3D Printed mimicking robotic Drill Arm

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Abstract

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The purpose of this project is to make a robotic drilling arm whish is controlled by the glove which has flex sensors on it to determine the movement of the arm during drilling process. The movement of fingers are controlled by a microcontroller, and the robotic arm is controlled by actuating servo motors. It is observed that robotic arm can simulate the movement of the human hand which is in the glove, during the test done. This robotic drilling arm can be used not only in automation, but also handling operations in dangerous environment where the humans are not able to operate.

Keywords:

Robotic Arm, Drill, flex sensors,

UNDERTAKING

I certify that research work titled “Design and Fabrication of 3D Printed Robotic Drilling Arm “is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged / referred.

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CHAPTER 1

Introduction

1.1. Background

A robotic arm sometimes referred to as an industrial machine which is often used to described as a ‘mechanical’ arm. Many studies had been conducted in both medical and engineering fields. It is a device that work and perform operations in a similar way as human arm, with a number of joints that either move along an axis or can rotate in certain directions. They are, in mostly programmable and used to perform specific tasks and most commonly used for manufacturing, fabrication, and industrial applications.

Robotic arms were originally designed to provide assistance in large production factories, most commonly in the manufacturing of cars and parts. They were also used to eliminate the risk of injury for workers, and to undertake huge number of tasks. These robotic arms were mostly used to undertake simple, repetitive drilling tasks. As robotic technologies started to develop in particular robotic vision and sensor technology, the role of robotic arms is changing.

1.2. Problem statement:

Our main purpose is to design a robotic drill arm that can copy the movement of human hand. In order to implement 5 DOF revolute type on robotic drill arm to perform on the basis of human hand movement with the help of sensor glove. To achieve that we must have knowledge of desired angles or position of each joint. The whole world is moving towards artificial intelligence but in our industries we still see manual drill machines that are heavy and not easy to use and specially in local for home use purpose if

someone is disable from feet then it's not easy for them to use manual drilling machine that's why we try introduce the robotic drill arm for industrial applications in the areas where people work in the dangerous area , also to reduce human effort, achieving more precision and also for its use in medical purpose to.

1.3. Objective:

The point of our venture is to build up an equipment and programming condition to control 5 degrees of robotic drill arm that can repeat movements made remotely by a gloved human as shown in Figure .In our application, it has been observed that it is conceivable to reenact human movements simultaneously by using flexibility sensors

The proposed technique is the primer advance for a human-machine association framework, in which a robotic arm imitates the developments of a human hand. A mechanical Arm is automated, generally programmable, with comparable capacities to a human arm. The connections of such a controller are associated by joints permitting either rotational movement, (for example, in a verbalized robot) or translational (direct) dislodging. The automated drill arm is an electro-mechanical framework comprising of numerous parts. In such a framework, development is given by electrical parts that furnish drive and control with a mechanical structure

1.4. Working principle :

This robotic drill is going to have 5 degrees of freedom. In this drilling arm there are going to be three links actually, one link which is vertical can also rotate about its axis which is base of model. Second arm has the motion in horizontal direction which can slide on the vertical arm. Third link is going to be our drilling machine with a drill chuck fitted

on it and it has linear motion as well as rotatory motion at some fixed angles. All of these links are going to be driven by 5 servo motors of 5v supply. These movements of servo motors can be controlled by glove that has five flex sensors of 2.2 inch on it in order to determine the movement of the fingers of the human hand. These sensors are going to be connected with Arduino microcontroller of 5v in which all the data is going to be installed. Signal of these sensors are going to be transfer

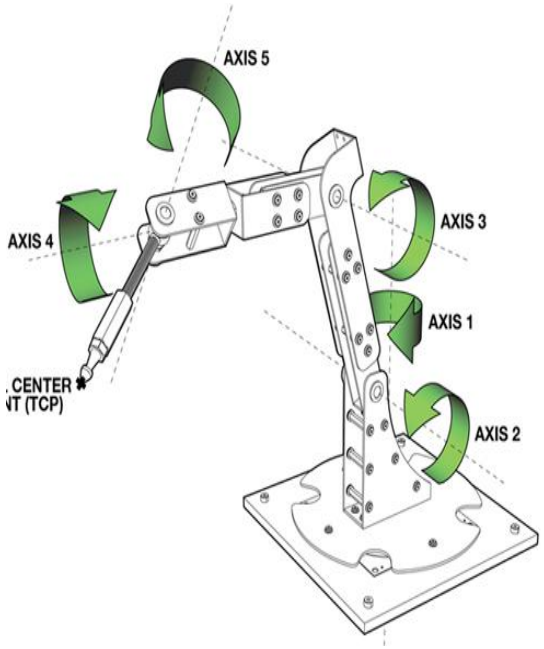

Figure 1.4-axes of arm

With the help of transmitter HC-12 and on the other hand RF-receiver module which is attached with drilling arm is going to receive these signals. Drill machine is going to be 12volt that is attached at the end of robotic drill arm and this drill machine is going to be work with the help of Accelerometer or magnetic sensors.

1.5. Procedure:

Basically we can divide this problem into four major parts. The first will be 3D design of the robotic hand. The Second will be the 3D printing of the parts. The third will be assembling of the parts. The fourth will be the development of control system which mainly consists of electrical components and their programming.

The procedure which is followed by us for the completion of this project is better understood by the flow chart diagram.

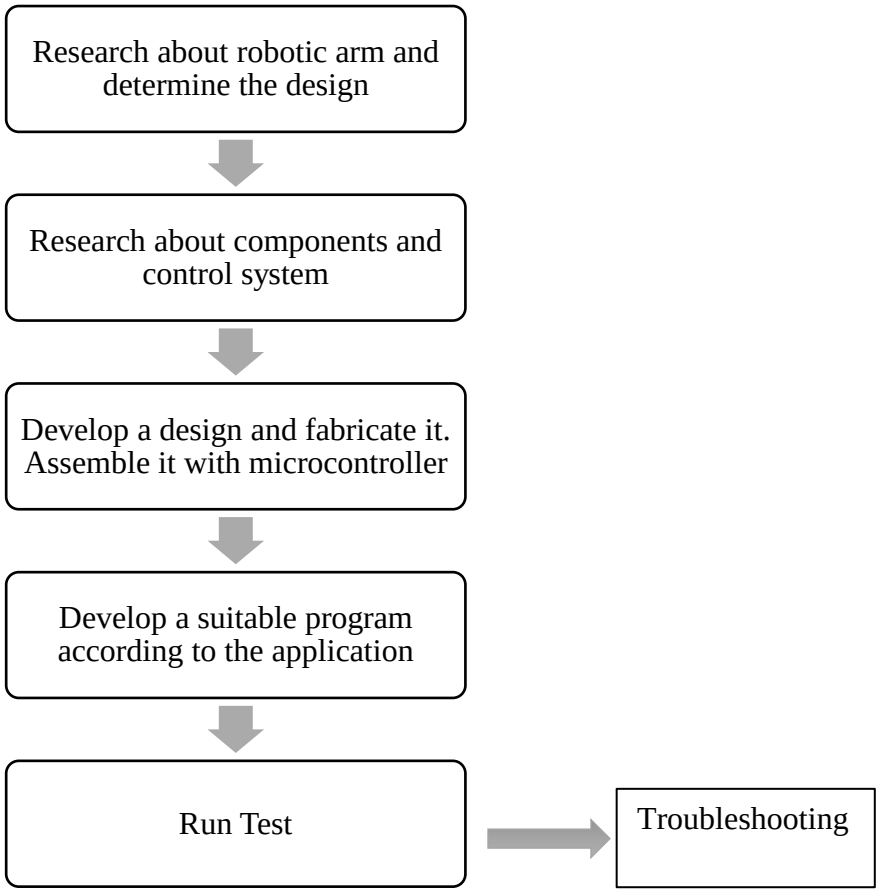

Figure 1.5 Block Diagram

1.5.1. Research about robotic hand and determine the design

Definite things are to be considered before starting a project. We have various ways to design a robotic arm but many questions are must to be pointed out before designing it such as how many degrees of freedom does the robotic arm have, type of links, what is the weight of the arm. The other factors regarding to their shape and size are dimensioning and strength of links.

1.5.2. Do research about components and control system

This part of procedure is much important as the design of robotic arm. After doing research about the design, the next thing is to research about their components which are responsible for their controlling. We must to be pointed our objectives and cost estimation in order to complete our project. For the control system we are going to a glove with flex sensors on it which provide us the exact same movement to our robotic arm.

1.5.3. Develop a design and fabricate it. Assemble it with microcontroller

For the designing of the parts of robotic arm we work on software (Solid works). After the designing we have to fabricate it, for that purpose generates G-codes for the specific fabrication of hand. Then these are given for 3D printing to the given design. After the fabrication some electrical components are used like servo motors, Arduino and some sensors for movement detection. These parts are finalized and assembled according to the working. After the fabrication next step is to assemble the 3D printed parts.

1.5.4. Develop a suitable program according to the application

For the working of robotic arm, it is essential to develop a program according to tasks which we have to define. The programming language which is used in such project is Arduino CC and C++. For the verification of a developed program, we simulate the working of robotic arm by using simulation software.

1.5.5. Run Test

As we develop a program, the next step is to test the working of this supposed program on robotic arm. As from the flowchart (1.4) if test run fails then we have to identify the faults then troubleshoot that error within a specific path.

1.6. Summary

In this chapter we have completed the research work, problem statement, objective and procedure which are required for the completion of this project.

In the next chapter we will discuss the methodology, literature review and some design aspects.

