DESIGN AND FABRICATION OF AUTOMATIC MEDICAL VENTILATION SYSTEM

A Thesis
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AUTOMATIC MEDICAL VENTILATION SYSTEM

A Thesis report Submitted to the Department of Mechanical Engineering for the partial fulfillment of the award of degree of "Bachelor of Science in Mechanical Engineering".

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Above all, we wish to convey our heartfelt thanks and love towards our parents to whom we owe everything. We are forever indebted to our parents for their understanding, endless support and encouragement when it was most required.

Abstract

Ventilator device are external devices that are designed to assist a patient to perform a particular task. It is to keep up or improve a breathing ability of a person if he encounters problem in his own breathing. Ventilators play a vital role in human's life. It is a piece of equipment, software program or product system that is used to increase, maintain, or improve the functional capabilities of persons with disabilities in breathing period.

This paper deals with the hardware design of a lab model ventilator. A prototype model of the ventilator has been designed and tested. Scripture under sight is defining the robustness and functionalities of ventilator which is not only easily transferable as well as it is very low cost and economics friendly. It is designed under the basic idea of being incorporated in huge human catastrophes in poorly resources enriched environments. It functions without human operator as it delivers breaths through the compression of an orthodox bag-valve mask. Different functions need to be performed for the purpose of ventilation i.e. pressure and required number of breathes per minute is managed by an easy to use input board comprising of buttons. In addition to that it also contains an alarm of high temperature for patient system as well as an assist control.

This piece of prototype is cost effective as well as energy efficient as far as the present technology in ventilators is concerned.

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List of abbreviations

AC	Alternative Current
AMBU	Artificial Manual Breathing Unit
BPM	Breaths Per Minute
BVM	Bag Valve Mask
DC	Direct Current
ICU	Intensive Care Units
kPa	Kilopascal
LCD	Liquid-Crystal Display
mm	Millimeter
O_2	Oxygen
PEEP	Positive End Expiratory Pressure
Rpm	Revolutions per Minute
Sec	Second
T	Torque

CHAPTER 1

INTRODUCTION

1.1 Introduction

This project aims to address the shortage of ventilators in developing countries by creating a low-cost, portable ventilator prototype designed to deliver artificial respiration. Traditional ventilators are often expensive and difficult to maintain, making them inaccessible in rural and underdeveloped areas. The ventilator prototype in this project substitutes a traditional flow analyzer with a potentiometer and needle valve to regulate airflow, making it a more cost-effective solution [1].

The ventilator operates initially with 1 bar of compressed air, controlled via a regulator, which passes through a solenoid valve for simple on/off operation. The airflow is directed through two pathways: one to the needle valve and potentiometer for fine adjustment, and the other to an exhalation valve. After adjusting the air flow, a 6mm to 8mm tube is attached to a test lung bag that simulates the inhalation and exhalation process of a patient. [2].

The prototype is designed to monitor four key ventilator parameters: inhalation and exhalation volume, air flow, and pressure, ensuring it provides the necessary support for respiratory failure. This solution is aimed at reducing the cost barrier to accessing mechanical ventilation in resource-poor settings, where medical equipment is often limited or non-existent. By offering an affordable and efficient alternative, this ventilator prototype can help mitigate the healthcare challenges caused by respiratory diseases and the lack of essential medical equipment in remote areas. [3].

1.2 Objectives

- To develop a low-cost ventilator system.
- To automate the AMBU bag using Arduino and a motor.
- Portable and User-Friendly Design
- To allow control over Breath Per Minute (BPM)

1.3 Methodology

The primary goal of this project is to design and develop an automated AMBU bag-based ventilator system capable of delivering consistent and controlled breathing support to patients in emergency and critical care situations. This device aims to serve as a low-cost, portable, and reliable solution, especially in low-resource environments where conventional ventilators are unavailable or insufficient, it will take the following steps.

- The system receives power through a regulated DC supply.
- The microcontroller initializes all connected components.
- User sets the desired breaths per minute (BPM) using the input buttons
- The microcontroller calculates timing based on the selected BPM.
- The motor starts compressing and releasing the AMBU bag accordingly.
- Compressed air or oxygen is delivered to the patient through the bag and tubing.
- The LCD displays BPM and motor status during operation
- The process continues in a loop to provide consistent respiratory support
- The system shuts down safely when powered off or stopped manually.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

Respiratory diseases and failure are significant public health issues in both developed and developing countries. Conditions such as asthma and chronic obstructive pulmonary disease (COPD) are increasingly prevalent due to factors like pollution, smoking, and the burning of biomass fuels—especially in low-income regions. In critical cases, patients require mechanical ventilation, which supports breathing by simulating the natural inhalation and exhalation process, allowing gas exchange in the lungs.

However, the ventilators commonly used in modern hospitals are expensive and technologically complex. Their high cost, along with maintenance challenges, makes them inaccessible for under-resourced healthcare systems. Many hospitals in developing countries either share ventilators, use unreliable refurbished units, or lack them entirely—particularly in rural areas.

To address this issue, a low-cost, portable ventilator prototype has been designed. The device aims to offer essential respiratory support without the high price of commercial ventilators. Instead of expensive components like flow analyzers, the prototype uses cost-effective alternatives such as potentiometers and needle valves. The system operates using compressed air at around 1 bar pressure, regulated and passed through a solenoid valve that controls airflow. The air is then split between a needle valve (with potentiometer) and an exhalation valve. Airflow is adjusted and directed to a test lung bag via 6mm to 8mm tubing, simulating the patient's inhalation and exhalation process.

This prototype is capable of illustrating four major ventilator parameters, ensuring basic functionality at a much lower cost. Its development is particularly valuable for countries with limited medical infrastructure, as it offers a practical solution to life-threatening respiratory failures. With proper scaling, such innovations can save countless lives during emergencies or pandemics by bridging the healthcare gap between urban centers and underserved rural areas.

2.2 Background

The global COVID-19 pandemic exposed the urgent need for affordable and portable ventilators, especially in developing countries. Ventilators are essential medical devices used to assist or replace spontaneous breathing in patients with respiratory failure or during surgery. However, due to the high cost, complex design, and limited availability, many rural hospitals and clinics cannot afford standard ventilator systems.

This project focuses on developing a low-cost, automated ventilator using an ambu bag, motor, microcontroller, and basic electronic components. The motor compresses the ambu bag rhythmically to push air into the patient's lungs, simulating natural breathing. This process is controlled electronically to ensure the correct breathing rate, volume, and timing.

Our design is cost-effective, easy to assemble, and can be used in emergency or resource-limited settings. It serves as a backup ventilation system in critical situations when traditional ventilators are not available. By offering a simple yet reliable solution, this project can play an important role in saving lives and supporting healthcare systems in times of need.

2.3 Literature Review

Several studies and research projects have been conducted on low-cost ventilators, especially during the COVID-19 pandemic. Many researchers focused on developing emergency ventilators using Ambu bags and microcontrollers. For example, the MIT E-Vent project introduced a motorized Ambu bag compression system with adjustable parameters like breathing rate and swept volume.

In 2020, multiple teams from universities and startups proposed open-source ventilator designs using Arduino or Raspberry Pi. These systems typically include sensors to monitor pressure, volume, and oxygen levels, along with motor control to automate the breathing process. Some designs also included alarm systems for patient safety.

A study published in the Journal of Medical Engineering discussed the importance of reliability and cost-effectiveness in ventilator systems. The article highlighted that in low-resource settings, simplicity and ease of use are critical.

Based on these findings, our project aims to develop a ventilator that is affordable, simple, and suitable for emergency use. Our system uses a DC motor to press an Ambu bag, controlled by an Arduino microcontroller, which is supported by sensor feedback for accurate operation.

2.4 Field of applications of gas flame detection

2.4.1 Emergency and Disaster Relief Operations:

In natural disasters, accidents, or pandemics where a sudden surge in patients occurs, hospitals often face ventilator shortages. This portable ventilator can be quickly deployed to provide life-saving respiratory support in such critical situations.

2.4.2 Rural and Underserved Healthcare Facilities:

Many rural clinics and small hospitals in developing countries lack access to standard ventilators due to high costs and infrastructure limitations. This prototype offers a practical solution for basic ventilation support in such areas, helping bridge the healthcare gap.

2.4.3 Ambulance and Mobile Medical Units:

During patient transportation, maintaining oxygen supply and stable breathing is essential. The compact nature of this ventilator makes it ideal for use in ambulances and mobile health units where space and resources are limited.

2.4.4 Temporary Medical Camps and Field Hospitals:

During vaccination drives, epidemic outbreaks, or health awareness camps, temporary setups are often created. This ventilator can serve as a temporary respiratory support device in such mobile healthcare environments

2.4.5 Educational and Research Institutions:

The project can be used in medical and engineering colleges to educate students about the base principles of mechanical ventilation, control systems, and low-cost medical device development.

2.4.6 Backup Device in Hospitals:

Even in well-equipped hospitals, this ventilator can serve as an emergency backup unit in case of power failures or equipment malfunction, ensuring uninterrupted patient care.

2.5 Existing system

Currently, most hospitals and healthcare facilities rely on advanced mechanical ventilators to support patients suffering from respiratory failure. These machines are capable of precisely controlling airflow, pressure, oxygen concentration, and other critical parameters required for artificial respiration. While highly effective and sophisticated, these ventilators come with several limitations, especially when considered for use in low-resource settings.

Modern ventilators are expensive and complex, requiring trained professionals for operation and regular maintenance. Their high cost makes them unaffordable for many clinics and hospitals, particularly in developing and underdeveloped countries. Moreover, these ventilators are not easily portable, which limits their use in emergency field conditions or during patient transport.

During pandemics like COVID-19 or in cases of mass casualties, even well-funded hospitals have faced shortages of ventilators. This has highlighted the vulnerability of existing systems and the urgent need for more scalable, cost-effective alternatives.

In rural areas, where power supply is unstable and access to technical support is limited, maintaining advanced ventilators becomes even more challenging. In some regions, hospitals rely on manual ventilation methods, such as manually operating an Ambu bag, which is not sustainable for long durations and depends on the availability of medical staff. Additionally, in many emergency cases or during ambulance transport, patients may not receive consistent ventilation support due to the unavailability of portable ventilators.

In summary, while the existing system of mechanical ventilation is technologically advanced, it lacks affordability, portability, and accessibility. These limitations create a need for a simpler, low-cost, and reliable ventilator system like the one proposed in this project, especially for use in rural, remote, or emergency conditions.

2.5.1 Definition

A mechanical ventilator is a medical device designed to assist or completely take over the breathing process for patients who are unable to breathe adequately on their own. It delivers controlled breaths of air, often enriched with oxygen, into the lungs and removes carbon dioxide, thereby ensuring proper gas exchange in the body.

In critical care settings, ventilators are essential for patients with severe respiratory conditions such as Acute Respiratory Distress Syndrome (ARDS), Chronic Obstructive Pulmonary Disease (COPD), or in cases of respiratory failure due to trauma, infection, or surgery. They can be invasive (using an endotracheal tube) or non-invasive (using a face mask).

Modern ventilators are typically equipped with sensors, microcontrollers, and software that allow medical professionals to customize breathing parameters such as tidal volume, respiratory rate, inspiratory/expiratory ratio, and oxygen concentration.

In contrast, the proposed low-cost ventilator system in this project aims to replicate the essential functions of these machines using simplified components such as a solenoid valve, regulator, needle valve, and Ambu bag mechanism. This design is intended for emergency, backup, or resource-limited settings, where conventional ventilators are not available or affordable.

