proposed. The concept is still under development. Future iterations will include changes induced by the results of our prototype testing. It will incorporate an adjustable inspiratory/expiratory ratio that will be displayed on a LCD screen. Many cost-affective and precise sensors that interact with the human body and ensure that air is administered deliberately and accurately will also be added. Our goal is to provide a new and inexpensive solution. Finally, we will test the ventilator on various patients' respiratory tracts to compare its performance with conventional ventilators before launching the product onto the market.

5.2 FUTURE SCOPE

The model can be improved by making some changes in the program and components. Some suggestions are given below-

- We can add a monitoring based control to automate control.
- We will increase its working accuracy level.
- We will add IoT Management System.
- We will add more sensor to detect patient various condition at a time.

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[9] The efficiency of bag-valve mask ventilations by medical first responders and basic emergency medical technicians. {https://scholarworks.lib.csusb.edu/cgi/viewcontent.cgi?article=3311&context=etd-

project}

[10] Arduino Nano
{https://en.wikipedia.org/wiki/Arduino_Nano}

[11] SWITCH MODE POWER SUPPLY
{https://en.wikipedia.org/wiki/Switched-mode_power_supply}

[12] RELAY
{https://en.wikipedia.org/wiki/Relay}

[13] SERVO MOTOR
{https://en.wikipedia.org/wiki/Servomotor#:~:text=A%20servomotor%20(or%20servo%20motor,a%20sensor%20for%20position%20feedback.}

[14] BVM BOX
{https://en.wikipedia.org/wiki/Bag_valve_mask}

Appendix

Micro-controller Code :

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,16,2);


#include <Servo.h>


Servo myservo;  // create servo object to control a servo

Servo myservo1;  // create servo object to control a servo


int pos = 0;    // variable to store the servo position

int pos1 = 0;    // variable to store the servo position

int pot = A0;


int switch1= 2;

int switch2= 3;


void setup() {

Serial.begin(9600);

lcd.init();

 lcd.backlight();

 lcd.begin(16,2);

 lcd.clear();

 myservo.attach(5);  // attaches the servo on pin 9 to the servo object
```

```
    myservo1.attach(6);  // attaches the servo on pin 9 to the servo object
pinMode(2,INPUT);
pinMode(3,INPUT);
pinMode(A0,INPUT);

}

void loop() {
 int switch11 = digitalRead (2);
  int switch22 = digitalRead (3);
  int pott = analogRead (A0);

  int pottt = pott/50;
  Serial.println(pottt);
  //  lcd.setCursor(0, 0);
//lcd.print("Value");

if(switch11 == HIGH){
  lcd.setCursor(0, 0);
lcd.print("Natural On ");
lcd.print("V:");
lcd.print(pottt);
lcd.print("   ");

for (pos = 0; pos <= 50; pos += 1) { // goes from 0 degrees to 180 degrees
    // in steps of 1 degree
```

```
    myservo.write(pos);              // tell servo to go to position in variable 'pos'
      myservo1.write(pos);              // tell servo to go to position in variable 'pos'
  delay(pottt);                       // waits 15 ms for the servo to reach the position
  }
  for (pos = 50; pos >= 0; pos -= 1) { // goes from 180 degrees to 0 degrees
    myservo.write(pos);              // tell servo to go to position in variable 'pos'
    myservo1.write(pos);              // tell servo to go to position in variable 'pos'
 delay(pottt);                       // waits 15 ms for the servo to reach the position
  }
}

if(switch11 == LOW){
   lcd.setCursor(0, 0);
lcd.print("Natural Off                ");
myservo.write(50);              // tell servo to go to position in variable 'pos'
      myservo1.write(50);
}
if(switch22 == HIGH){
  lcd.setCursor(0, 1);
lcd.print("Cylinder On ");


}
if(switch22 == LOW){
  lcd.setCursor(0, 1);
lcd.print("Cylinder Off  ");
```

```
}
  delay(100);
}
```