CHAPTER 2

Literature Review

Artificial intelligence deviate from computer science which deals with the machines which are able to perform any kind of tasks. It is also a part of engineering field which is the composition of the artificial intelligence. The capability of artificial intelligence to build a machine that will imitate or mimic the behaviors of humans, and with the passage of time it will replace all the human beings with the machines. If we had to compare the AI and other computational automatic devices , while AI machines takes less time and AI machines based on the needs of the person (personal needs). He said AI few industries like oil and gas, these industries techniques linked with each other. According to him with a little bit of efforts and contribution to all the areas which are neglected from all the developments, AI techniques and machines help them to develop. He said all the AI techniques and the developments will concerns all the systems and operations as well. [1].

He suggested that drill effector is the fundamental prime explanation of robotic sub drilling system. This flexible robotic drilling system which will effect on the quality of drilling and its performance. He also said that robotic drilling system have an amazing and good movements and ability of programming. The robotic drilling system, which performance will affect the whole quality and productivity, the drill end effector is an exceptional tool, whose programming function and structural design based on the

construction process of the aviation pursuit. Moreover, these studies are more concentrated in the university, and the product remains in the prototype stage. [2].

According to him assistance task from a robot will play a crucial role in the drilling performance system. . They ought to supervise the axial vibration sensation along the drill string at a practical resonant frequency, and immerse as a robot end effector for drilling. [3].

Jie Lang conducted simulation for end effector configuration for robotic drilling machine basically there are three way of end effector configuration. He tested three configuration on titanium plate He analyze during experiment and simulation in MATLAB that pointing configuration of end effector is produce less wear and less energy consumption and it also provide the good productivity [4].

In many recent years robotic drilling are used in aerospace industry. In aerospace we required high precision and high efficiency. For this purpose automatic drilling is required for this key coordinate system is develop both robot and end effector is moved with laser coordinate. Four laser sensor are used to detect the normal vector in surface. During experiment automatic drilling produce high quality holes which meet the requirement of aircraft [5].

In order to improve the accuracy of autonomous drilling system they use three different method first one numerical technique is newton method and second one is calibration of TCP. They conducted both simulation and experiment both simulation and experiment show the accuracy of hole in autonomous drilling system [6].

To solve problem of drilling in mining it is proposed that robotic drilling is used because drilling in mine is difficult task and it also danger for worker safety. It is necessary to use robotic drilling manipulator. For this purpose he develop prototype of robotic drill and the process is divided into sub process [7].

Manual drilling is labor intensive works especially for titanium structure. In order to reduce human effort and improve accuracy of hole robotic drilling is design. The robotic drilling system consist of four component end effector senor, controller and also programming. In aviation industry accuracy and precision is required. He conducted research on drilling on titanium and alloy and data show that robotic drilling give tolerance b/w 0.3 to 0.2mm and it also reduce human requirement. [8].

Boeing wholly manufacture 737 aircraft. But their production rate is low, in order to increase production and meet the market demand they use industrial robot with some significant improvement. Which have high level of accuracy and reliability. They uses articulated robotic body which have six axis of freedom and added side mounted drill and trimming. The system reduce the cost of production and provide high rate of production [9].

Qiang Zhan conducting research on error occurring during the positioning of robotic drilling and purposed some solution. In aircraft assembly high accuracy is required so the robot system is based upon the accurate mathematical model. In order to improve flexibility and roughness hand eye system is developed. The relation between robot coordinate and vision coordinate is established and position of target can be achieved by using error. By using camera it can reduce the positioning error of end effector [10].

Diego Gabriel conducted research on force control in drilling by using industrial robot for this purpose he has taken three parameter feed rate power and torque. By controlling force during drilling operation help us to avoid failure of material. His experimental investigation strategy is to set the force limit between robot and surface. He set 2 limit of forces 20 and 30N when force is 30N and reduce it robot velocity he achieve more depth than when the force is not in control [11].

In robotic manipulator there are two types of error occur one is on rigid link and second one is o flexible link. That error cause linear deformation of robotic arm according to saund these error can be minimize by using CNC controller without reducing the volume of robotic position and these calibration is made through real time forward kinematic [12].

Robotic drilling system are used in mass production especially in aerospace industry. Many improvement are made about accuracy and payload motion of industrial robot that are required in aerospace industry. Devieg Russell designed one side drilling end effector for kuka robot. The end effector is controlled by CNC. Both end effector and pressure foot provide stiffness to clamp axis [13].

Coulson conducted research on autonomous drilling robot for bony a cochleostomy surgery. The robotic drill design in such way that its gives information about force and torque needed for tool during drilling process without damage endostea membrane .That information is used to minimize drill penetration in far surface [14].

The main component of drilling system is drill end effector. In aerospace assembly holes perpendicularity is very important for this purpose. Yuan proposed micro adjusting normal to surface mechanism that make drill end effector is static. The drilling point is

measure with adjusted angle of four laser sensor. The angle can be adjusted with motor experiment show that micro adjusted system provided high accuracy and efficiency [15].

In order to solve drilling problem in curved surface following research are conducted two type of drilling take place in aerospace industry. Manual and robotic drilling. In order to tackle the problem of drilling on curved surface vector setting technique is adopted and position on the curved surface is determine spatial measuring technique [16].

In order to guide robotic arm in proper position in accurately manner cuveas proposed hybrid visual camera the camera is mounted on robotic arm with that data robotic arm can easily configuration is trajectory. He conducted experiment on universal bot hybrid camera achieve 95 percent success in eleven iteration [17].

Molfino conducted research on automation in construction. The purpose of this paper to is develop automatic drilling system that are able to create hole in rocky wall up to 20mm depth with the help of rods. The rods are mounted on a robotic manipulator. For drilling system feed rate and drilling head is required. The robot drilling is faster 2 to 5 timed than the conventional drilling system [18].

In this paper he tackle the problem regarding the autonomous drilling for this purpose he proposed the directional drilling with steerable system. The system improve the trajectory and drilling parameter in autonomous drilling [19].

In robotic drilling system many nonlinearity disturbance can occur such as friction.in this paper purpose a sliding mode of drilling end effector by third order integration. This system is simulate in mat lab which verify the reduction of disturbance in end effector by using sliding contact [20].

In this paper he described an autonomous drilling solution for industry. Drilling operations decisions are taken automatically by intelligence by analyzing which series of actions will reduce the time required to reach the section Total Depth. The estimated time to drill the remaining of the part is used into the predicted time to execute the series of actions. In that way, a balance between maximizing performance and reducing risk levels during drilling is achieved. If it choose too aggressive action plan, then it could lead to greater chances for drilling incidents to occur which can also increase the total duration to reach the section Total depth. [21].

This report is about the robotic arm which copy the motion of human hand in order to pick or make grip to some object. In this paper the author tells us about development of arm that is designed in such a way that it is able to hold some light weight items. This arm is made of aluminum material and it has four degrees of freedom and these degrees of freedom can be performed by servo motors that is attached with arms. In this report an experiment is performed by lifting objects from one place to another in order to examine the torque characteristics of robotic arm. [22].

This report depicts the development of visual software package in which a robot AL5B will be developed which is used as an educational tool. The paper includes fundamentals of robotics, motion planning, interface and control. The man purpose is to

apply the concepts of robotics in order to facilitate educational, industrial institutions. The work includes the Kinematic analysis of AL5B robot arm, development of graphical user interface for testing purpose and use it as an educational experimental tool.[23].

In this paper he describes the experimental and analytical performance of robot drilling specifically on alloy materials. For heavy structures materials manual drilling consumes more time and quality of holes drilled by robot drilling is unstable. He said that the industrial robot with agile motion is possible to machine a component for drilling. Industrial robots with high precision and six axis Degree of freedom are considered to be used for better robot manufacturing processes and drilling. His work is to significantly improve performance of robot drilling over conventional drilling. **[**24].

This paper is about robotic arm that has five- axis with a vision camera and it is designed in order to perform the function like pick and place. Kinematic analysis is also conducted and a prototype is made in order to test results. Motion analysis is also done on ADAMS software in order to compare results with kinematics. In order to detect the crack and location image processing is also done by using MATLAB and LabVIEW software[25].

This report analyzes the kinematic solution of robotic arm that has five degrees of freedom in which one is prismatic joint and other four are revolute joints. By the help of geometric projection and limiting the ranges of degree of freedom an analytical solution is obtained. The solution is also validated by testing it on randomly ten different poses and it is found that robotic arm is able to achieve orientation targets and position targets in numerical errors. The results of kinematic solution shows that computational costs will be reduced that leads the robot to better response. [26].

In this report a three degrees freedom of robot is designed. It also has angular rotation that is given by servo motor. Furthermore, Arduino microcontroller is used to examine the angular position of robot controlled by a signal. Dynamic calculations and design testing has been done in order to provide well established product. Additionally, forward and inverse kinematics and mathematical equation is also used to analysis arms workplace[27].

This report includes the design is proposed to use servos in order to power joints and implement inverse kinematics of robotic arm for visualization of joint movements MATLAB robotics toolbox is used. Microsoft C# programming language is used to develop control software of robotic arm. The robotic arm for the sake of performing variety of functions can be reprogrammed which generally make the project unique for industrial and educational purposes. [28].

In this report, a control system for robot arm of 5 degree of freedom is developed which is composed of main controller and five motor controllers. Arm microprocessor is used to develop the main and motor controllers.to stimulate the motion of robot arm a 3d robot based on open Gl was developed. The distributed control system for new revolute arm is utilized by using one chip microprocessor. Besides main and motion controller there ia s communication system. A trajectory test was performed to test the robot system where position control result showed good performance. [29].

This paper is about the design and development of five-degree freedom of robotic arm. In this paper the servo motors were selected in order to power each joint of robotic arm and then torque exerted at each joint was calculated and then servo motors were

selected according to required rate of torque. This robotic arm is controlled by servo controller and also Microsoft C # programming language is used to specify the position of arm in space. [30].

2.1 Our approach:

We are doing a research on the prototype of robotic hand which will copy the movement of a human hand. For this prototype we are using five servo motors. These motors prescribed the position of Arm very accurately. For this purpose the flex sensors can be very useful. The programmed Arduino which is used in this project is Arduino Nano.