2.5.2 Field visit

To understand the real-life applications and challenges of ventilator systems, our project team conducted field visits to several healthcare centers and hospitals. During these visits, we observed the functioning of modern ventilators, their control systems, and the difficulties faced by hospital staff in using and maintaining these devices, especially in low-resource settings.

Discussions with doctors and respiratory therapists revealed that high costs, frequent maintenance requirements, and lack of trained personnel are major concerns in the usage of traditional ventilators. We also learned that rural hospitals often do not have access to sufficient numbers of ventilators, leading to a crisis during emergency situations.

These field experiences provided us with critical insights and validated the need for a portable, low-cost ventilator that can be deployed quickly in emergencies and in underserved areas.

2.5.3 ICSS

The Intensive Care Support System (ICSS) is a comprehensive setup found in hospitals, particularly in Intensive Care Units (ICUs), designed to support critically ill patients who require continuous monitoring and life-supporting devices. This system includes ventilators, patient monitoring systems, infusion pumps, defibrillators, oxygen supply systems, and other emergency medical equipment.

The main goal of ICSS is to stabilize patients who are suffering from life-threatening conditions such as respiratory failure, cardiac arrest, severe trauma, or post-operative complications. Among all these, mechanical ventilators play a central role in ICSS by ensuring proper oxygenation and removal of carbon dioxide from the patient's lungs.

However, in developing countries, the full ICSS setup is often unavailable in rural or under-equipped hospitals due to the high cost and maintenance of these systems. This leads to a lack of support for patients in critical need, especially during pandemics or natural disasters.

Our proposed low-cost ventilator model is intended to serve as an essential component of an affordable and simplified ICSS setup. It can be used in emergency cases or in areas where a complete ICSS system is not available, thus helping to save lives in resource-limited settings.

- Detecting Number of breaths per minute.
- Detecting amount of air delivered to the lungs in one breath.
- Control of airflow using a needle valve and potentiometer.
- Detection of airway pressure
- Oxygen concentration in delivered air.
- Detecting proper functioning of the exhalation process.
- Duration of air intake and release.

2.5.4 Limitations of existing system

The existing mechanical ventilator systems, while efficient in advanced hospital settings, face several challenges when considered for use in low-resource or rural areas. One of the primary limitations is their high cost, which makes them unaffordable for many small or underdeveloped healthcare facilities. In addition to the cost, these machines are often technically complex and require skilled medical professionals for operation, which may not always be available in remote locations.

Moreover, ventilators are typically concentrated in urban hospitals, creating a shortage in rural and remote areas where they are often needed most. Another challenge is the high maintenance cost associated with these devices, as they require regular servicing and technical support. The size and design of many existing ventilators make them bulky and difficult to transport, reducing their effectiveness in emergency situations or mobile healthcare units.

Furthermore, most ventilators are dependent on a constant supply of electricity, which makes them unreliable in areas with unstable or limited power infrastructure. In times of crisis, such as pandemics or natural disasters, these limitations become even more apparent, as the available units are often insufficient to meet the sudden surge in demand. These issues highlight the need for low-cost, portable, and easy-to-use ventilator systems that can be implemented in resource-limited settings.

2.5 Others Safety System

In our designed ventilator prototype, several important safety features have been included to ensure patient safety and proper functionality. Firstly, a pressure control system has been implemented to prevent excessive pressure on the lungs. It maintains airflow within a specific range, thereby reducing health risks for the patient. Secondly, a sound alarm system has been integrated, which automatically alerts the user in case of any malfunction inside the device, abnormal pressure, or obstruction in airflow.

Additionally, the device includes a filtering system that purifies the inhaled air and reduces the risk of germs or dust particles entering the patient’s respiratory system. These safety features make the ventilator more reliable and ensure patient protection, especially in resource-limited settings

CHAPTER 3

Methodology

3.1 Block Diagram

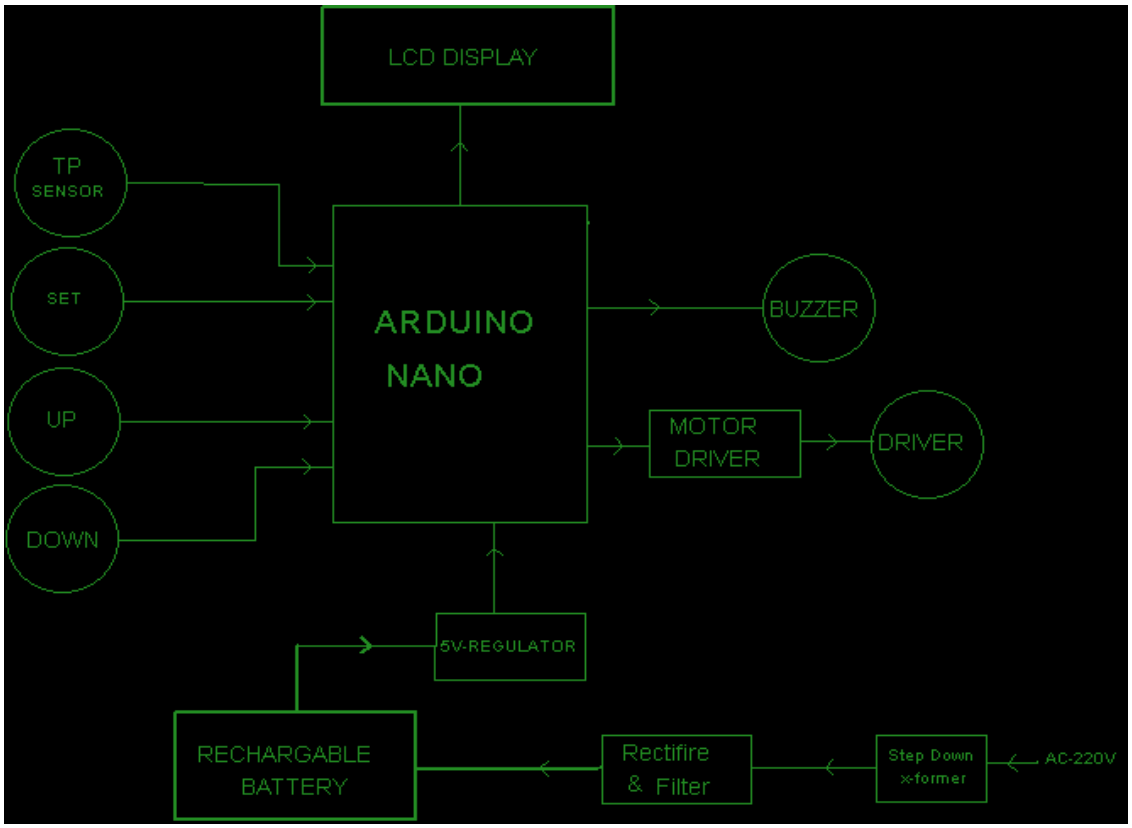


Figure 3.1: Block Diagram

Fig 3.1 shows the block diagram of the implemented project. Arduino Nano is connected to the source by the help of a power adapter and sensors and LCD display are also connected to the microcontroller.

3.2 Working Principle

- The AMBU bag pushes air into the patient's lungs at regular intervals.
- A single belt compresses the AMBU bag based on calculated force and timing.
- The control system calculates required pressure and air volume for each compression.
- When the patient temperature rises beyond the safe limit, the buzzer automatically gives an alarm.

3.3 Circuit Diagram

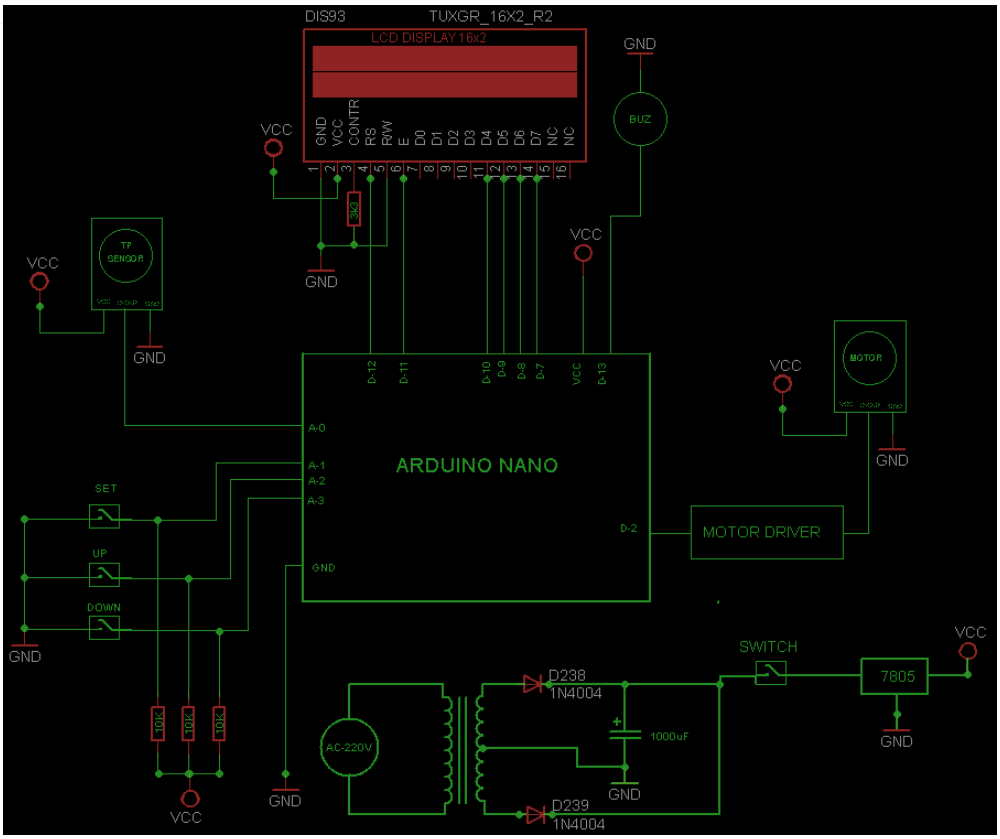


Figure 3.2: Circuit Diagram

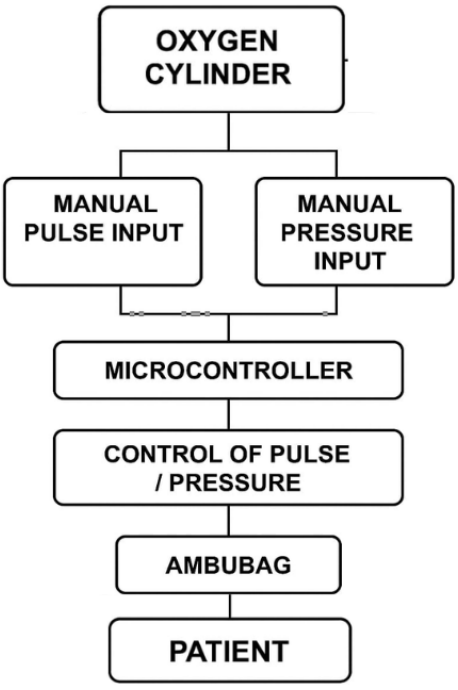


Figure 3.3: Program Flow Chart

CHAPTER 4

DESIGN AND CONSTRUCTION OF APPARATUS

4.1 Introduction

Hardware is the most important part of any project. In this chapter we explain used component of our project. In our project used hardware is given below,

- Arduino Nano
- 103 Temperature Sensor
- Breadboard
- Bridge diode
- DC Gear motor
- Adapter (AC to DC 12V)
- Buzzer
- Resistor
- 12v relay
- Push switch and cap
- Tip 122 power Transistor
- Transformer
- Temperature sensor
- Ac cord
- Capacitor 2200uf
- 470uf capacitor
- Power Switch
- Ventilation set
- LCD Display

4.2 Arduino Nano Microcontroller

This part is Brain of this project. The Arduino Nano is a microcontroller board based on the ATmega328p. Arduino is an open-source, prototyping platform and its simplicity makes it ideal for any types of projects to use as well as professionals and Students. Arduino Nano has great advantage that it has built-in chip which work as a USB-to-serial converter. In this project we use Arduino-Uno which is consist of ATmega328p Microcontroller with 16MHz crystal. It works upon the signal which gets from IR Sensor. There are data signal from IR Sensor. The CPU decides what to do at which condition. In this project we use Pin No. 2, 3, 4, 5, to get output. If Arduino-UNO get signal via Pin 0 (Rx) it analyzes the signal and give output signal

through the output pin.

