DESIGN AND FABRICATION OF REMOTE CONTROLLED ROBOTIC ARM FOR SHIPMENT OF CHEMICALLY HAZARDOUS WASTE MATERIALS IN FACTORY.

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LETTER OF AUTHORIZATION

It is hereby declared that the work presented in this project titled **"Design and fabrication of remote controlled robotic arm for shipment of chemically hazardous waste materials in factory"** is an outcome of the systematic and planned performance carried out by the students under the supervision of Wing Commander G.M. Jahangir Alam, Instructor Class-A of Department of Mechanical Engineering, MIST, Dhaka. This thesis or any part of it has not been submitted to elsewhere for the award of any other degree or diploma or other similar title or prize.

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ABSTRACT

Every year many workers are injured, become ill or are killed because of exposure to harmful chemical substances. These incidents cause human suffering, loss of production and high medical cost. This robotic arm aims to give assistance and guidance to employers and workers to promote a safe and healthy work environment and prevent injuries. And also repetitive tasks and high accuracy have become the two contradictory needs of any industrial process. By introducing autonomous robotic applications, simple repetitive tasks can be accomplished keeping the demands of the accuracy and speed in mind. This report presents an approach mechanical system design concept and fabrication of three degrees of freedom jointed-arm robot with locally available materials, which should perform industrial task such as pick-and-placement of waste chemically hazardous material. The special feature of this robotic arm is that it can rotate on its base around 360° and a gripper system. This robotic arm has forward-backward motion and rotation on the base. These function and the movement of the arm is controlled by a lab view program via servo & DC motors, PC, motor drive IC, arduino and an Wi-Fi control module.

Mechanical gripper has been built as end effector and is capable of grasping diverse objects, even under external disturbances, within own workspace of the arm possible. Control of the robotic arm assembly has been achieved successfully using two DC motors and four servo motors. By controlling these six motors the robot can achieve a total of five degrees of freedom.

The arduino implements the position control on the motors. The project shows that the program allows the arduino to automatically adjust their commands to be appropriate for the arm dynamics and the task. The design aims to provide fine manipulation in performing industrial tasks, while still maintaining the simplicity of design, miniaturization, and lightness are also achieved.

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CHAPTER – 1

INTRODUCTION

The last two decades have witnessed a significant advance in the field of robots applications. Many more applications are expected to appear in space exploration, battlefields and in various activities of daily life in the coming years. Now-a-days various chemically hazardous materials are produced in factories which are very much dangerous for human body. Our project is to build a robotic arm model which can discharge these hazardous materials without any touch of human body. Robot is a mechanical device that performs automated tasks and movement according to either pre-defined program or a set of general guidelines and direct human supervision. These tasks either replace or enhance human work such as in manufacturing construction or manipulation of heavy and hazardous materials. To pursue a challenging career in a design environment that utilizes our skills and knowledge to best suit organizational growth. Man is progressive and the Engineers are the pioneers to the progress. The objective of being an engineer is to achieve the capability of performing laborious jobs with ease using certain mechanisms. With the advancement of modern technology manual labor is more & more replaced and reduced by the use of technological excellence

Jointed Arm robots are suitable for a wide variety of industrial tasks, ranging from welding to assembly. A jointed arm robot has some rotational axes connecting rigid links and a base. It is sometime called an anthropomorphic arm because it closely resembles a human arm. It usually stands on a base on which it can rotate, while it can articulate at the “shoulder” joint, which is just above the base. The robot can also rotate about its “elbow” and “wrist” joints. These names match those of the corresponding human parts.

The “hand” of a robot is known as gripper, an end effector, an actuator, or end-of-arm tooling. It consists of the driven mechanical devices attached to the end of the manipulator, by which objects can be grasped or acted upon. The robot may require a different type and design of hand for each different object to grasp or each different tool to build. In some cases, the hand itself acts as the tool. Clearly, designing grippers properly is a key task in robotics.

Over the last few years, there has been much interest in the area of multi-fingered robot hands and dexterous manipulation. Dexterous multi-fingered end effectors are potentially ideal for applications requiring a combination of dexterity and versatility for grasping a wide range of objects. The desire to design and construction of more dexterous hands has fueled an ongoing surge of activity in the areas of grasping and multi-fingered end effectors. Since the introduction of the groundbreaking and highly successful Stanford/JPL and Utah/MIT dexterous hand designs in the 1980's, various robot hands have been designed, constructed, and tested. Concurrently, a significant body of work in synthesis and analysis of multi-fingered grasps has been built up. Surveys of these efforts can be found in a number of publications and texts, including.

However, at this time, few dexterous hands have been successfully applied to practical applications. Many of the robot hands developed to-date have been complex, expensive, and/or bulky, featuring remote actuation via tendons, and have often not been physically robust, with reliability being a problem. Currently, there is a strong interest in developing simpler, more 'minimalist' hand designs. This paper describes a mechanical system design concept and a prototype implementation of a 5 DOF jointed-arm robot, which should perform industrial task such as pick-and-place operation. The design aims are to provide fine manipulation in performing industrial tasks, while still maintaining the simplicity of design, miniaturization, and lightness.

1.1. OBJECTIVE

The objective of the project is to design and implement of gripper with robotic arm by using servo and DC motors that has the capabilities to create a motion to the robotic arm to bear load. Besides that, the robotic arm is designed for the shipment of hazardous material in the factories specially the chemical wastes . The design of robotic arm is reliable and it can be used for its purpose.

Furthermore, the sub-objectives for this project is to write a precision program to control the dc servo motor, find and choose the good performance of the de servo motor and create a reliable and simple movement for the robotic arm and gripper.

It is aimed to carry important and valuable objects where human entrance is risky. It can also be used to perform household works and make our life easy.

The main materials used here are wood. Then the required holes are drilled and after that they are folded to give them the required shape. After the assembly of the full body parts, the required circuit is constructed and a graphical program is used to fulfill the purpose.

The robotic arm we have constructed is controlled by a Wi-Fi controlled module and the data is sent via arduino, so the robot can be controlled from a desirable distance thus avoiding complications of wires.

CHAPTER – 2

LITERATURE REVIEW

2.1 ROBOTS

2.1.1 Definition of Robots

A reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks.

2.1.2 Etymology

The word robot was introduced public by Czech writer Karel Capek in his play R.U.R (Rossum's Universal Robots), which premiered in **1921**. The play begins in a factory that makes artificial people called robots, but they are closer to the modern ideas of androids and clones, creatures that can be mistaken for humans. They can plainly think for themselves, though they seem happy to serve. At issue are whether the robots are being exploited and the consequences of their treatment.

However, Karel Capek himself did not coin the word; he wrote a short letter in reference to an etymology in the Oxford English Dictionary in which he named his brother, the painter and writer Josef Capek as its actual originator. In an article in the Czech journal Lidove noviny in **1933**, he explained that he had originally wanted to call the creatures' *labori* (from Latin labor, work). However, he did not like the word, and sought the advice from his brother Joseph, who suggested "*roboti*". The word *robota* means literally work, labor or serf labor, and figuratively "drudgery" or "hard work" in Czech and many Slavic languages. Serfdom was outlawed in **1848** in Bohemia, so at the time Capek wrote R.U.R, usage of the term *robota* had broadened to include various types of work, but the obsolete sense of "serfdom" would still have been known.

2.1.3 History of Robots

Many ancient mythologies include artificial people, such as the mechanical servants built by the Greek god Hephaestus Vulcan to the Romans, the clay golems of Jewish legend and clay giants of Norse legend, and Galatea, the mythical statue of Pygmalion that came to life.

The beginning of the robots may be traced to the Greek engineer Ctesibius. In the **4th** century BC, the Greek mathematician Archytas of Tarentum postulated a mechanical steam-operated bird he called "The Pigeon".

In the **3rd** century BC text of the Lie Zi, there is a curious account on automata involving a much earlier encounter between King Mu of Zhou Chinese emperor **10th** century BC and a mechanical engineer known as Yan Shi, an 'artificer'.

In the **4th** century BC, the Greek mathematician Archytas of Tarentum postulated a mechanical steam-operated bird he called "The Pigeon". Hero of Alexandria (**10-70 AD**) created numerous user-configurable automated devices, and described machines powered by air pressure, steam and water. Su Song built a clock tower in china in **1088** featuring mechanical figurines that chimed the hours.

Al-Jazari (**1136-1206**), a Muslim inventor during the Artuqid dynasty, designed and constructed a number of automated machines, including kitchen appliances, musical automata powered by water, and the first programmable humanoid robots in **1206**.

Leonardo da Vinci (**1452-1519**) sketched plans for a humanoid robot around **1495**. Da Vinci's notebooks, rediscovered in the **1950**s, contain detailed drawing of mechanical knight now known as Leonardo's robot, able to sit up, wave its arms move its head and jaw.

In **1738** and **1739**, Jacques de Vaucanson exhibited several life-sized automatons: a flute player, a pipe player and a duck. The mechanical duck could flap its wings, crane its neck, and swallow food from the exhibitor's hand, and it gave the illusion of digesting its food by excreting matter stored in a hidden compartment.

2.1.4 Modern Developments

The Japanese craftsman Hisashige Tanaka (**1799-1881**), known as "Japan's Edison", created an array of extremely complex mechanical toys, some of which served tea, fired arrows drawn from a quiver, and even painted a Japanese kanji character. The first electronic autonomous robots were created by William Gray Walter of the Burden Neurological institute at Bristol, England in 1948 and 1949. They were Elmer and Elsie. These robots could sense light and contact with external objects, and use these stimuli to navigate.

The first truly modern robot, digitally operated and programmable, was invented by George Devol in **1954** and was ultimately called the Unimate. Devol sold the first Unimate to General Motors in **1960**, and it was installed in **1961** in a plant in Treton, New Jersey to lift hot pieces of metal from a die casting machine and stack them. To help to review the past and recent developments & researches regarding Robots, is describing below:

During World War II (**1939-1945**) the first mobile robots emerged as a result of technical advances on a number of relatively new research fields like computer science and cybernetics. They were mostly flying bombs.

Between **1948-1949** W. Grey Walter builds Elmer and Elsie, two autonomous robots that looked like turtles. they were called Machina Speculatrix because these robots liked to explore their environment.

By the time of **1961-1963** , The Johns Hopkins University develops 'Beast'. Beast used sonar to move around. When its batteries ran low it would find a power socket and plug itself in. And in **1969** Mowbot was the very first robot that would automatically mow the lawn.

At **1970** The Stanford Cart line follower was a mobile robot that was able to follow a white line, using a camera to see. It was radio linked to a large mainframe that made the calculations. At about the same time (**1966-1972**) the Stanford Research Institute is building and doing research on Shakey, a robot named after its jerky motion.

After period in **1976-77** NASA sends two unmanned space crafts to Mars and the first Star Wars movie A New Hope features R2D2, an autonomous mobile robot and C3PO, a humanoid. They make robots known to the general public.

At early **1980**s, the team of Ernst Dickmanns at Bundeswehr University Munich builds the first robot cars, driving up to 55 mph on empty streets.

In **1990**s Joseph Engelberger, father of the industrial robotic arm, works with colleagues to design the first commercially available autonomous mobile hospital robots, sold by Helpmate.

During **1993-1994**, Dante I and Dante II were developed by Carnegie Mellon University. Both were walking robots used to explore live volcanoes.

In **1995**, one of Ernst Dickmanns' robot cars (with robot-controlled throttle and brakes) drove more than 1000 miles from Munich to Copenhagen and back, in traffic, at up to 120 mph, occasionally executing maneuvers to pass other cars (only in a few critical situations a safety driver took over). Active vision was used to deal with rapidly changing street scenes.

Between **1996-97**, NASA sends the Mars Pathfinder with its rover Sojourner to Mars. The rover explores the surface, commanded from earth. Sojourner was equipped with a hazard avoidance system.

About **2004-05**, Robosapien, a biomorphic toy robot designed by commercially

Boston Dynamics creates a quadruped robot intended to carry heavy loads across terrain too rough for vehicles.

In **2007**, History is made with the DARPA Urban Grand Challenge, with six

Vehicles autonomously completing a complex course involving manned vehicles and obstacles.

Kiva Systems clever robots proliferate in distribution operations; these smart shelving units sort themselves according to the popularity of their contents.

And in **2008**, Boston Dynamics released video footage of a new generation Big Dog able to walk on icy terrain and recover its balance when kicked from the side.

CHAPTER 3

CONCEPT OF ROBOTIC ARM SYSTEMS

3.1 ROBOTIC ARM

Typically, robotic arm are used to perform jobs that are difficult, hazardous or monotonous for human . They lift heavy objects, paint, weld, handle chemicals, and perform assembly work for days at a time without suffering from fatigue. Robotic arm are defined by the nature of their movement. This section describes the following.

3.2 CLASSIFICATION OF ROBOTIC ARM

- Cartesian
- Cylindrical
- Polar
- Articulated
- SCARA
- Parallel

3.2.1 Cartesian Robotic Arm

Cartesian, or gantry, robots are defined by movement limited by three prismatic joints .The workspace is defined by a rectangle resulting from the coincident axes.

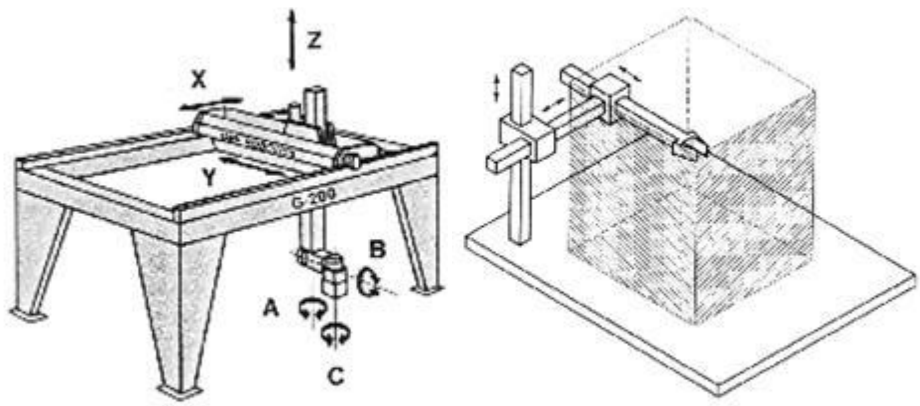


Figure 3.1: Cartesian Gantry Robot Arm

3.2.2 Cylindrical Robotic Arm

If one of the Cartesian robot's prismatic joints is exchanged for a revolute joint, a cylindrical robot is formed. A cylindrical robot's movement is defined by a cylindrical coordinate system. Figure 3.2 demonstrates this unit's thick shelled cylindrical workspace.

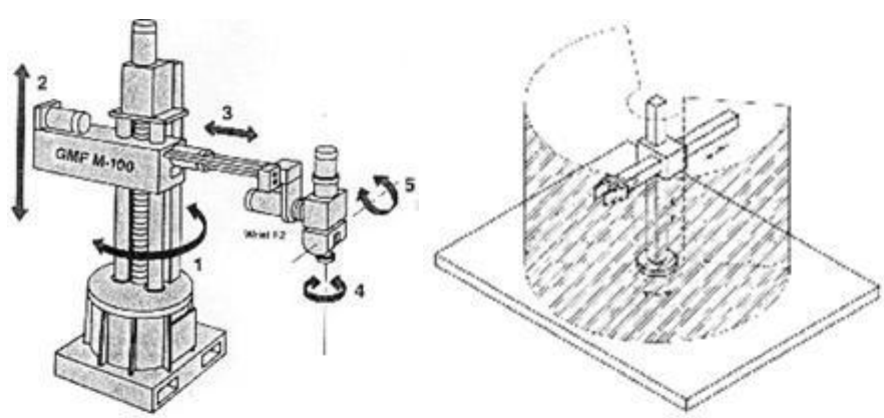


Figure 3.2: Cylindrical Robot Arm

3.2.3 SCARA Robotic Arm

SCARA (which stands for Selectively Compliant Articulated Robot Arm) is a specialty robot which has two parallel rotary joints to provide compliance in a plane. A third prismatic joint allows the arm to translate vertically. SCARA robots differ from articulated robots in that its workspace consists of two concentric cylinders, demonstrated in figure .This robot arm is specialized for assembly operations that involve placing parts on top of one another. The gripper can raise, lower, and rotate to orient the component to be assembled.

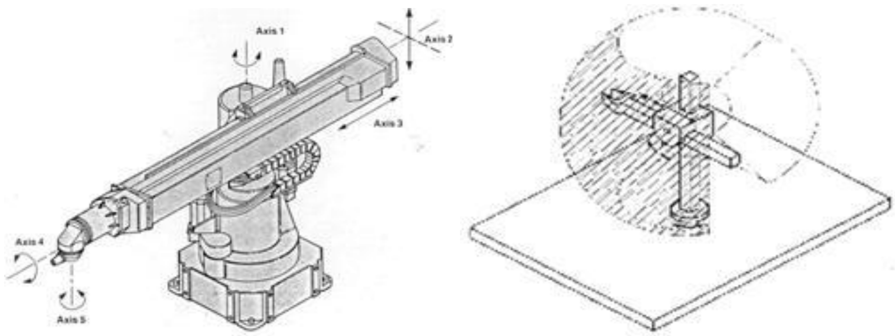


Figure 3.3: Scara Robot Arm

3.2.4 Articulated Robotic Arm

Substituting a revolute joint for the final prismatic joint turns the arm into an articulated arm. Any robot whose arm has at least three rotary joints is considered to be an articulated robot (figure 3.4). The workspace is a complex set of intersecting spheres.

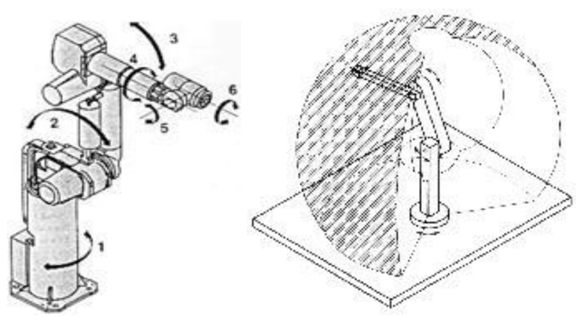


Figure 3.4: Articulated Robot Arm

3.2.5 Polar or Spherical Robotic Arm

These type of robots are used for handling at machine tools, spot welding, die casting, fettling machines, gas welding and arc welding. It's a robot whose axes form a polar coordinate system.

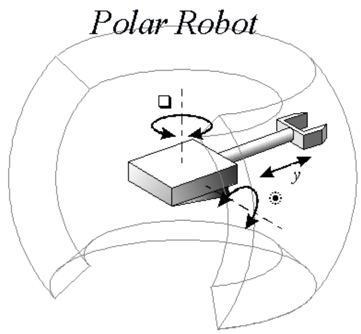


Figure 3.5: Polar Robot Arm

3.2.6 Parallel Robot

A parallel robot is a closed loop system. The end effector is connected to a base via multiple kinematic chains. Parallel robots are very fast, light, strong, and reliable. It's a robot whose arms have concurrent prismatic or rotary joints. It is used in a mobile platform handling cockpits .

Figure 3.6: Parallel Robot

CHAPTER-4

APPLICATION OF ROBOTIC ARM

4.1 Application of robotic arm

Robotic arms are found in a variety of locations including the automobile and manufacturing industries. Robotic arms cut and shape fabricated parts, assemble machinery and inspect manufactured parts. Some types of jobs robotic arms do: load bricks, die cast, drill, fasten, forge, make glass, grind, heat treat, load/unload machines, machine parts, handle parts, measure, monitor radiation, run nuts, sort parts, clean parts, profile objects, perform quality control, rivet, sand blast, change tools and weld.

Outside the manufacturing world robotic arms perform other important jobs. They can be found in hazardous duty service, CAD/CAM design and prototyping, maintenance jobs, fighting fires, medical applications, military warfare and on the farm. The application of robotic arms in our day to day life are discussed below –

4.1.1 Material handling

A robotic arm can move, select or packs product. These are also used to automate feeding or disengaging parts or tools from one location to another. Material handling applications are varied in nature. It may be simple parts transfer – a robotic arm may pick up a part from a conveyor or take apart from a machine and place it on a conveyer. Robotic arm used for this purpose is usually stationary. They may be mounted on rails or slides to add to horizontal mobility. They may even be placed on automated guided vehicles (AGVs) moving on the floor.