2.2 Methodology:

The methodology of our final year project is that fist we have to make its 3D designs on software (Solid works). After the successful design is complete we have to print it using 3D printer. Next we have to make the robotic arm mimicking the human hand. We will be using the design and programming software, microcontrollers and some electrical motors for movement of hand.

CHAPTER 3

Design of robotic Arm

3.1. Robotic Arm:

To design robotic arm it is necessary to understand what is robotic arm and its different component. It is electro-mechanical industrial machine which is often used to describe as a mechanical arm .there are different types of industrial robot like Sacra, Spherical, Parallel and Articulated robot. For our project we select articulated robot.

3.2. Articulated Robot:

It is type of industrial robot closely resemble to human arm the main feature of this robot it consist of two or more rotary joint. Articulated robotic arm have three linear axes as well as two rotational axis. Articulated robot have more degree of freedom as compared to other types of robots. Its application in manufacturing industry like picking welding as well as drilling. The articulated robotic arm consist of following component.

a) Base
b) Shoulder
c) Upper arm
d) Forearm
e) Wrist
f) End effector

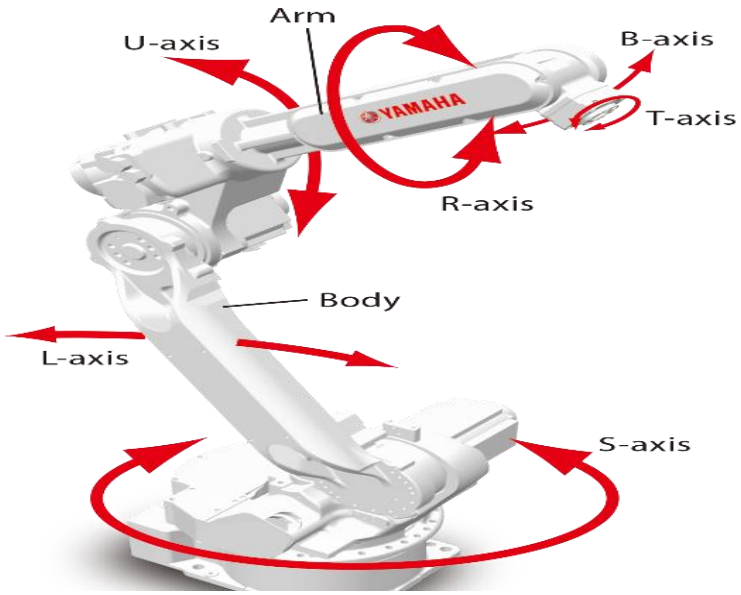

Figure 3.2- Structure of robotic arm

3.3. List of parts design in solid works:

Table 3.3- List of parts

ITEM NO.	PART NUMBER	Description	QTY.
1	Part 1	Base	1
2	Part 2	Shoulder	1
3	Part 3	Forearm	1
4	Part 4	Upper arm	1
5	Part 5	wrist	1
6	Part 6	Drill holder	1
7	Part 7	cover plate	1
8	Part 8	Motor	1
9	Part 9	Chuck	1
10	Part 10.	Drill bit	1
11	Part 11	Bolt	4

3.4. 3D Parts in solid works:

There are eleven parts of robotic drilling arm starting from the base end to the drill bit and we design the entire robotics arm on solid works according to our requirement of degree of freedom. We have total five degree of freedom in our robotic arm. First we make the individual parts and then we assemble it to make final geometry of robotic arm and then we make exploded view of our arm.

3.4.1. Base

The first part of our robotic arm is base. It is a fixed part the bottom of shoulder part is connected to it. The design of base such that it hold the both shoulder and servo motor. And that servo motor is connected to the shoulder part.

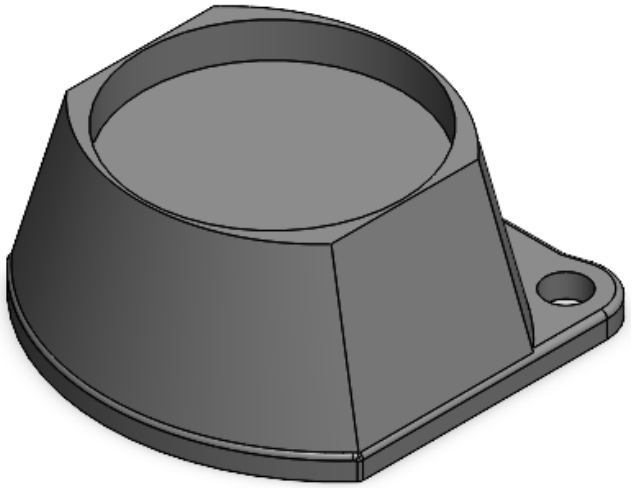

Figure 3.4.1- Base

3.4.2. Shoulder

It is second part of robotic arm it is attached to the base with first servo motor. Shoulder is design such way that it hold the upper arm and can rotate at the 0 to 180 degree of servo motor. It can moves along the rotational direction.

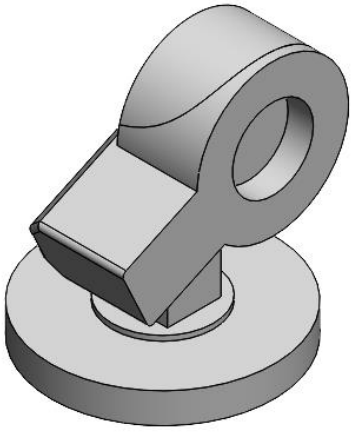

Figure 3.4.2-Shoulder

3.4.3. Forearm

The next part that is connected to upper arm is forearm. The function of forearm is to move up and down in linear direction with third servo motor it is design such way that it can hold the wrist servo motor at front face of forearm.it is main part of robotic arm.

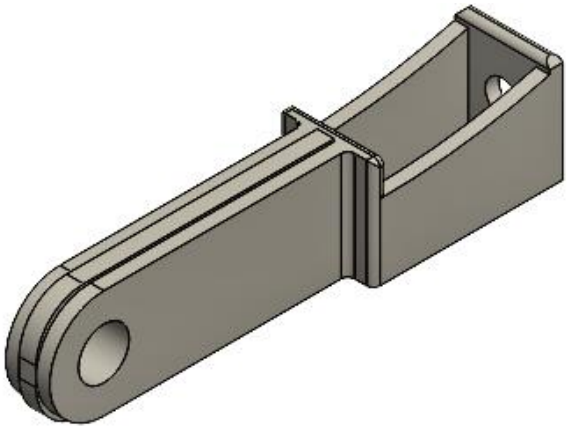

Figure 3.4.3.-Forearm

3.4.4. Upper arm

It is connected to the shoulder arm in such way that is can move in linear direction just like the human arm. It is attached to the servo motor. Servo is attached to right side of shoulder which is connected to the upper arm

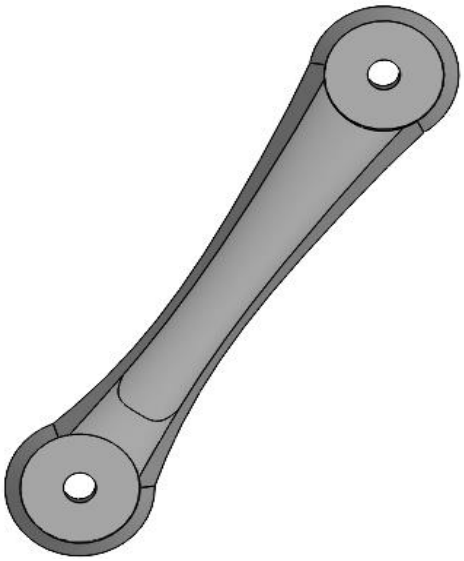

Figure 3.1.4.-Upper Arm

3.4.5. Wrist

It is rotational part of robotic arm and it is connected to the forearm with fourth servo motor. It can rotate 0 to 180 degree. The purpose of the this part is to rotate the end effector holder at specific angle according to need

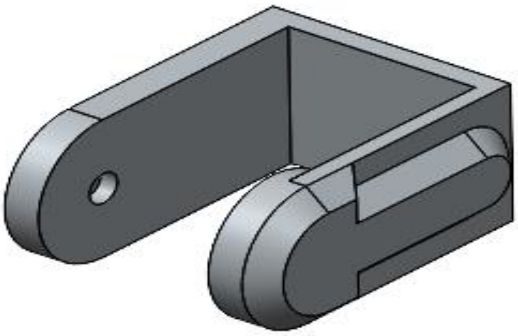

Figure 3.4.5.-Wrist

3.4.6. End effector holder & cover plate

This part hold the drill machine the shape of this part design such that it minimize the vibrations of drill machine. It is capable of moving linear moment in up and down direction. The cover plate is attached in the Front face of end effector holder.

