# KATHMANDU UNIVERSITY

SCHOOL OF ENGINEERING

**DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING**

# FINAL PROJECT REPORT


## ROBOTIC ARM

A **First year project report** submitted in partial fulfilment
of the requirements for the degree of
Bachelor of Engineering

**By:**

Anupam Koirala (11042)

Ashim Gautam (11034)

Anusandhan Tripathi (11057)

Romanch Nyaupane (11048)

Samyam Shrestha (11056)

Saugat Karki (11040)

**May 2022**

# CERTIFICATION

# FIRST YEAR PROJECT REPORT

# ON

# ROBOTIC ARM


**by:**

Anupam Koirala (11042)

Ashim Gautam (11034)

Anusandhan Tripathi (11057)

Romanch Nyaupane (11048)

Samyam Shrestha (11056)

Saugat Karki (11040)


**Approved by:**

1. Project Supervisor

| _____ | _____ | _____ |
|---|---|---|
| (Signature) | (Name) | (Date) |

2. Head of the Department

| _____ | _____ | _____ |
|---|---|---|
| (Signature) | (Name) | (Date) |

# ABSTRACT

The aim of this project is build a robotic arm which is capable of lifting a placing objects of 20 gram. The robotic arm primarily comprises of three sections i.e., Input section, Control Unit and Actuators. The robotic arm is controlled by moving several potentiometer place in the joints of a dummy arm. The input from the dummy arm is then processed by the control unit which comprises of arrays of 555 timer circuits. The Control Unit then provides necessary signal to the actuators. The actuators are servo motors strategically placed in the joints of the robotic arm. The robotic arm is a prefect opportunity for us to familiarize with discrete electronics such as timer circuits, servo motors.

# ACKNOWLEDGMENT

We would like to extend a very warm thanks to our supervisor Dr. Bishal Silwal and our Project Coordinator Pramish Shrestha for approving us to build robotic arm as our academic project for the duration of this semester. We would also like to thank our entire faculty and the Department of Electrical & Electronics engineering for their help and support for the completion of this project. We expect similar support in the future too. Also, we would like to thank Ms. Sunita Thapa for her help in providing the necessary equpiments for the project and Mr. Santosh Shaha sir, teaching assistant of DoEEE, for his help , guidance and clearing our doubts and confusions while doing the project.

# SYMBOLS AND ABBREVIATIONS

| A. Abbreviations | fullform |
|---|---|
| PCB | Printed Circuit Board |
| PWM | Pulse Width Modulation |

# Table of Contents

# CHAPTER I : INTRODUCTION

Robotic arm is a widely used tool in big industries and research areas. They have a wide application in the medical field as well. The sole purpose of building this device is to make the work efficient and deplly in such dangerous places where it is too risky for the humans.

## 1.1 Background

George Devol was the man who invented the robotic arm and whose name is on the patent that was filed for in 1954 and granted in 1961. But it was Joseph Engelberger, the man who co-founded the company Unimation, who sold that invention, the Unimate, to the industrial world. The fact that the engineering can provide the alteration to the traditional use of human hands to that of a robotic arm is itself interesting and wonderful.

The problem this robot tries to solve is not only about work efficiency and productivity but also but the working mechanisms and the fundamental principles that operate behind to make it functional. It removes the danger of accident to humans while working in big industires and this is the reason for its study and research. Several engineers and tech enthusiasts have made their contribution in this field and have made significant changes in the design and working principle over the deacdes. We take for granted today but every progress and development of industires, research and medical field has the hidden hero as a robotic arm.

## 1.2 Motivation

The motivation behind this project is to understand the basic working mechanisms of various electrical components like servo motors, 555 IC timer, capacitors, diodes, resistors, breadboard. This project is done as a reference to gain the knowledge about the timer circuit along with its pulse modulation. The behaviour of servo motors and the stepper motor is understood while doing the project. After the completion of the project, it will be

beneficial to the future generations to gain the knowledge about it and also provide a path for devoloping such robots in the future. With our aim of creating a robotic arm, we will be creating a new frontier to make the use of such knowledge into effective practical life situations solving the problems.

### 1.3 Problem Description

The use of robotic arm in today's world is common. It carries a wide application in the firld of industralization and automation. Many doctors too are using this in the medical field. The robotic arm can be a replacement for someone who had lost their arms. It can be deployed in those fields dangerous to human. Through this, various research and critical rescue operations can be carried. Hence to bring a solution to all theses scenarios, robotic arm is a must have solution.

### 1.4 Objectives

The main objectives of our project include:

- To design a user-controllable robotic arm without using a microcontroller.
- To demonstrate the robotic arm lifting small weights.
- To familiarize and about various components to be used in the project for future.

### 1.5 Methodology

- Firstly, detailed literature and technological survey is carried out. Then essential required components to do the project are distinguished.
- The prototype circuits are first tested on the breadboard. The ready circuit was designed on KiCad. All the parts will be assembled and tested for any problems.
- Finalized product went through process to make it look visually appealing.

- We did our project according to our initial proposed plan. However, there were some errors and flaws in the electrical equipments.
- We succeded in making and designing our circuit in breadboard and went on further devoloping the PCB of our design.
- But due to somme short circuits and disfunction of the microcontroller our project was put into hault for several times.
- Each times, we cornered our problems and figured it out, moving to next step.
- At one point, after the completion of the PCB design, the servo motors were vibrating a lot more than the usual. But we used three batteries for each servo motors to solve the problem.