4.1.2 Loading and Unloading

This application sometimes be a dangerous work environment. By using robotic arm can protect workers from injury while increasing part cycle time. These kind of robot work efficiently, tirelessly and accurately.

4.1.3 Part transfer

The simple task of moving a part or object from one location to another within the work area is one of the most common applications for a robotic arm today. Often, it is necessary to acquire a part from a remote location and to place it in a compartmentalized box or cartoon. Once all the compartments are filled, the box is moved to another location within the work cell, where it is sealed and stacked for future use. Though part transfer was once entirely done by hand, many industries have now converted to robot part transfer system as way to save on labor costs and speed up production processes. Part transfer also increases accuracy and precision, which helps shops to create a better product.

4.1.4 Palletizing

Industrial palletizing refers to loading and unloading parts, boxes or other items to or other items to or from pallets. Automated palletizing refers to an industrial robot performing the application automatically. It also able t5o handle heavy payloads and have large horizontal and vertical reaches that allow parts to b palletized from varying distances.

4.1.5 Assembly operation

Human beings are capable of assembling a group of diverse parts to produce either a finished product or a subassembly because of their ability to utilize good–eye–hand coordination in conjunction with the important sense of touch. However, these jobs may extremely tedious because of their repetitious nature.

Robots lend themselves well to the tedious and repetitive nature of assembly tasks provided that the proper planning and design have been done. In addition, their high level of repeatability has allowed the development of some new technologies in electronic assembly.

4.1.6 Parts Inspection

Robotic arms have been used to inspect finished parts or subassemblies in order to increase product quality. Te automobile industry is an example of a group of companies that is striving to upgrade its product by automating the inspection process. Inspection of electronic devices can also be performed by robotic arms. For example, a printed circuit (PC) board often must be checked for missing or improperly drilled holes before the components are places on the board.

4.1.7 Parts Sorting

Often, groups of parts are produced in an unsorted manner either to reduce costs or because of tolerance variations inherent in the manufacturing process. Robotic arms have been used to perform the task of sorting.

4.1.8 Foundry

The harsh conditions and jobs common to foundries, forge shops, steel mills, and many automotive plants are well-suited to robot automation. While human workers may have issues with these harsh conditions, robotic arm type robot can work in those environments without needing breaks, days off or vacation. It is designed to work in hot and hazardous environments and can withstand high levels of dust as well as exposure to harsh chemicals and high pressure sprays.

CHAPTER–5

ASSEMBLY SETUP

5.1 GENERAL STRUCTURE OF A ROBOTIC ARM

Robotic arm is a robot manipulator, usually programmable, with similar functions to a human arm. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement.

A kinematic chain is the assembly of several kinematic pairs connecting rigid body segments. The complexity (in terms of calculating the forward and inverse kinematics) of the chain is determined by the following factors:

It's Geometrical shape:

The business end of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand. The end effector can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application

This is a fundamental concept relating to systems of moving bodies in mechanical engineering, aeronautical engineering, robotics, structural engineering, etc.) In chemical engineering, degrees of freedom are used to determine if a material balance is possible for a given process.

A robot arm or a robot hand can be split up in two major subsystems:

- The mechanical system
- The control system

5.2 MECHANISM FOR MOVEMENT OF ARMS

Actuator method : Mechanical linear actuators typically operate by conversion of rotary motion into linear motion. By this method arms are moved by means of mechanical actuator. This actuator gives linear movement, which gives the arm movement .

Figure 5.1 :Mechanical Actuator

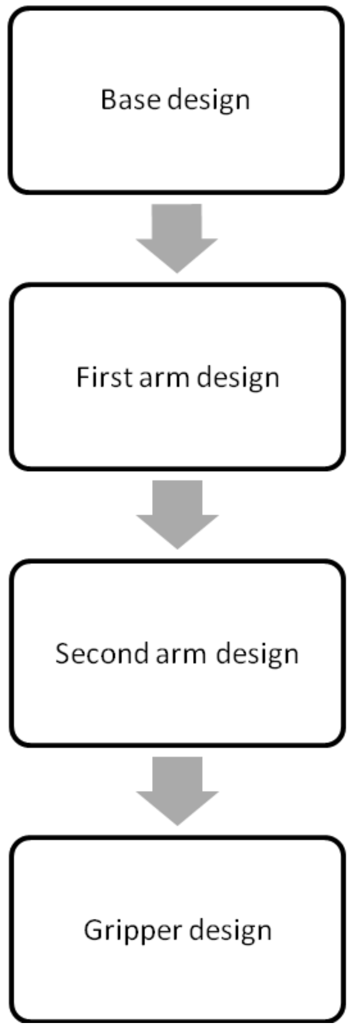
Direct Rotational Method : By this method the arms of a robotic arms are attached with DC or servo motor , this motors gives rotation to the arm joint and the arms moves with the motor rotation .

Figure 5.2: Servo motor for rotational movement of arm

5.3 DESIGN

Before fabricate the robotic arm we made a CAD design by using solid works software . This design gave us a complete view of the robotic arm before fabrication .

Designing sequence is given bellow :



5.3.1 Base design

The design of base of the robot allows it to support the arm. A portion of the base is removed for placing a dc gear motor, which helps in rotation of the arm. Four wheels are attached at the bottom of the base for forward and backward movement.

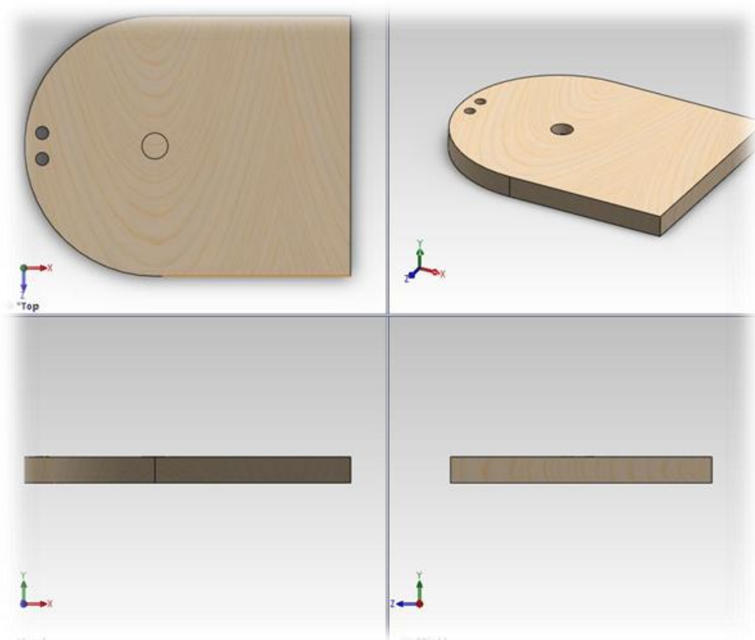


Figure 5.3 : Design of base.

5.3.2 First arm design :

First arm is the most load caring member of the structure .first arm is designed with two simple straight bar attached with a disk , having drilled whole on the top.

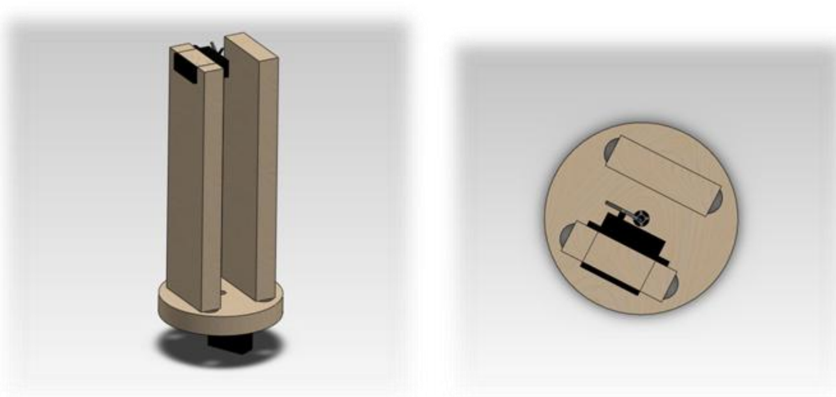


Figure 5.4 : Design of first arm

5.3.3 Second arm design

Second part of the robotic arm which holds the gripper with load . It has one part which carries a servo motor and gripper shaft.

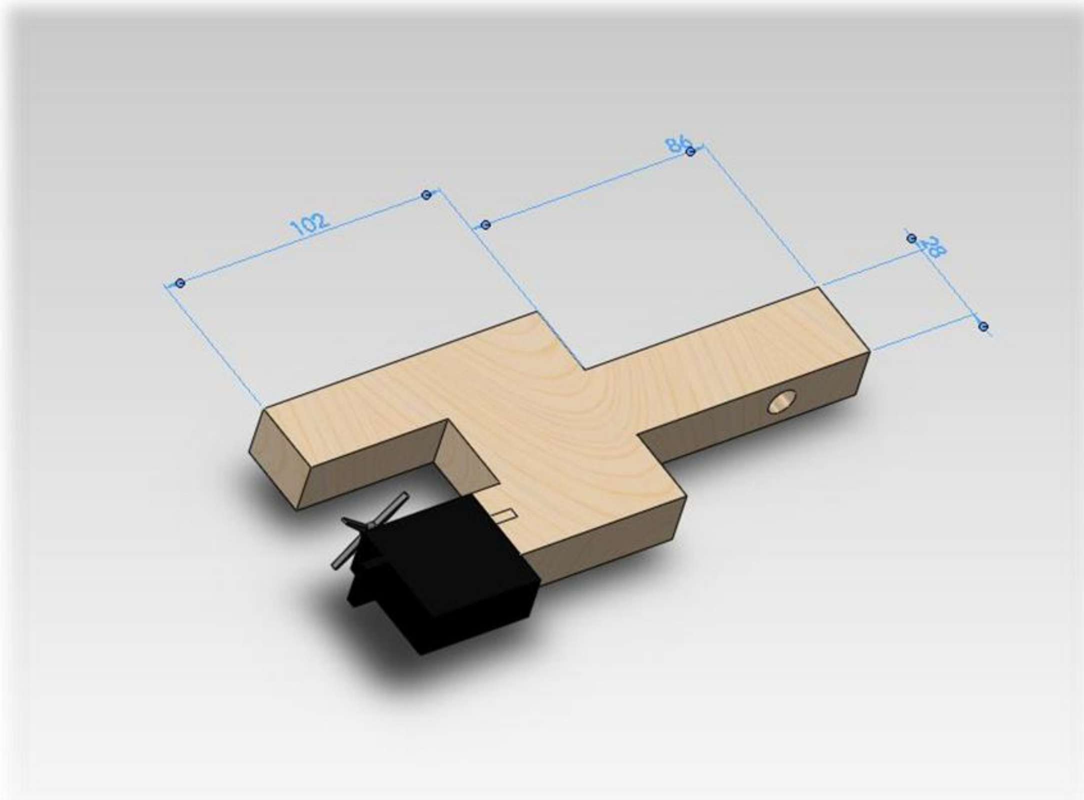


Figure 5.5 : design of second arm .

5.3.4 gripper design

This is the part which holds the load to be carried . First part of the gripper is connected with the second arm and second part has the load holding claws . Claws are made of four individual members , two of which are connected to the gears . These gears are meshed with each other. One is connected with the servo motor , when the motor rotates this gives a displacement .

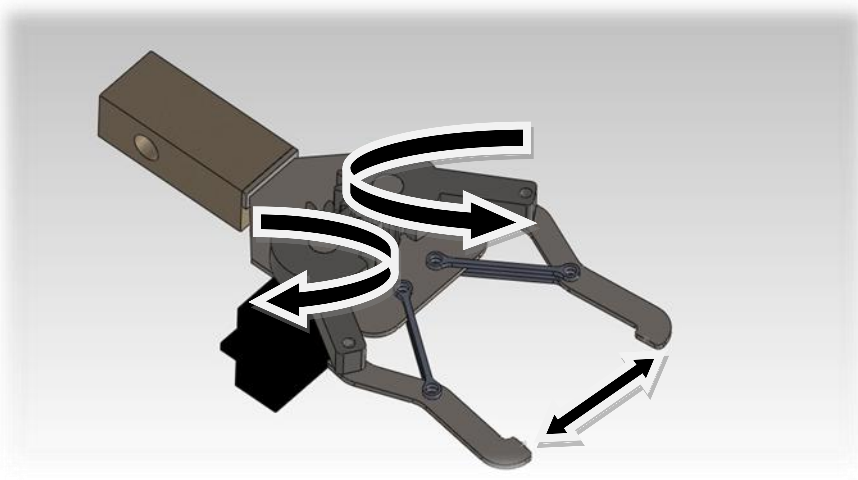


Figure 5.6 : Gripper design .

When motor rotates gears rotates in opposite direction to each other , and give a displacement of maximum 98 cm.

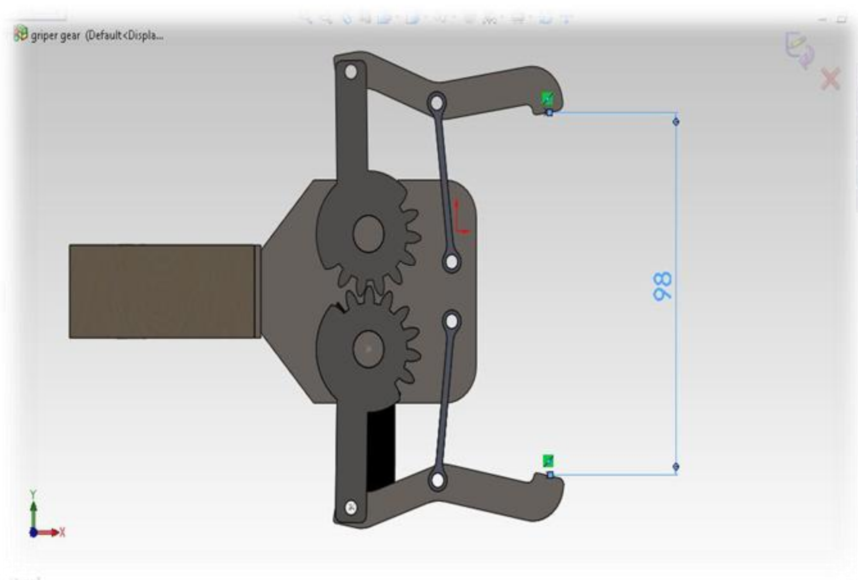


Figure 5.7 : Gripper displacement .

5.3.5 Whole assembly design

These parts are assembled in a assembly file , in solid works .

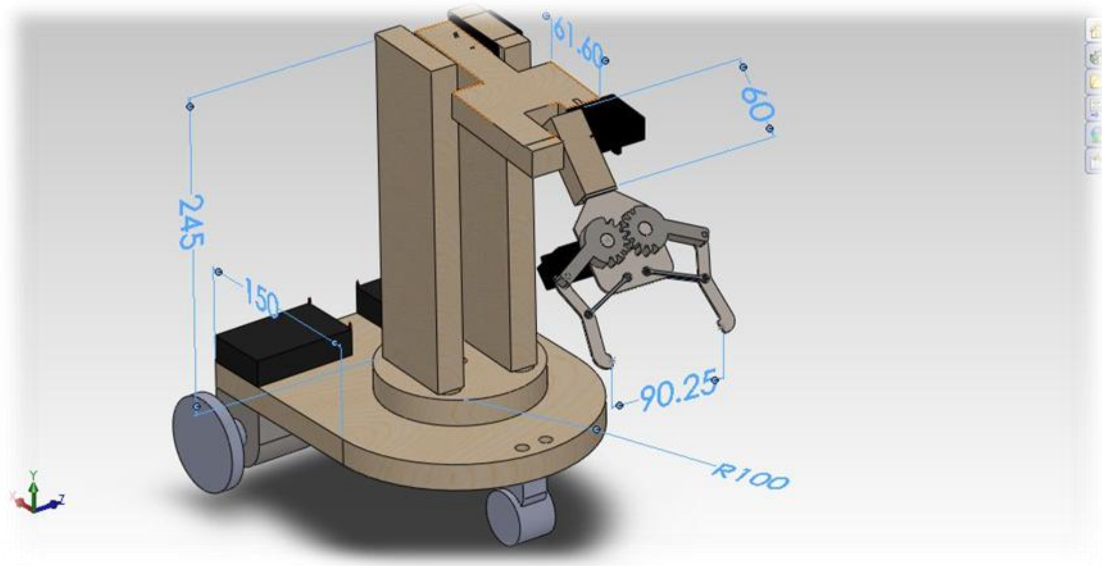


Figure 5.8 : Whole assembly .

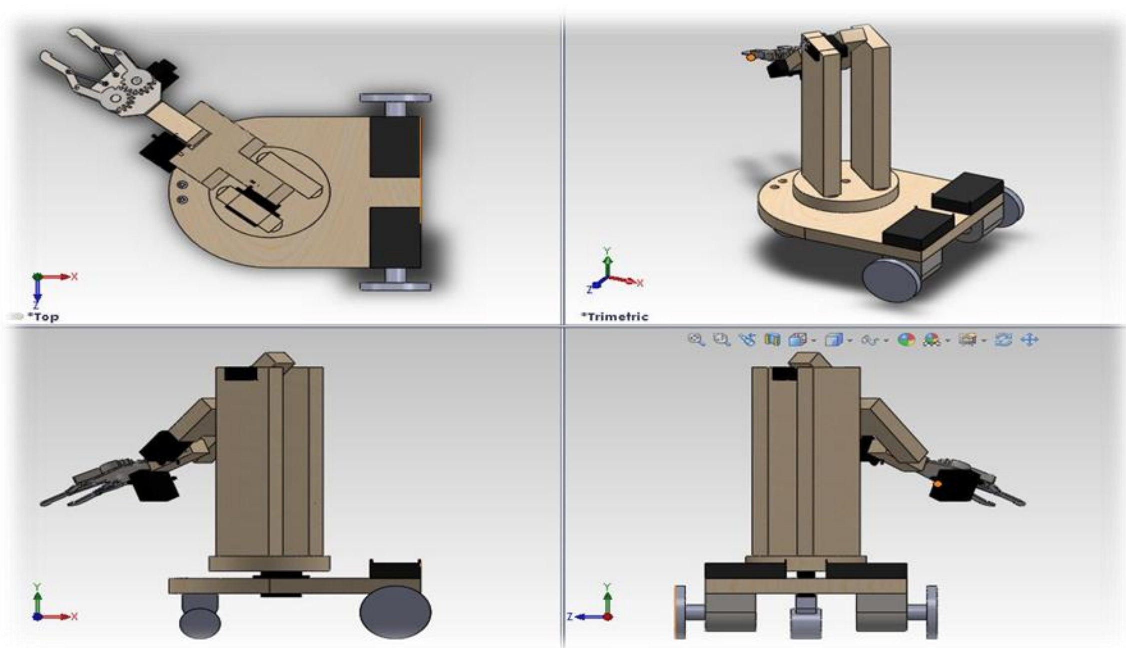


Figure 5.9 : Whole assembly in different view .

5.4 FABRICATION

5.4.1 fabrication of base

The base on which the construction is laid is made of wood. The length of the base is 25 cm, width is 20 cm and the thickness is about 5 cm. The hole made to attach the shaft of the motor with rotating panel of the arm is in the position 15 cm×10 cm of the base. The rotating panel which rotates via motor is about the diameter of 10 cm. The hole is made in its centre position to attach the shaft coming from the lower base panel. On the rotating panel the arm is fixed. As the rotating panel rotates with the help of a gear motor, which is situated under at the base, the robotic arm rotates.

To give motion to the base four wheels have been attached. The rare wheels are bigger than the front wheels. The front two wheels are fixed with the lower base panel of the base. The rear wheels are made of wood and diameter of the each rear wheel is 2 inches. Two front wheels are attached via shaft with two pieces of wood on both sides of each wheel. The two pieces of wood is attached with the lower base panel. The rotating panel is fixed with the shaft connected to the gear motor under lower base panel by cutting the exact shape of the motor in the upper base panel. The depth of the base is large enough to compensate the vibration while rotating.