- **Features of the Arduino**
  UNO: Microcontroller:
  ATmega328p Operating
  Voltage: 5V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM
  output) Analog Input Pins: 6
- Flash Memory: 32
  KB SRAM: 2 KB
  (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

4.2.1 Arduino Platform

Arduino is open-source electronics prototyping platform based on flexible hardware and software. The Arduino is a simple yet sophisticated device which is based on Atmel's ATmega microcontrollers. The Arduino software is supported by Windows and Linux operating systems despite the fact that most microcontrollers are limited to Windows operating system. The software language is based on AVR C programming language and can be expanded through C++ libraries. There are various types of Arduino micro controller board available in the market including the Arduino kits and Arduino shields.

4.2.2 Arduino Nano Board

Arduino Nano is one of the microcontroller boards manufactured by the Arduino and it is a microcontroller board based on Atmel's ATmega328P microcontroller. "Uno" means one in Italian and the Nano board is the latest in a series of USB (Universal Serial Bus) Arduino boards which is the reference model for the Arduino platform. The Arduino Nano board has a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, a reset button, 6 analog inputs and 14 digital input/output pins (of which 6 can be used as PWM outputs).



Figure 4.1: Arduino Nano

It uses the Atmega16U2 programmed as a USB – to-serial converter instead of FTDI USB – to– serial driver chip which was used in all the pre-ceding boards. The board has 32 KB flash memory of which 0.5 KB is used by boot-loader, 2 KB of SRAM, 1 KB of EEPROM and 16 MHz clock speed.

Reprinted from the Arduino Board Nano Fig 1 shows the Arduino Nano Board manufactured by the Arduino in Italy. It can be powered via a USB connection or with an external power supply. As can be seen in Fig 1, pins A0 to A5 are the analog input pins, pins 0 to 13 are 14 digital input/output pins and the pins with a "~" sign can be used as digital pins PWM o can be used as input or output pins by selecting the mode by using the function Pin-Mode() and then using the function digital Read () or digital Write() according to the ne-cecity. Pins 0(RX) and 1(TX) are used for serial communication while pins 10(SS), 11(MOSI), 12(MISO) and 13(SCK) are used for SPI (Serial Peripheral Interface) communication. In addition to pin 0 and 1, a Software Serial library allows serial communication on any of the Uno's digital pin.

4.2.3 Power supply, inputs and outputs

Either Arduino is supplied with USB connection or with an external power supply (recommended with 7-12V), outputs are going to have a continuous voltage due to voltage regulators and stabilization capacitors present on the board. These power supply pins are:

- **VIN:** it is the input power supply that will have the same voltage that we are supplying the Arduino with the external power supply
- **5V:** power supply of 5V, this voltage may come from VIN pin Anda voltage regulator or from the USB connection.

- **3.3V:** power supply that will provide 3.3V generated by an internal regulator, with a maximum current of 50 mA.
- **GND:** grounding pins

4.2.4 Digital inputs and outputs

Each of the 14 digital pins can be used as an input or output. Besides, each pincan supply or receive a maximum of 40 mA and has a pull-p resistance from 20 to50 kOhm. In addition, some pins have specialized functions such as:

- Pin 0 (RX) and 1 (TX). They are used to receive (RX) and transmit (TX)in TTL serial communication.
- Pin 2 and 3. External interruptions. Pins in charge of interrupting the sequential program established by the user.
- Pin 3, 5, 6, 9, 10 and 11. PWM (pulse width modulation). They form 8output bits with PWM with the function analog Write ().
- Pin 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI (Serial peripheral interface) communication.
- Pin 13. LED. There is a LED connected to the digital pin 13. When the pin value is HIGH, the LED is on, and when the value is LOW, the LED is off.

4.2.5 Analog inputs

Arduino UNO has 6 analogical inputs, from A0 to A5, and each one offers a resolution of 10 bits (1024 states). By default, there is a voltage of 5V, but that range can be modified using the pin AREF and using the function analog Reference (), where the user introduces the DC external signal he wants to use as reference.

4.3 Buzzer

A buzzer is an electrical device that makes a buzzing noise and is used for signaling. A buzzer has a piezo disc and an oscillator inside. When the buzzer is powered, the oscillator generates a frequency around 2-4 kHz and the piezo element vibrates accordingly to produce the sound. As soon as the gas leak is detected, the buzzer automatically rings to alert the users about the gas leak.



Figure 4.2: Buzzer

4.3.1 LM35 Precision Centigrade Temperature Sensors:

LM35 is a precision integrated circuit temperature measuring device. Its output is voltage which is linear to the temperature. LM35 device draws only 60 μA from the supply, it has very low self-heating of less than 0.1°C in still air

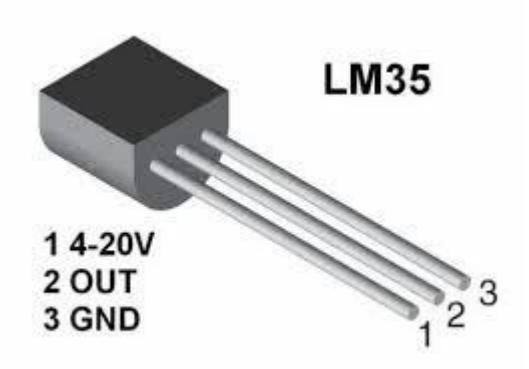


Figure 4.3: Temperature Sensors

4.3.2 DC Motor

A Direct Current (DC) motor is a rotating electrical device that converts direct current, of electrical energy, into mechanical energy. An Inductor (coil) inside the DC motor produces a magnetic field that creates rotary motion as DC voltage is applied to its terminal. Inside the motor is an iron shaft, wrapped in a coil of wire. This shaft contains two fixed, North and South, magnets on both sides which causes both a repulsive and attractive force, in turn, producing torque. ISL Products designs and manufactures both brushed DC motors and brushless DC motors. We tailor our DC motors size and performance to meet your desired specs. Need help determining the right motor for your application? Check out our Motor Selection Tool.

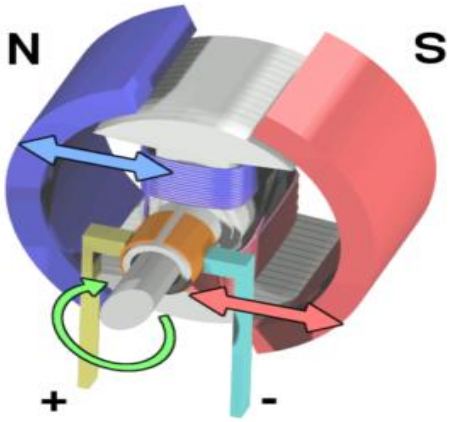


Figure 1 - Inside the DC Motor

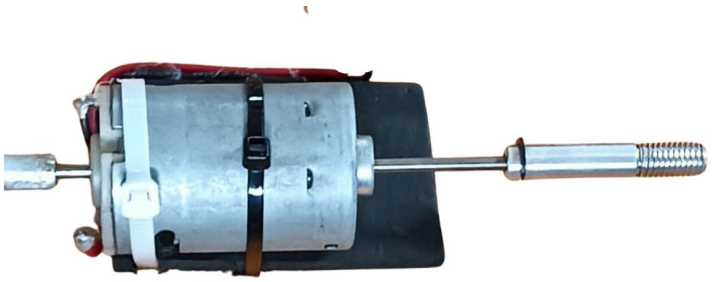


Figure 4. 4: DC Motor

4.3.3 DC Gear Motor

A gear motor is an all-in-one combination of a motor and gearbox. The addition of a gear head to a motor reduces the speed while increasing the torque output. The most important parameters in regards to gear motors are speed (rpm), torque (lb-in) and efficiency (%). In order to select the most suitable gear motor for your application you must first compute the load, speed and torque requirements for your application. ISL Products offers a variety of Spur Gear Motors, Planetary Gear Motors and Worm Gear Motors to meet all application requirements. Most of our DC motors can be complimented with one of our unique gearheads.

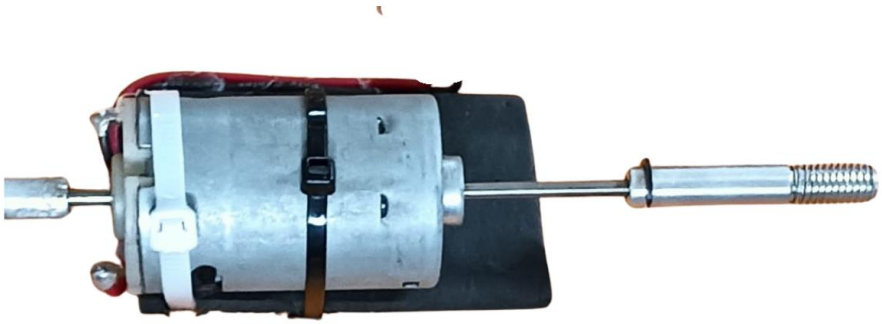


Figure 4. 5 : Gear Motor

4.3.4 Motor Selection Process

The motor selection process, at the conceptual design phase, can be challenging but our engineers are here to help. We provide a concierge approach to all of our DC motors and gear motors projects. Our team of engineers work with you to provide the optimal component solution. The following key points can help you determine and select the most appropriate motor or gear motor for our application. You can also use our DC Motor / Gear Motor Selection Guide to help us narrow down your exact motor/gear motor requirements.

4.3.5 Design Requirements

A design assessment phase where the product development requirements, design parameters, device functionality, and product optimization are studied.

4.3.6 Design Calculations

Calculations used to determine which motor would be the best solution for your application. Design calculations determine gear ratio, torque, rotating mass, service factor, overhung load, and testing analysis.

4.3.7 Types of DC Motors/Gear motors

The most common electrical motors convert electrical energy to mechanical energy. These types of motors are powered by direct current (DC).

- Brushed
- Brushless (BLDC)
- Planetary Gear Motors

- Spur Gear Motors
- Stepper
- Coreless & Coreless Brushless
- Servo
- Gear heads

Motor Specifications – Once the design calculations are performed, and the application parameters are defined, you can use this data to determine which motor or gear motor will best fit your application. Some of the most common specs to consider when selecting a motor or gear motor would be:

- Voltage
- Current
- Power
- Torque
- RPM
- Life Expectancy / Duty Cycle
- Rotation (CW or CCW)
- Shaft Diameter and Length
- Enclosure Restrictions

4.3.8 Gear Motor Performance Curves

A motors performance and gearbox performance are combined into one graph by displaying three specific parameters. These three parameters are speed, torque and efficiency. These performance curves are essential when selecting a gear motor for your application.