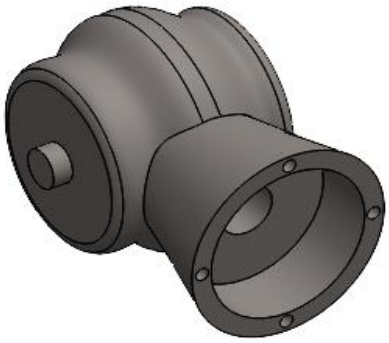

Figure 3.4.6.-End effector holder

a) Cover plate

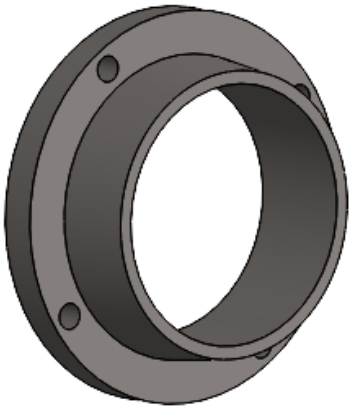

Figure 3.4.6 a- Cover Plate

3.4.7. Drill machine & Drill bit

These both part are connected to end effector holder. And drill bit connected to machine

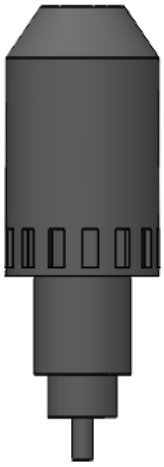

Figure 3.4.7-Motor

b). Drill Bit

Figure 3.4.7 b-Drill

3.5. Final Assembly

Figure 3.5. - Final Assembly

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3.6. Exploded view

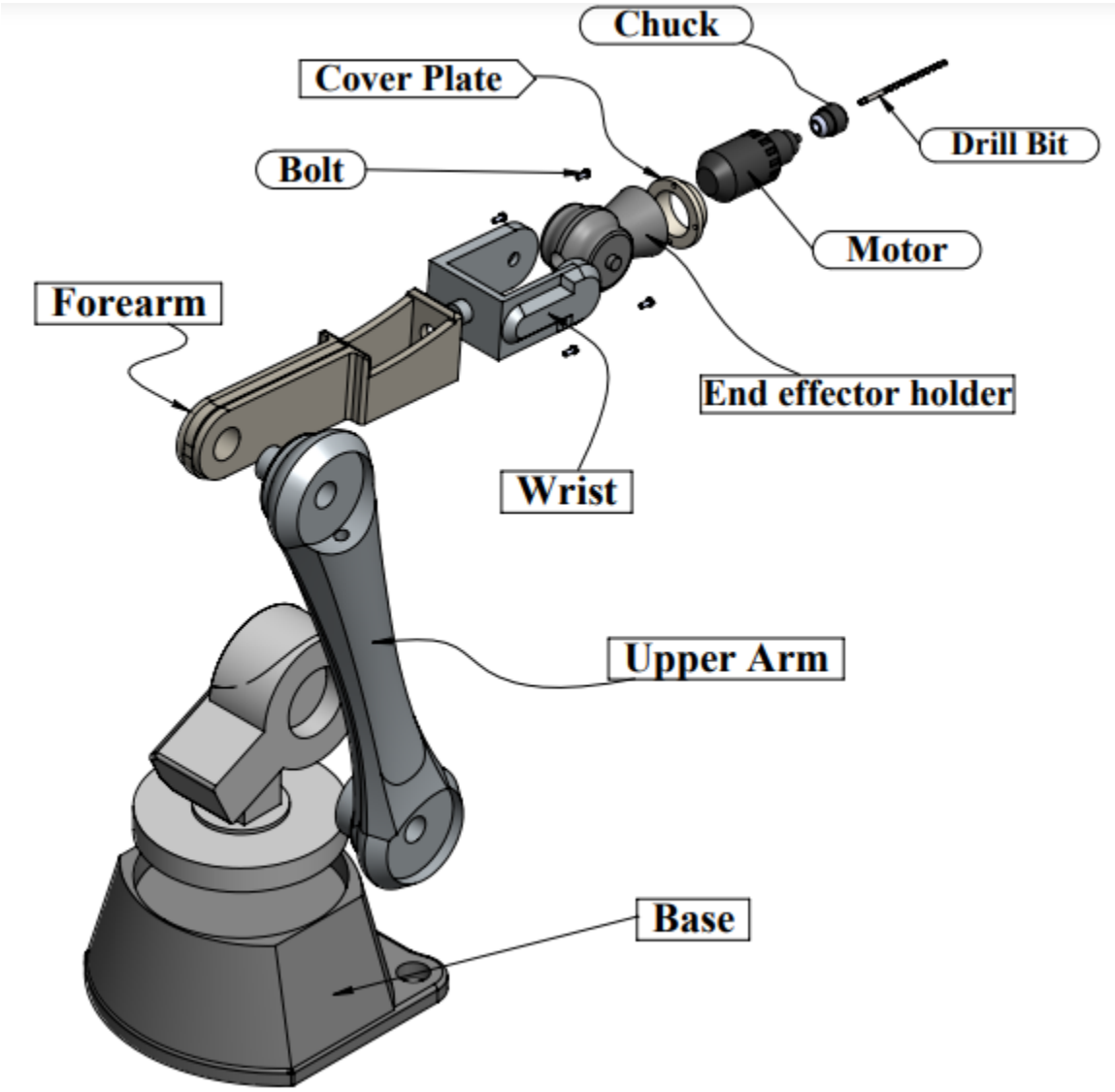

Figure 3.6: Exploded view

CHAPTER 4

Analysis of robotic drilling arm

In this chapter we are going to perform analysis on robotic drilling arm. Analysis play an important role in designing the product. In robotic arm motion is a key factor in designing. Further for validation of result we compared same analysis with different sizes of meshing to verify that meshing is not impact on our result.

4.1. Multibody dynamics analysis

It is it is motion analysis in which we study the behavior of rigid link or flexible that are interconnect with each other and the mechanism behave under the action of translational and rotational displacement. Basically motion analysis describe the kinematic behavior of a system. It has many application like robotics, aerospace, biomedical etc.

In this analysis link is defined by constraints like universal, revolute etc. that restricts the relative motion of body usually the equation of motion is Lagrange equations or newton the types of constraints are fellows

a) Revolute
b) Universal
c) Cylindrical
d) Spherical

Each of them restrict the degree of freedom. Degree of freedom defined as number of independent coordinate that describe the motion of a body

4.2. Material

The material of our robotic arm is polylactic acid.it is material that are widely used in prototype. The properties of PLA are shown in following table.

Table 4.2-Material properties of PLA

Properties	**Values**
Density	1.210 $g \cdot cm^{-3}$
Poisson Ratio	0.3
Young Modulus	1280 MPa

4.3. Meshing

It is an important part of an analysis because meshing impact the result of our analysis.it is necessary to do proper meshing. Either we do meshing automatic or manual proper mesh will affect our simulation. For our analysis we do automatic meshing and we also apply the sizing command in order to reduce the size of element.

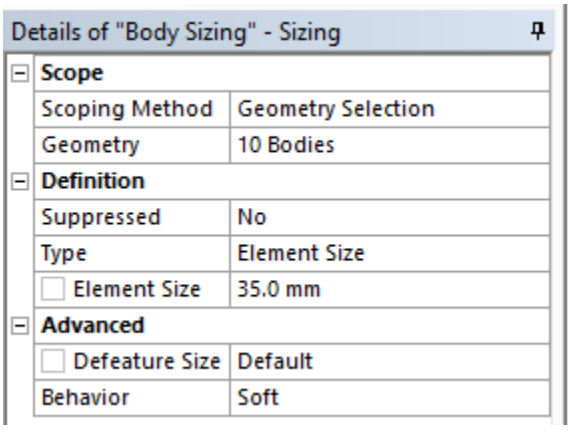

Figure 4.3-Body sizing

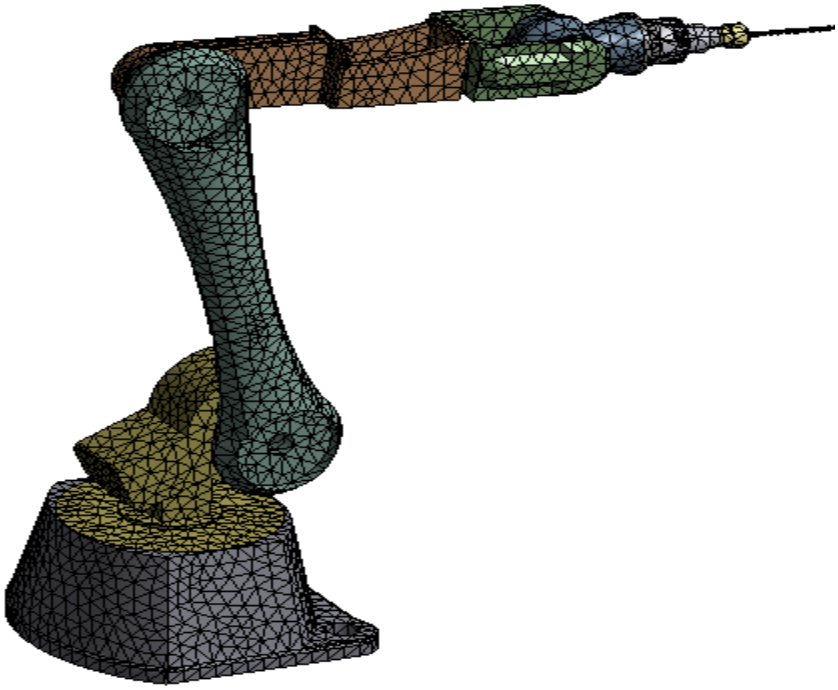

Figure 4.3- Meshing

4.4. Boundary condition

The next step after the meshing is boundary condition. In this part we will define that at which point body is fixed and free to move.in robotic arm the bottom of base is fixed to the surface while all five links or joints are free to rotate in a certain direction i.e. linear or rotational according to a certain value of degree provide in tabular data