### 1.6 Limitations

- This is just a prototype of a actual robotic arm.
- It cannot raise heavier objects.

### 1.7 Organisation of Report

The first chapter of the report comprises of Introduction which consists of sub-topics like background, motivation, problem description, methodology, objectives, limitations, etc. The second chapter gives the detailed literature survey and the technological survey. The third chapter of the report deals with the system analysis and the final result of the project. The last part concludes the report and gives a short summary of the project. Then the references taken from external texts are given.

## 1.8 Summary

In this introduction chapter, the main theme of the project is discussed. The purpose and its implementation in our daily life is included in this section. The first chapter of this report mainly deals with the introduction part of the project. A basic background of robotic arm is given. Then the problems descriptions and the motivation behind the project is given. The main objectives of the project is outlisted. There are a few limitations of the project that are mentioned. The overall methodology of the project is also summarized.

# CHAPTER II: LITERATURE SURVEY

Servo motors are actuators which are equipped with feedback system which enables them to move with great number of precisions. The model of servo motor to be used in the project is MG-90S. As per the datasheet, the motor can rotate approximately 180 degrees (90 degrees in each direction). We have a relation between the duration of pulse width and the angle of rotation. It is given as,

$$x° \; of \; rotation = (1 + 180 \; x \;) \; milliseconds$$

555 timer circuit can be used to generate the pulse required for controlling the servo motor.

## 2.1 Literature Survey

"Robot Night" is considered to be the first sophisticated robotic arm which was developed by Leonardo da Vinci in 1495. It had 4 degrees of freedom and an analog on board controller. It sat up, opened its arm and closed them in a grabbing motion. After, few centuries another important addition was made by Wolfgang von Kempelen who developed a chess playing arm. Although, the machine didn't analyze the game and depended upon the user's input; the working mechanism of the arm was quite sophisticate[1].

In 1950s, George Devol developed "Unimate" which was an industrial robotic arm which worked on a General Motors assembly line in New Jearsey. The machine's job was to transport die casting from an assembly lines and welding parts on auto mobiles. These tasks were very dangerous when performed by humans due to the toxic fumes and risks of injury. The project subsequently evolved into the PUMA (Programmable Universal Manipulation Arm). The Unimate program is considered to be the first applicability-based development in the field of robotic arm[2].

Although, the robotic arm was preliminarily developed to reduce risks to human in assembly lines and make the assembly lines efficient. Recently, robotic arm system is also widely used in medicine field and space missions. “da Vinci Surgical System” developed by Intuitive Surgical is a robotic surgical system which can perform surgeries using minimal invasive approach and high precision. Similarly, robotic arms have been used in International Space Stations in order to capture approaching cargo ships for docking and other tasks that are potentially too dangerous, too difficult or simply impossible for astronauts to do[3].

To sum up, robotic arms have multidimensional application and have played a significant role in preventing human casualty and improving the efficiency in several tasks. It is an important area of study of robotics. The rise concepts like mobile medicine and prospects of space exploration have emboldened the development in the field of robotic arm.

## 2.2 Components

### 2.2.1Resistor

Resistor, as the name says is a device capable of resisting the passage of electric current. Due to the property of resisting current, it has various application which includes controlling speed of motors (variable resistors) dividing voltage, generate heat, adjust signal level etc.

**Figure 1 resistor**

### 2.2.2 Capacitor

Capacitors are device that are capable of storing charges and can discharge almost immediately. They can be used in time dependent circuit as they charge and discharge at regular intervals. They can also be used in circuit that require sudden release of energy like flash circuit of a camera.

**Figure 2 Capacitor**

### 2.2.3 555 Timer IC

The 555 timer IC is a very cheap, popular and useful precision timing device which can act as either a simple timer to generate single pulses or long-time delays.

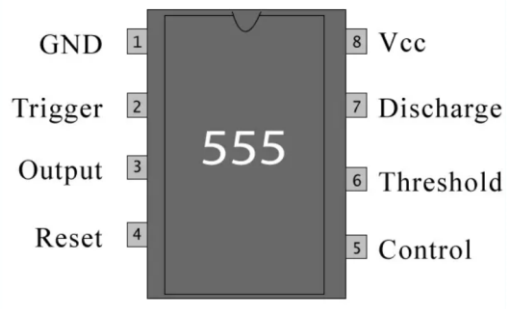



**Figure 3 555 Timer IC**

### 2.2.4 Servo Motor

A servo motor allows a precise control of the angular position, velocity, and acceleration.

**Figure 4 Servo Motor**

### 2.2.5 Potentiometer

This device is used to control the output voltage across its terminal. Its common application can be seen as volume control in speakers. It contains wiper arm by rotating which we can change resistance of circuit in many fractional values of the given resistance and by using this resistance, we can vary the voltage accordingly.

**Figur 5 Potentiometer**

### 2.2.6 Stepper Motor

A stepper motor, also known as step motor or stepping motor, is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can be commanded to move and hold at one of these steps without any position sensor for feedback (an open-loop controller), as long as the motor is correctly sized to the application in respect to torque and speed.

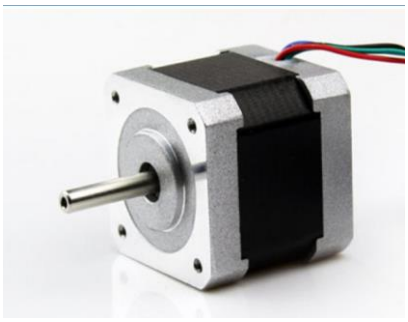


**Figure 6 Stepper Motor**

### 2.2.7 Diode

A diode is defined as a two terminal electronic component that only conducts current in one direction.

