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DESIGN AND DEVELOPMENT OF HUMANOID ROBOTIC HAND PROTOTYPE FOR PICK AND PLACE

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Abstract:

This project is aimed at designing and developing a robotic hand which can aid the physically challenged persons mainly for those who lack their fore arm and wrist. The developed robotic hand helps need in pick &place of components requiring two degrees of freedom for a Cartesian work volume of 500 mm. A prototype with 2 links and 1 revolute joints consisting of 4 jaws as the end effectors is designed and manufactured to carry a load of 0.500 kg. The prototype is made of mild steel to make it rigid for load carrying and also to provide ease of manufacturing. The joints are driven by permanent magnet dc motor provided with a lead screw arrangement. The controlling of the robotic hand is operated with the help of toes, involving pitch and gripper open and close. The kinematic simulation for the robotic hand is done using Robo Analyzer software and the reach, work volume and speed of motion is simulated. By providing a higher torque motor and metal which is strong and light could help carrying more loads. The fabricated robotic hand is tested by replacing cylindrical and rectangular components from one place to another.

Key Words: Robotic Hand, Pick and Place, Handicapped & Toe Control

1. Introduction:

Robotic arm with gripper is a programmable mechanical arm with functions similar to human arm. Gripper is a device that is capable of generating sufficient gripping force to retain the object in its position. Generally robotic arm with gripper is employed for material handling applications in industries, which is similar to pick and place operation performed by human arm. The development of humanoid robotic hand to carry out similar function can be an immense benefit for human race, especially to differently abled. The human arm is analogous to Cartesian mechanical arm, whose arm has one revolute joint, whose axes are coincident with a Cartesian coordinator.

R. A. D. M. P. Ranwaka (2), has used robotic arm with a gripper to lift the object and to perform pick and place operation in a three dimensional work volume. Wai Mar Myint (3) has developed a system for automatic control of the robot end effector. Simulation software is developed for kinematic link, to do kinematic analysis and also a program is written for controlling the servo motors. I. M. H. Van Haaren, (4) has explained about robotic dynamics Ms. Shweta, (5) has developed algorithms for controlling the movement of robot arm and proved it by controlling the joints using a servo motor and a micro-controller. H. S. Lee; (8) simplified the CAD/CAE/CAM process for manufacturing the robot manipulator. R. U. R. Rossums; (9) given a short introduction about basics of robotics in context with artificial intelligence. C. R. Roche; (10) proposed a screw based method to replace D-H method for kinematic modelling and compared the results of both methods. (5) Integration of micro-controller with the robot arm to get the feedback and provide actuating signals(2)Kinematic analysis of various joints and links in the robot arm to move the end effector to the specified place(3)Lead screw and DC motor power calculation and calculation to determine the payload of the robot. Robo Analyzer is used to do simulation of the robot arm to determine the work volume, position, velocity, acceleration.

2. Definition of the Problem:

For the physically challenges persons find it difficult to do their basic needs in pick and place. To aid their ability to handle items, a minimum control of 2 degrees of freedom is required for them to access over a Cartesian work volume.

3. Kinematic Analysis:

I designed a prototype robot arm with 2 degrees of freedom. The kinematic analysis is the relationships between the positions, velocities, and accelerations of the links.

4. Denavit - Hartenberg Representation of Forward Kinematic of Robot Forward Kinematics:

In forward kinematics, the length of each link and the angle of each joint are assumed and we have to calculate the position of any point in the work volume of the robot, the below equation used.

$$^{Tool}T_{Base} = {}^{Elbow}T_{Base} \times {}^{Tool}T_{Elbow} = {}^{1}T_{0} \times {}^{2}T_{1}$$