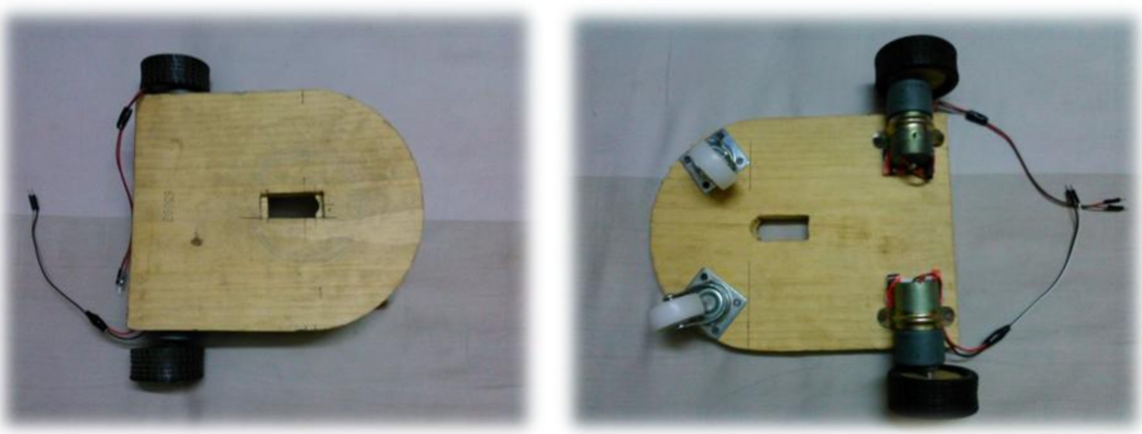


Figure 5.10 : Fabrication of base .

5.4.2 Fabrication of first arm

The main objective of first arm is to hold the second arm and the gripper along with the load it carries . First arm is made with low density wood , kerosene wood . It is 25 cm long and 6.5 cm in width . Two bar of wood of this dimension is attached in a disc of diameter 10 cm . First of this arrangement can rotate 360 degree by the disc which is attached with a servo motor .

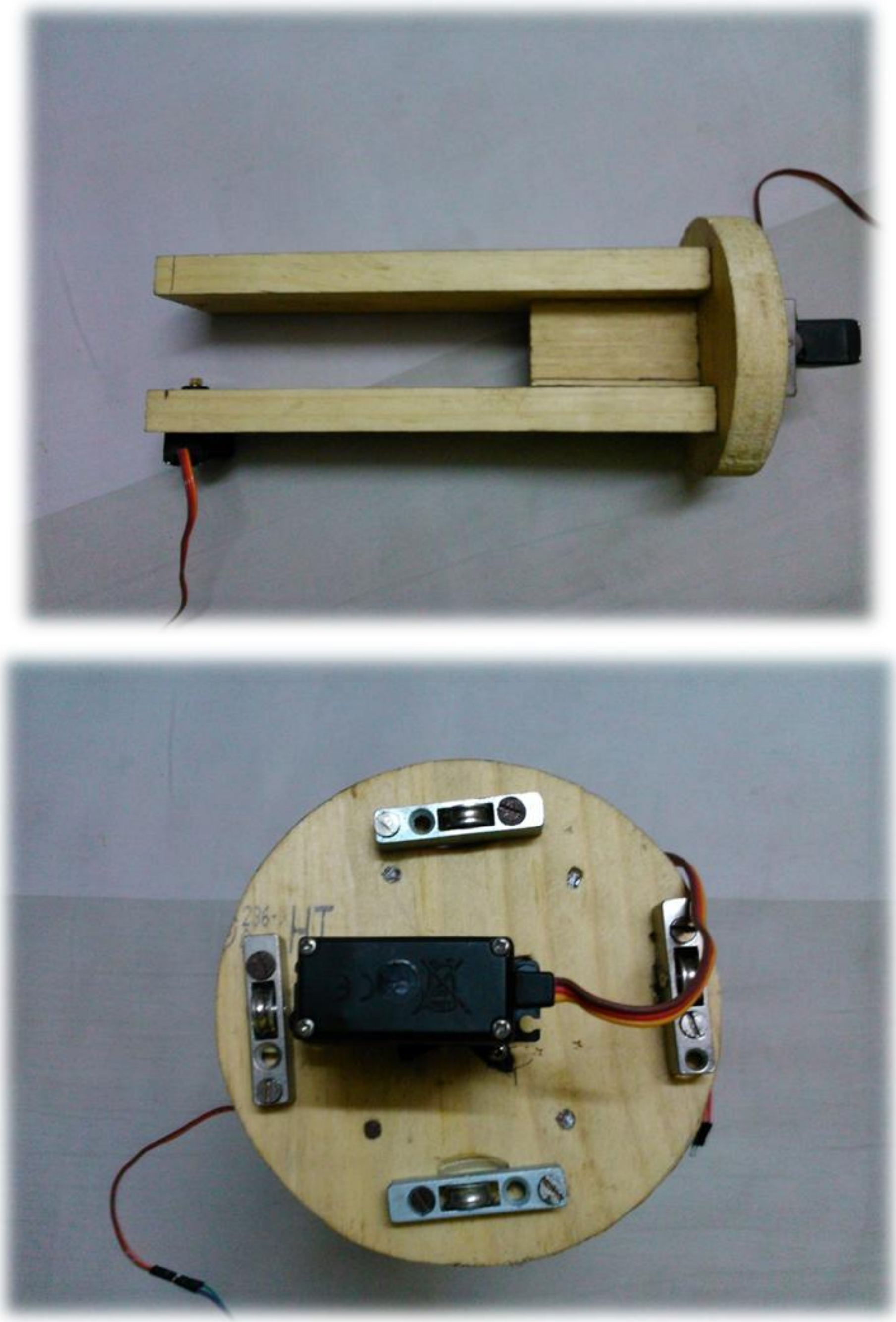


Figure 5.11 : Fabrication of first arm .

5.4.3 Fabrication of second arm

Second arm is the second part of the arm , which holds the gripper. It rotates 180 degree by a servo motor attached with the first arm . And also give a rotation to the gripper section . It is made of wood . 18 cm in length . It has two section at the end . one section holds the motor another section holds the shaft .

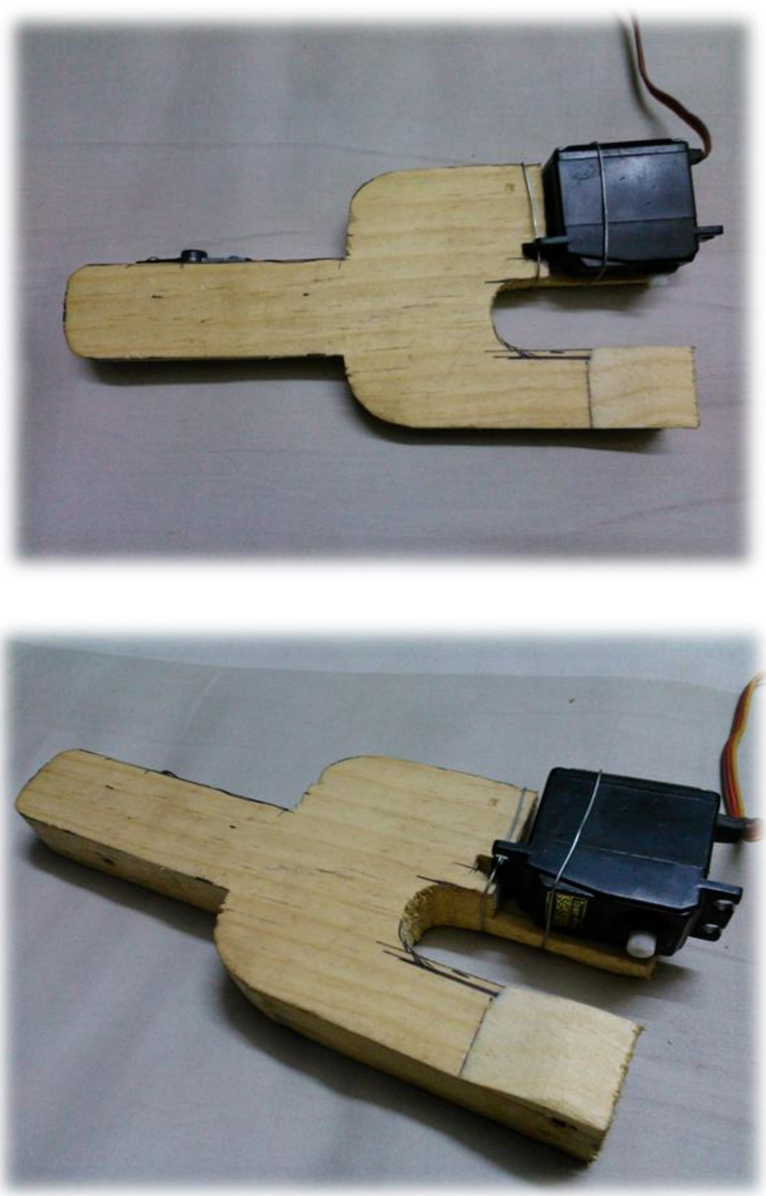


Figure 5.12 : Fabrication of second arm .

5.4.4 Fabrication of gripper

Gripper is the load holder of the arm . It is made of wood and aluminum alloy . There are two half gears meshed with each other. And the gear members are attached with each other so that they move linearly with the rotational motion of the servo motor . This motion gives the gripping action .

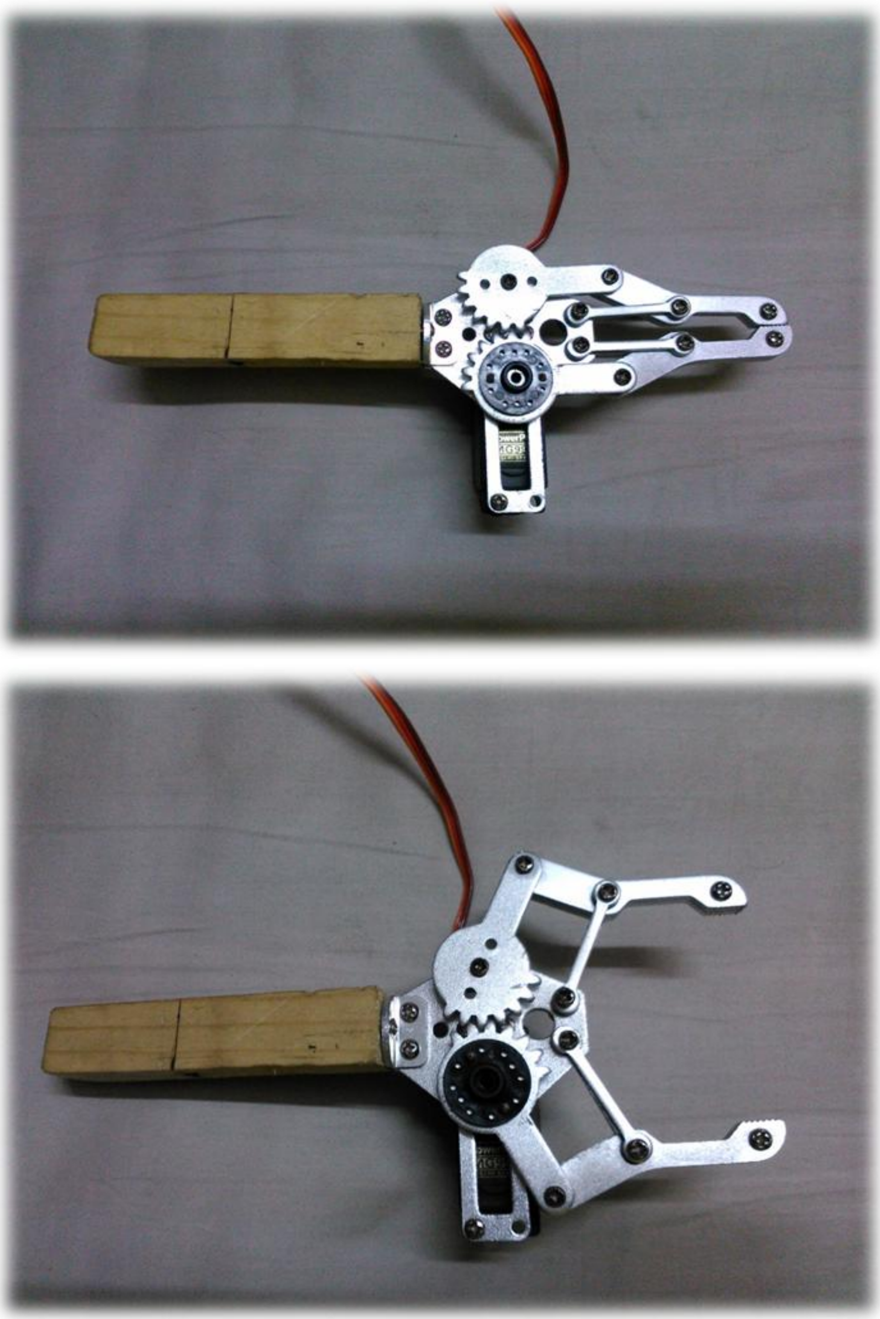


Figure 5.13 :Fabrication of gripper .

5.4.5 fabrication of wheel

There are four wheels in this assembly . Two of them are made of wood , and 6.5 cm in diameter . These wheels are attached with the motors . These motors rotates the wheel in forward , backward , left and right direction by method of differential .

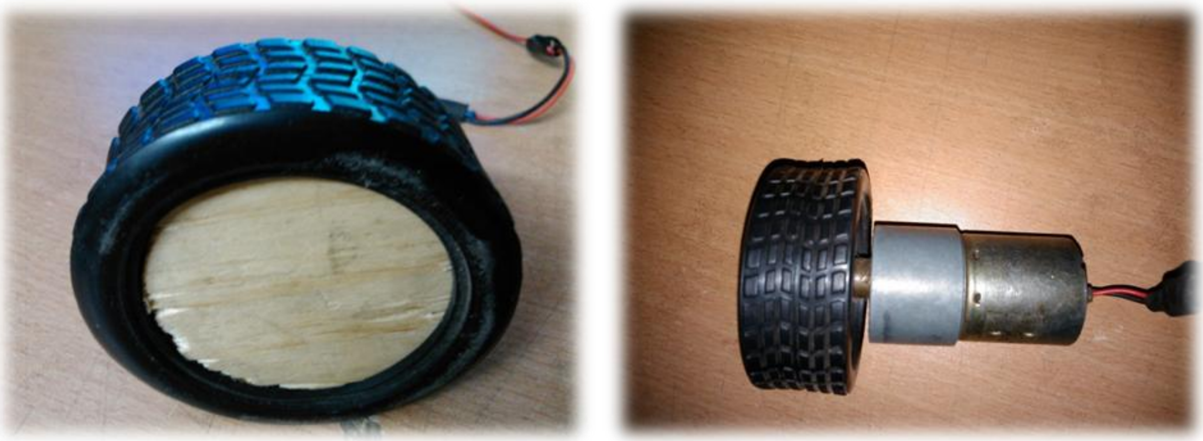


Figure 5.15 : Fabrication of gripper .

Another two wheels are cluster wheel which are universal directional , can give any direction of motion . These are assembled in the front of the assembly .

Figure 5.15 : Fabrication of front wheel .

5.4.5 Balancing components

In our assembly we faced some balancing problems . To overcome this problems we attached some extra components . To maintain the first arm balance we attached four sliding wheel bellow the first arm disc .

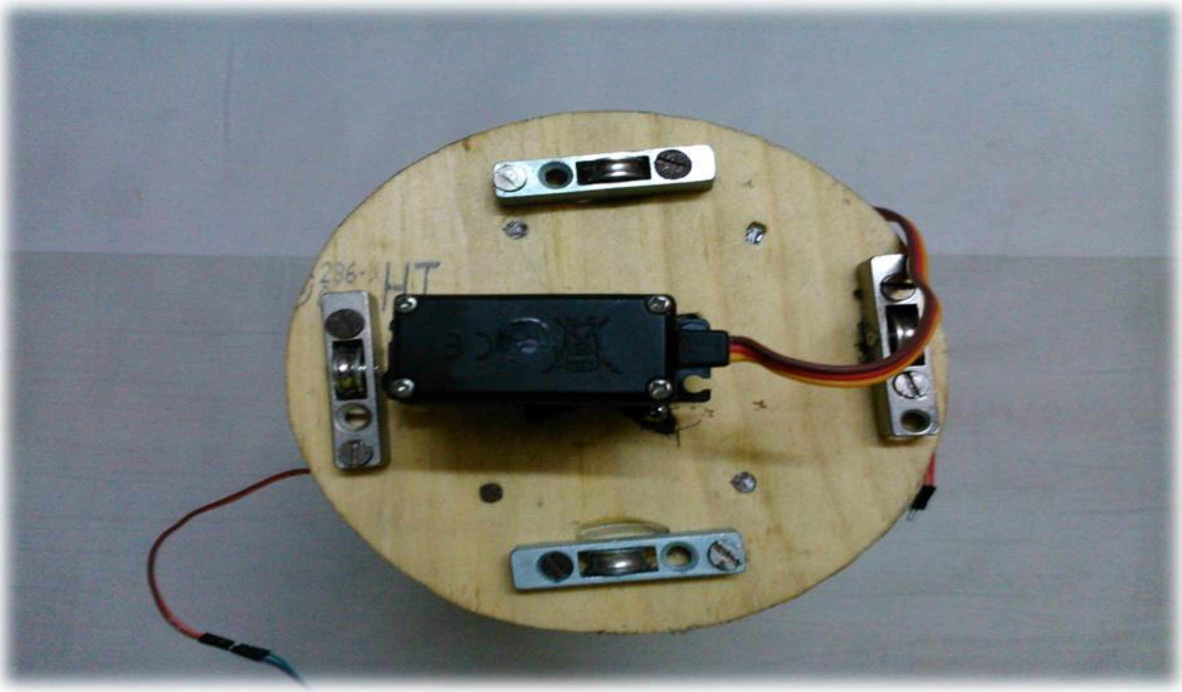


Figure 5.16 : Balancing wheels.

To give the second arm more balanced load on it we used a spring behind the second arm .

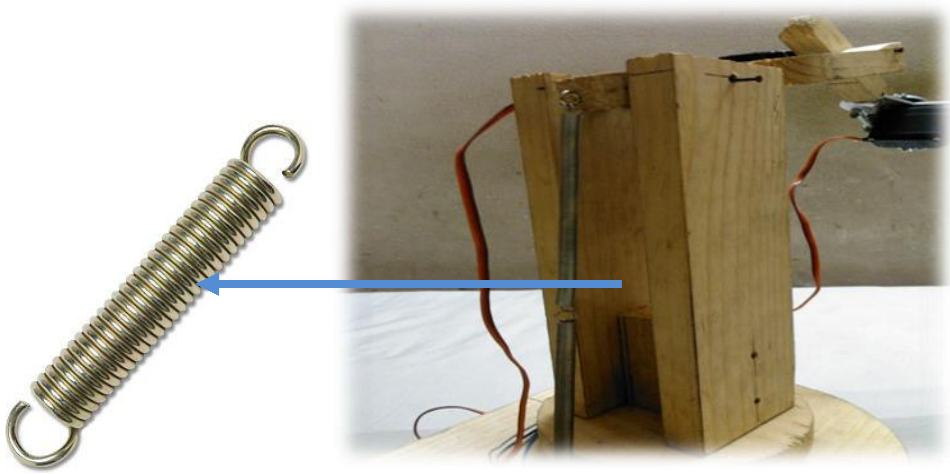


Figure 5.17 : Balancing spring.