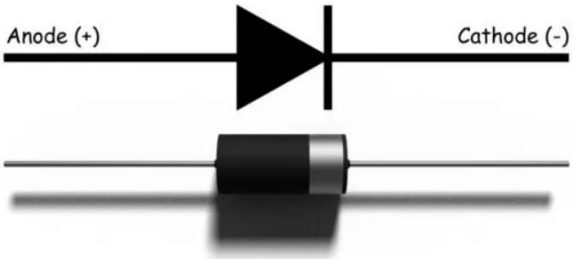



**Figure 7 Diode**

### 2.2.8 Stepper Motor Driver (DRV 8825)

This is used for rotating the stepper motor. The stepper motor acts as a lower base for rotating the joint arm which is connected with the servo motor.

**Figure 8 DRV 8825 Stepper Motor Controller**

| | |
|---|---|
| **Name** | DRV 8825 Stepper Motor Controller |
| **Operating Supply Voltage Range** | 8.2V to 45V |
| **Continuous Current Per Phase** | 1.5 A2 |
| **Maximum Current Per Phase** | 2.2 A3 |
| **Minimum Logic Voltage** | 2.5 V4 |
| **Maximum Logic V** | 5.25 V4 |
| **Microstep Resolutions** | full, 1/2, 1/4, 1/8, 1/16, and 1/32 |
| **Reverse Voltage Protection** | No |

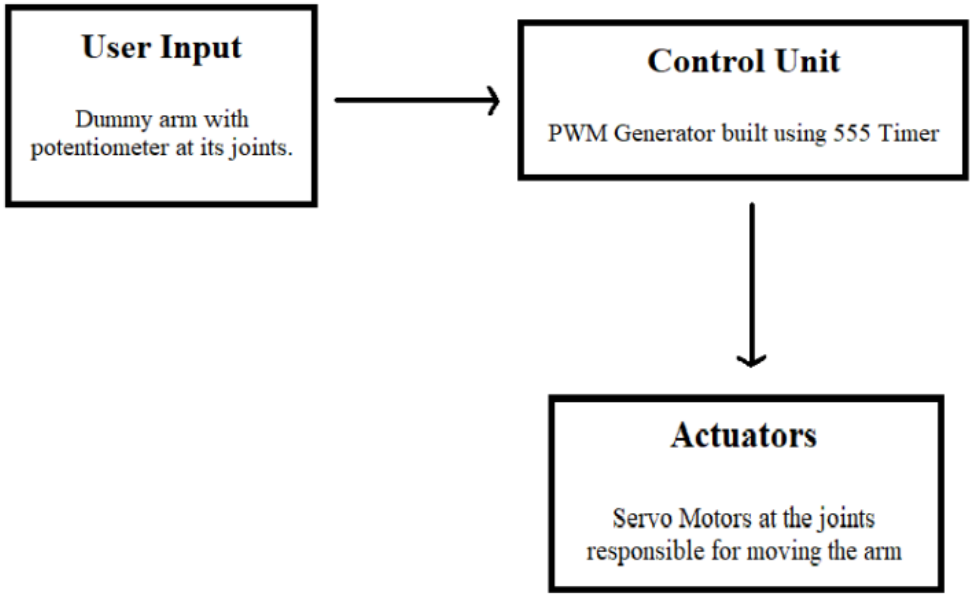
**Figur 9 DRV 8825 Specification**

## 2.2 Summary

From the age of agriculture to industrialization, civilization has progressed a long way forward. Nowadays, most of the industries use robotic arms and many other fileds are researching on this subject for application.

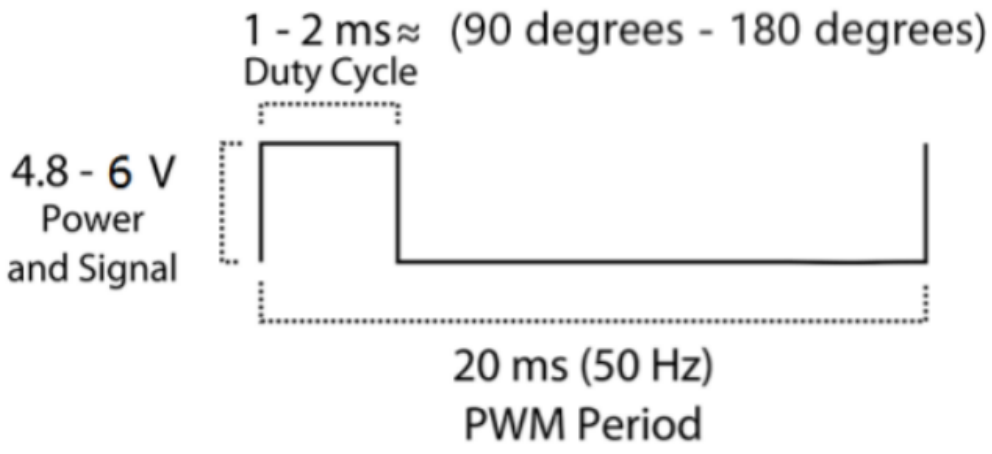
# CHAPTER III: METHODOLOGY AND RESULT

## 3.1 System Overview




**Figur 10 Block Diagram illustrating the functioning of robotic arm.**

Servo motors are actuators which are equipped with feedback system which enables them to move with great number of precisions. The model of servo motor to be used in the project is MG-90S. As per the datasheet, the motor can rotate approximately 180 degrees (90 degrees in each direction).