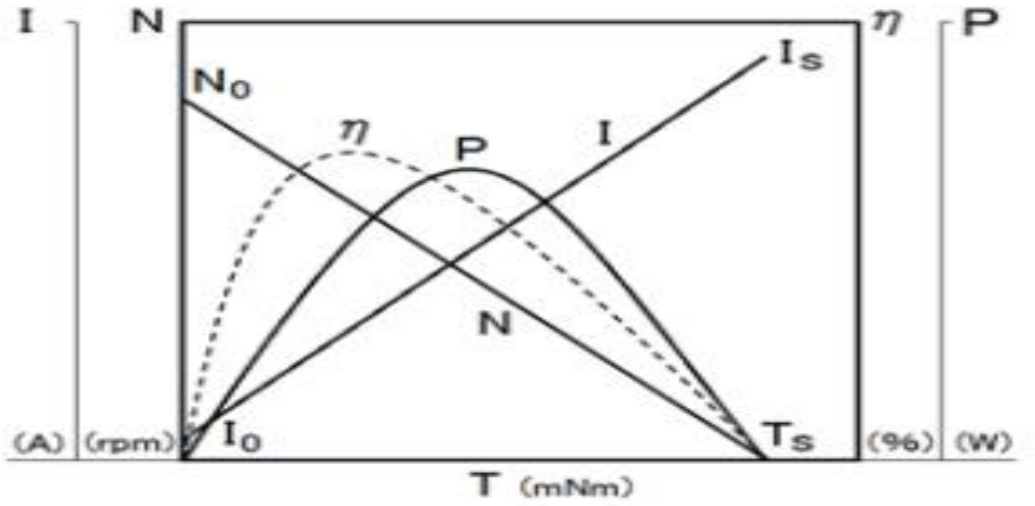


Figure 4. 6: Performance Curve

4.3.9 Speed/Revolutions (N)

(unit: rpm) indicated as a straight line that shows the relationship between the gear motors torque and speed. This line will shift laterally depending on voltage increase or decrease.

4.3.10 Current (I)

(unit: A) indicated by a straight line, from no load to full motor lock. This shows the relationship between amperage and torque.

4.3.11 Torque (T)

(unit: gf-cm) this is the load borne by the motor shaft, represented on the X-axis.

4.3.12 Efficiency (η)

(unit: %) is calculated by the input and output values, represented by the dashed line. To maximize the gear motors potential it should be used near its peak efficiency.

4.3.13 Output (P)

(unit: W) is the amount of mechanical energy the gear motor puts out.

For example, let's consider the performance curve below (figure 5) for a DC gear motor.

- Maximum operating efficiency (70%) for this motor would occur at 3.75 lb-in / 2,100 rpm.
- As torque increases the speed and efficiency decrease. The result of increased torque is poor output performance and the device will eventually fail to function once the motor reaches its stall torque (18 lb-in).

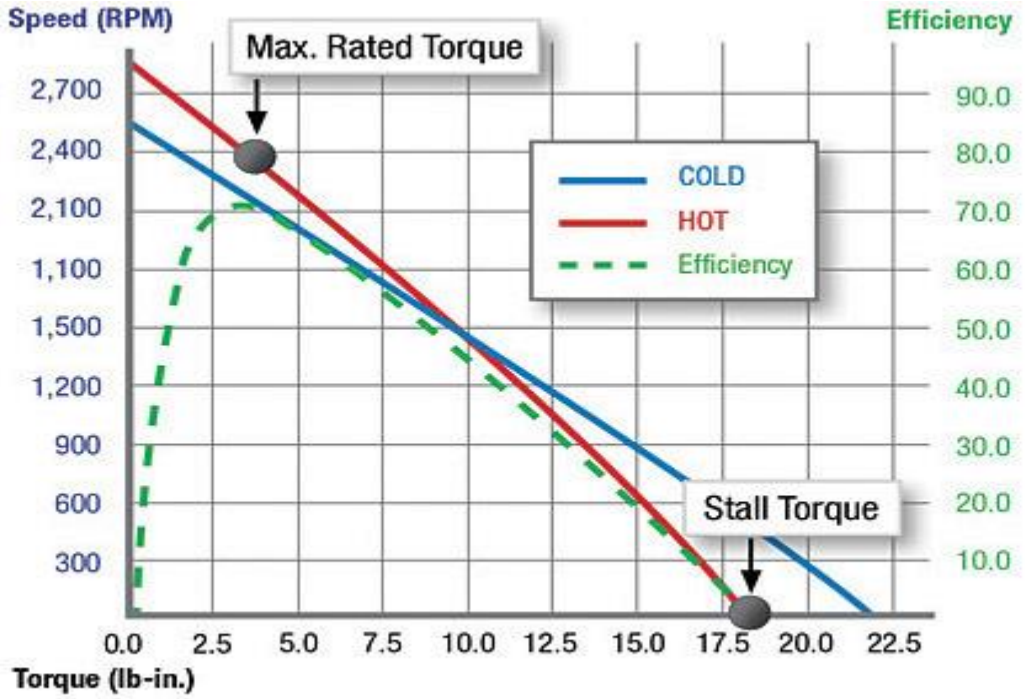


Figure 4. 7: DC Gear Motor Performance Curve

Gear motor performance curves are a helpful tool when selecting a motor for your application. To get the most out of the performance curves it's important to thoroughly understand the applications requirements. You can use your load and speed requirements to help determine the required torque. Most DC motor and gear motor manufactures provide performance curves upon request.

4.4 Transformer

An electrical transformer works on the principle of Mutual Induction, which states that a uniform change in current in a coil will induce an E.M.F in the other coil which is inductively

coupled to the first coil.

In its basic form, a transformer consists of two coils with high mutual inductance that are electrically separated but have common magnetic circuit. The following image shows the basic construction of a Transformer.

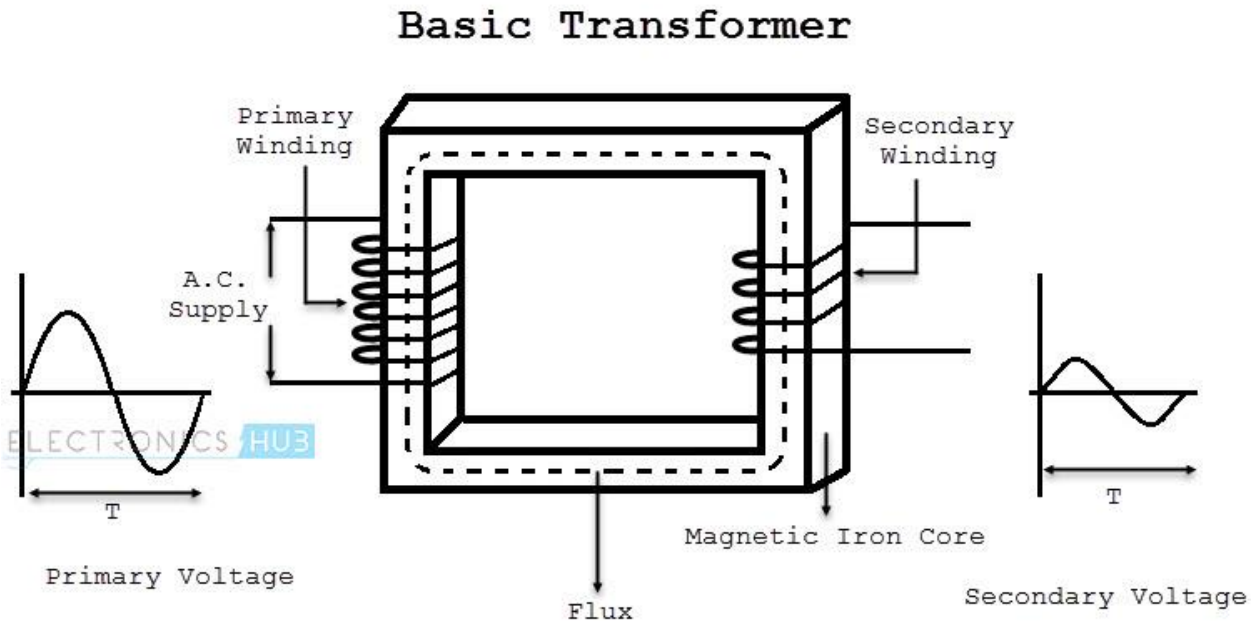


Figure 4. 8: Basic Transformer

4.4.1 Transformer Work

The first set of the coil, which is called as the Primary Coil or Primary Winding, is connected to an alternating voltage source called Primary Voltage.

The other coil, which is called as Secondary Coil or Secondary Winding, is connected to the load and the load draws the resulting alternating voltage (stepped up or stepped down voltage).

The alternating voltage at the input excites the Primary Winding, an alternating current circulates the winding. The alternating current will result in an alternating magnetic flux, which passes through the iron magnetic core and completes its path.

Since the secondary winding is also linked to the alternating magnetic flux, according to Faraday's Law, an E.M.F is induced in the secondary winding. The strength of the voltage at the secondary winding is dependent on the number of windings through which the flux gets passed through.

Thus, without making an electrical contact, the alternating voltage in the primary winding is transferred to the secondary winding.

NOTE: Depending on the construction of the transformer, the voltage at the secondary of the transformer may be equal, higher or lower than that at the primary of the transformer but the time period of the voltage i.e. its frequency will not change.

4.4.2 Relation Between Voltage and Turns

Let NP be the number of turns of the coil in the Primary Winding and NS be the number of turns of the coil in the Secondary Winding.

If the alternating voltage at the primary side of the transformer is VP and the alternating voltage at the secondary side of the transformer is VS, then the relation between the voltages at primary and secondary and number of turns of the coil in primary and secondary is given as follows.

VP/VS = NP/NS

4.4.3 Step Down Transformer

A Step down Transformer is a type of transformer, which converts a high voltage at the primary side to a low voltage at the secondary side.

If we speak in terms of the coil windings, the primary winding of a Step down Transformer has more turns than the secondary winding. The following image shows a typical step down transformer.

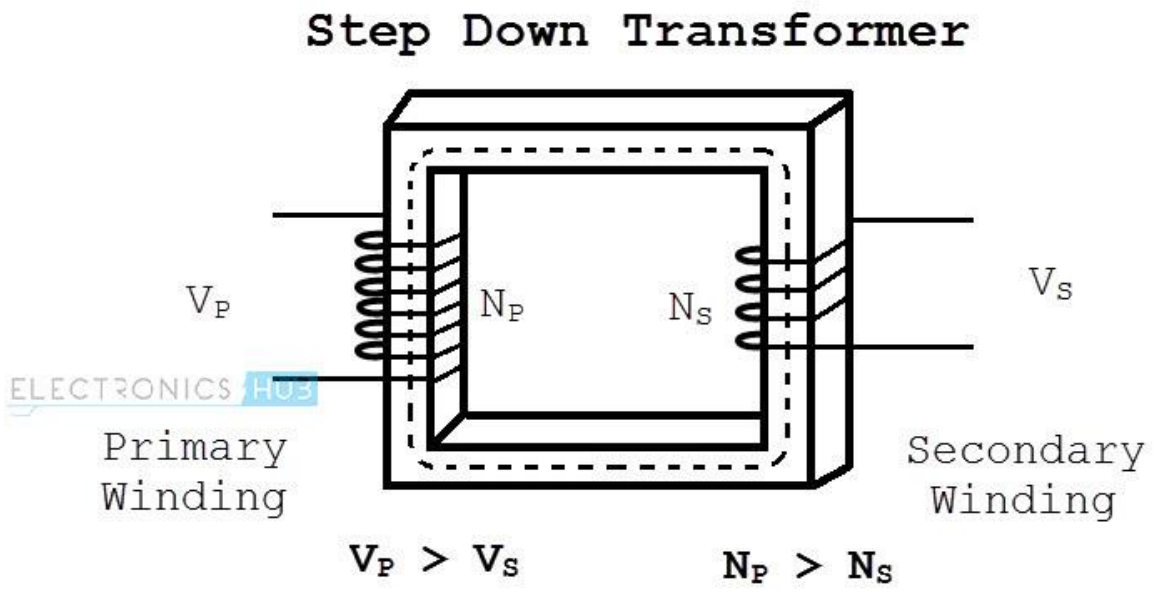


Figure 4. 9: Step Down Transformer

4.4.4 Example of Step Down Transformer

For example, consider the following situation. The number of turns in the primary winding of a transformer is 3000 and that in the secondary winding is 150. If the alternating voltage at the primary of the transformer is 240V, then the voltage at the secondary of the transformer can be calculated using the following equation.