5.4.6 Whole assembling process

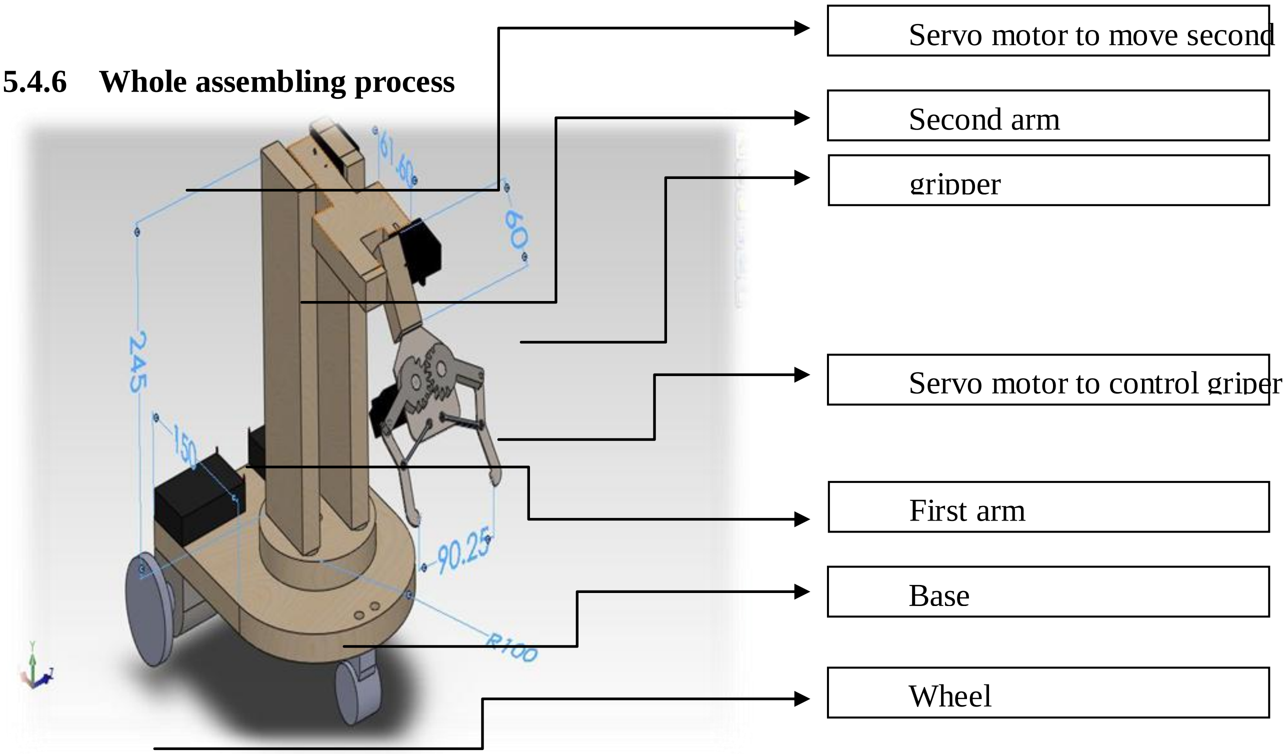


Figure : 5.18 Whole system assembly CAD design.

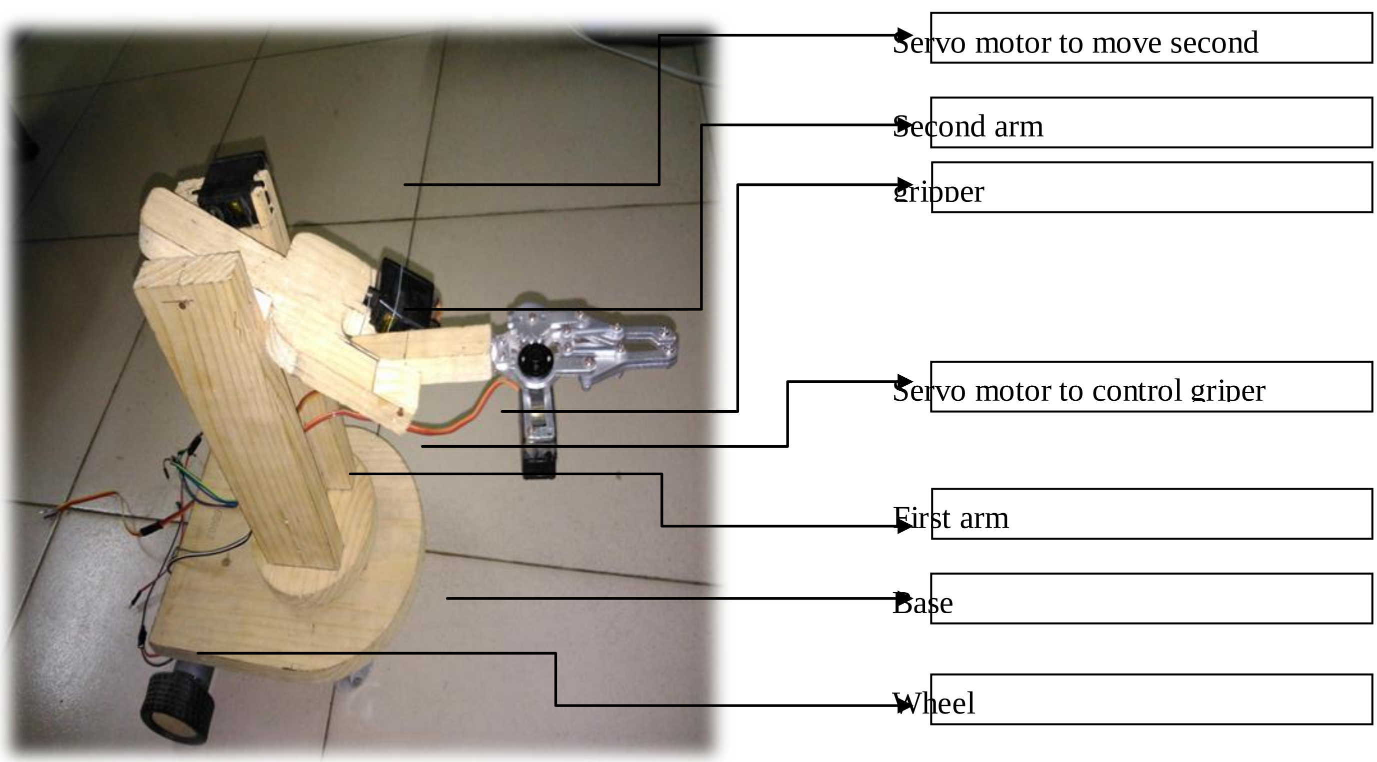


Figure : 5.19 Whole system assembly Fabricated .

CHAPTER – 6

CONTROL SYSTEM

6.1 CONTROL SYSTEM THEORY

The control system of a robot arm determines which of the potential skills provided by the mechanical system can actually be exploited.
The control system must meet several conflicting requirements:

- Many input/output resources like actuator or sensor signals must be attached. For example for a minimum hand with 6 degrees of freedom, at least 6 analog outputs to the motors must be estimated. With force and tactile sensors for every finger and additional object state sensors, the number of inputs quickly increases to several dozen.
- Quick reactions in real-time to external events are required. If for example a slipping of the grasped object is detected immediate counter measures must be taken.
- High computing power for several different tasks must be available. For example path planning, coordinate transformations, closed loop control in software are executed in parallel for multiple fingers as well as for the object.
- Small physical size is needed to be able to integrate the control system into the manipulation system.
- Short electrical connections between the control system and the actuators and sensors should be used. This is especially relevant for the sensors because otherwise massive interference might disturb the sensor signal.

To cope with the requirements the control hardware is usually distributed among several specialized processors. For example the input/output on the lowest level (motors and sensors) can be handled by a simple microcontroller, which is also of small size and thus can be integrated more easily into the manipulation system. But the higher levels of control need more computing power and the support of a flexible real time capable operating system. This can be achieved most easily with PC-like components. Therefore the control hardware often consists of a non-uniform, distributed computing system with microcontrollers on the one end and more powerful processors on the other. The different computing units then have to be connected with a Communication system

6.2 CONTROL SYSTEM DESCRIPTION

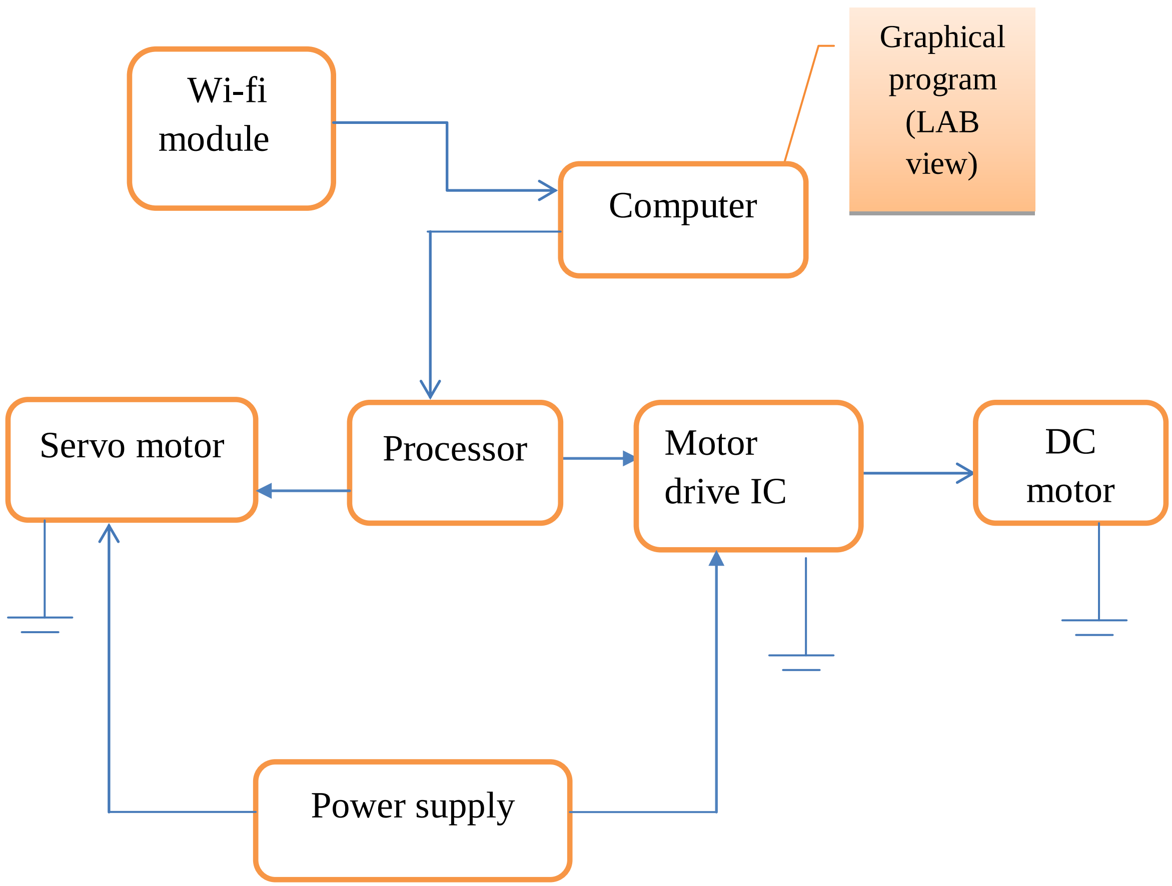


Figure 6.1 : Schematic Diagram of control system.

Input: our control system starts with a mobile phone which is operated by android operating system. Input command is given by this phone , and then it is transmitted through Wi-Fi networking system to a personal computer , then the computer pass the data to the processor of the system . Here we used ARDUINO as the main processing unit of the system.

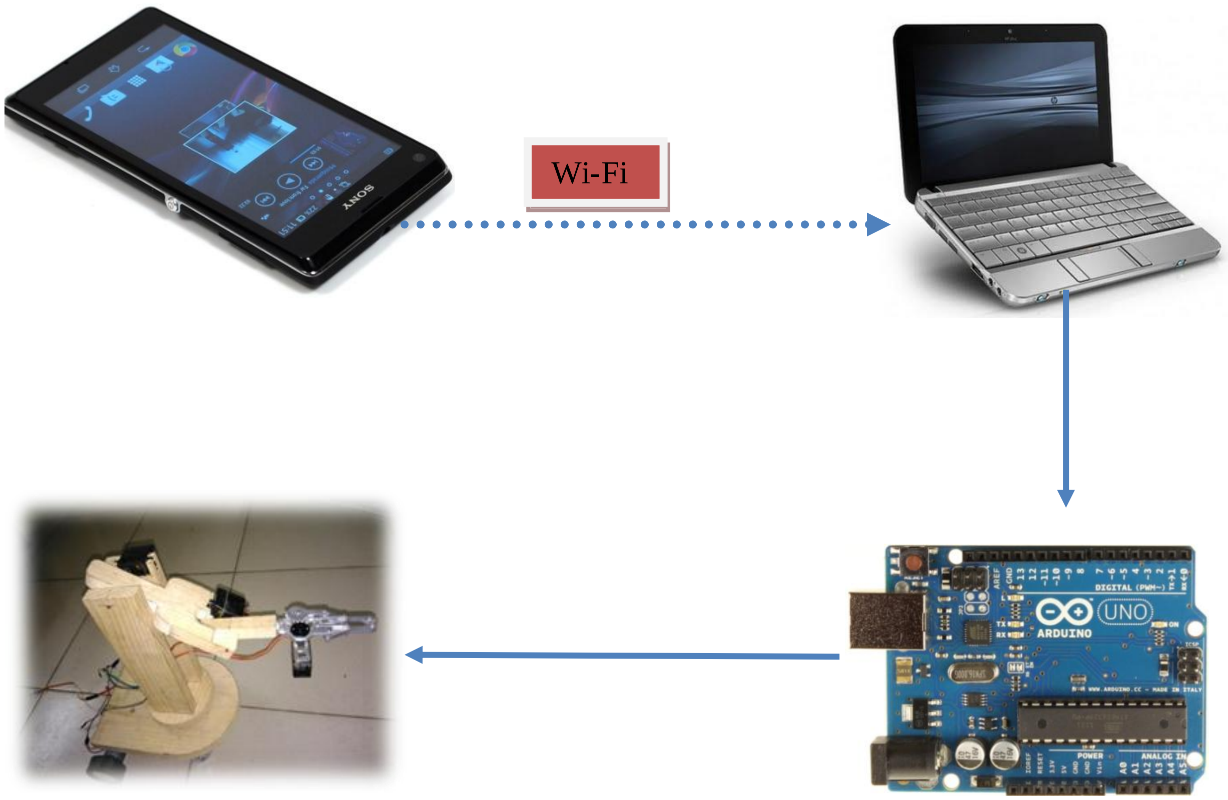


Figure 6.2 : Data Transfer system .

Process: The incoming data then processed by ARDUINO (Modified micro controller processor) , than this processed data is send to the main system to control different servo motor and dc motors .

Output: The incoming processed data than controls different motors .The communication medium is Wi-Fi network through which the data is sent to the pc. A software named POCKET DESKTOP is used to make the pc interfacing with the mobile. Incoming data from the mobile is transferred and processed by the software named LAB VIEW. This software communicate with arduino. Arduino processes this data and send it to the servo motor and a dc motor driver. Servo motors are powered by a 6v battery from outside. So these motors take the signal data from the arduino board. Motor driver takes the signal and powers the dc motors to direct the whole system in required direction. this is how the whole system control unit works.

6.3 ELECTRONIC CONTROL AND ACCESSORIES

6.3.1 Electronic Components

The main components of electronic control systems are -

- Motors(DC Gear And Servo)
- Relay
- Integrated Circuit (l293d)
- Microcontroller ARDUINO UNO.
- Resistors(1KΩ, 4.8 KΩ)
- Capacitors (10µF,1 µF)
- LED
- PCB
- Wire connector
- Electronic rail
- Wire (UTB Cat 5)

6.3.1.1 Motors

An electric motor uses electrical energy to produce mechanical energy. The reverse process that uses mechanical energy to produce electrical energy is accomplished by a generator or dynamo. Traction motors used on locomotives and some electric and hybrid automobiles often performs both tasks if the vehicle is equipped with dynamic brakes.

The classic division of electric motors has been that of Direct Current (DC) type's vs Alternating Current (AC) types. This is more a de facto convention, rather than a rigid distinction. For example, many classic DC motors run happily on AC power. There are different types of motors used in various purposes. Such as, AC induction motor, AC synchronous motor, Stepper motor, Brushless DC motor, Brushed DC motor etc.

In constructing the robotic arm four gear motors and one servo motor have been used. Starting from the wooden base there are two gear motors in the bottom connected with the wheels. This is used to move the whole setup at any direction. The next gear motor is attached to the upper base panel which rotates the base. The next one is a servo motor on the wooden base connected with the elbow. This is used to control the movement of the elbow having the capacity. Next one is at the end of the elbow and the beginning of the gripping system. This motor is used to control the rotary movement of the gripper. Here we used two types of motors DC Gear motor and the other is Servo motor. The figures below illustrates the position of the motors exactly –

Figure 6.3 : DC geared motor .

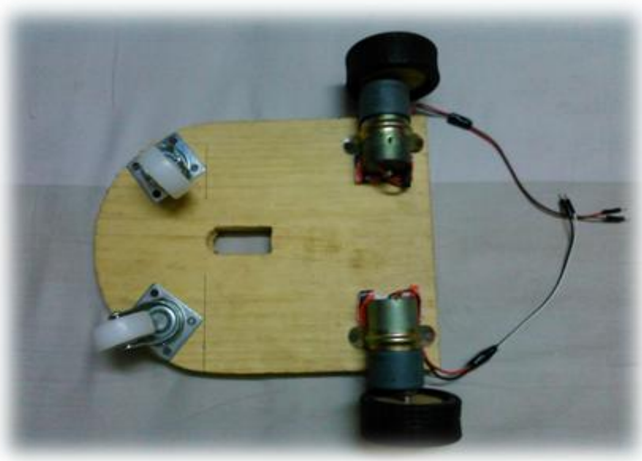


Figure 6.4 : DC geared motor bellow the base .

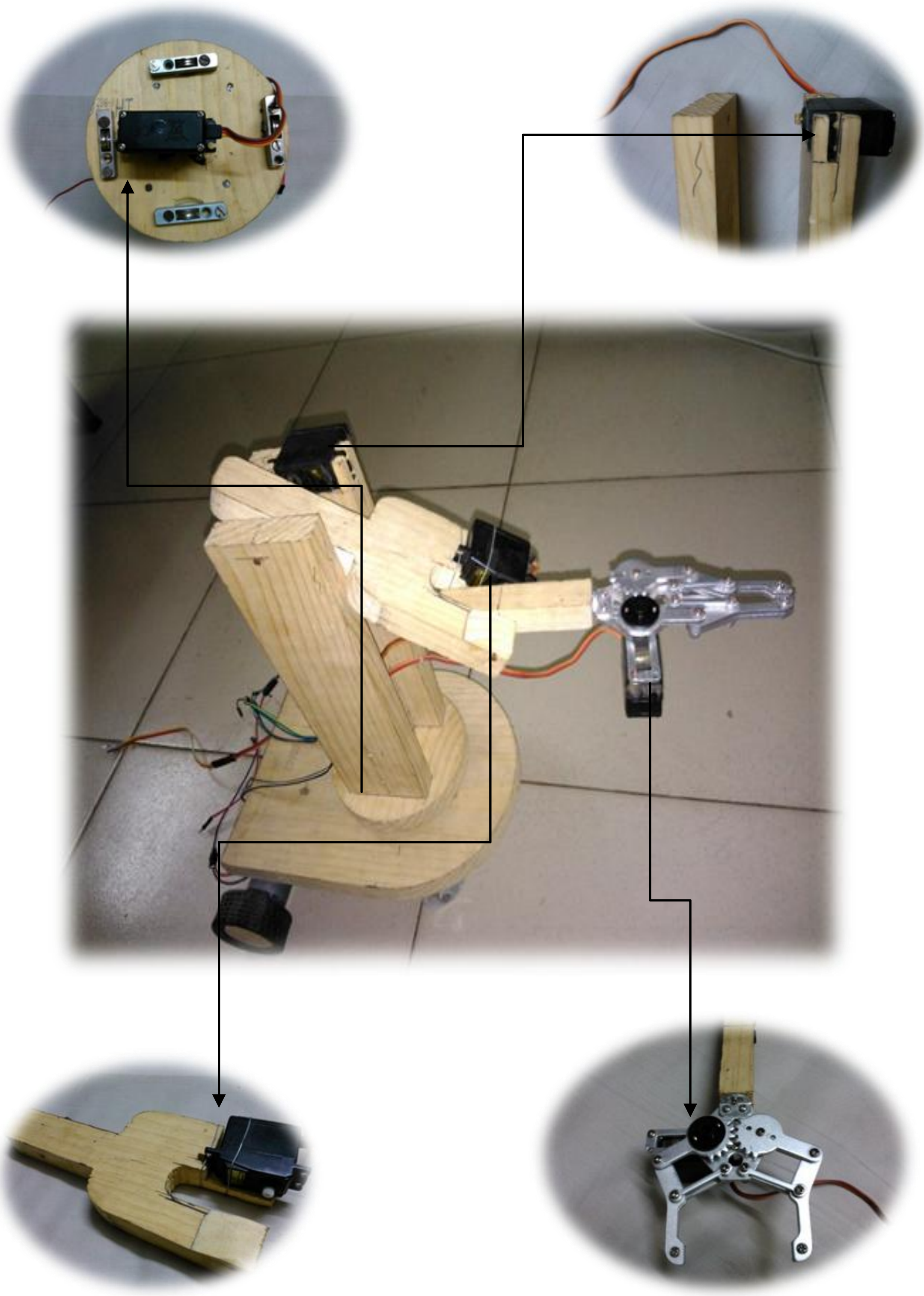


Figure 6.5 : Servo motors in different possition .