**Figur 11 Diagram explaining the relation between pulse width and degrees of rotation**

The above figure extracted from the datasheet of the servo motor helps us derive a relation between the duration of pulse width and the angle of rotation.

$$x° \; of \; rotation = (1 + x \; 180 \;) \; millisecond$$

### 3.2 555 Timer Astable Mode

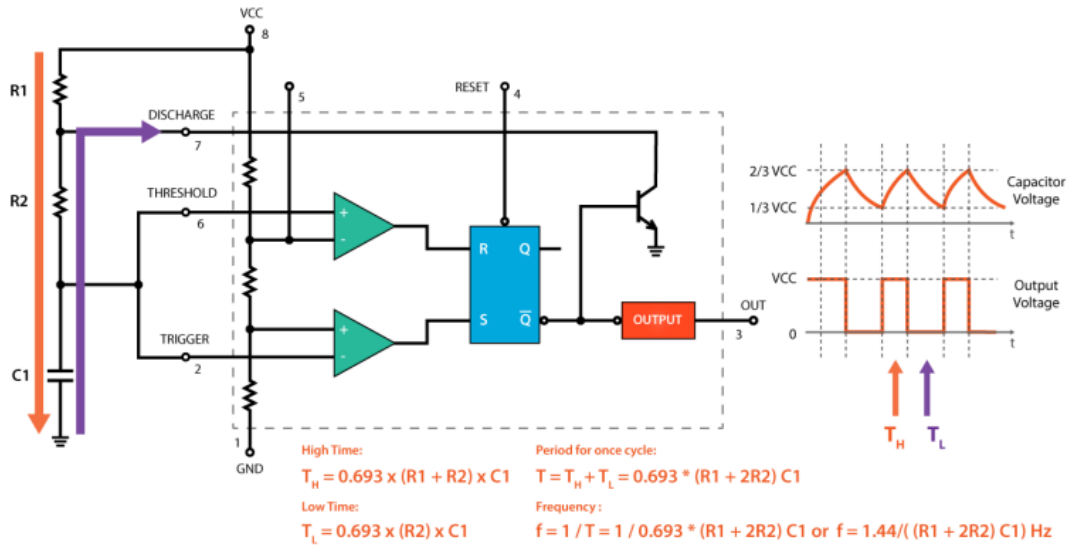



**Figure 12 Schematic Diagram of 555 Timer in Astable Mode**

The figure above is quite illustrative about the working of 555 timer in astable mode. The 555 Timer can be used to generate PWM signal of desired duty cycle and frequency. The generated frequency then can be used to control the servo motors.

The resistors R1, R2 and capacitor C1 can be varied in order to modulate the signal. The mathematical relation between the specification of the components and the output signal is also mentioned in the figure.

### 3.3 Working of Robotic Arm

We have kept stepper motor in the base so as to rotate the base of the arm in all the directions. Following the base, we keep a servo motor1 vertically above certain height from the base and again attach the tip with another servo motor2 which is kept horizontally. The servo motor3 is kept at the arm which is used to grip the objects.