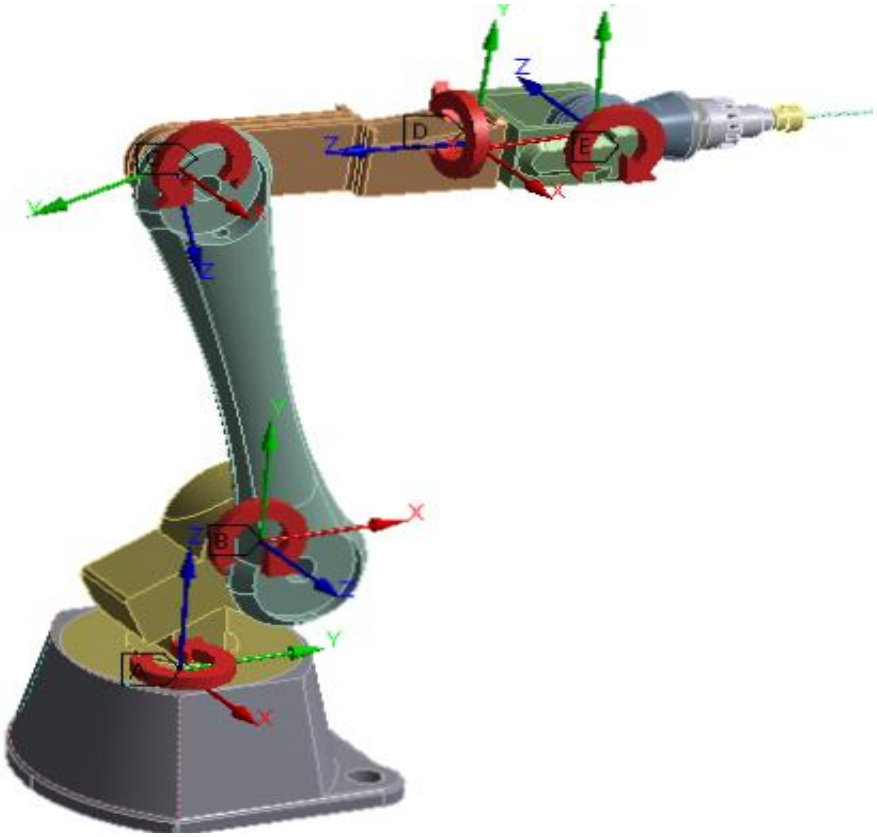

Figure 4.4-boundary conditions

4.5. Results

We evaluate the total deformation and Equivalent stresses, strain, as well as shear stresses

4.5.1. Deformation

The result shown that the maximum deformation occur at the tip of drill bit about 12.602mm while minimum deformation on the base bottom is 6.6516×10^{-6}mm. Basically deformation show the change of shape of robotic drill arm under the action of joint rotation. Joint load is applied on each parts.

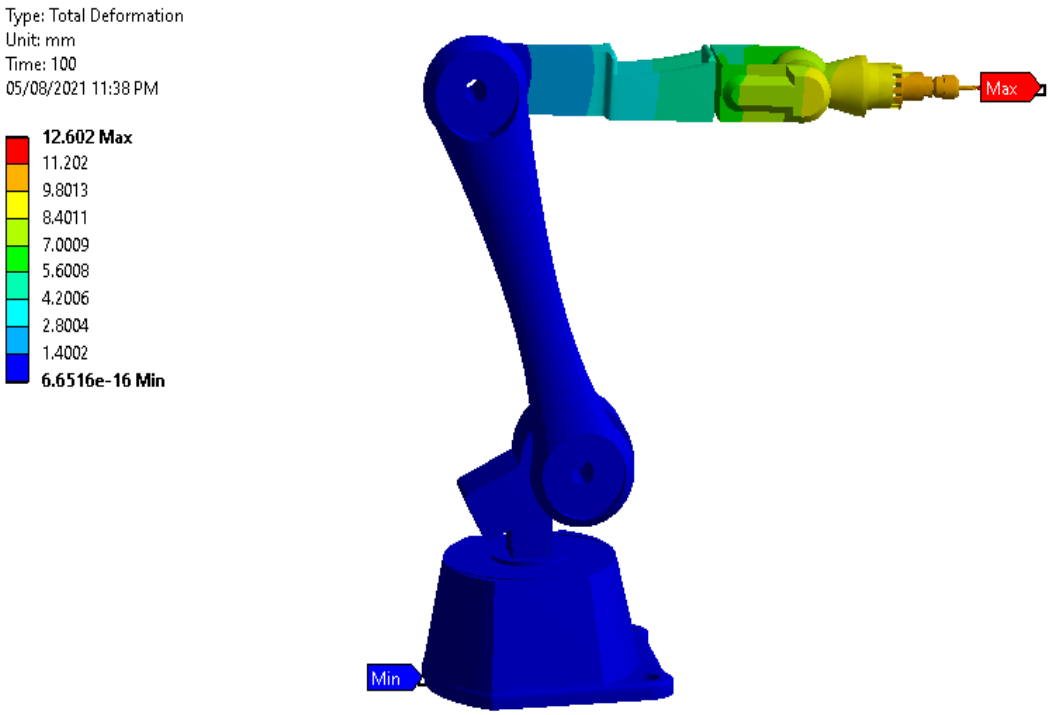

Figure 4.5.2-Deformation

4.5.2. Equivalent stresses

The max equivalent stresses occur at wrist part where wrist hold the end effector the max stress is 0.06103 MPa and minimum is $5.56x10^{-7}$ MPa. The figure shown the following result. The following results shown that under the action of rotation of each joint or links.in each joint we apply certain degree of joint load starting from 0.5 to 25 degree.

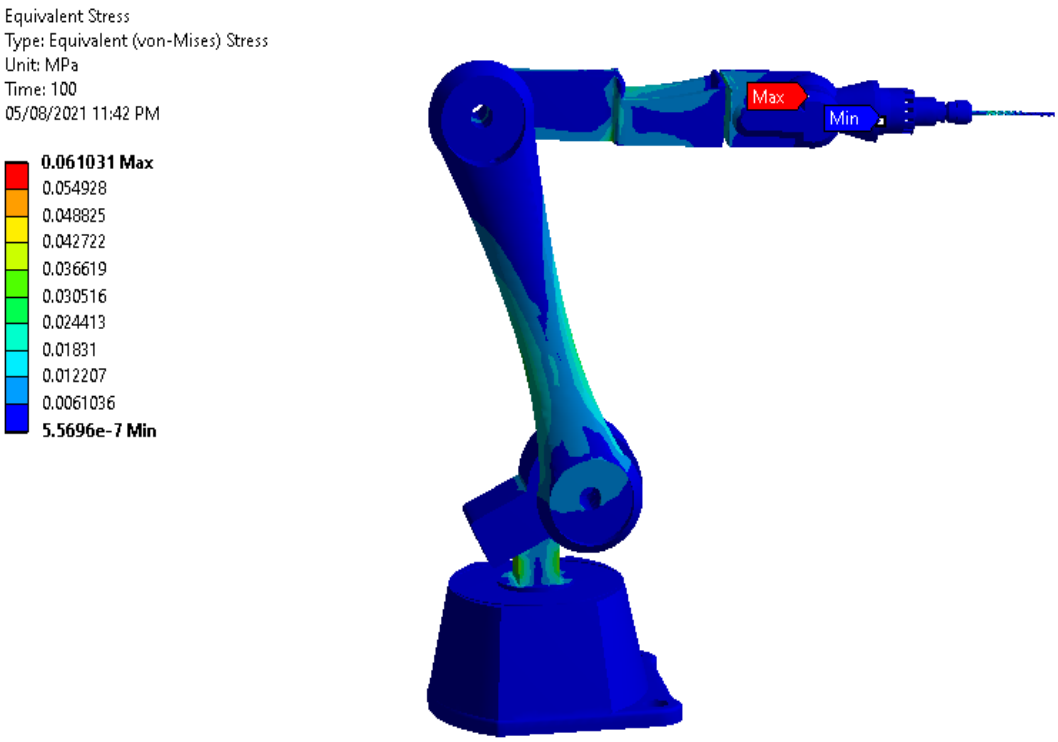

Figure 4.5.1-Eqivalent stress

4.5.3. Equivalent Strain

The following figure shown the equivalent strain on robotic arm under the action of certain degree of joint load on each axis of rotation. The maximum value of strain shown at link between the end effector holder and wrist part. And the minimum value at entire drill bit.

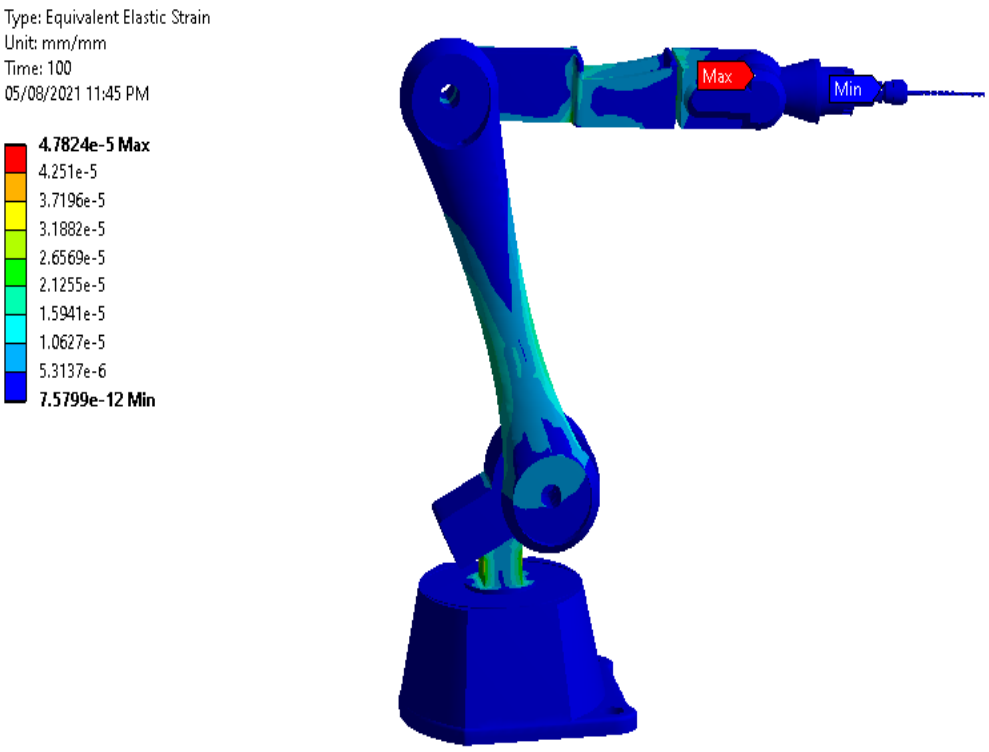

Figure 4.5.3-Equivalent strain

4.6. Result Conclusion

From the following above analysis of multibody dynamics analysis we can conclude that deformation occur after arm move certain set of degree of rotation of each joints or links. The main purpose of this analysis is to determine the deformation of robotic arm when it move in forward kinematic as well as inverse kinematic. During drilling the force is act on the arm that cause the deformation.