There are four servo motors in this robotic arm to give different motion in different direction . All motors are showed in above figure .

The reasons behind choosing this type of motor than the others are –

- They are very common and have been used for a long time. As a result they are reliable, sturdy and relatively powerful.
- The motor exhibits high torque at small angular velocities, which is useful in accelerating a payload up to speed.
- The motor exhibits a large holding torque with a DC excitation. Thus it has the property of being a “self-locking” device when the stationary.
- It exhibits excellent positioning accuracy and even more important, errors are noncumulative.
- Since open-loop control can be employed with the motor, it is often unnecessary to use a tachometer and/or an encoder. Thus cost is reduced considerably.
- Motor construction is simple and rugged.
- It has generally a long maintenance free life.

6.3.1.2 Relay

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

When an electric current is passed through the coil, the resulting magnetic field attracts the armature and the consequent movement of the movable contact or contacts either makes or breaks a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing.

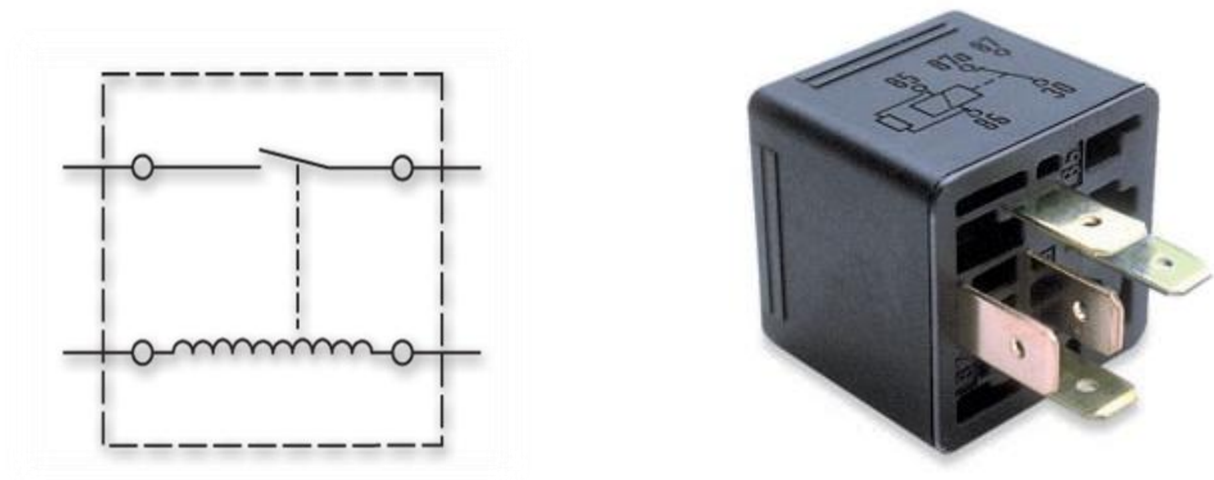


Figure 6.6 : Magnetic relay .

6.3.1.3 Integrated circuit

In electronics, an integrated circuit (also known as IC, microcircuit, microchip, silicon chip, or chip) is a miniaturized electronic circuit (consisting mainly of semiconductor devices, as well as passive components) that has been manufactured in the surface of a thin substrate of semiconductor material. Integrated circuits are used in almost all electronic equipment in use today and have revolutionized the world of electronics.

Integrated circuits are used for a variety of devices, including microprocessors, audio and video equipment, and automobiles. Integrated circuits are often classified by the number of transistors and other electronic components they contain:

ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

Revision 3 of the board has the following new features:1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible with both the board that uses the AVR, which operates with 5V and with the Arduino Due that operates with 3.3V. The second one is a not connected pin, that is reserved for future purposes.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Figure 6.7 : ARDUINO UNO .

L293D

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bi directional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled and their Outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications. On the L293, external high-speed output clamp diodes should be used for inductive transient suppression.

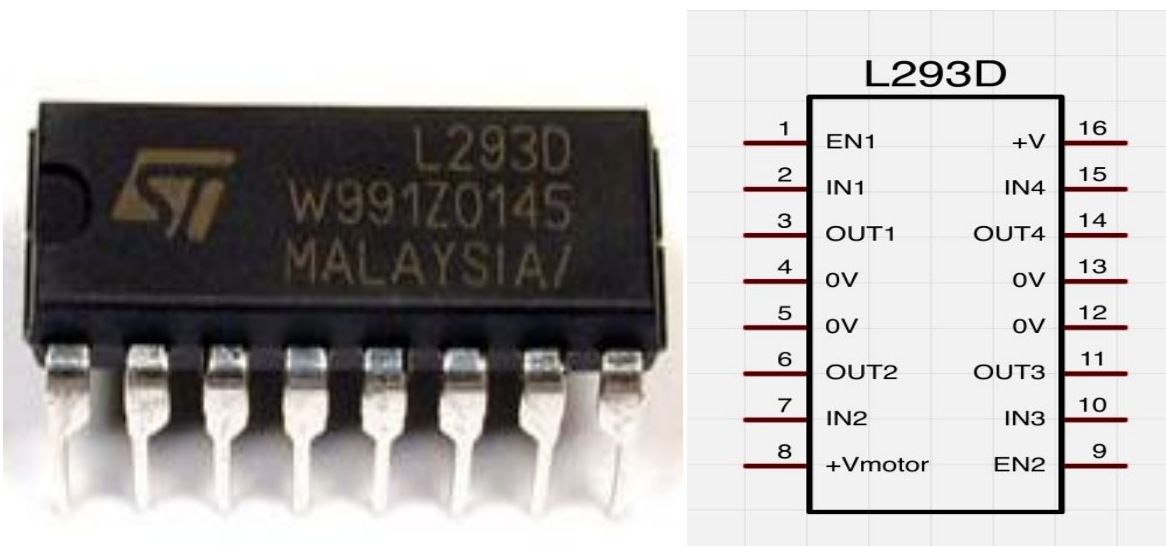


Figure 6.8 : L293D Motor driver IC.

IC 7805

The 7805 provides circuit designers with an easy way to regulate DC voltages to 5v.Encapsulated in a single chip/package (IC), the 7805 is a positive voltage DC regulator that has only 3 terminals. They are: Input voltage, Ground, Output Voltage. Although the 7805 were primarily designed for a fixed-voltage output (5V), it is indeed possible to use external components in order to obtain DC output voltages of: 5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, 20V, 24V. Note that the input voltage must, of course, be greater that the required output voltage, so that it can be regulated downwards. The main features of IC 7805 are as follows

- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

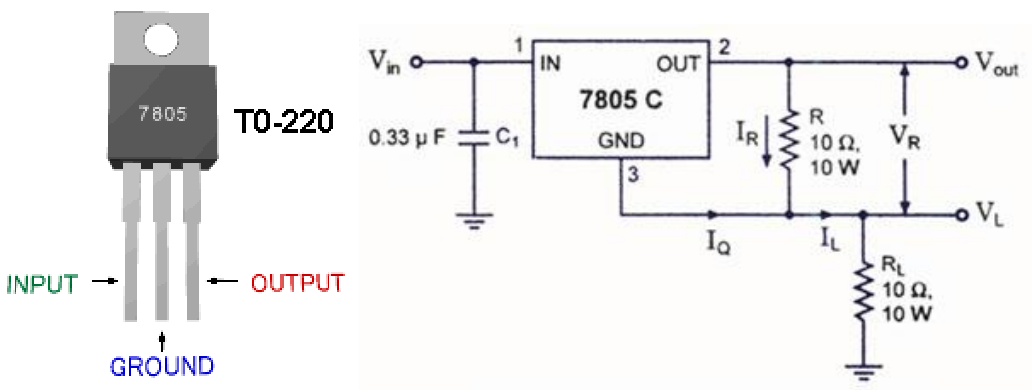


Figure 6.9 : IC L293D .

Resistors

A resistor is a two-terminal electrical or electronic component that opposes an electric current by producing a voltage drop between its terminals in proportion to the current, that is, in accordance with Ohm's law: $V = IR$. The *electrical resistance R* is equals to the voltage drop *V* across the resistor divided by the current *I* through the resistor. Resistors are used as part of electrical networks and electronic circuits . An image of the resistor is attached here:

Figure 6.10: Resistors (sample)

The symbol is used to indicate a resistor in a circuit diagram known as schematic. Resistance value is designated in units called ‘Ohm’. A thousand ohm resistor is typically shown as 1K-ohm (kilo Ohm), and 1000k-ohms is written as 1 M-ohm(mega ohm). In our project we used 10k resistance & 4.8 resistors.

Capacitors A capacitor is an electrical/electronic device that can store energy in the electric field between a pair of conductors (called "plates"). The process of storing energy in the capacitor is known as "charging", and involves electric charges of equal magnitude, but opposite polarity, building up on each plate.Capacitors are often used in electric and electronic circuits as energy-storage devices. They can also be used to differentiate between high-frequency and low-frequency signals. This property makes them useful in electronic filters. Capacitors are occasionally referred to as condensers. This is considered an antiquated term in English, but most other languages use an equivalent, like "*Kondensator*" in German, "*condensador*" in Spanish, or "*Kondensa*" in Japanese.A image of the capacitor is attached here

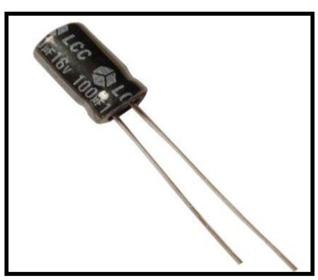


Figure 6.11 : Capacitor .

6.4 Electronic Circuit Design

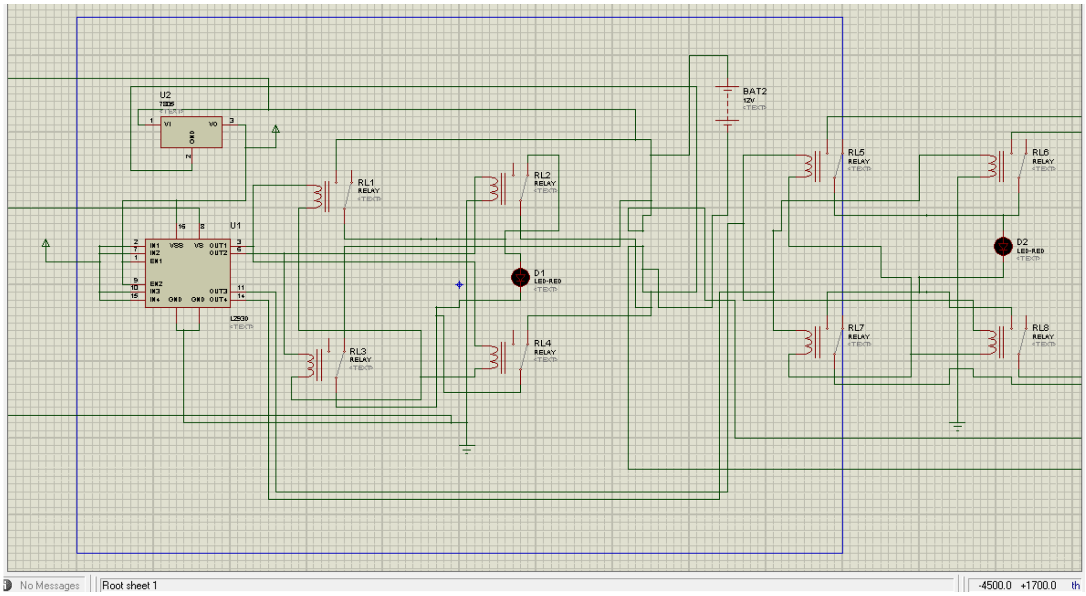


Figure 6.12 Electronic circuit Design

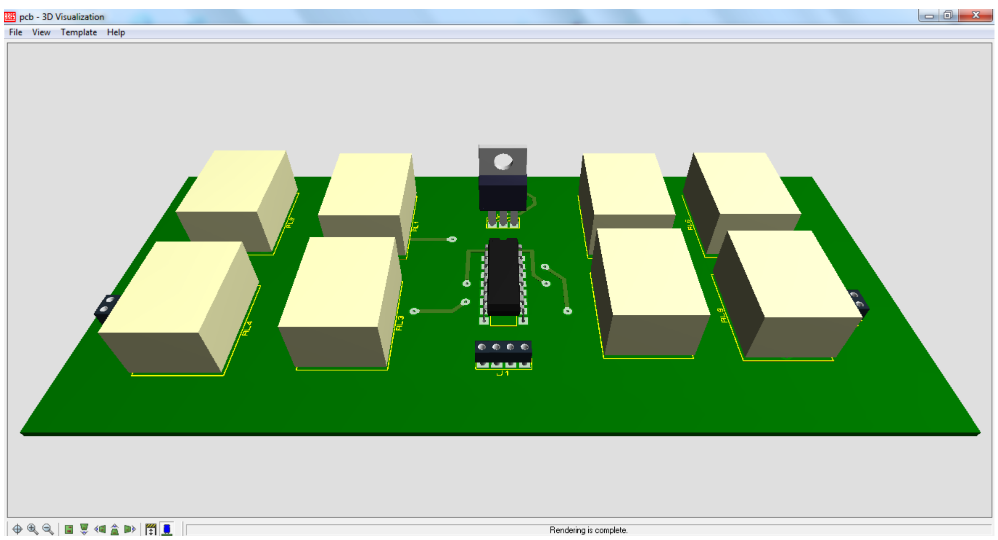


Figure 6.13 : Electronic circuit simulated view.

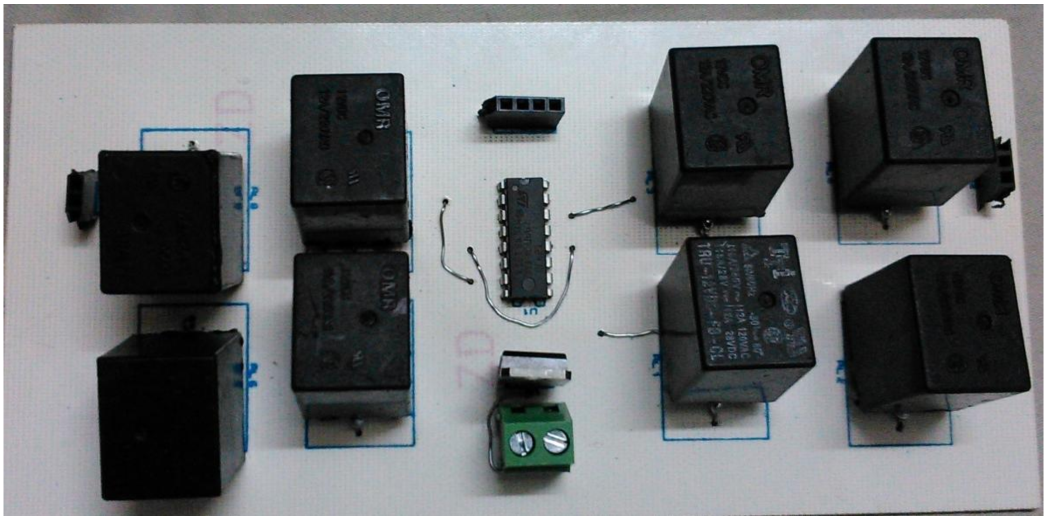


Figure 6.14 : Circuit of DC Motor driver.

6.5 Lab-View programming

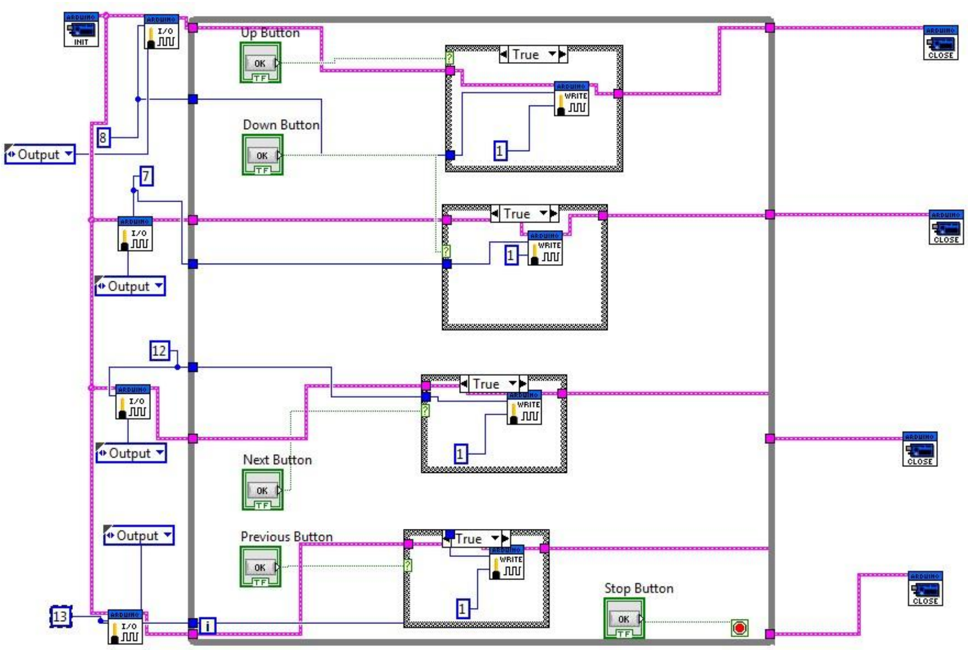


Figure 6.15 : Lab view program to control 4 servo motor

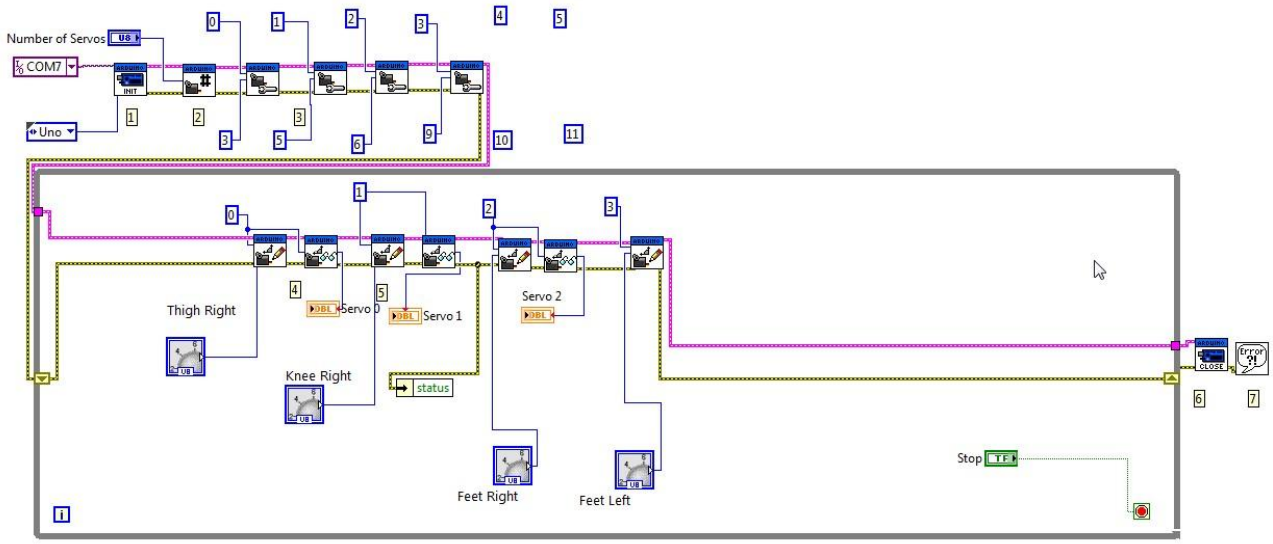


Figure 6.16 Lab view program to control 2 DC motors.