VP/VS = NP/NS

Here, NP is primary winding turns = 30000

NS is secondary winding turns = 150

VP is voltage at the primary winding of the transformer = 220V

VS is the voltage at the secondary of the transformer =?

Using the above equation, VS = (VP * NS)/NP = 240*150/3000 = 12V

Hence, the voltage at the secondary winding of the transformer is 12V, which is less than that at the primary. Therefore, the transformer in this subject is a Step down Transformer.

Read this interesting post on TYPES OF TRANSFORMERS

4.4.5 Power Step down Transformer

The power in a transformer is measured using the product of voltage and current. The power in a transformer is rated in Volt – Amps VA (or Kilo Volt – Amps kVA for larger transformers). Ideally, the power in any transformer is constant i.e. the power available at the secondary of the transformer is same as the power at the primary of the transformer.

This is even applicable to a step down transformer. But, since the voltage at the secondary of a step down transformer is lesser than that at the primary, the current at the secondary will be increased in order to balance the total power in the transformer.

4.4.6 Current and Voltage Relation in Step Down Transformer

We will now see how this works. Let VP be the voltage at the primary, IP be the current at the primary and PP be the power at the primary side of the transformer.

We know that the power can be calculated by simply multiplying the voltage and current. Hence, the power at the primary side of the transformer is given by

PP = VP * IP

Similarly, let VS be the voltage at the secondary, IS be the current at the secondary and PS be the power at the secondary side of the transformer.

The power at the secondary of the transformer is given by

PS = VS * IS

Since, the power in a transformer is constant, PP = PS.

Which means, VP * IP = VS * IS

As VS is less than VP in a step down transformer, IS has to be more than IP. Hence, the output voltage in a step down transformer is less than that of the primary voltage and the output current is more than the input current.

From the above analysis, we can define a Step down transformer as a device which converts a High Voltage and Low Current alternating source to a Low Voltage and High Current alternating supply.

NOTE: The above power calculation is for an ideal transformer where there are no loses. Practically, there will loses in the form of iron losses and copper losses that should be taken in to consideration (even though the losses are small).

4.4.7 Step down Transformer is used

All the street transformers which we see near our homes are step down transformers. They take a 11kV alternating voltage at the primary and convert it to 220V for distributing it to our homes. Before the wide usage of switching power supplies, almost all low voltage wall adapters use step down transformers.

4.5 AMBU bag

Full meaning Artificial Manual Breathing Unit (AMBU). 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.
A hand held device commonly used to provide positive pressure ventilation to patients who are not breathing or not breathing adequately.

4.5.1 Other Name

- AMBU Bag
- Manual Resuscitator
- Self-inflating bag

4.5.2 Indication

- Respiratory Failure
- Respiratory Arrest
- In case of Ventilator failure
- Transfer of critical patients between wards.
- In between suctions

4.5.3 Type of AMBU bag

- Adult
- Pediatric
- Infant

4.5.4 Techniques to adequate ventilation

- "EC" or "CE"technique
- C-Compression
- E-Elevation

4.5.6 Parts of AMBU Bag

1. Non-rebreathing patient valve
2. Intake valve
3. Compressible self refilling ventilation bag
4. Nipple for oxygen tubing
5. Oxygen reservoir bag
6. Oxygen reservoir
7. Ambu mask
8. Oxygen extension tubing

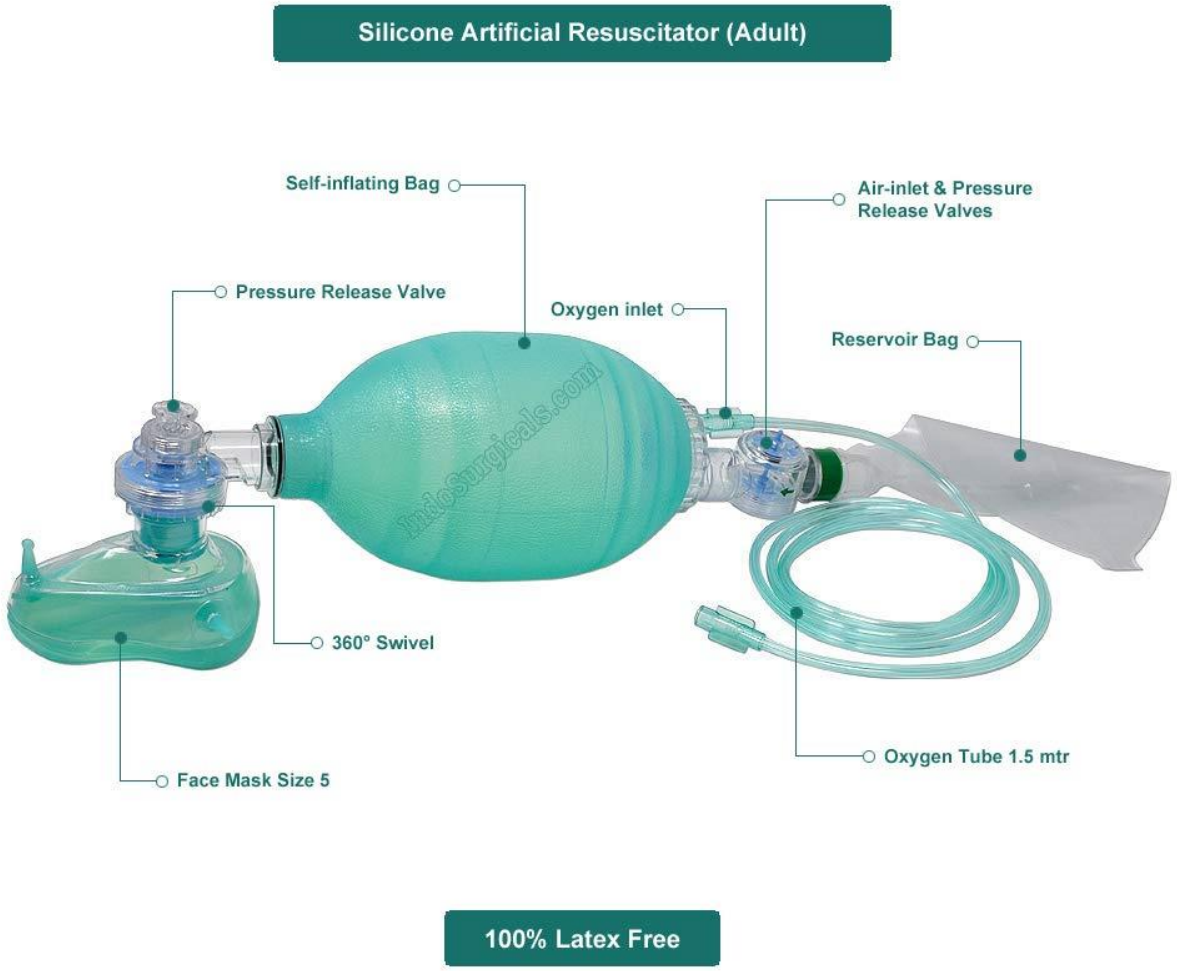


Figure 4.10: AMBU bag

4.5.7 Self-Inflating Bag: Manual Resuscitator

The self-inflating bag, as its name implies, inflates automatically without a compressed gas source. Since it is not dependent on a compressed source for inflation, it is inflated always, is ready to use and is portable. There are four parts of the self-inflating bag:

- Air inlet
- Oxygen inlet Patient outlet

- Valve assembly

4.5.8 Air Inlet

As the bag re-expands following compression, air is drawn into the bag through a one-way valve that may be located at either end of the bag. This is the air inlet.

4.5.9 Oxygen inlet

The oxygen inlet, which is located next to the air inlet, is a small nipple or projection to which oxygen tubing can be attached. In the self-inflating bag, an oxygen tube is not necessary for the bag to function. It has to be attached only if the infant is to be resuscitated with an oxygen-enriched air mixture rather than with room air.

4.5.10 Patient outlet

The patient outlet is where air exits from the bag to the infant through a mask or an endotracheal tube.

4.5.11 Valve assembly

Self-inflating bags have a valve assembly positioned between the bag and the patient outlet. When the bag is squeezed during ventilation, the valve opens, releasing oxygen/air to the lungs of patient. When the bag re-inflates (during the exhalation phase of the cycle), the valve is closed. This prevents the patient's exhaled air from entering the bag and being rebreathed.

4.5.12 Pressure gauge

Some self-inflating bags have a small hole or projection for attaching a pressure manometer/gauge located close to the patient outlet. A pressure gauge is an extra piece of equipment which measures pressure generated by the bag in centimeters of water. This gauge allows us to control the pressure of the air or oxygen being delivered to the patient.

4.5.13 PEEP valve

An adjustable PEEP (positive end expiratory pressure) valve can be connected to valve assembly. It is useful if one is resuscitating extremely low birth-weight babies (< 1 kg) or while manually ventilating a baby disconnected from the ventilator.

- ONTOP-IN 2012: Self Inflating Bag
- AIIMS – WHO CC 2

4.5.14 Using bag with oxygen

The NRP recommends that room air resuscitation can be initiated in term babies with back up facility for supplemental oxygen if baby does not improve despite 90 seconds of effective ventilation with room air. Since oxygen is considered to be a drug, its use in neonates must be carefully controlled. When the self-inflating bag is used without a reservoir, every time the bag inflates, room air is drawn into the bag by way of the air inlet along with hundred percent oxygen through the O2 inlet. As a result, the concentration of oxygen actually received by the patient is about 40 – 70 percent.

4.5.15 Oxygen reservoir

High concentrations of oxygen can be achieved with a self-inflating bag through the use of an oxygen reservoir. An oxygen reservoir is an appliance that can be attached over the bag's air inlet. It provides a chamber filled with a high concentration of oxygen. During re-inflation, instead of room air being drawn in, the bag draws the highly oxygen enriched air in the reservoir. This permits administration of as high as 90-100 % oxygen

4.5.16 with a self-inflating bag.

Therefore, all self-inflating bags used in a delivery room must have oxygen reservoirs.

4.5.17 Safety feature

Two safety features are built into resuscitation bags to prevent high pressures being delivered inadvertently to lungs. Any resuscitation bag used for neonates should have at least one of the two features. The first is pressure release valve, also known as a pop-off or safety valve. These pressure release valves are set to release at 30-40 cm of water. Therefore, if pressures in excess of this limit are generated, the valve opens, preventing the excess pressure from being

transmitted to the infant.