CHAPTER 5

Electrical Components

5.1 Flex Sensors

Flex sensors are the type of sensors which can measure the deflection through the change in resistance. When the pressure applied on the flex sensors it has a structure that changes its resistance. Flex Sensors are used in many applications. They are used in:

- Robotic Applications
- Game Consoles
- Medical Devices

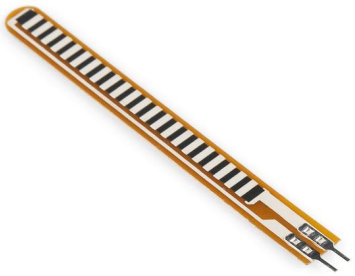

Figure 5.1 Flex Sensor

5.2 Servo motor (MG995)

There are numerous kinds of servo engines accessible in market and each motor has its own quality and applications. Most of the intrigue Servo engine works from 4.8V to 6.5V, the higher the voltage higher the power we can achieve, yet most typically they are worked at +5V. Essentially all recreation action servo engine can divert just from 0° to 180°.

Servo engine is a rotating actuator that gives exact control of rakish position, speed or increasing speed. For all the joint, MG995 engine is utilized, which is appeared in fig 4.2, in light of required force and voltages.

Figure 5.2 Servo Motor

The specifications of MG995 are shown in table 5.2

Table 5.2- Specification of servo MG955

Model	MG995
Weight	55g
Operating voltage	4.8 – 7.2 V
Torque on 4.8v	10kg-cm
Torque on 6.6v	12kg-cm
Degree of rotation	180°
Gear type	Metal
Dead band width	1 µs
Pulse cycle	1 ms

5.3 Arduino

The micro controller used for controlling the joints is Arduino Nano. Arduino Nano is a board which has 22 pins in total in which 14 pins are digital pins and the rest 8 are analogues pins. The microcontroller used in the Arduino Nano is at mega 328. The Arduino board and at mega 328 is shown in fig. 5.13 and 5.14 respectively.

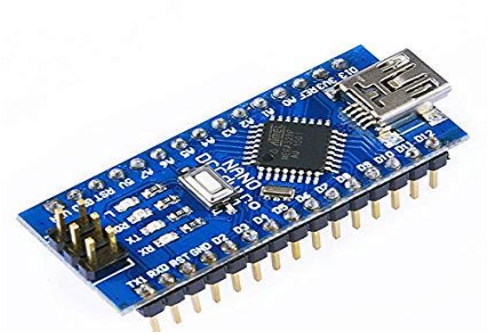

Figure 2.3-Nano Arduino

5.4 Transmitter and Receiver

To make the framework remote a lot of transmitter and collector is utilized. The pack incorporates one sets of transmitter and beneficiary modules and one sets of spring reception apparatuses for expanding the correspondence separation. Furthermore, the recurrence is 433MHz. It is well known for controller frameworks, for example, Remote control moving doors, brilliant vehicle, savvy home, and so on.

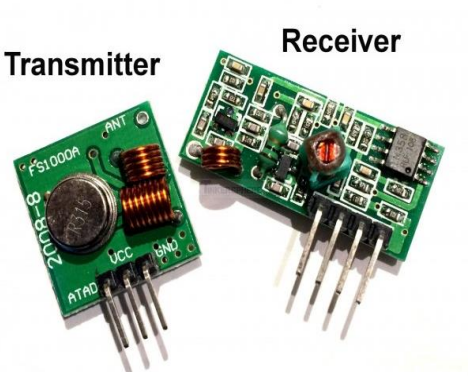

Figure 5.4-Transmitter &Receiver

5.5. Gyroscope

It is an electronic device use. It consist of six motion out of six motion the three axis motion of accelerometer and other three axis of motion is to detect angular velocity along the X, Y,Z . it can also be used for temperature sensor module

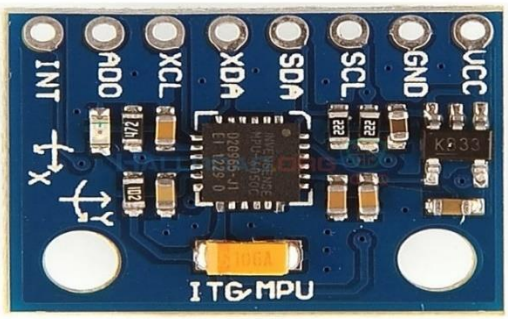

Figure 5.5 Gyroscope

5.6. Boost converter

Boost converter basically used in order to convert low voltage to high voltage. We are using **XL6009 boost converter** and reason of using this converter is that drill machine is operated at 12v

Figure 5.6 boost converter

CHAPTER 6

Working of robotic drill

6.1. Working of Flex Sensors:

Two methods, one-way and two-way, are used in the production of flex sensors.

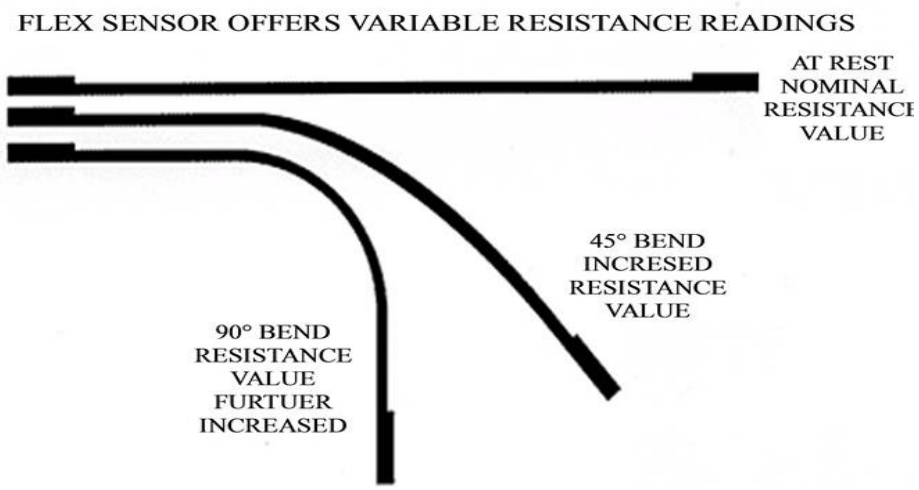

Figure 6.1-Flexible Sensor: proportional to the amount of bending

Human fingers can only be bent in one direction so, the sensor type has been chosen unidirectional and these sensors can bend from 0 to 90 degrees and resistance of these sensors is operate from 0 to 999Ω. As these sensors are attached with Servo motors so these motors have angle from 0 to 180 degrees that was possible. The connection between the flex sensors we have mounted on the glove and the angle values of the servo motors are as shown in Table 6.1.

Table 6.1-Flexibility sensor angle-resistance connections

Flex sensor	Finger bend	Flex Sensor Resistance	Servo motor angle
1. (base) Resistance set (777 to 800)	0	777 Ω	0
	45	789Ω	95
	90	800 Ω	180
2. (lower arm) Resistance set (772 to 784)	0	772 Ω	0
	45	779 Ω	85
	90	784 Ω	100
3. (upper arm) Resistance set (751 to 795)	0	751 Ω	0
	45	780 Ω	30
	90	795 Ω	60
4. drill attach Resistance set (771 to 790)	0	771 Ω	0
	45	781 Ω	55
	90	790 Ω	100

When we bend finger at some angle between 0 to 90 degrees then the resistance of sensors that are attached on glove changes and positions of the robotic drill arm changes at some angle according to it which is shown as an example in three ways (Figure)

6.2. Working of Gyroscope:

The gyroscope we are using is **mpu6050** and it is complete 6 axis motion device. It has 3-axis of Gyroscope and 3-axis of accelerometer and a Digital Processor all in small chip.

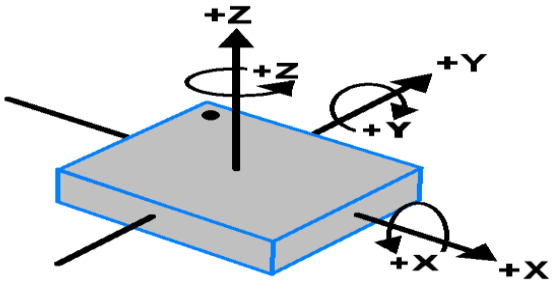

Figure 6.2.1- Three-way motion of gyroscope

As our concern is only with gyroscope so accelerometer motions are not using. We are only using 2 axis of gyroscope which is x and y. By **y-axis** we are providing rotational movement to drill and by using **x- axis** our drill machine will be ON.