CHAPTER–7

OPERATION

7.1 OPERATION CONTROL

To control and get the efficient performance from the robotic arm a procedure should be maintained. As the principle mentioned above illustrates that, the driving component is the battery it should be taken a good care. The same thing is applicable for all other components as well to get a constant performance for a long time.

There are total eight commands to operate the robotic arm. Four commands are to control the motion of arm and another four is to control the arm and gripper movement .

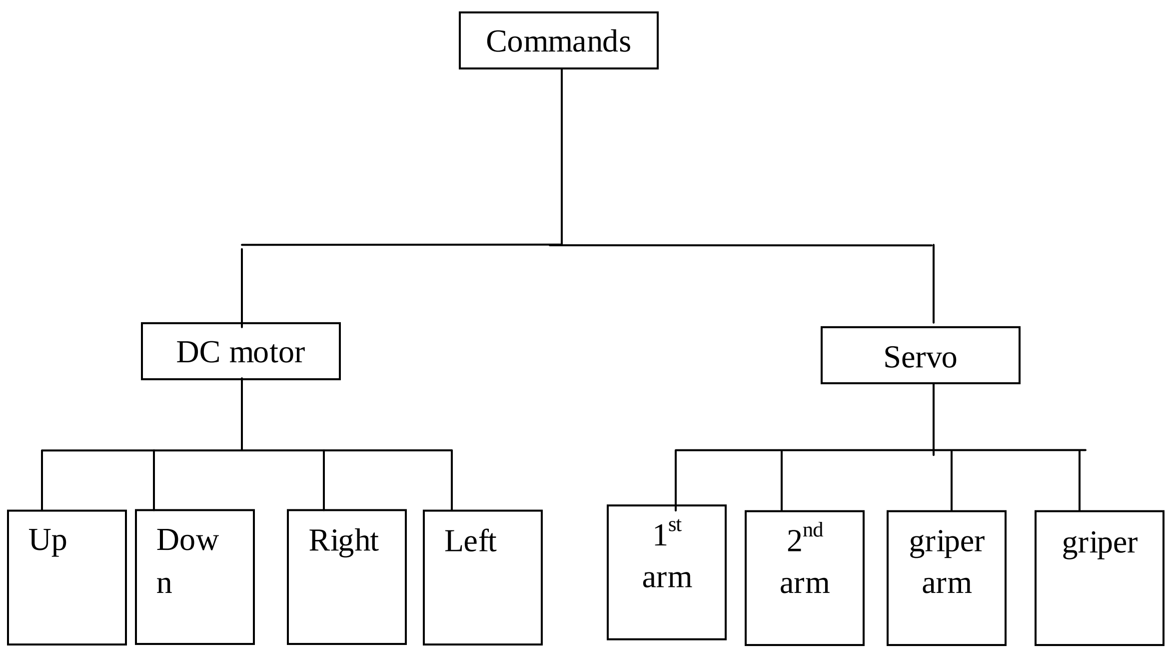


Figure 7.1 : Control commands.

7.1.1 DC motor operation

There are four commands to control the DC motors . Four bits are transferred from the ARDUINO board to the motor control driver for different commands . L293D takes the commands and then powers the relays which runs the motors . Motors are turned by following differential method to give different motion .There is a DC motor control panel interface made in LAB view program . From this panel we can control four DC motors in any direction required .

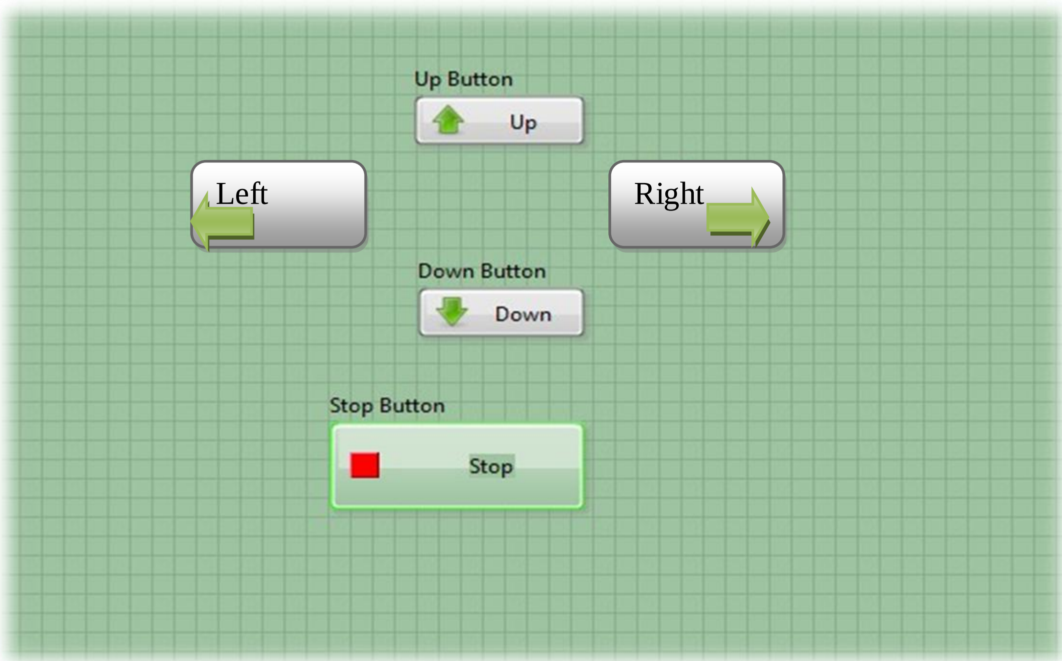


Figure 7.2 : DC motor control panel in LABVIEW .

7.1.1.1 UP command:

To give straight motion up command should be activated . Which will give two DC motor same speed and at same direction .

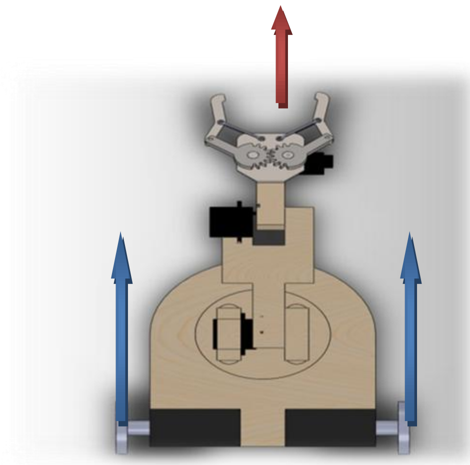


Figure 7.3: Up command operation .

7.1.1.2 DOWN command:

By activating down command both motors will rotate at same direction but opposite to the up command. It gives a backward motion to the arm assembly.

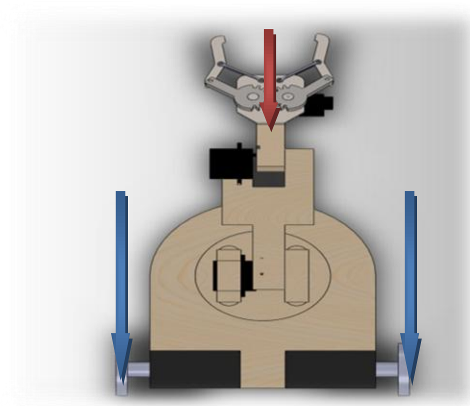


Figure 7.4: Down command operation.

7.1.1.3 LEFT command operation:

By activating this command right motor becomes stationary and left motor turns at greater speed. So the whole assembly turns left from its position.

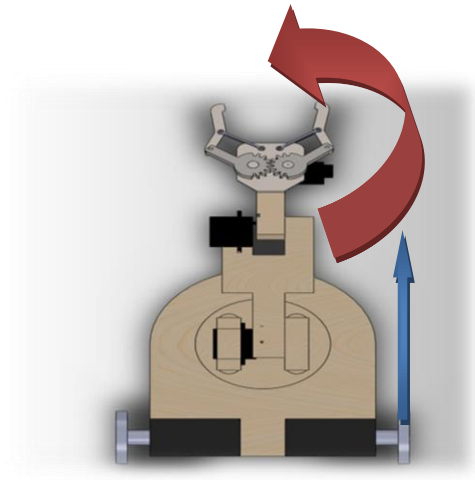


Figure 7.5: LEFT command operation

7.1.1.4 RIGHT command operation:

By activating this command left motors becomes stationary and right motor rotates at greater speed, by which whole assembly turns right .

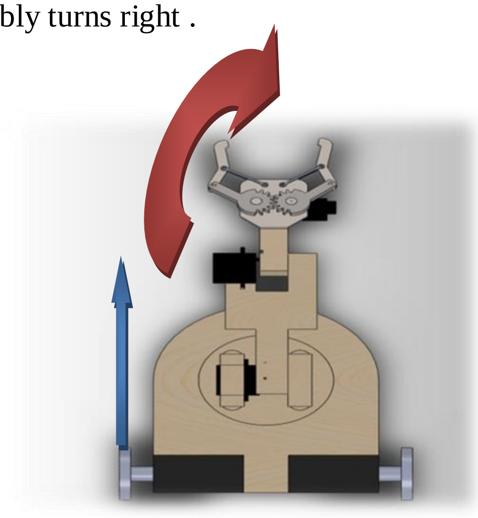


Figure 7.6 : RIGHT command operation .

7.1.2 Servo motor control operation

To control servo motors there is another control panel in LABVIEW program. There are four servo motors to control different arms.

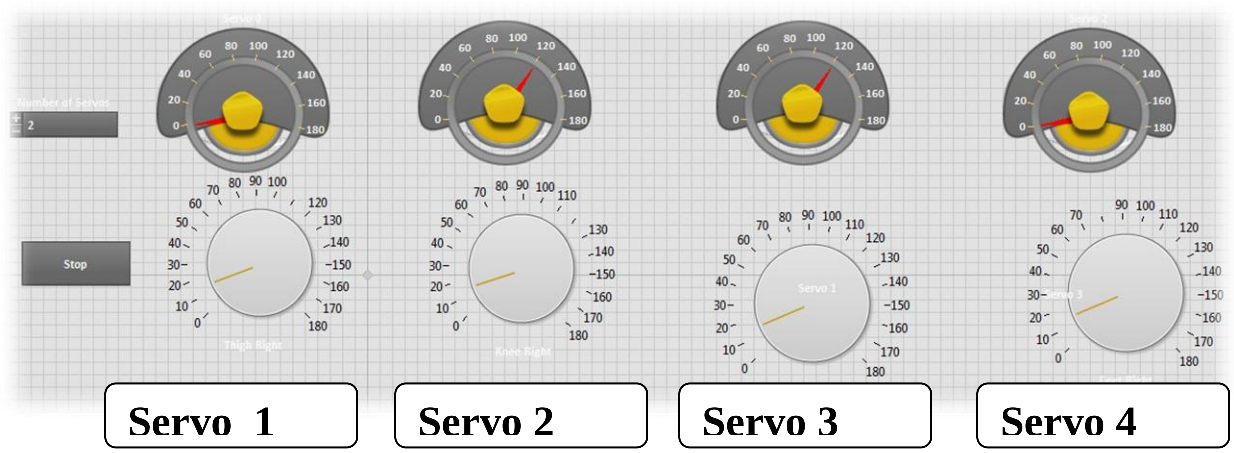


Figure 7.7: servo motor control panel.

7.1.2.1 Servo (1) operation

By activating this command servo 1 turns clockwise or anti clockwise to turn the 1st arm clockwise or anti clock wise centering the normal axis.

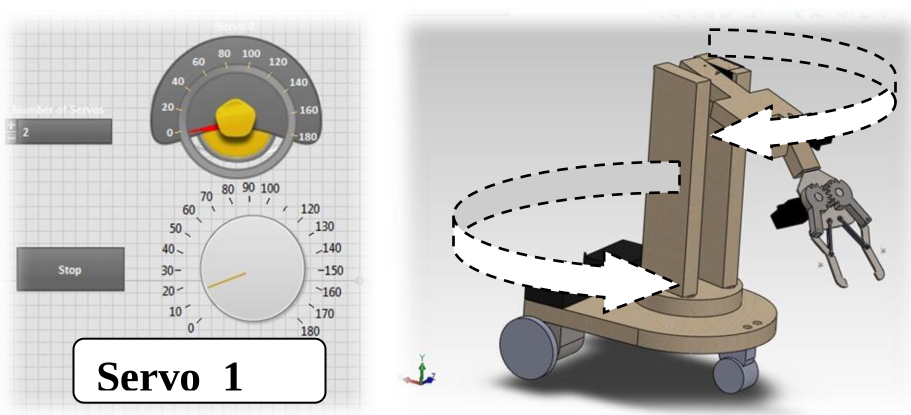


Figure 7.8 : Servo (1) control operation .

7.1.2.2 Servo (2) operation

By activating this command servo 2 turns clockwise or anti clockwise to turn the 2nd arm clockwise or anti clock wise centering the longitudinal axis .

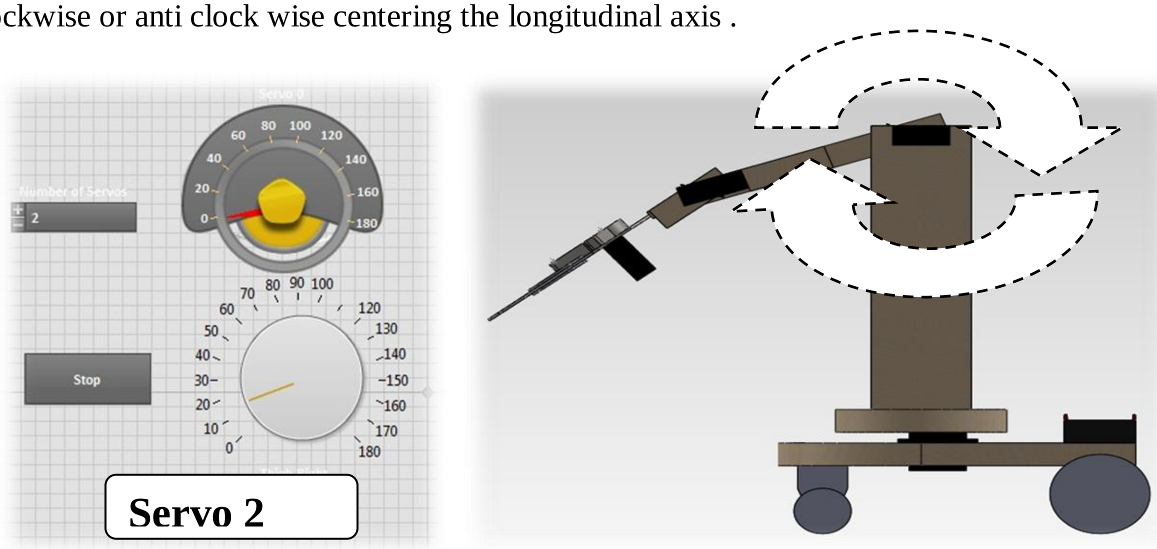


Figure 7.9 : Servo (2) control operation .

7.1.2.3 Servo (3) operation

By activating this command servo 3 turns clockwise or anti clockwise to turn the gripper arm clockwise or anti clock wise .

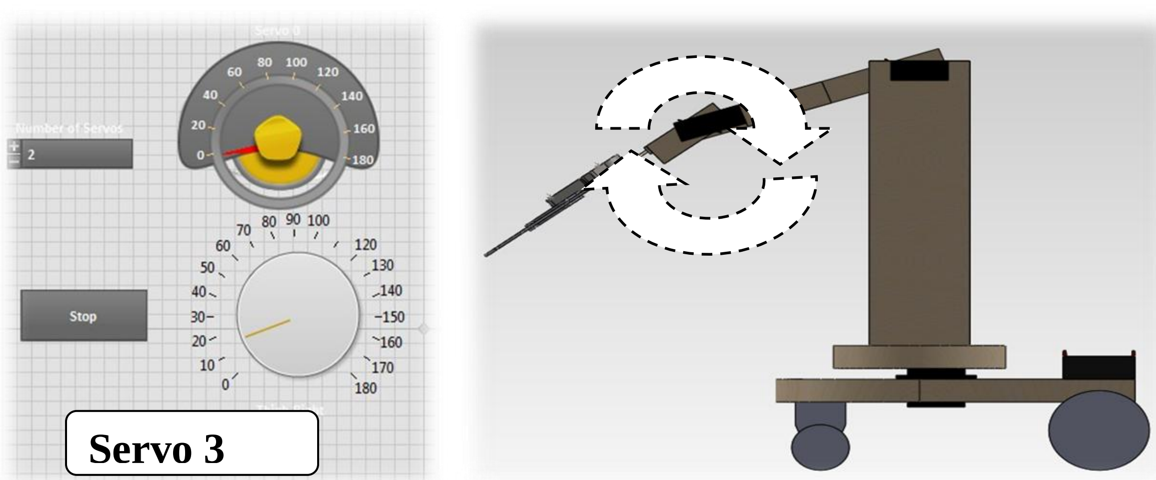


Figure 7.10 : Servo (3) control operation .

7.1.2.4 Servo (4) operation

By activating this command servo 4 turns clockwise or anti clockwise and controls the gripper inward or outward.

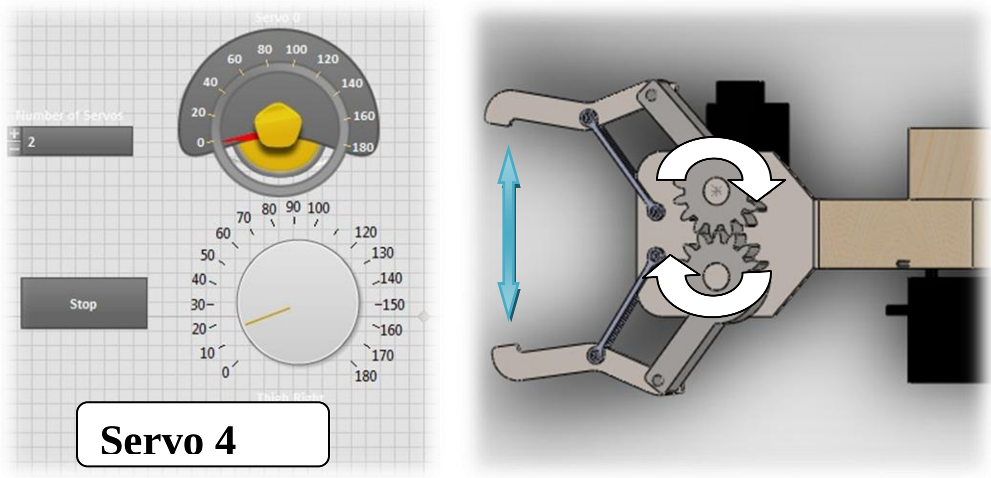


Figure 7.11 : Servo (4) control operation .

CHAPTER-8

PERFORMANCE TEST

8.1 DOF (Degree of Freedom)

This robotic arm assembly carries five degree of freedom. The arm part carries three degree of freedom and the base carries other two degree of freedom . Following figure shows the degree of freedoms .