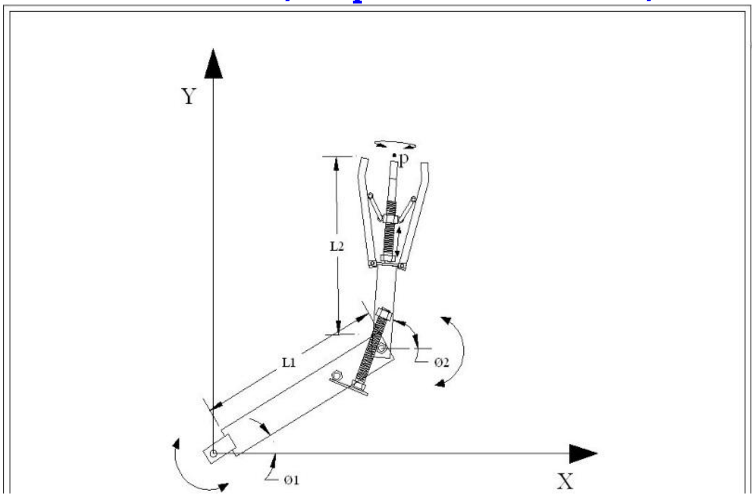


Figure 1: Forward Kinematics

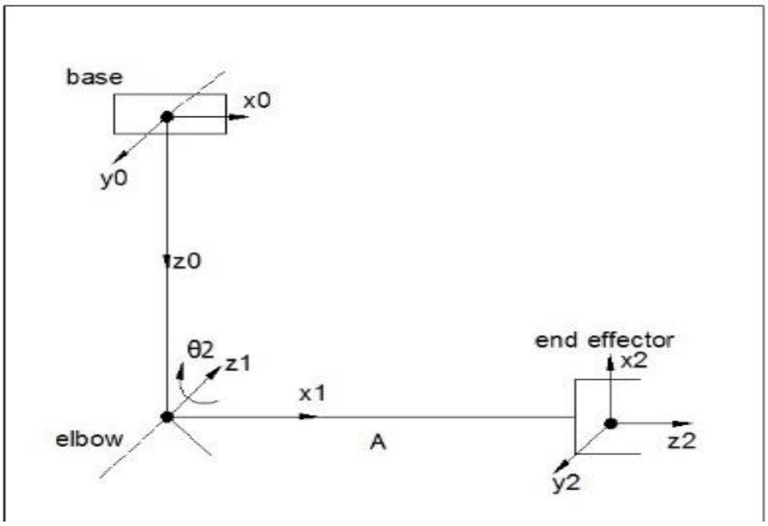


Figure 2: D-H Parameter

The figure 3 determines the total reach that can be achieved by the robotic hand by forward kinematics. The terminologies mentioned in the fig3 are as shown below.

L1=link 1 , L2=link 2, θ1=joint angle, θ2=joint angle

The D- H parameter for the robotic hand is shown in the fig 2 where, the length of the links are fixed along with the base, whereas the angle is varied based on the co-ordinate position that is to be reached by the end effector. The co-ordinate axes at both the joints used are mentioned in the figure. The values of the D-H parameters are mentioned in the table 1.

Table 1: kinematic parameter table

Joint	**Type**	**θ**	**d**	**a**	**α**	**SHP**
1	Base	Fixed	d1	0	π/2	0
2	Elbow	-90 TO +90	0	0	π/2	0

Over the Area a robot can move and activate its wrist *end* is called as a work volume. It is also denoted as the work envelope and work space. It is important typical of selecting a robot for particular application.

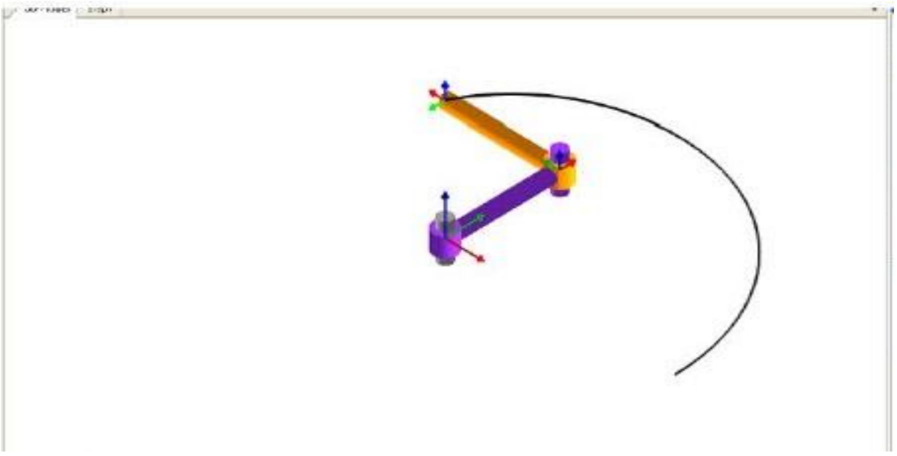


Figure 3: Work Volume

Length of movable and main each has 250 mm. probability hand can rotate up to 130 deg. And total extension of hand is 500 mm.