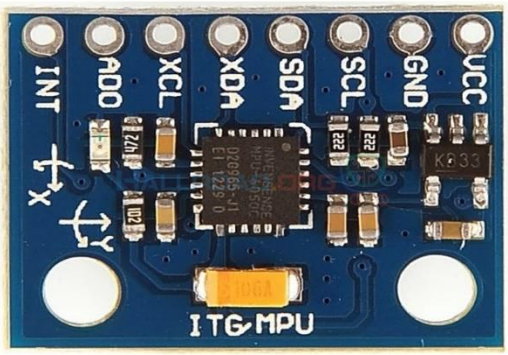

Figure 6.2.2-Mpu6050 Gyroscope

The connection of gyroscope with the nano Arduino is shown below the figure 6.2.3 and also

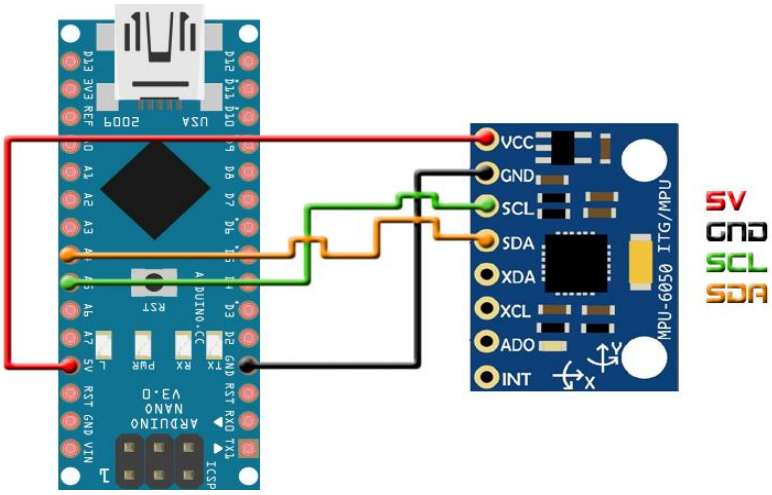

Figure 6.2.3-Connection b/w Gyroscope nano Arduino

The connection between gyroscope sensor on glove and angle values on servo motor can be seen in table 6.2

Table 6.2-Gyroscope sensor angle-resistance connections

Gyroscope	**Wrist angle**	**Flex Sensor Resistance**	**Drill**
X-axis	0	559 Ω	**OFF**
	90 (below)	605 Ω	**ON**
Y-axis Resistance set (100 to 600)	**Wrist angle**	**Flex Sensor Resistance**	**Servo motor angle**
	90	300Ω	0
	8	100 Ω	10
	160	600 Ω	180

The rotational movement of drill depends on wrist rotation and similarly drill ON and OFF also depends on wrist movement. If we rotate our wrist then drill also rotate and if we bend down our wrist then drill ON otherwise it remains OFF. Some examples shown in figures below.

6.3. Link between Servo motor and flex sensors

The cables coming out of the flexibility detection sensors have been combined on a circuit board and made suitable for Ethernet cable connection. The reason why Ethernet cable is preferred is that the sensor glove is easy to wear on human hands. In this way, it has been made possible to complete the cable connection after the glove worn comfortably. In Figure 6.3, there are flex sensor and Arduino microcontroller connections. Sensors are connected to the microprocessor analog input according to the voltage divider principle.

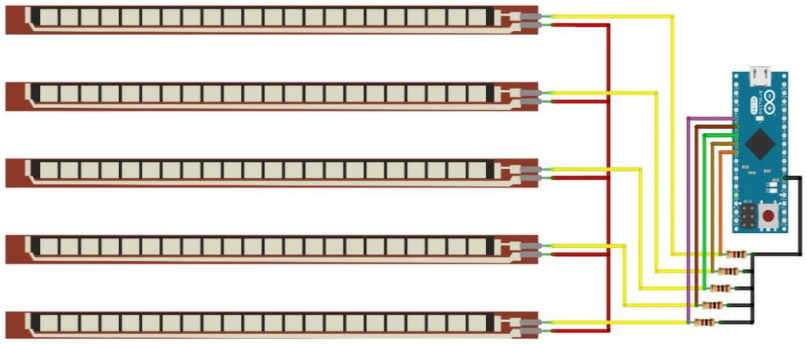

Figure 6.3- flex sensors attached with microcontroller

Micro servo motors were used for the movement of the robot hand, due to their small size. Each servo motor has a torque of 2kg.cm and this torque is sufficient for functional robotic arm movements; it is necessary to choose a more powerful motor for load carrying applications. Arduino-servo motor connection is shown in Figure 6.3.2

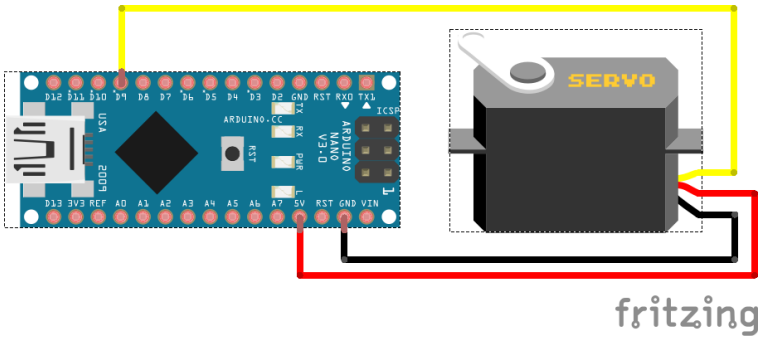

Figure 6.3.2-Servo Arduino connection

22 channel camera cable is used for micro servo motor connections. Servo motors are fed through a common channel and signal cables are divided into 5 separate channels. Servo motors used are two-wire DC motor, gear, potentiometer, micro motor containing integrated circuit and an output shaft. The control system sends a coded signal to the servo motor and sends a command to go to certain angular positions, and this coded signal will be kept on the input line, and the servo motor will be positioned. The potentiometer control circuit allows for monitoring the current angle of the servo motor. The integrated control unit provides position control with the feedback it receives from the potentiometer. At the point when the control circuit identifies the right position, it stops the engine. On the off chance that the control circuit recognizes that the edge isn't right, it positions the engine until the edge is right.

The degree of rotation of motor with respect to bending of flex sensor as shown in table 6.3

Table 6.3. Degree of rotation of motor with respect to bending of sensor

Bending of Flex Sensors (degree)	**Rotation of Servo motor (degree)**
0	0
30	60
45	90
60	120
75	150
90	180

6.4. System Operation

The information obtained from the flex sensors is processed in our main controller, the micro controller (Arduino), analogue enter the values position information Pulse width modulation PWM to control servo motors by rotation [4, 5, 6] applying servo sent to the motors. This process is also done for five servo motors. Since the resilience sensors are sensitive to ambient conditions, the microcontroller first records the value received from the flexible sensors by calibrating when the system is powered up. This value is used to correct later measurements and ensure accuracy. The system constantly monitors the analog information coming from the flexibility sensors, this data is transformed linearly into the servo motor position with the help of the mapping command. Thus, every value

change in the flexible sensor has a certain angle. The position information obtained is transferred to the servo motors using pulse modulation. This cycle is repeated continuously.

6.5. Microcontroller and regulator

Arduino Nano is an advancement board with **ATmega328** chip. This board has 21 computerized inputs/yields in which 13 are digital pins and 8 are analogue sources and has 3 to 8 MHz resonator, USB association. The nano controller which is attached at glove is using only analogue pins for receiving analogue signals because flex sensors only operate with analogue signals and nano that is used for operating drill is using digital pins for receiving digital signals.

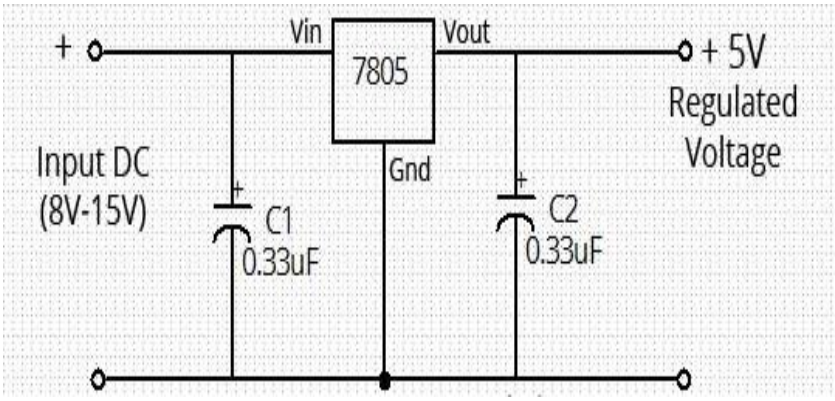

Figure 6.5 circuit diagram of regulator 7805

Since there are 5 servo engines in our framework, there is no requirement for an extra card. It has been necessary to use a power circuit to feed these servo motors. An external **regulator 7805** circuit has been used in glove in order to convert 8v that is coming from battery to 5v because our nano controller only operated on 5v supply. Regulator circuit and microcontroller; It is positioned in two separate boxes due to problems such as heating and magnetic field. The whole system is powered by a single adapter and its operating value is 6v.

6.6. Boost converter and Relay

Boost converter basically used in order to convert low voltage to high voltage. We are using **XL6009 boost converter** and reason of using this converter is that drill machine is operated at 12v but the supply we are giving to whole circuit is 6v because most of the machinery we using is operated on 5v or 6v but if supply 6v to drill machine its output will be very low so that's why placed booster in breadboard that converts 6v to 12v and supplied it to drill machine so that its output will be maximum.

Figure 6.6-Boost converter

Relay is also placed in breadboard and it is used to control the high-power voltage circuit with low power signals. As the output coming from nano controller pins is 12 to 13 milli ampere which is very low and booster Xl6009 cannot be operated on that power because it is high power circuit and its maximum current rating is 2 amp so that's why we placed relay between nano controller and booster so that they control high current booster with the help of low power signals coming from pins.

Figure 6.6.2-Relay

6.7. How to do Connections of drill arm (Receiver)

In the wake of mounting the servo motors on drilling arm we interface them to the force gracefully and Arduino, utilizing a little breadboard. The negative is connect on the breadboard to the Arduino's GND. Everything the GNDs in a circuit require to be associated for it to work. Use the force connector for the receiver.

6.7.1. How to Connect the Servo Motors:

- Connect the first servo to the first analog of Arduino.
- Connect the second servo to the second analog of Arduino.
- Connect the third servo to the third analog of Arduino.
- Connect the fourth servo to the fourth analog of Arduino.
- Connect the fifth servo to the fifth analog of Arduino.