The pop-off valve may be temporarily occluded to allow pressure in excess of 40 cm of water to be administered. This may be necessary to ventilate a neonate's stiff, nonrated lungs, especially with the first few breaths. Any self-inflating bag in which one can bypass the pop-off valve should have a pressure gauge attached to it.

The second safety feature is the pressure gauge or manometer which measures the peak inspiratory pressure delivered.

4.5.18 Use

1. To provide intermittent positive pressure ventilation
2. To provide peak end expiratory pressure in preterm babies
3. To judge pressure required before connecting baby to ventilator.

ONTOP-IN 2012: Self Inflating Bag

4.5.19 Misuse

1. Never use the bag for providing free flow of oxygen
2. Excessive pressures may result in pneumo-thorax
3. Prolonged ventilation with 100% oxygen may lead to oxygen toxicity
4. The use of bag is to be avoided in meconium stained liquor prior to oropharyngeal suctioning and in diaphragmatic hernia

4.5.20 Resuscitation masks

Masks come in a variety of shapes, sizes and materials. The selection of a specific mask for a particular infant will depend on how well it fits the infant's face. Resuscitation masks have rims that are either cushioned or non-cushioned. Non cushioned masks do not have a padded soft rim and thus have a firm, abrupt edge, whereas cushioned masks have a rim made of either a soft, flexible material, such as foam rubber, or an air-inflated ring.

A cushioned-rim mask has several advantages over a mask without a cushioned rim:

- The rim conforms to the shape of the infant's face, making it easier to form a seal.
- It requires less pressure on the infant's face to obtain a seal.

- There is less chance of damaging the infant's eyes if the mask is incorrectly positioned.

4.5.21 Shape

Masks may be either round or anatomically shaped.

Round: A round mask can be effective in obtaining a seal for ventilation. If the mask is too small, it may not fit over the mouth and nose correctly. If the mask is too large, pressure may be exerted on the eyes.

Anatomically shaped: Some masks are shaped to fit the contours of the face. These masks are referred to as anatomically shaped masks. They are made to be placed on the face with the most pointed part of the mask fitting over the nose. It is easier to obtain a seal with an anatomical mask.

4.5.22 Masks come in several sizes.

The rim of the appropriate sized mask must cover the tip of the chin, the mouth, and the nose, but not the eyes.

ONTOP-IN 2012: Self Inflating Bag

AIIMS – WHO CC 4

- Too large a mask will lead to ineffective seal and possible eye damage.
- Too small a mask will not cover the mouth and nose and may occlude the nose.

4.5.23 Decontamination

Washing and rinsing: Thorough decontamination of the resuscitator is necessary, ideally after each use. Disassemble all parts. Wash thoroughly in warm water using a detergent that is compatible with the resuscitator materials. Rinse all the parts thoroughly in clean water. Dry them before reassembling. Disinfection/sterilization: Disinfection is the process by which all the live organisms

get killed while in sterilization even the spores are killed. Chemical disinfection can be done

by soaking in 2% glutaraldehyde active solution for 20 minutes. Sterilization procedure takes at least 6 hours. One can use ethylene oxide for gas sterilization while boiling and autoclaving can be used for all disassembled parts of resuscitator except the reservoir. All parts should be dried before reassembling.

4.6 Jumper Wire

A jump wire (also known as jumper wire, or jumper) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a bread board or other prototype or test circuit, internally or with other equipment or components, without soldering. Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.



Figure 4.11: Jumper Wire

4.7 LCD Display

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers.



Figure 4.12: LCD Display

Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and seven-segment displays, as in a digital clock. It use the same basic technology, except that arbitrary images are made from a matrix of small pixels, while other displays have larger elements. LCDs can either be normally on (positive) or off (negative), depending on the polarizer arrangement. For example, a character positive LCD with a backlight will have black lettering on a background that is the color of the backlight, and a character negative LCD will have a black background with the letters being of the same color as the backlight. Optical filters are added to white on blue LCDs to give them their characteristic appearance**.**

4.8 Arduino Software

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.

4.9 Relay

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or such combinations thereof.[21]

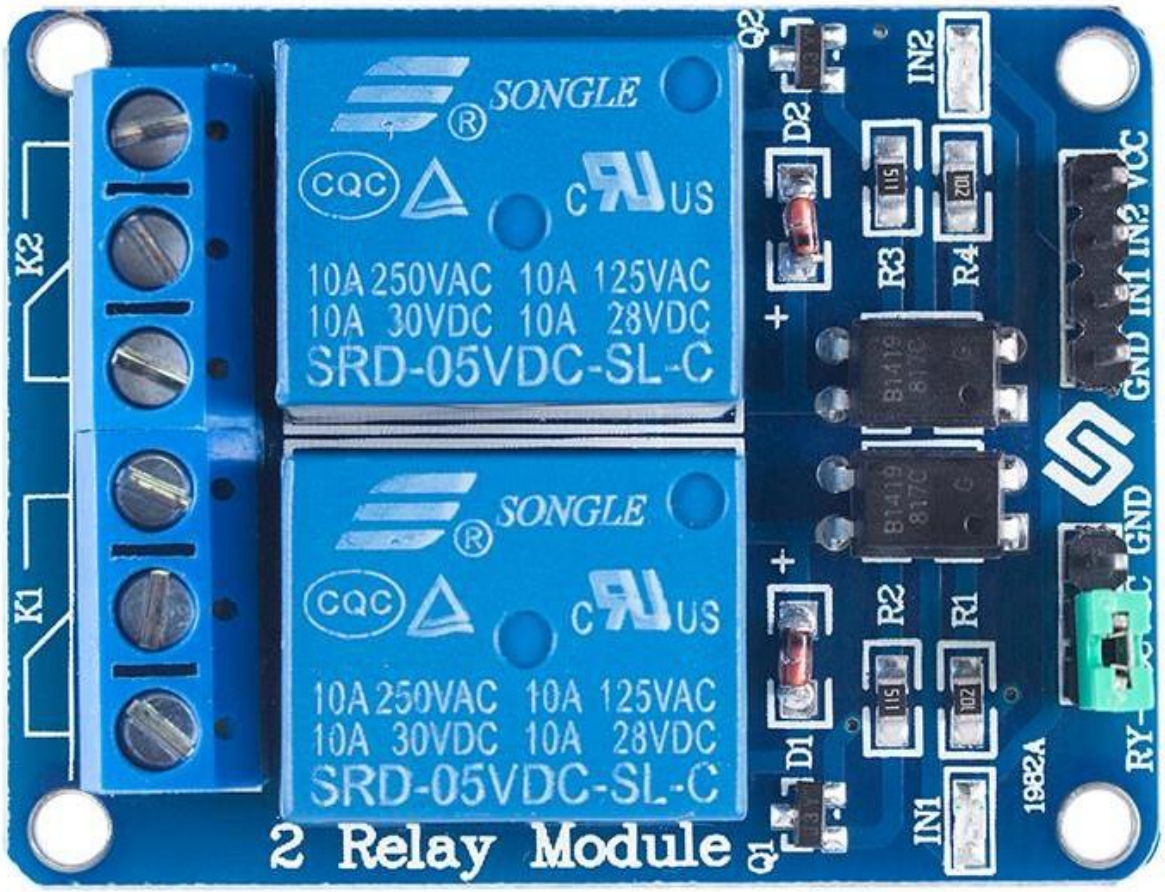


Figure 4.13: Two channel Relay

- **Multimeter**

A multimeter also known as VOM (Volt-Ohm meter) is an electronic measurement instrument that combines several measurement functions in one unit. A typical multimeter would include basic features like the ability to measure voltage, current, capacitance and other electronic parameters in a circuit. A digital multimeter displays the measured values in numerals.



Figure 4.14: A digital multimeter.

- **Set of screw drivers**

Every threaded fastener needs a way of turning it. It may have a head with a shape that a driver can engage. A screwdriver is designed to increase the hand's turning motion to the small, specially designed tip that is inserted into the screw. The two most common screwdrivers tips available are the Standard (or Flat tip) screwdriver used for screws with slotted heads, and the Phillips (or Cross-head) screwdriver which is used for screws with cross shaped recesses in the head. Handles of screwdrivers are most commonly made from a plastic resin or wood and can sometimes even have a rubberized covering to improve grip. Some fasteners can be turned either by Standard or Phillips tips. Choosing the right

screwdriver for the job allows you to complete your project successfully and eliminate stripped screws.



Figure 4.15: Set of screw drivers

- **Pliers**

A very simple and ancient invention, pliers are basically two pieces of metal, joined together near the center. One side is the handle; the other side is the nose. When you squeeze the handle side, the nose squeezes accordingly. There are several types of pliers, and the most common are flat-nose and needle-nose. Pliers are used to grab and "ply" (manipulate) a thing. You are most likely to use them to bend or "crimp" a wire; or to squeeze or hold something that is too small, too sharp, too hot, or too corrosive for your fingers. You might also use pliers to reach into a place where your fingers can't — electronic devices, water pipes, and such, etc.



Figure 4.16: A Pliers

- **Soldering Iron**

A soldering iron is a tool with a metal tip that gets really hot. We're talking like 800 degree Fahrenheit, though you can adjust the temperature on a good iron. Its job is to transfer heat to things like wires, transistor leads, and pads on PCBs. After the appropriate areas are heated properly, solder is applied also there is a longer-lasting tool that will work for a much wider variety of applications and a proper heat control to boot. There are also soldering guns available, but you should only use these when repairing thick cables and never on PCBs, as the tips have a live voltage running through them that can damage sensitive electronics.



Figure 4.17: Soldering iron

4.10 Schematic Views of the project



Figure 4.18: Top View

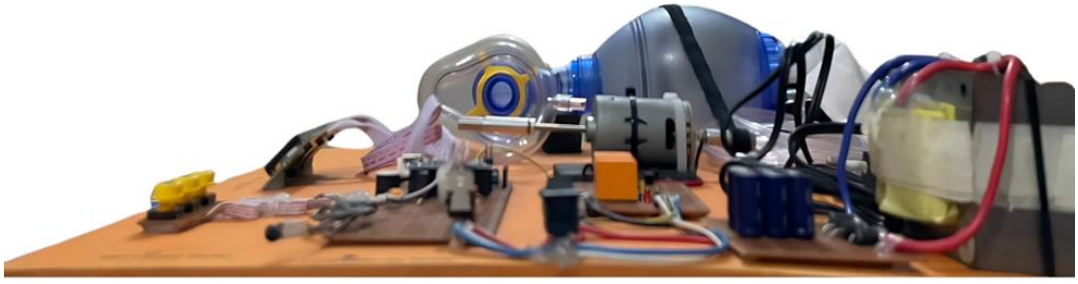


Figure 4.19: Front View

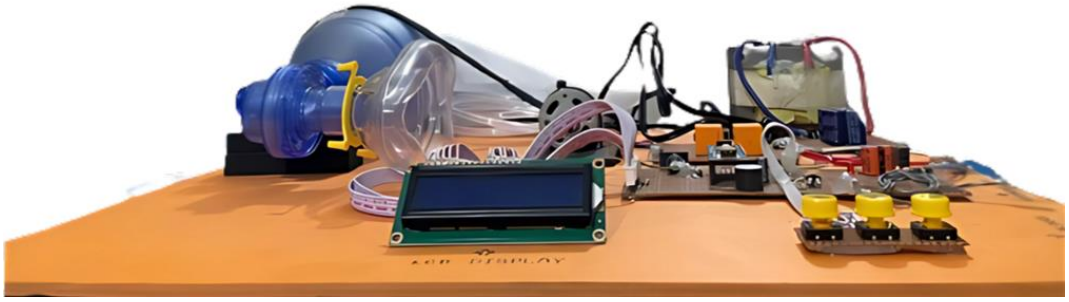


Figure 4.20: Side View

CHAPTER 5

RESULTS & DISCUSSION

5.1 Result

The result of integrating an automatic medical ventilation system with an AMBU bag is a consistent and controlled method of providing respiratory support. The motorized system automates the manual process of squeezing the AMBU bag, ensuring reliable inhalation and exhalation cycles. This eliminates human error and fatigue, improving the accuracy of ventilation

By automating the squeezing of the AMBU bag, healthcare providers no longer need to manually operate the device, reducing their physical strain and allowing them to focus on other critical aspects of patient care. This also increases the overall efficiency of medical teams, particularly in high-pressure situations where multiple patients need attention.