### 3.4 Circuit Setup

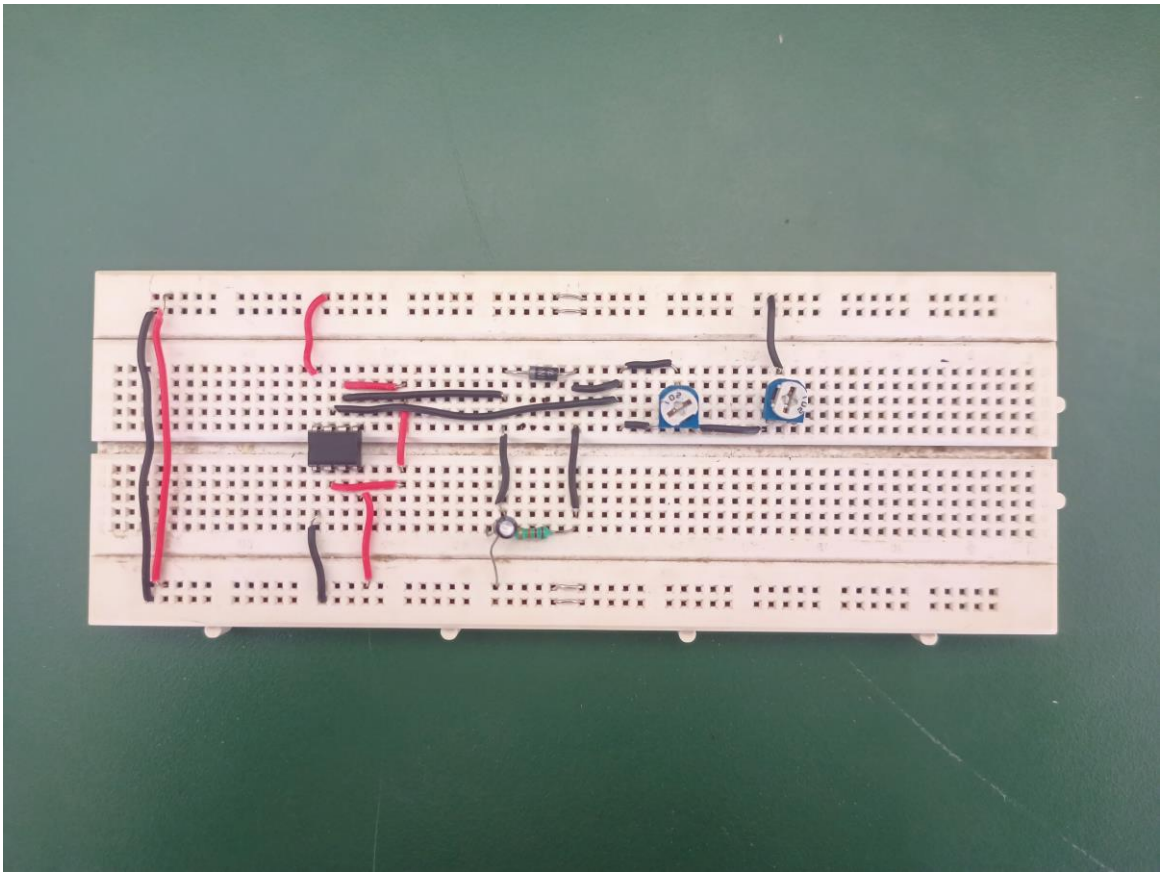


**Figure 13 Breadboard Circuit for servo motors**

The circuit for the servo motor consists of 555 timer IC, 2.5 microfarad cacpaitor, a diode, potentiometer and 12k ohm resistors. The circuit is setup as shown in the figure above. For the circuit of 555 timer, the circuit is connected according to the figure below.

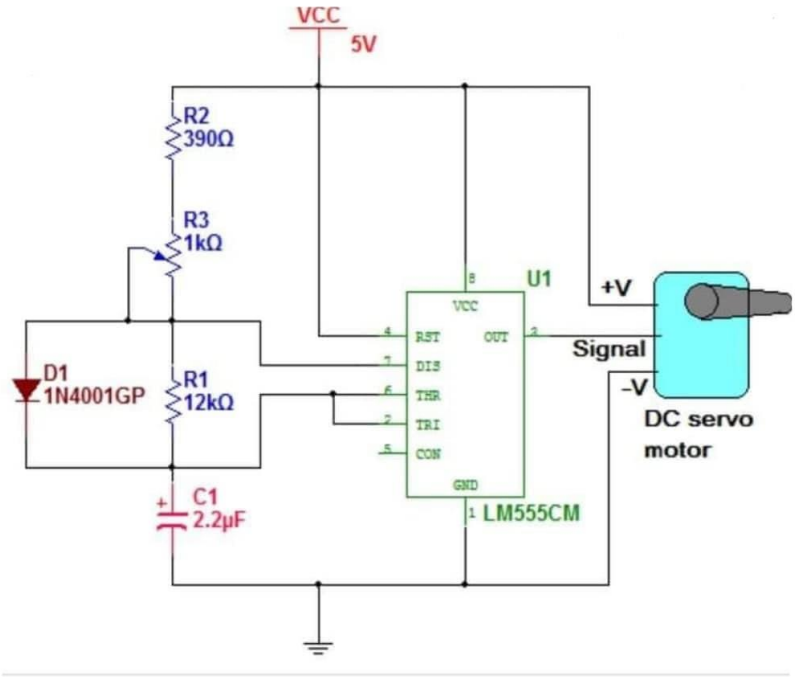



**Figure 14 Srevo Motor Circuit Using 555 Timer IC**

### 3.4.1 Working of Circuits

Through the use of 555 timer circuit, by maintaining the value of resistor and the ground capacitor, a signal is sent to the servo motors. The high time and low time is calculated from the formula which is given as,

$T_{high} = 0.693 * (R_1 * C)$

$T_{low} = 0.693 * R_2C$

**C = Capacitor**

**$R_1$ = Resistor used while charging**

**$R_2$ = Resistor uesd while discharging**

**$T = T_{high} + T_{low.}$**

Through this the pulse width signal is calculated as 0.5 to 2.5 millisecond. This signal is send to the servo motor and the stepper motor. Now, the degree of rotation of the servo motor is controlled by varying the value of the resistance with the help of potentiometer. Now, the stepper motor is driven by DRV 8825 stepper motor driver which rotates the stepper motor. The stepper motor is connected to the base of the robotic arm. The base

rotates the servo motor in 360 degrees. Finally, with the proper connection of the servo motors in the arms the robot is made functional.