Circumference = π x hand length = π x 500 = 1570.8 mm

Two degree of freedom for the humanoid hand is required to do the basic pick and place application as determine by analysis of motion of the concern body.

The humanoid robot hand consists of two links and one joint. Each links are meant to has a length of 250 mm and they are attached together to form a rotational motion. The rotational angle of the links over the joint is considered to be 130 degree.

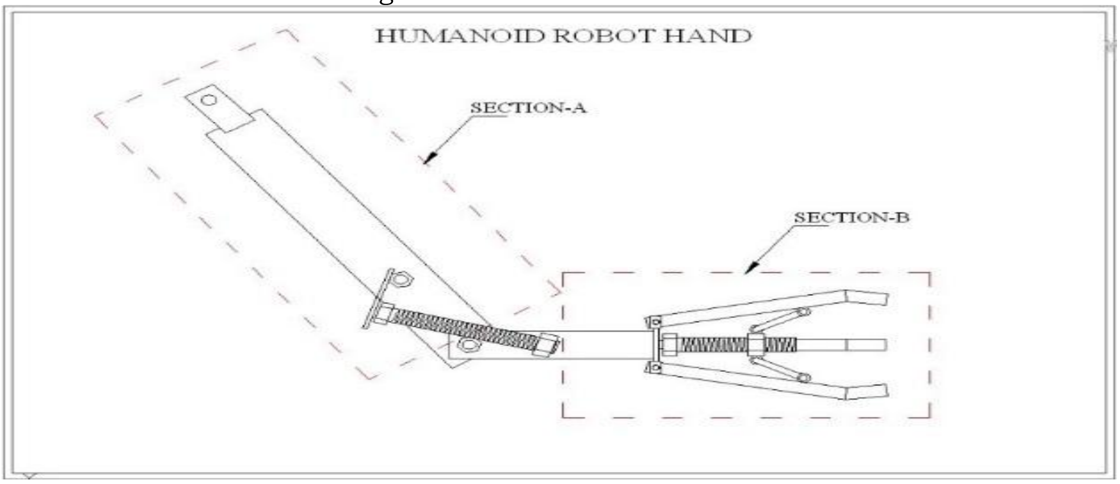


Figure 4: Humanoid Robotic Hand Model

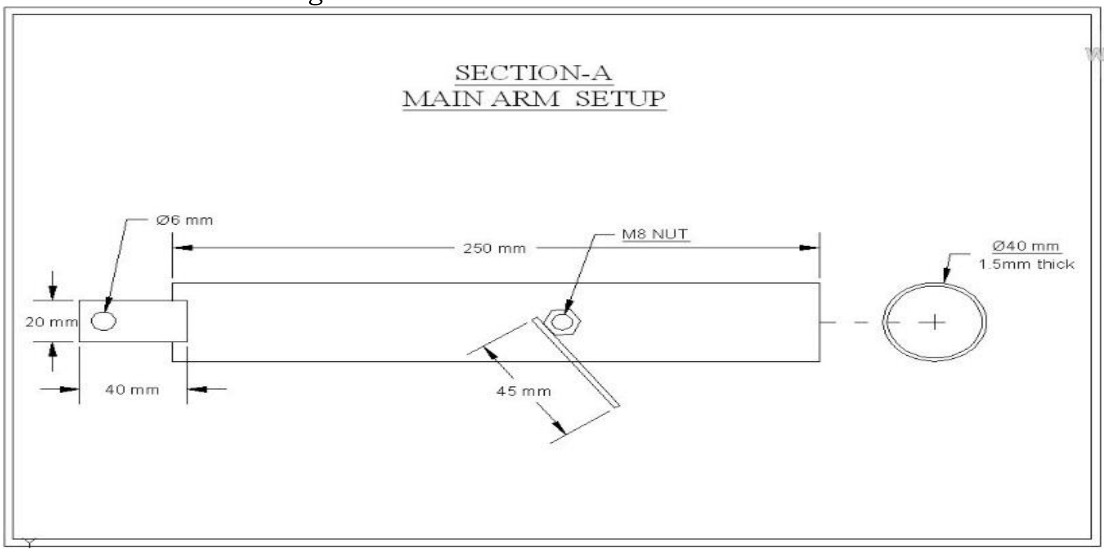


Figure 5: Link

5. Construction:

In this project we have designed the model for materials handling, a lead screw actuating gripper Connected to Motor shaft. Two sets of motor are used lead screws are using for arm and gripper actuation. 45 rpm dc motor is connected with 70 mm lead screw rod that is used to actuate the gripper. 10 rpm dc motor with 100 mm lead screw is used to actuate the arm. Typically directions of rotation of lead screw in gripper control the gripper finger in terms of grip and release. Arm movement and gripper movement is controlled by ATMEL 8051 microcontroller. In the circuit contains five switches for up, down, grip, un-grip and stop.

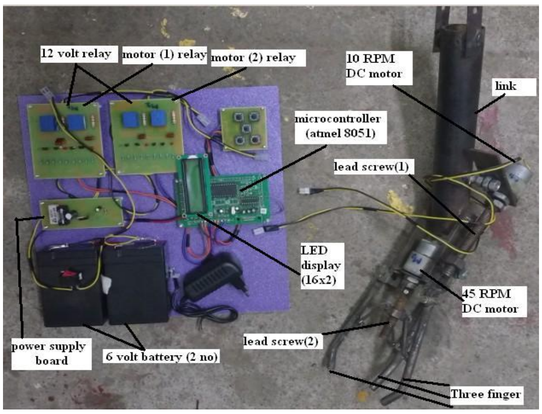


Figure 6: Micro-Controller

Table 2: DC Motor Specification for Gripper

S.No	Parameters	Value
1	Speed (N)	45RPM
2	Voltage(V)	12 Volt
3	Current(I)	0.3 A (loading condition)
4	Current (I)	0.06A(No Load Condition)
5	Power (P)	3.6Watt
6	Motor efficiency	36%
7	Motor shaft diameter	6mm