One of the key advantages is the affordability of this system compared to traditional ventilators. The motorized AMBU bag system provides a cost-effective solution, making ventilator support more accessible to healthcare settings, particularly in resource-limited regions or developing countries.

The system is compact and portable, which makes it ideal for use in ambulances, field hospitals, or emergency situations. Its portability ensures that it can be rapidly deployed in critical settings where immediate ventilation support is needed.

Moreover, the system addresses the shortage of ventilators in rural or underserved areas by offering a practical and affordable alternative. This is especially valuable in regions where access to conventional, high-cost ventilators is limited.

Finally, the system is capable of providing artificial respiration, allowing for the exchange of oxygen and carbon dioxide, which is crucial for patient survival when natural breathing is not possible. This ensures that patients can receive the necessary support in critical situations.

In conclusion, the integration of an automatic ventilation system with an AMBU bag results in an affordable, portable, and efficient solution that ensures consistent and reliable respiratory support, improving patient outcomes, especially in emergency or resource-limited environments.

Table 5.1 : Human Average Breaths Rate

Age	Breaths Per Minute
Newborns	44
Infants	30
Children (1-7 years)	24
Adults	18

In our ventilator system, if we set the interval to 1000 milliseconds, it completes 1 pulse or breath.

Now,
A baby's lung expands and contracts 44 times in 60 seconds.
That means 44 / 60 ≈ 0.7333 times per second.

To find how long one pulse takes:
1 / 0.7333 ≈ 1.3636 seconds per pulse

Convert seconds to milliseconds:
1.3636 × 1000 = 1363.6 ms ≈ 1364 milliseconds

- For Infants,

A Infants's lung expands and contracts 30 times in 60 seconds.
That means 30 / 60 ≈ 0.5 times per second.

To find how long one pulse takes:
1 / 0.5 = 2 seconds per pulse

Convert seconds to milliseconds:
2 × 1000 = 2000 milliseconds.

- For Children (1-7 years)

A Children's lung (1-7 years) expands and contracts 24 times in 60 seconds.
That means 24 / 60 = 0.4 times per second.

To find how long one pulse takes:
1 / 0.4 = 2.5 seconds per pulse

Convert seconds to milliseconds:
2.5 × 1000 = 2500 milliseconds.

- For Adults

An Adult's lung expands and contracts 18 times in 60 seconds.
That means 18 / 60 = 0.3 times per second.

To find how long one full cycle (one expand and one contract) takes:
1 / 0.3 = 3.33 seconds per cycle

Convert seconds to milliseconds:
3.33 × 1000 = 3333 milliseconds.

Table 5.2 ： Time(ms) Per Breaths

Number of Breaths (per minutes)	Time(ms) Per Breaths
18	3333
24	2500
30	2000
44	1364

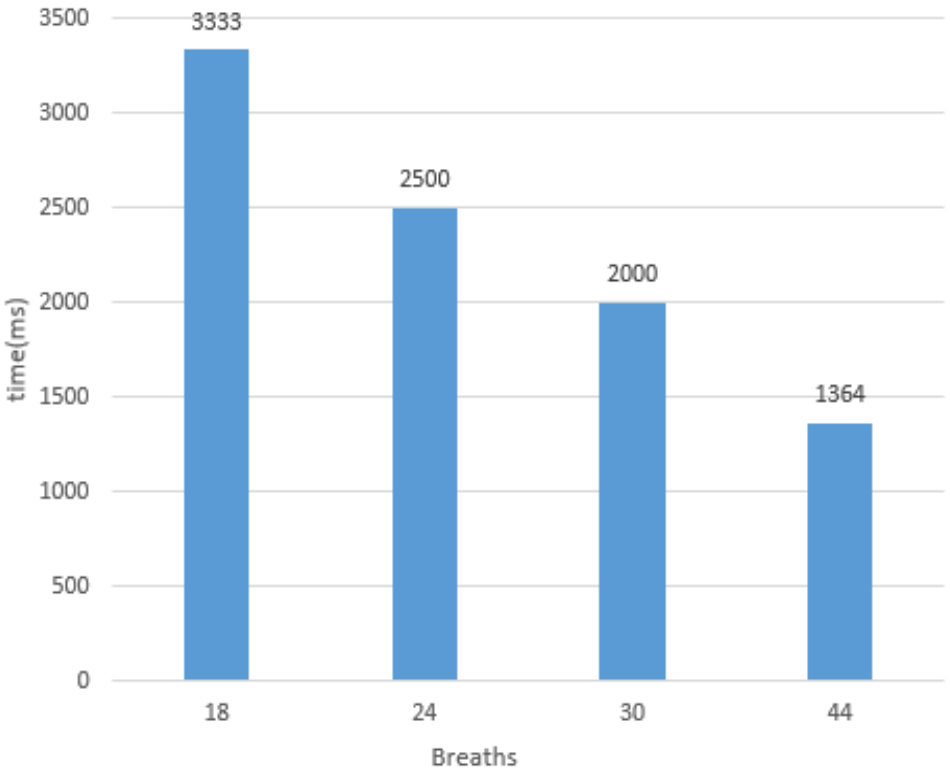


Fig 5.3: Number of Breaths VS times

X-axis Number of Breaths per Minute

Y-axis Time per Breath in milliseconds

We connected an oxygen cylinder with a flow rate of 10–15 L/min to the AMBU bag connector. Then, we adjusted the pressure based on different types of patients and recorded the corresponding results.



Fig 5.4 : Oxygen Cylinder



Fig 5.5 : Pressure Gauge

Table 5.6: Oxygen Delivery via AMBU Bag (10–15 L/min Flow)

Age Group	**Pressure (kPa)**	**Pressure (set on device %)**	**Swept Volume(ml)**	**Oxygen Delivered per Breath(ml)**
Infant	1.7	43	75	45-90
Child (1-5yr)	2.2	55	150	90-180
Child (5-12yr)	2.7	68	300	180- 360
Adult(12-59yr)	3.5	88	400	450-540
Elderly (60+ years)	3	75	475	360-495

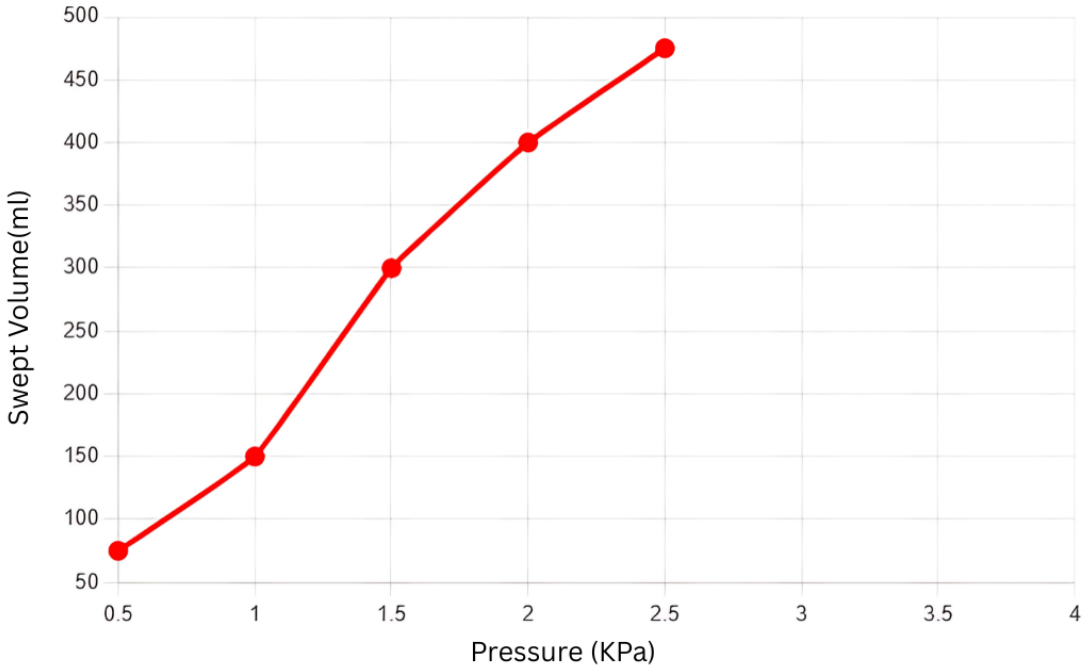


Fig 5.7: Oxygen Delivery by AMBU Bag

The relationship between the pressure applied to an AMBU bag and the swept volume of oxygen delivered. The x-axis represents pressure in kilopascals (kPa), while the y-axis indicates the swept volume in milliliters. This categorizes data based on different age groups, ranging from infants to elderly individuals.The graph shows a clear positive correlation between pressure and swept volume. As the pressure increases, the volume of oxygen delivered also increases.

For instance, infants receive a swept volume of approximately 75 ml at 1.7 kPa,

while adults (aged 12–59 years) receive about 400 ml at 3.5 kPa.

The elderly slightly lower pressure of 3.0 kPa, have the highest swept volume at 475 ml, possibly due to adjusted device settings to meet their respiratory needs.

This trend highlights how oxygen delivery by an AMBU bag can be effectively adjusted according to the patient age and lung capacity by varying the pressure applied. Such data is crucial in clinical settings to ensure that patients receive the appropriate volume of oxygen per breath, especially in resource-limited environments where manual resuscitators like AMBU bags are commonly used

5.2 Description

Respiratory diseases like asthma, chronic obstructive pulmonary disease, and other lung conditions are major health issues globally, exacerbated by factors like air pollution, smoking, and biomass fuel usage. These diseases often require mechanical ventilation, a technology that supports breathing by exchanging oxygen and carbon dioxide in the lungs. However, current ventilators are expensive, making them unaffordable for resource-poor countries, where many hospitals share ventilators or use unreliable refurbished models. Additionally, rural areas often lack access to such devices. To address this, a low-cost portable ventilator prototype has been developed. The design replaces a flow analyzer with a potentiometer and needle valve, reducing costs. The system uses compressed air regulated at 1 bar and a solenoid valve for on/off control. It also includes a test lung bag to simulate inhalation and exhalation, allowing for artificial respiration. This affordable solution could significantly improve access to ventilators, particularly in underdeveloped regions, where demand often exceeds supply due to high .

5.3 Overall Objective

The main objective of this project was to develop a low-cost automatic medical ventilation system, and this objective has been successfully achieved. The system was built using affordable components such as an AMBU bag, Arduino Nano, DC motor, and basic electronic parts. According to the report, it is suitable and effective for use in resource-limited environments.