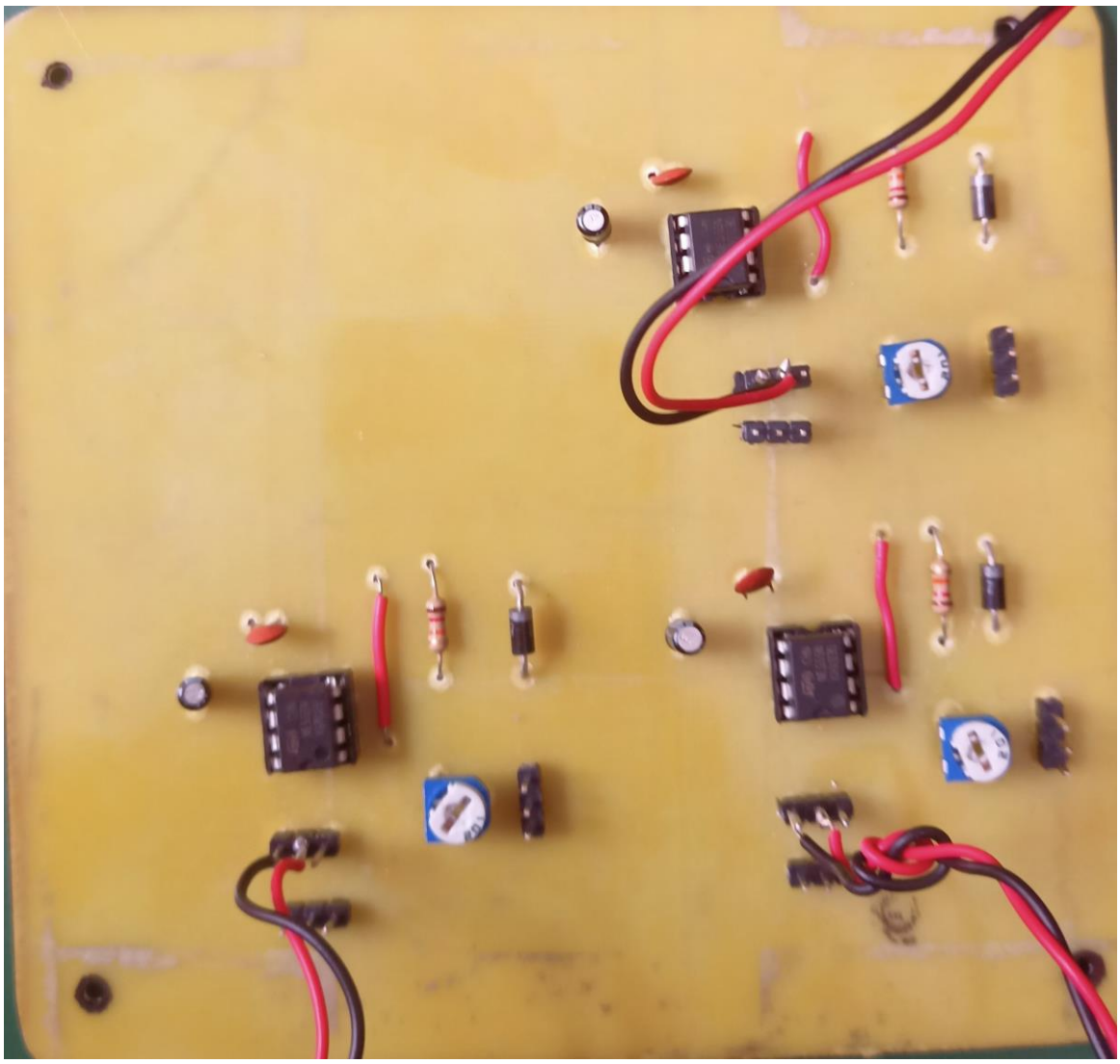


**Figure 15 Servo Motor PCB**

For the stepper motor, it is an electric motor whose main feature is that its shaft rotates by performing steps, that is, by moving by a fixed amount of degrees. The basic working principle of the stepper motor is the following: By energizing one or more of the stator phases, a magnetic field is generated by the current flowing in the coil and the rotator aligns with this field. In our project, the rotation of the stepper motor is controlled by the DRV 8825 Motor Driver Controller.