A lead screw and nut mate with impression surfaces, and therefore they have a relatively high friction compared to mechanical parts which mate with rolling surfaces and bearings. Their efficiency is classically between 25 and 70%, with higher pitch screws tending to be more efficient. A higher achievement, and more expensive, different is the ball screw. Electrical power of the motor is defined by the ensuing formula:

$$Pin = I \times V$$

$$P\,out = T \times \omega$$

Calculate angular speed if you know rotational speed of the motor in rpm:

$$\omega = \frac{N\,X\,2\pi}{60}$$

Efficiency of the motor is calculated as mechanical output power separated by electrical input power:

$$E = \frac{Pout}{Pin}$$

Therefore

$$P_{out} = P_{in} \times E$$

After substitution we get

$$T\,x\,\omega = I \times V \times E$$

$$T \times N \times 2\pi \,/\, 60 = I \times V \times E$$

Torque of the Motor:

The formula for calculating torque will be

$$T = \frac{I \times V \times E \times 60}{N \times 2\pi} \qquad (1)$$

$$= \frac{(0.3x12x0.36x60)}{45x2\pi}$$

Torque = 2.8 Kgcm

Table 3: Lead Screw Specification Gripper

S.No	Parameters	Value
1	Pitch of the lead screw (P)	3 mm
2	Speed of Lead Screw (N)	45 rpm
3	Outer diameter (OD)	12mm
4	Inner diameter (ID)	10mm
5	Thickness (T)	1mm
6	Length (L)	70mm

The table 3 gives the specification of lead screw used in gripper attached with the motor.

The linear velocity of the lead screw= N x p

$$= 45 \times 3$$

$$= 125\ mm/min = 2.0833\ mm/s$$

Hand speed of folding and extension is 2.0833 mm/s.

The angular velocity of the lead screw

$$\omega = \frac{2\pi N}{60}$$

$$= 4.7123\ radian/s$$

Power of the lead screw, P = 3.6 W

Maximum withstanding capacity = $\frac{Torque}{radius\ \ of\ \ lead\ \ screw}$

$$= \frac{0.275}{0.006}$$

Maximum withstanding capacity =45.83 N

Maximum withstanding capacity of hand and gripper is 4.6 Kg.