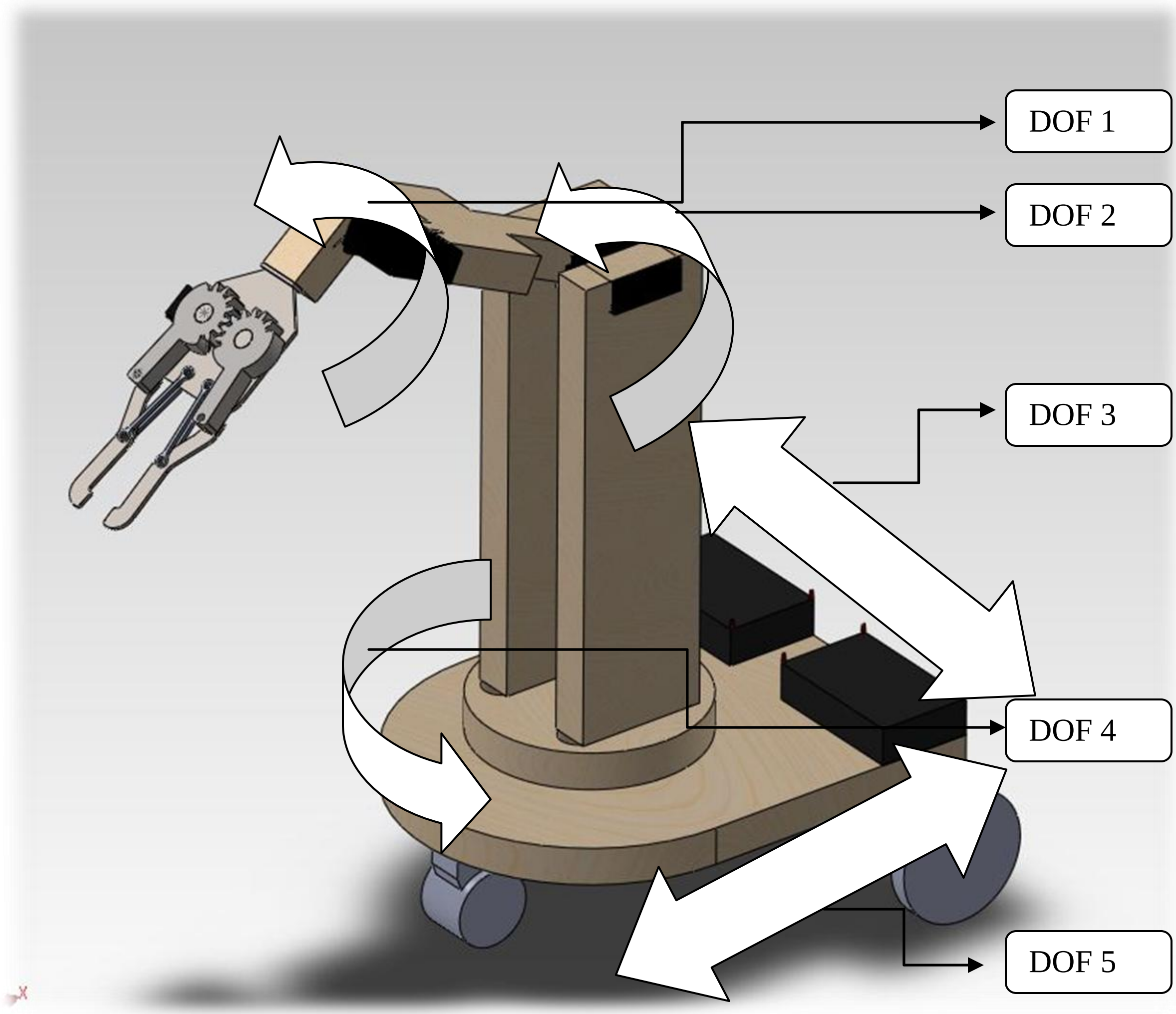


Figure 8.1 : 5 Degree of freedom of robotic arm

8.2 WORKING SPACE

The robot workspace (sometimes known as reachable space) is all places that the end effector (gripper) can reach. The workspace is dependent on the DOF angle/translation limitations, the arm link lengths, the angle at which something must be picked up at, etc. The workspace is highly dependent on the robot configuration.

Our robotic arm's (without base freedom) Degree of Freedom is 3.

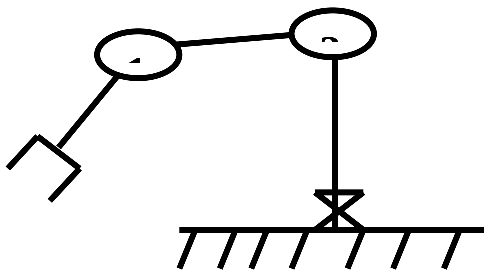


Figure 8.1 : DOF configuration

By using solid works software we get a simulated work space for the robotic arm . It's a spherical shaped space which is hollow in center is showed in following figure .

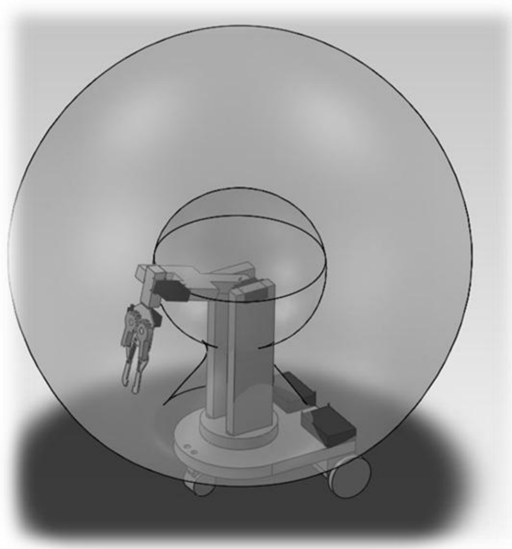


Figure 8.2 : Working space simulation in slid works .

Cross section of the space is showed bellow . Here we see that inside the spherical shaped working space there is hollow space where the end effector cant reach .

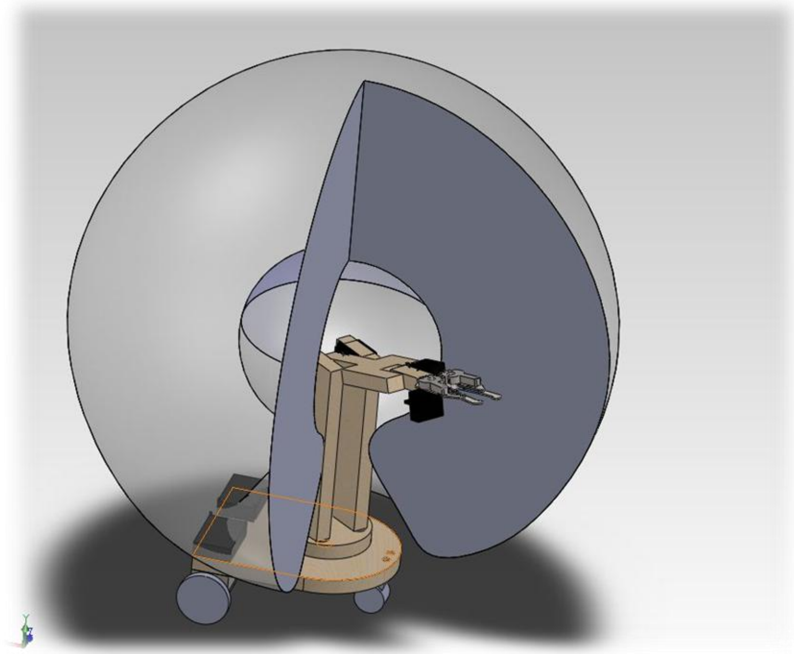


Figure 8.3: Cross section of work spce .

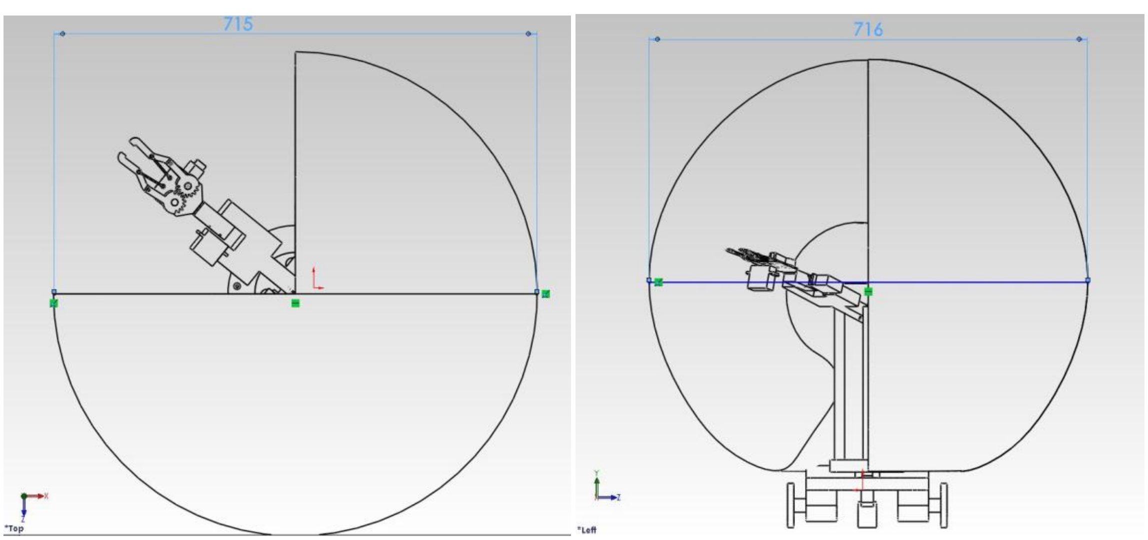
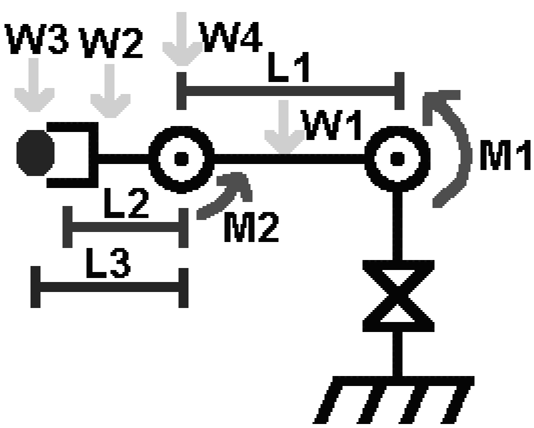


Figure 8.4: Dimension of working space .

8.2 FORCE CALCULATIONS OF JOINTS

This is where the project starts getting heavy with calculation. Before even continuing, we strongly recommend to read the mechanical engineering tutorials for statics and dynamics. This will give us a fundamental understanding of moment calculations for arm.The point of doing force calculations is for motor selection. We must make sure that the motor we choose can not only support the weight of the robot arm, but also what the robot arm will carry (the blue ball in the image below).The first step is to label the FBD , with the robot arm stretched out to its maximum length.

Robot Arm Torque and Force Analysis:



Choose these parameters*:*

Weight of each link

Weight of each joint

Weight of object to lift

Length of each linkage

Figure 8.5: Free Body Diagram of robotic arm for torque calculation.

Next we did a moment arm calculation, multiplying downward force to the linkage lengths. This calculation has done for each lifting actuator. This particular design has just two DOF that requires lifting, and the center of mass of each linkage is assumed to be Length/2.

Torque about Joint 1:

M1 = L1/2 * W1 + L1 * W4 + (L1 + L2/2) * W2 + (L1 + L3) * W3

Torque about Joint 2:

M2 = L2/2 * W2 + L3 * W3

As we can see, for each DOF we add the math gets more complicated, and the joint weights get heavier. We will also see that shorter arm lengths allow for smaller torque requirements.

8.3 FORWARD KINEMATICS

Forward kinematics is the method for determining the orientation and position of the end effector, given the joint angles and link lengths of the robot arm. To calculate forward kinematics, we use some trigonometric and algebraic method.

For our robot arm example, here we calculate end effector location with given joint angles and link lengths. To make visualization easier for you, I drew blue triangles and labeled the angles.

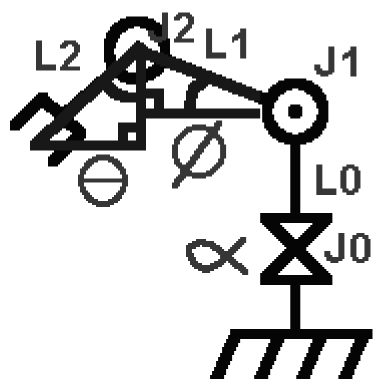


Figure 8.6: Free Body Diagram to calculate forward kinematics.

Assume that, the base is located at x=0 and y=0. The first step would be to locate x and y of each joint.

Joint 0 (with x and y at base equaling 0):

x0 = 0
y0 = L0

Here,

L1=15 cm
L2= 15 cm

Joint 1 (with x and y at J1 equaling 0):
cos(Ø) = x1/L1 => x1 = L1*cos(Ø)
sin(Ø) = y1/L1 => y1 = L1*sin(Ø)
Joint 2 (with x and y at J2 equaling 0):

sin(θ) = x2/L2 => x2 = L2*sin(θ)

cos(θ) = y2/L2 => y2 = L2*cos(θ)
End Effector Location (make sure your signs are correct):

x0 + x1 + x2, or 0 + L1*cos(Ø) + L2*sin(θ)

y0 + y1 + y2, or L0 + L1*sin(Ø) + L2*cos(θ)
z equals alpha, in cylindrical coordinates

The angle of the end effector, in this example, is equal to $\theta^{+\,Ø}$.

8.4 VELOCITY (AND MORE MOTION PLANNING)

Calculating end effector velocity is mathematically complex, so we will go only into the basics. The simplest way to do it is assume that robot arm (held straight out) is a rotating wheel of L diameter. The joint rotates at Y rpm, so therefore the velocity is

Velocity of end effector on straight arm = 2 * pi * radius * rpm

However the end effector does not just rotate about the base, but can go in many directions. The end effector can follow a straight line, or curve, etc.

With robot arms, the quickest way between two points is often not a straight line. If two joints have two different motors, or carry different loads, then max velocity can vary between them. When the end effector to go from one point to the next, we have two decisions. Have it follow a straight line between both points, or tell all the joints to go as fast as possible - leaving the end effector to possibly swing wildly between those points.

In the image below the end effector of the robot arm is moving from the blue point to the red point. In the top example, the end effector travels a straight line. This is the only possible motion this arm can perform to travel a straight line. In the bottom example, the arm is told to get to the red point as fast as possible. Given many different trajectories, the arm goes the method that allows the joints to rotate the fastest.

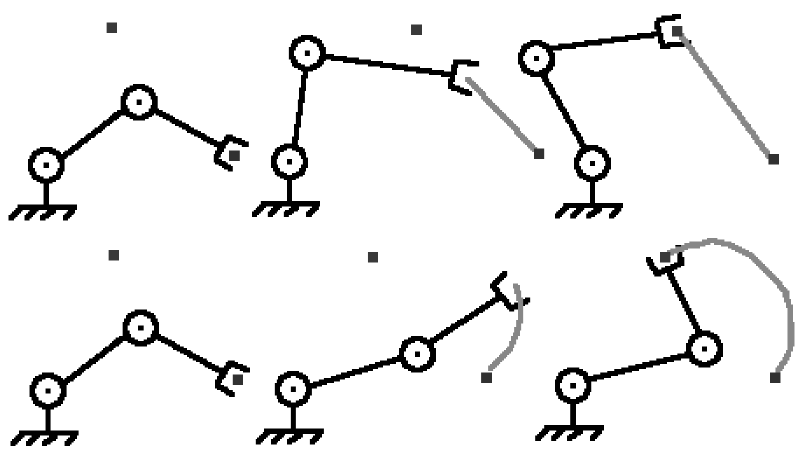


Figure 8.7: Different options to reach the goal .

8.5 ARM SAGGING

Arm sagging is a common affliction of badly designed robot arms. This is when an arm is too long and heavy, bending when outwardly stretched. When designing your arm, make sure the arm is reinforced and lightweight. Do a finite element analysis to determine bending deflection/stress such as we did

Keep the heaviest components, such as motors, as close to the robot arm base as possible. It might be a good idea for the middle arm joint to be chain/belt driven by a motor located at the base (to keep the heavy motor on the base and off the arm).

Volumetric Properties
Mass:0.129861 lb Volume:22.45 in^3 Density:0.00578 lb/in^3 Weight:0.129673 lbf

Properties	
Name:	Balsa
Model type:	Linear Elastic Isotropic
Yield strength:	2e+007 N/m^2
Elastic modulus:	3e+009 N/m^2
Poisson's ratio:	0.29
Mass density:	159.99 kg/m^3
Shear modulus:	3e+008 N/m^2

Type	Min	Max
URES: Resultant Displacement	0 mm Node: 4	0.000870119 mm Node: 1458
Type	**Min**	**Max**
ESTRN: Equivalent Strain	1.53361e-009 Element: 3462	1.28672e-005 Element: 4139

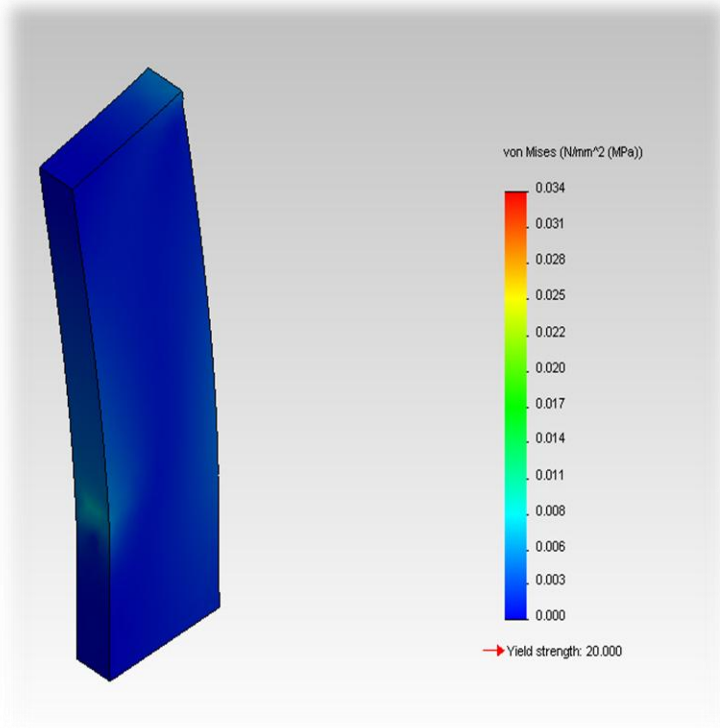


Figure 8.8: Dynamic element analysis of first arm showing stress.

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 4	0.000870119 mm Node: 1458

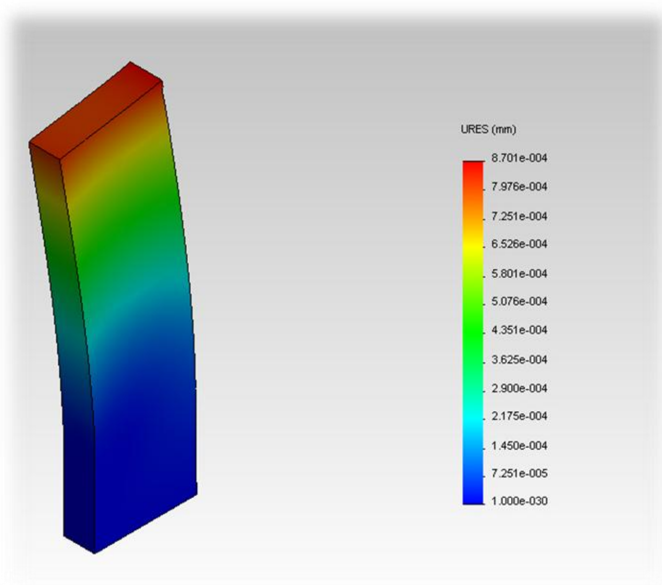
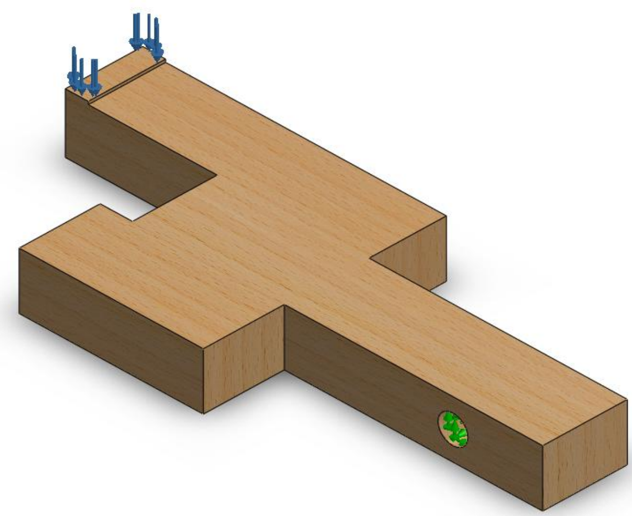


Figure 8.9 : Dynamic element analysis of first arm showing displacement.