6.7.2. How to connect of the HC-12 Module:

- VCC must be connected with +5v of Arduino
- GNG must be connected with the GND of Arduino.
- SET must be connected with the digital 6 pins of the Arduino.
- RXD must be join with the digital 4 pins of the Arduino.
- TXD must be connected with the digital 5 pins of the Arduino.
- Connect reservoir capacitor of 1 mF in parallel with GND and VCC pins
- Connect HC-12 to a 6V 200mA source. Drill machine is operated on 12v supply so we must place **boost converter XL6009** on breadboard than convert 6v to 12v.

6.8. How to do Connections of the Glove (Transmitter)

It is necessary for flex sensors to have a proper circuit in order to work with Arduino. Flex sensors are sensors which can measure the deflection of change in position through change in resistance, so we use resistor as a voltage divider.

Connect the fundamental GND (ground) wire to all individual GND wires from the sensors, gets associated with the GND of the Arduino. From Arduino +5V goes to the fundamental positive voltage wire. From each flex sensor the wire is associated with a different simple info pin through the voltage divider. The circuit onto a little PCB that could be effectively mounted onto the glove. You can construct the circuit on the little breadboard rather than the PCB.

Use a battery of 8v for circuit of the glove.

6.8.1 Connections of the flex sensors:

- Join first sensor to first analog Arduino.
- Join second sensor to second analog of Arduino.
- Join third sensor to third analog of Arduino.
- Join fourth sensor to fourth analog of Arduino.
- Join fifth sensor to fifth analog of Arduino.

6.9. Schematic Diagrams

6.9.1 Transmitter:

Transmitter is used to transmit electromagnetic waves carrying a signal/message. In this project it is used to transmit the signal from glove to robotic drill so a desired movement can be obtained. When a movement is made from gloved human hand the transmitter send a signal to the receiver which read the input signal and provide the output which is the movement of robotic drill arm.

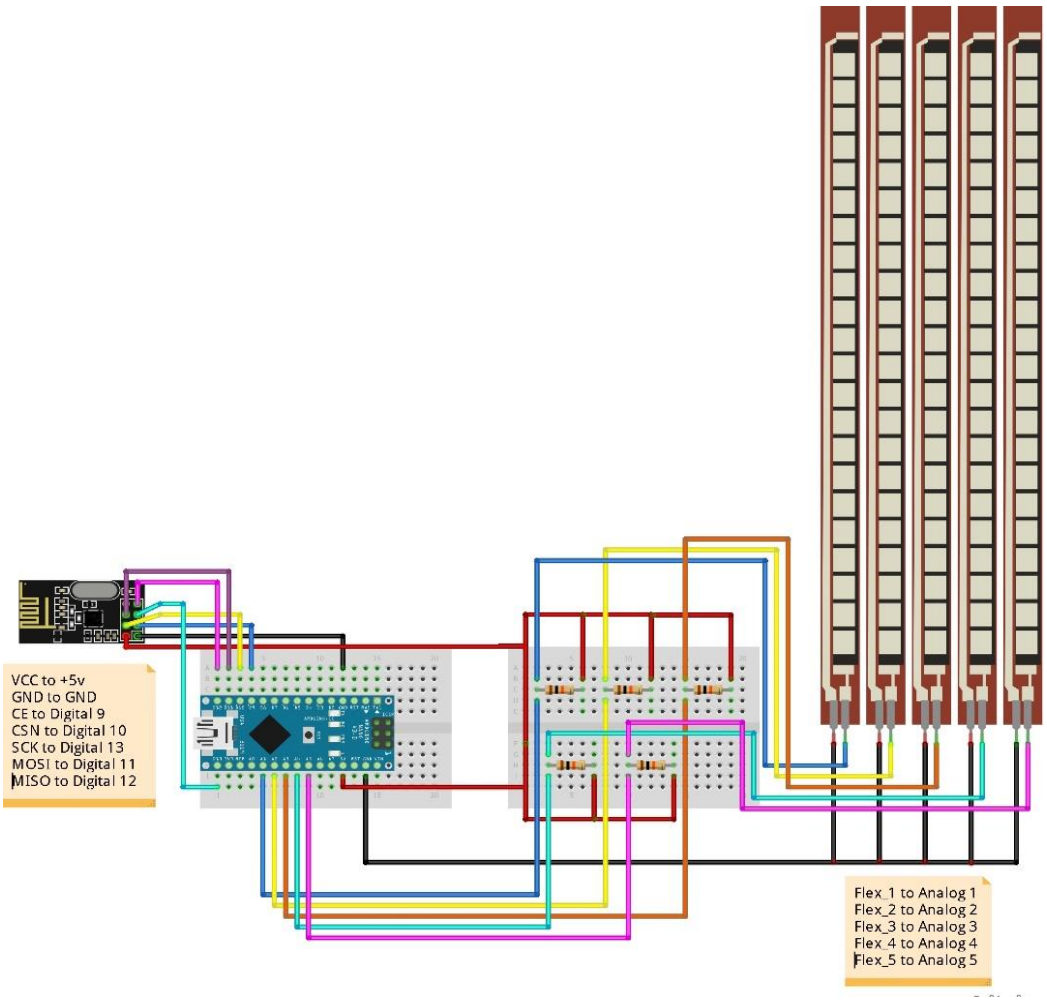

Figure 6.9.1 transmitter

6.9.2 Receiver:

Receiver, reads the input signal from transmitter and send it to servo motors in result we get our desired movement of drill arm.

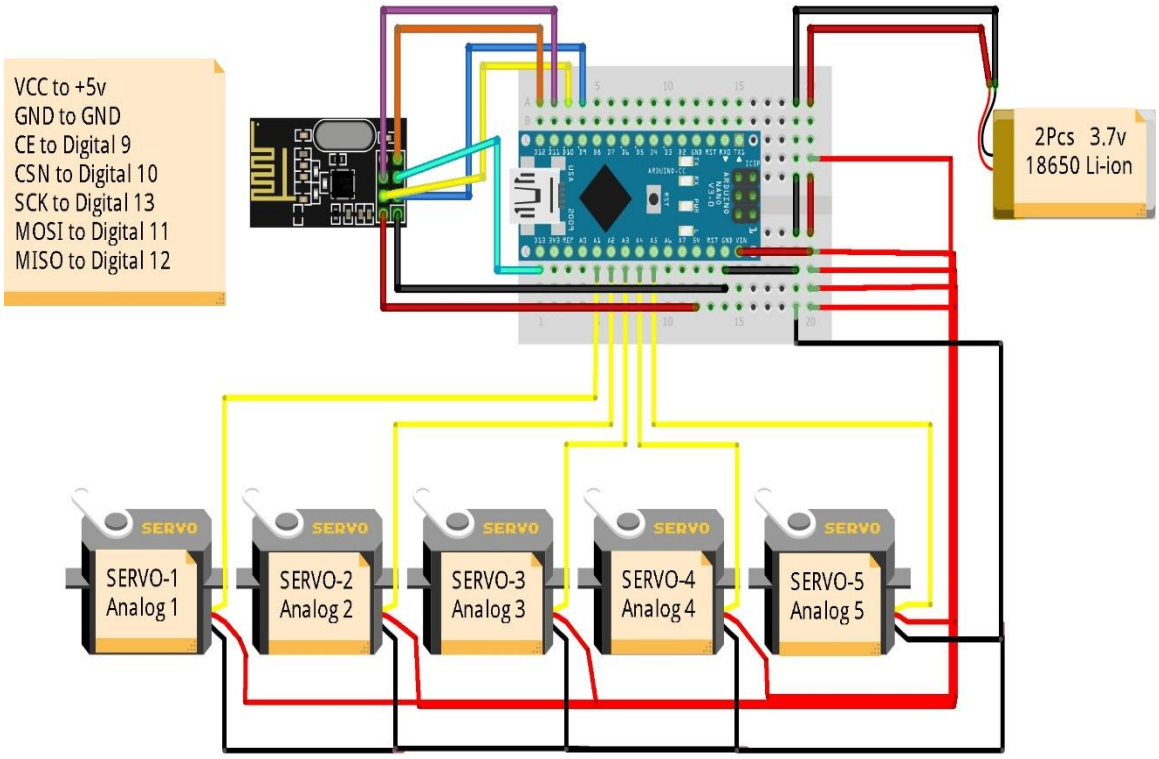

Figure 6.9.2 receiver

CONCLUSION

The robotic is play an important role in the fields of manufacturing as well as in the biomedical. In this project we developed a prototype Robotic Arm for drilling process. The main purpose of this project is to give the equipment and programming condition that will have the option to control the movement made distantly by the gloved human and play out the control of the five degrees of robotic arm. In our prototype tests it has been seen that the sensors can control the movement of the robotic arm without any issue. This is very user-friendly robotic arm that is able to perform the drilling process with the help of links attached to its motors which controls its motion by using micro-controller.. The AC power adapter supplying voltage of 6V and current of 5Amp is connected to the servo motors. The problem encountered is that slight vibrations in the robotic arm are observed due to the high current drawn by the micro servo motors during the first start-up of robotic arm.

From the following above analysis of multibody dynamics analysis we can conclude that deformation occur after arm move certain set of degree of rotation of each joints or links. The main purpose of MBD analysis is to determine the deformation of robotic arm when it move in forward kinematic as well as inverse kinematic. During drilling the force is act on the arm that cause the deformation .In future many modification is possible in this project to increase the degree of freedom i.e. six or seven, imaging processing, computer vision control, and laser detecting drilling. The benefit of the imaging processing is robotic arm is control by digital image without the involvement of human which increase the reliability of robot.in order to increase the degree of freedom design modification is needed for six degree of freedom one rotational degree of freedom is to add in end effector holder.

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