With the known torque value from the formula used in equ (1) the maximum load carrying capacity is found to be 4.6kg

Table 4: DC motor specification used in joint

S.No	Parameters	Value
1	Speed (N)	10 RPM
2	Voltage(V)	12 Volt
3	Current(I)	0.3 A (loading condition)
4	Current (I)	0.06A(No Load Condition)

5	Power (P)	3.6Watt
6	Motor efficiency	36%
7	Motor shaft diameter	6mm

Torque of the Motor:

Torque (T) =12.6 Kg cm

The table 4 gives the specification of lead screw used in joint attached with the motor. Maximum withstanding capacity of hand and gripper is 20.89 Kg. With the known torque value from the formula used in equ (1) the maximum load carrying capacity by the motor is found to be 20.89 kg.

Frictional Torque;

= 376.75 N-mm

Acceleration torque;

= 0.239 N-mm

Total Torque;

= 376.98 N-mm

Power Supply:

A 12v battery is used as a power source, the resister of 5ohm/5v is placed next to the battery followed by a fuse of 2Amp, 7805 regulator is used in order to regulate the power supply board, the capacitors of 2nos is used such as 1000μF and 10μF respectively .output power supply of 12v is available in the output end.

6. Micro-Controller:

ATMEL 8051 microcontroller is used in the circuit, two dc motor of 45rpm and 10rpm respectively are employed in the circuit. Input to the dc motor comes from relay. Whereas the input of relay comes from battery supply 12v.each motor consists of two relays, every relay has two resistor and one LED light which is used as a indicator of power supply to the relay, the relay's resister is connected with micro-controller ports such as p3.2INTI,p3.3INTI,P3.4/TO,P3.5/T1 respectively

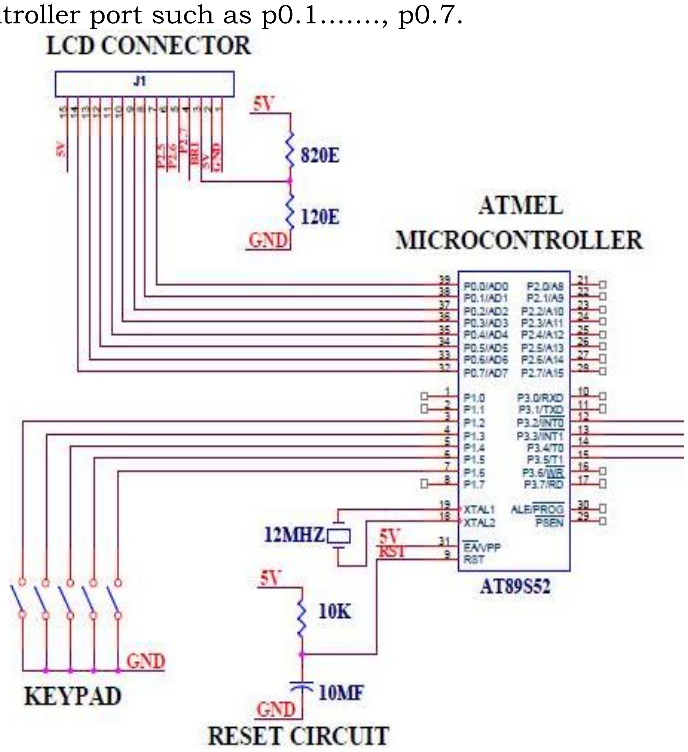
The total power requirement of the system is supplied through two 6v battery connected in series.

The voltage regulator used is 7805-5V and it provides a constant 5V supply to the microcontroller.

The commonly used relay type are end common, normally open and normally close, each requiring an operating voltage of 12V.

In the designed humanoid arm four relays of normally open type was used. The fuse act as a contact breaker between the power supply board and microcontroller, whenever the power supply changes from 5V either in positive or negative direction. Two capacitors of 10mf and 1000 mf are used in to circuit to maintain the voltage and to reduce the noise in power supply board.