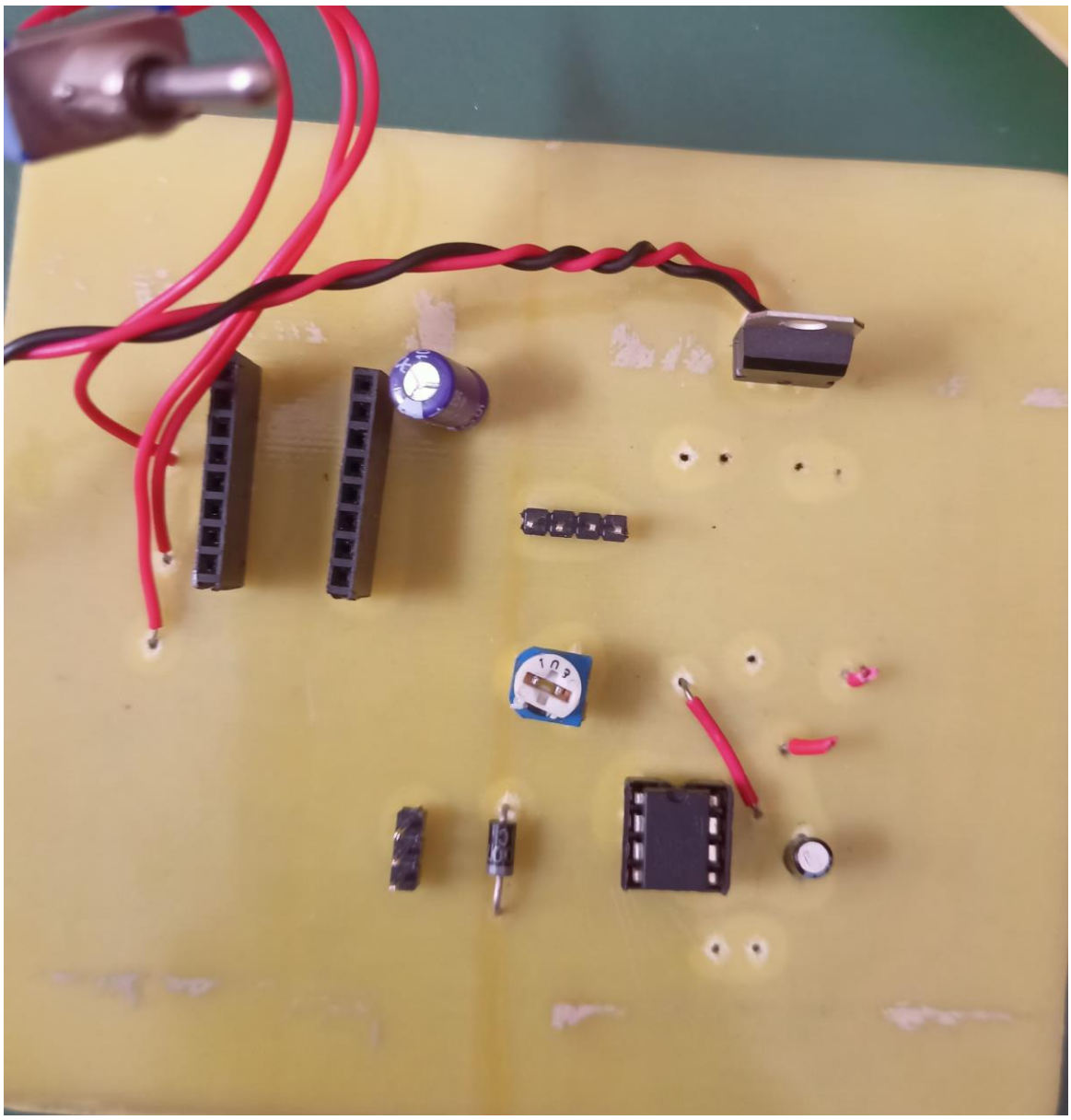


**Figure 16 Stepper Motor Circuit PCB**

### 3.5 Project Activity

We did our tasks in following order:

1. Completed design and simulation of prototypes of the servo motor and stepper motor controller circuit in simulation platform (Tinker Cad).

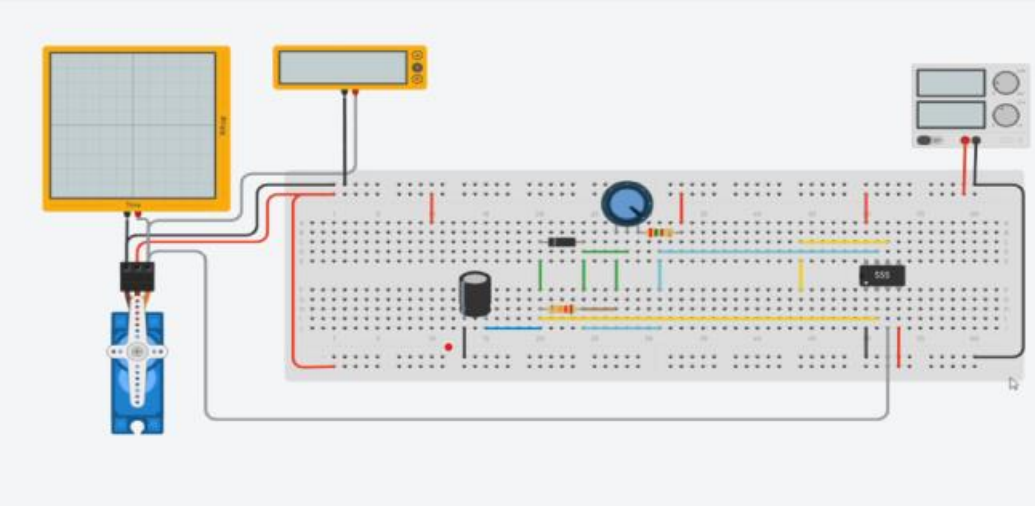


**Figure 17 Simulation On Tinker Cad**

2. Simplification of the design.
3. Collection of necessary components and conduction of their test on breadboard.
4. Implementation of the tested circuit on PCB.
5. Implementation of design on PCB.
6. Testing and troubleshooting of final product

### 3.6 Problem Analysis

#### Technical

When we were using motor driver for the stepper motor, similar problem for several times occured. The pins of motor driver were frequently short circuted due to our mistake and so we had to change it frequently. Also, the servo motors were vibrating due to noise. The probem was countered with the application of three 5 volts battery for the each servo motors.

#### Economic

Our total expenditure for the project is mentioned in the table below.

| Component | Quantity | Cost(Rs.) | Total(Rs.) |
|---|---|---|---|
| Servo Motors | 4 | 350 | 1400 |
| DRV 8825 | 2 | 500 | 1000 |
| Stepper Motor | 2 | 1980 | 3960 |
| Glossy Paper | 7 | 40 | 280 |
| Rectifier Diode | 16 | 60 | 960 |
| Resistor | 25 | 50 | 1250 |
| 3- Way Switch | 3 | 86 | 258 |
| Capacitor | 15 | 75 | 1125 |
| 555 timer IC | 12 | 150 | 1800 |
| | | | **Total = 12033/-** |

### 3.7 Summary

This chapter gives a detailed explanation of the working system of the robotic arm. A system overview of the working principle is provided. Then a detailed explanation of the components used and the circuit setup is given. The project activities done in sequential order is specified. Then a problem comparative analysis is done.