An automated mechanism was created using Arduino and a motor, which compresses the AMBU bag at specific intervals. This system effectively replaces manual operation and ensures proper ventilation automatically.

The system provides consistent breathing support and includes programmable Breaths Per Minute (BPM), enabling uninterrupted oxygen supply without the need for human intervention.

The device is compact, lightweight, and easily portable, making it suitable for emergency environments such as ambulances or temporary medical setups. It features an LCD display and button controls, making it user-friendly and easy to operate.

In emergency situations, such as power outages or ventilator failure in hospitals, this device serves as a reliable backup. Its simple power supply system and built-in safety alarms enhance its reliability and safety.

The device is also easy to maintain, as it uses readily available and easily replaceable components. This helps reduce maintenance costs and complexity.

Users can adjust BPM using buttons, and the Arduino automatically calculates the timing to maintain the correct breathing rate. According to the report, the device accurately delivers appropriate BPM for different age groups, supported by data tables and graphs.

Overall, this project has successfully developed an effective, low-cost, automatic, user-friendly, and emergency-capable ventilator system.

5.4 Overall Performance

The Automatic Medical Ventilation System is a low-cost, portable, and reliable ventilator developed using an AMBU bag and Arduino-based control system. Unlike manual ventilation, this system automates the process of providing controlled breaths at set intervals, allowing users to easily adjust the breaths per minute (BPM) based on patient needs.

It is capable of adjusting pressure and oxygen delivery according to the age group of the patient

(infants, children, adults, elderly), making it versatile in application. The system includes safety alarms that activate in case of abnormal pressure, system malfunction, or high patient temperature, ensuring enhanced safety and monitoring.

Due to its compact size, energy efficiency, and user-friendly interface, the system is ideal for emergency use, ambulances, field hospitals, disaster zones, and rural healthcare facilities where advanced ventilators are often unavailable or unaffordable.

Compared to expensive and complex commercial ventilators, this system offers a practical and effective solution for resource-limited settings. It features an LCD display, sensors, and input buttons that allow healthcare providers to monitor and adjust settings easily and quickly.

In conclusion, the ventilator system stands out as a life-saving innovation, especially suited for critical care in emergency or under-equipped environments.

5.5 Application

This project can be used at

- Emergency Medical Situations
- Ambulances and Field Hospitals
- Disaster Relief Operations
- Hospitals with Ventilator Shortages:
- Homecare for Chronic Respiratory Conditions
- Military and Tactical Settings
- Medical Training
- Emergency Respiratory Support During Pregnancy:
- COVID-19 Pandemic Situations
- Support for Surgical Patients

5.6Advantage of Safety Monitoring System

- Available at a much lower cost compared to expensive ventilators.
- Lightweight and easy to carry, suitable for ambulances or remote areas.
- Provides quick respiratory support in emergency situations.
- Can be used in surgery, ICU, homecare, or disaster relief.
- Sensors and alarms ensure the safety of the patient
- Useful for medical training and improving skills.

5.7 Importance Of Ventilation System

The project titled “Automatic Medical Ventilation System” was initiated to address the urgent need for low-cost, portable ventilator solutions, particularly in developing and resource-limited settings. The primary goal of this project is to develop a reliable and affordable ventilator using an AMBU bag automated with basic electronic components like an Arduino Nano and a DC motor.

The system is designed to automate the process of manual ventilation by controlling the compression of the AMBU bag based on programmed breaths per minute (BPM). It delivers a consistent volume of air and oxygen to patients who are unable to breathe adequately on their own.

The project scope includes designing, constructing, and testing a functional prototype that can deliver artificial respiration to patients of various age groups infants, children, adults, and elderly by adjusting pressure and swept volume according to medical requirements. Safety features such as pressure alarms, temperature monitoring, and LCD display interfaces are also integrated into the system to enhance reliability.

Key objectives of this project include ensuring continuous ventilation support, maintaining simplicity in design for ease of use and maintenance, and providing a system that is cost-effective and energy efficient. It is especially intended for deployment in rural hospitals, field clinics, ambulances, and disaster-relief scenarios where conventional ventilators may be unavailable or unaffordable.

The project team followed a detailed methodology involving hardware selection, circuit design, programming of microcontrollers, and testing under different pressure and breathing conditions. The system has demonstrated effectiveness in delivering proper oxygen levels through various pressure settings and durations, as shown in performance data and test graphs.

In summary, this project successfully initiates the development of an automated medical ventilation system that is affordable, portable, and user-friendly. It has the potential to serve as a life-saving device in emergency and low-resource settings, addressing a significant healthcare gap in ventilator availability.

CHAPTER 6

Conclusion

6.1 Conclusion

The Automatic Medical Ventilation System is a cost-effective, portable, and user-friendly solution that provides essential respiratory support in emergency situations and routine care. Its compact design makes it especially valuable in resource-limited settings, particularly in remote areas or developing countries, where access to advanced medical equipment is often scarce. With features like real-time monitoring, automatic adjustments, and manual override, it ensures patient safety while offering efficient care. Its energy efficiency and training potential further enhance its utility, making it a versatile and life-saving tool for healthcare providers in critical conditions.

6.2 Future work

Integrating AI and machine learning can allow the system to automatically adjust ventilation settings based on the patient's condition, improving accuracy in real-time. Additionally, remote monitoring would enable healthcare providers to adjust settings from a distance, reducing the need for direct intervention.

Linking the system to patient health records will help personalize ventilation settings based on medical history, improving the treatment process. Further, enhancing the system's portability and battery life will make it more suitable for use in remote areas with limited resources.

The addition of advanced sensors, like oxygen, blood pressure, and carbon dioxide monitors, would ensure more comprehensive real-time monitoring. Making the system more cost-effective will improve its accessibility, especially in developing countries.

Finally, the system could be integrated with telemedicine platforms and potentially support multi-patient ventilation, optimizing resource usage in healthcare facilities.

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Appendix

```
#include<LiquidCrystal.h>
#define BUZ 13
#define PUMPin 4
#define PUMPout 3
#define HEATER 5
#define LEVAP A3
#define LEVBP A2
#define LEVCP A1
#define UP_PIN A5
#define DN_PIN A6
#define SET_PIN A7
int
temp=0,i=0,cnt,cnt1,TF=0,SEC,M
IN,HR,MSGF1,MSGF2,HON=90,
HOF=95,BUZF=0,RLF=0,
LEV,LEVA,LEVB,LEVC,Tf,Tc;
void setup()
{

 pinMode(LEVAP,INPUT);
 pinMode(LEVBP,INPUT);
 pinMode(LEVCP,INPUT);
 pinMode(UP_PIN,INPUT);
 pinMode(DN_PIN,INPUT);
 pinMode(SET_PIN,INPUT);

 pinMode(PUMPin, OUTPUT);
 pinMode(PUMPout, OUTPUT);
 pinMode(BUZ, OUTPUT);
 lcd.setCursor(0,0);
 lcd.print("WELCOME TO ");
```

```
lcd.setCursor(0,1);
lcd.print(" su ");
digitalWrite(BUZ, LOW);
delay(1500);
lcd.setCursor(0,0);
lcd.print(" SUBMITTED BY: ");
lcd.setCursor(0,1);
lcd.print(" mokarrram ");
delay(1500);

lcd.setCursor(0,0);
lcd.print(" DEBASISH ");
lcd.setCursor(0,1);
lcd.print(" ");
delay(2500);

digitalWrite(BUZ, LOW);
delay(60);
digitalWrite(BUZ, HIGH);
delay(60);
digitalWrite(BUZ, LOW);
delay(60);
digitalWrite(BUZ, HIGH);
delay(60);
digitalWrite(BUZ, LOW);
delay(500);

lcd.print("Circuit Digest ");
delay(500);
lcd.setCursor(0,1);
lcd.print("System Ready... ");

SendMessage();
```

```
}
////////////////////////////////////////////////
//////////////////////////
////////////////////////////////////////////////
//////////////////////////
void loop()
{
 Temperature();
 LOAD_CONTROL();

 ////////////////////
 LEVA= digitalRead(LEVAP);
 LEVB= digitalRead(LEVBP);
 LEVC= digitalRead(LEVCP);
 if(LEVA==1)
 LEV=10;
 if(LEVA==0)
 LEV=20;
 if(LEVB==0)
 LEV=60;
 if(LEVC==0)
 LEV=100;

 DISPLAY1();
 }
////////////////////////////////////////////////
//////////////////////////
void Temperature()
{
 Tc = analogRead(A0);
 Tf = (Tc * 9.0)/ 5.0 + 32.0;
}
////////////////////////////////////////////////
```

```
//////////////////////////
//////////////////////////////////////////////
//////////////////////////
void DISPLAY1()
{
 lcd.setCursor(0, 0);
 lcd.print("LEV:");
 lcd.print(LEV);
 lcd.print("% ");
 lcd.print(HON);

 lcd.setCursor(0, 1);
 lcd.print("T:");
 lcd.print(Tf);
 lcd.write(0xdf); // for dgree sign
 lcd.print("F ");
 lcd.print(HOF);
}
//////////////////////////////////////////////
//////////////////////////
void check()
{
 if(!(strncmp(str,"p1on",4)))
 {
 digitalWrite(PUMPin,HIGH);
 SendMessage1();
 }
 if(!(strncmp(str,"p1off",5)))
 {
 digitalWrite(PUMPin,LOW);
 SendMessage2();
 }
 if(!(strncmp(str,"p2on",4)))
```

```
 {
 digitalWrite(PUMPout,HIGH);
 SendMessage3();
 }
 if(!(strncmp(str,"p2off",5)))
 {
 digitalWrite(PUMPout,LOW);
 SendMessage4();
 }
 if(!(strncmp(str,"HON",3)))
 {
 digitalWrite(HEATER,HIGH);
 SendMessage3();
 }
 if(!(strncmp(str,"HOFF",4)))
 {
 digitalWrite(HEATER,LOW);
 SendMessage4();
 }
 if(!(strncmp(str,"WLEV",4)))
 {
 SendMessage4();
 }
 if(!(strncmp(str,"TP",2)))
 {
 SendMessage5();
 }
}
////////////////////////////////////////////////
//////////
////////////////////////////////////////////////
//////////
void SendMessage()
```

```
{
Serial.println("AT+CMGS=\"+88
017788\"\r");
Serial.println("SYSTEM
READY...");
}
void SendMessage1()
{
Serial.println("AT+CMGS=\"+88
01680657376\"\r");
Serial.println("PUMP-IN ON");
}
void SendMessage2()
{
Serial.println("AT+CMGS=\"+88
01680657376\"\r");
Serial.println("PUMP-IN OFF");
}
void SendMessage3()
{
Serial.println("AT+CMGS=\"+88
01680657376\"\r");
Serial.println("PUMP OUT ON");
}
void SendMessage4()
{
Serial.println("AT+CMGS=\"+88
01680657376\"\r");
Serial.println("PUMP OUT
OFF");
}
void SendMessage5()
{
```

```
Serial.println("AT+CMGS=\"+88
01680657376\"\r");
Serial.println(Tf);
}
////////////////////////////////////////////////
/////
void LOAD_CONTROL()
{
 if(LEV==10)
 digitalWrite(PUMPin, HIGH);
 if(LEV==100)
 digitalWrite(PUMPin, LOW);

 if(Tf > HOF)
 {
 digitalWrite(HEATER,LOW);

 digitalWrite(BUZ,HIGH);
 }
 if(Tf < HON)
 {
 digitalWrite(HEATER,HIGH);
 }

}
```