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.53361e-009 Element: 3462	1.28672e-005 Element: 4139



Volumetric Properties
Mass:0.0570441 lb Volume:9.86922 in^3 Density:0.00578 lb/in^3 Weight:0.0570054 lbf

Properties	
Name:	Balsa
Model type:	Linear Elastic Isotropic
Default failure criterion:	Unknown
Yield strength:	2e+007 N/m^2
Elastic modulus:	3e+009 N/m^2
Poisson's ratio:	0.29
Mass density:	159.99 kg/m^3
Shear modulus:	3e+008 N/m^2

Figure 8.10 : Dynamic element analysis of second arm link(1) .

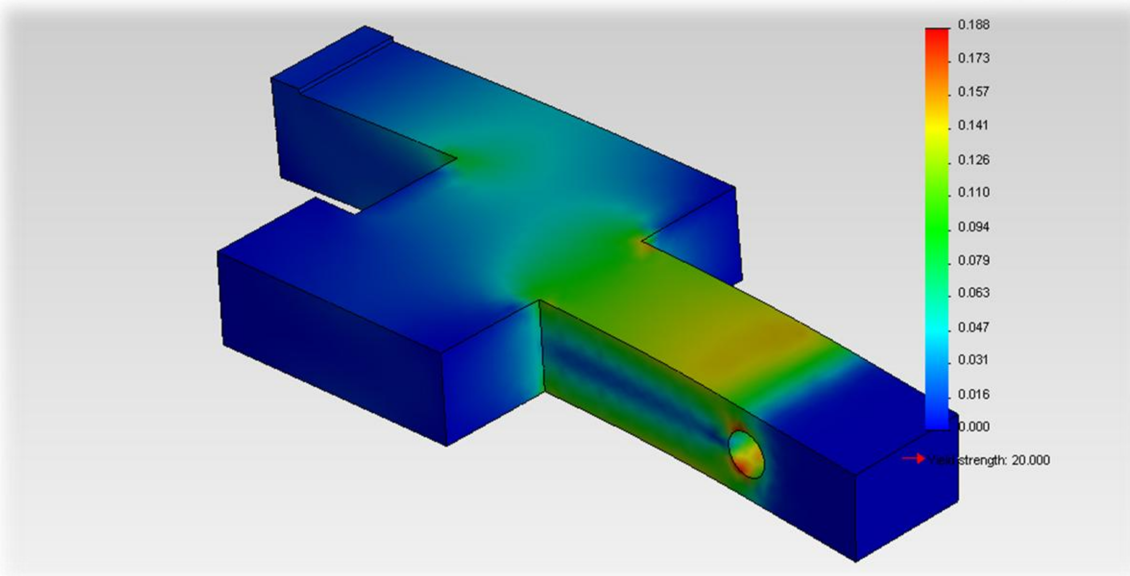


Figure 8.11 : Dynamic element analysis of second arm link(2) showing stress .

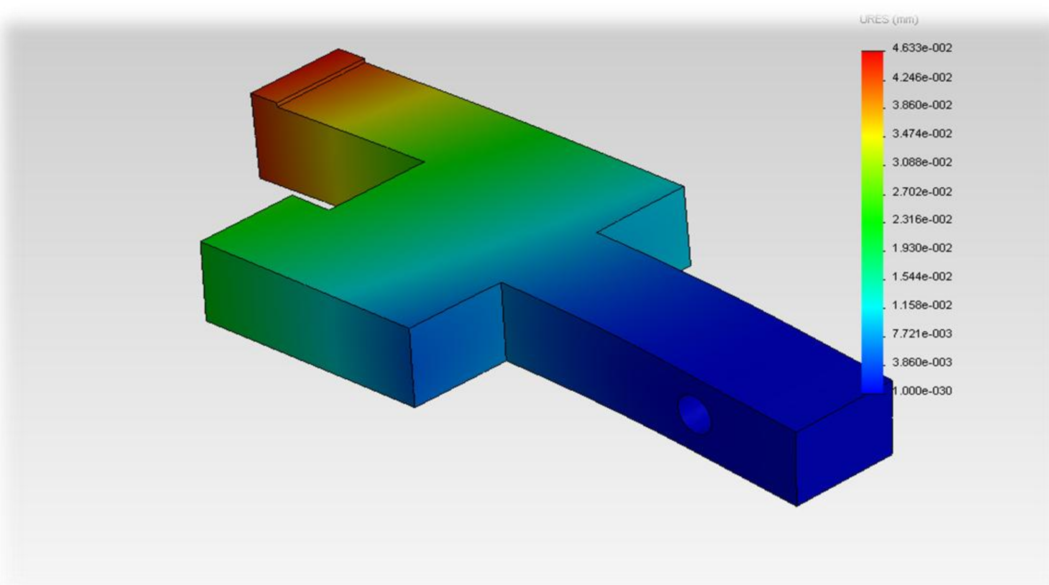
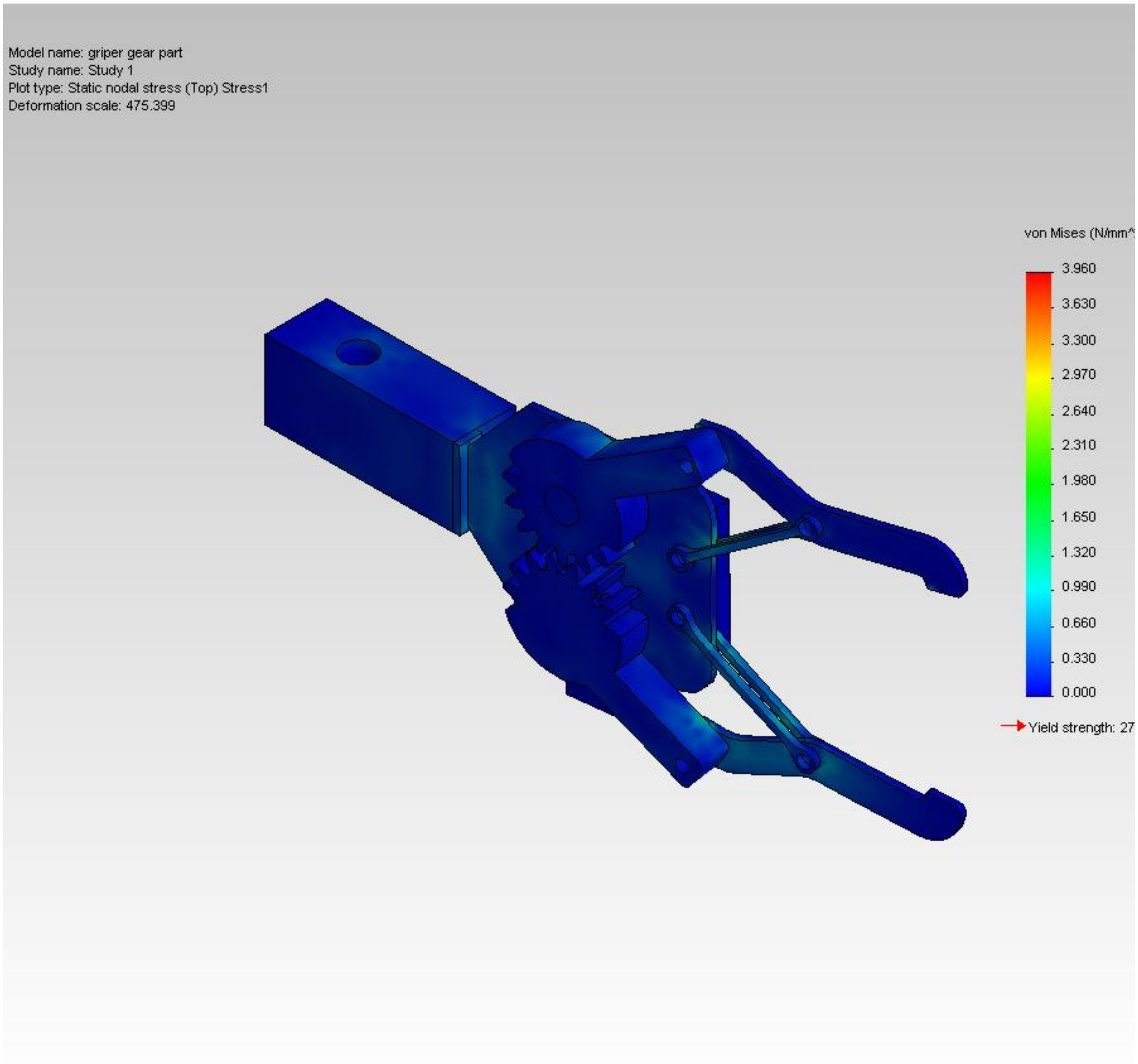


Figure 8.12 : Dynamic element analysis of second arm link(2) showing displacement .

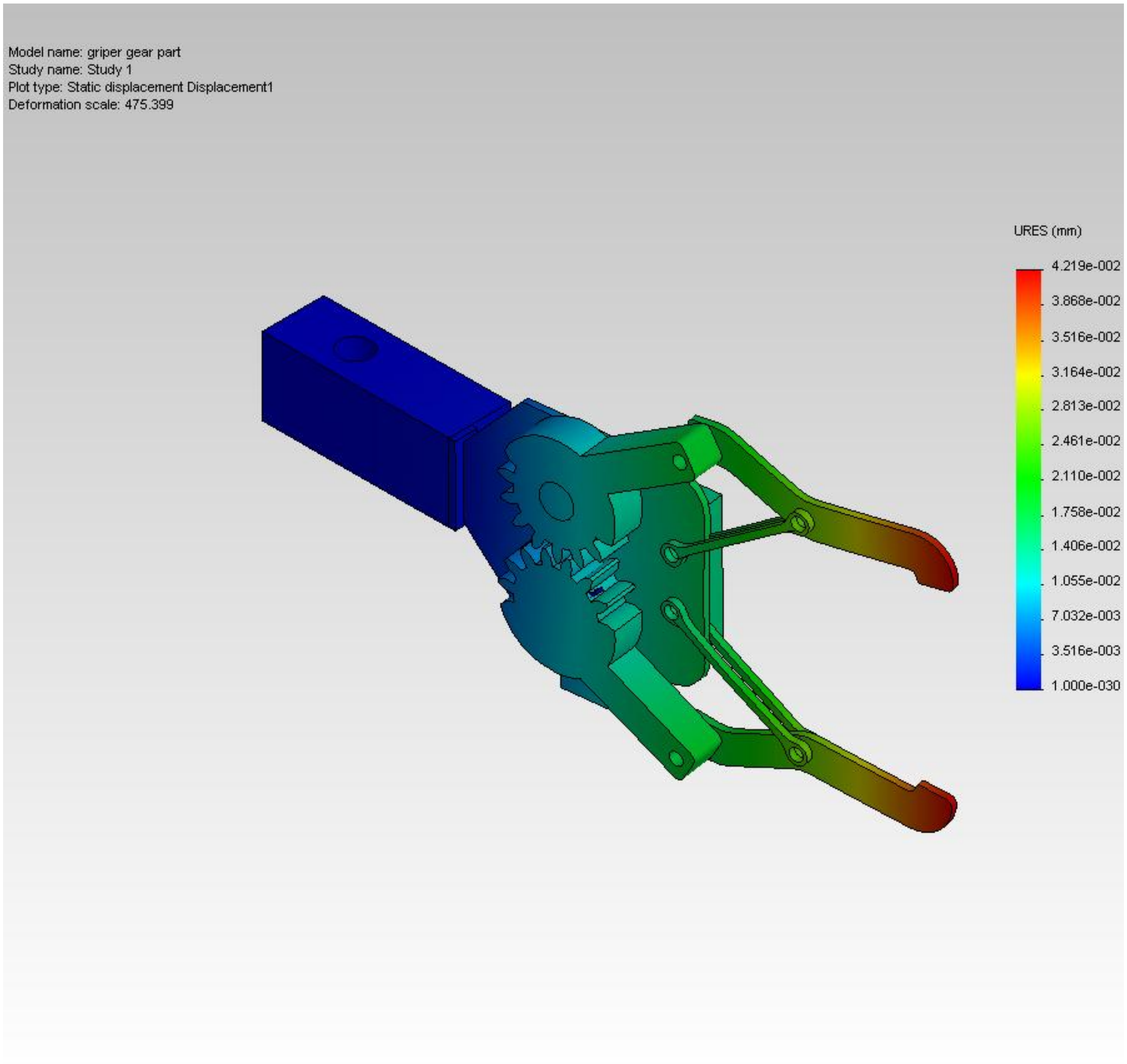
Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/mm^2 (MPa) Node: 3553	3.96013 N/mm^2 (MPa) Node: 38



griper gear part-Study 1-Stress-Stress1

Figure 8.13 : Dynamic element analysis of gripper showing stress.

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 3553	0.0421913 mm Node: 28



griper gear part-Study 1-Displacement-Displacement1

Figure 8.14 : Dynamic element analysis of gripper showing displacement .

8.6 POWER CHARACTERISTICS

8.6.1 Current

Current consumption changes with load .

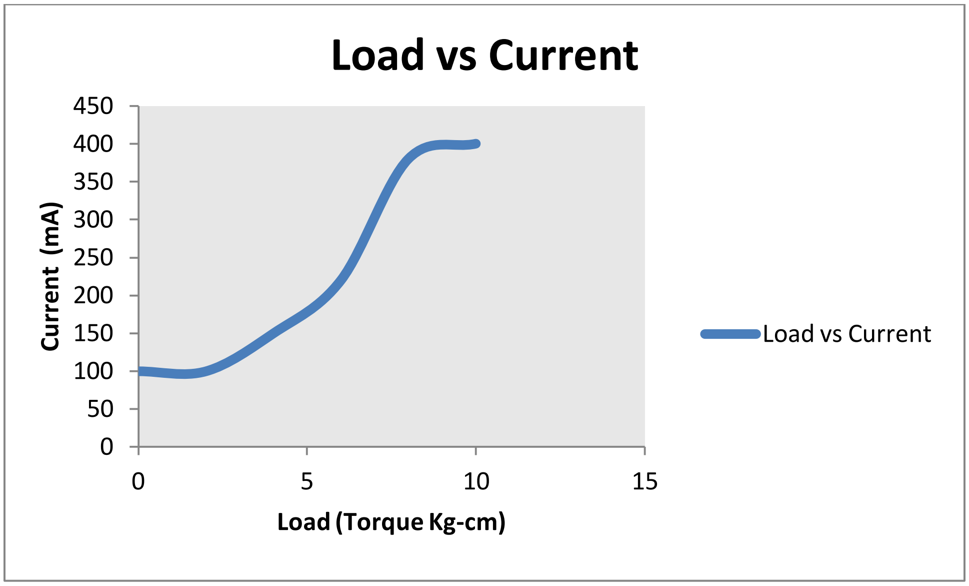


Figure 8.15 : Load vs Current graph.

8.6.2 Voltage

Voltage drop in the servo motor increases with increasing load

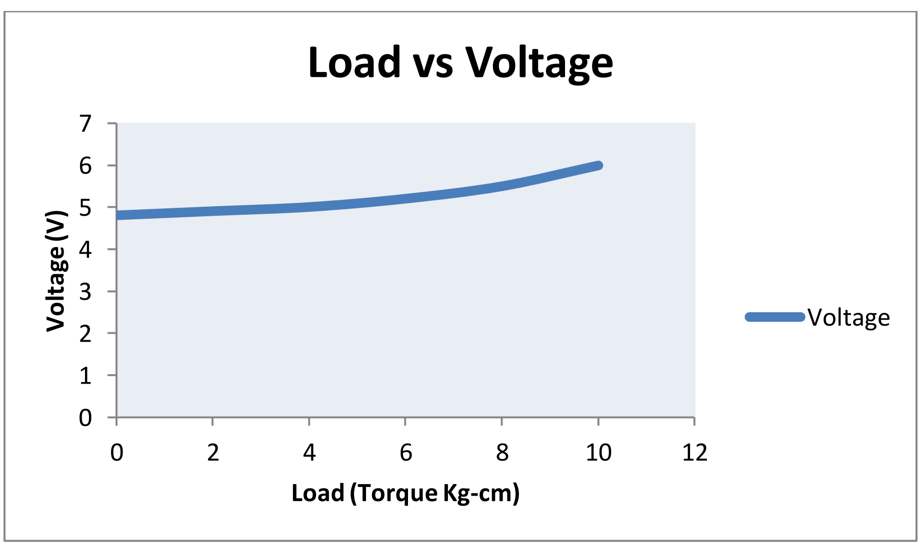


Figure 8.16 : Load vs voltage graph .

8.6.3 Power

Power consumption increases with increasing load .

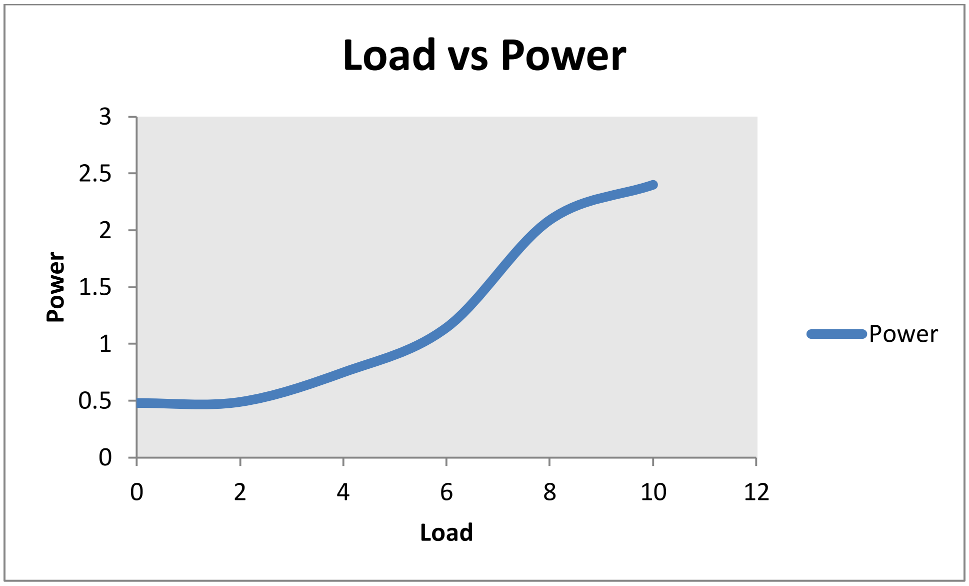


Figure 8.17 : Load vs Power graph .

CHAPTER- 9

SUMMARY AND RECOMMENDATION

9.1 SUMMARY

On the basis of result and discussion so far, the following features can be summarized:

- Robotic arm with low costing can be fabricated by locally available materials and instruments.
- A suitable mechanical, programming and control system is required to perform better manipulation with robotic arm.
- Robotic arm is capable to grip objects with various size, shape and load.
- A mechanical arm recreates many of the moments of the human arm having a full 360 degree circular motion.
- A Robotic arm can perform lot of tasks more essentially than human beings because they are so precise.
- A very strong multidiscipline team with good engineering base is necessary for the development of robot and robotics.
- It is expected that flexible automation and robotics technology in particular, will play an important part in the revolutionizing progress of technology.

9.2 RECOMMENDATION

It is sometime necessary to modify the technology according to the change of time, change of demand. So, there is still some room for improvement in the robotic arm. For further perfection and to increase the efficiency of the robotic arm the following recommendations put forward on the basis of experience gained out of the thesis work and investigation:

- The speed of the Robotic arm is comparatively slow as the requirement. By using high capacity motor or brushed motor the speed of the setup can be increased.

- The load carrying capacity of the Robotic arm can be improved better by using high torque motor or using better material for construction.

- Clear rubber bands wrapped on the both side of the gripper can increase the gripping ability when picking up objects.

- The robotic arm is controlled by a remote control. It can be modified by using touch screen module.

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