# CHAPTER IV: CONCLUSION

This project consists of design, model and demomstration of a robotic arm. The robotic arm is composed of servo motors and stepper motors. The servo is connected with the sandalwood and the tip of the arm is made. The circuit is based on the principle of 555 timer IC. The project is significant in various ways. It works as a demonstration for the working of a robotic arm and can be used as a reference for the future devolpment. Our project practical impications can be in the field of picking up of some objects which are lighter but it cant be used for picking up of heavier objects.

This project is cretainly helpful in our field of study as it helps us understanding the concept of 555 timer IC, pulse widh modulation, working mechanisms of servo motors, and DRV 8825 Motor Driver, capacitors, etc. This field of study is helpful in the future semester as well. We gained a lot of knowledge on stepper motor and also about the 555 timer working on a astable mode.

# Reference


[1] J. J.Craig, Introduction to Robotics: Mechanics and Control, 3rd Edition, Pearson, 2005.

[2] S.-H. Suh, S. K. Kang, D.-H. Chung and I. Stroud, Theory and Design of CNC Systems, Springer Science & Business Media, 2008.

[3] Datasheet of MG90S, Tower Pro.

[4] Dejan. [Online]. Available: https://howtomechatronics.com. [Accessed 2 February 2022].

[5] J. F. Gieras, Permanent Magnet Motor Technology: Design and Applications, Third Edition, CRC Press, 2011.

[6] L. Nocks, The Robot-The Life Story of a Technology, 2007.

[7] J. P. Laboratory, "Jet Propulsion Laboratory, NASA," [Online]. Available: https://www.jpl.nasa.gov/. [Accessed 15 1 2022].

[8] "Wikipedia," [Online]. Available: https://en.wikipedia.org/wiki/Resistor.

[9] P. Scherz and S. Monk, Practical Electronics for Inventors, Fourth Edition, McGraw Hill Professional, 2016.

[10] "Wikipedia," [Online]. Available: https://en.wikipedia.org/wiki/Potentiometer.

[11] https://www.intuitive.com/en-us/products-and-services/da-vinci

[12] https://robots.ieee.org/

[13] Intuitive - da Vinci - Robotic Surgical Systems

## *Gantt Chart*

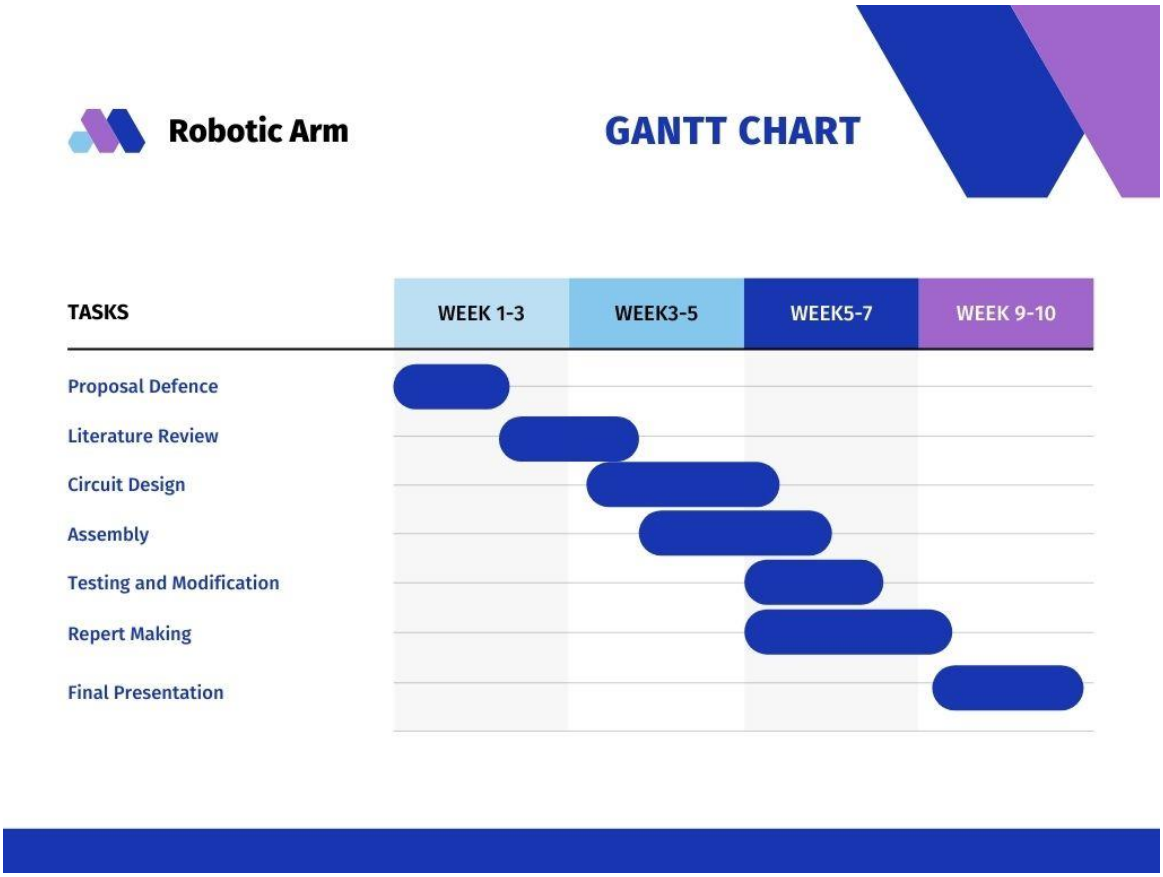



**Figure 18 Gantt Chart of The Project**

Task Completed.