Key Pad is directly connected to the micro-controller of port P1.2, P1.2, P1.3, P1.4, P1.5 and P1.6 respectively and also reset circuit is connected to the RST port of micro-controller, the five keys of keypad is used for grip, Ungrip, stop, down and up respectively. The LCD is used to display the ongoing key function with the help of 16×2, whereas 16 and 2 Number of character and lines respectively. LCD is connected to the micro-controller port such as p0.1……., p0.7.



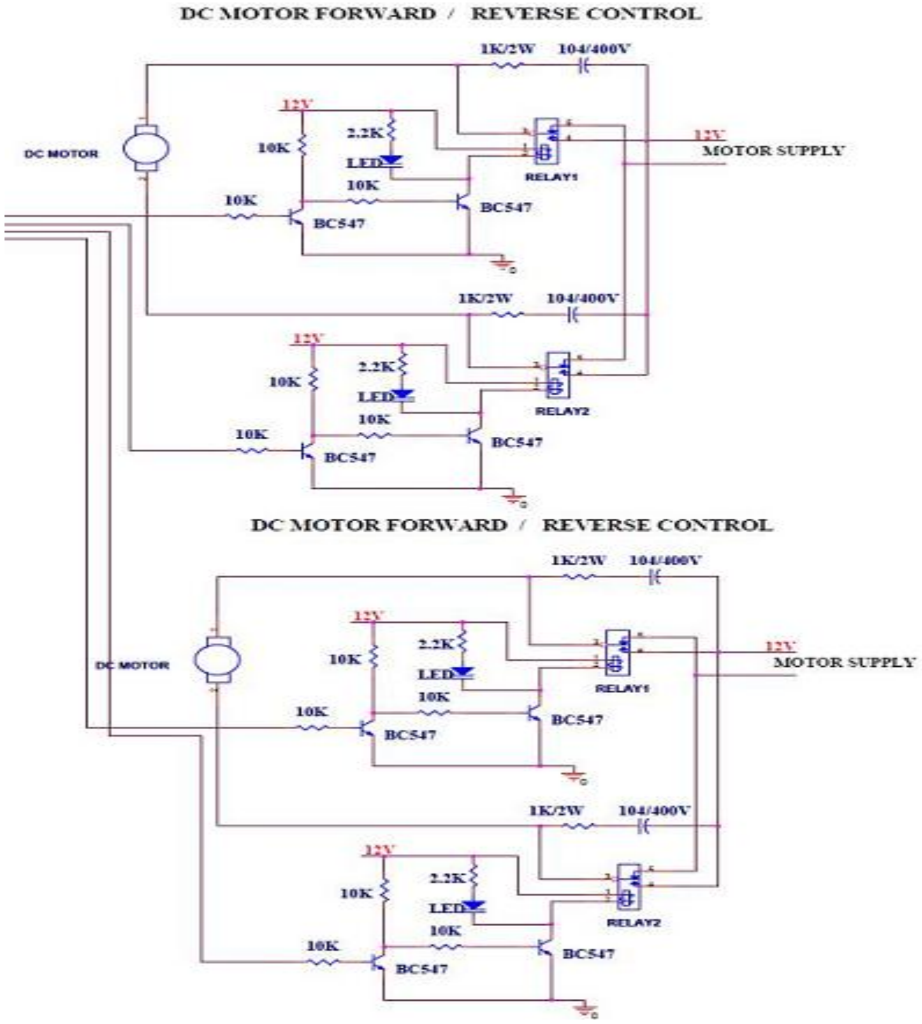


Figure 8: Micro controller circuit

7. Micro-Controller Software:

KELL$_{U}$VISION5 software is used in order to perform UP, DOWN, STOP, GRIP, UNGRIP function using the keys S1, S2.....and S5 respectively, which are connected to the micro-controller ports of P1.4......P1.7.Similarly r1,r2......r4 relays are connected to P1.0........P1.3 respectively.

```
#include<reg51.h>
 #include"smcl_lcd8.h"
sbit S1=P1^4;
sbit S2=P1^5;
sbit S3=P1^6;
sbit S4=P1^7;
sbit S5=P3^2;
sbit r1=P1^0;
sbit r2=P1^1;
sbit r3=P1^2;
sbit r4=P1^3;
 void main()
{
 r1=r2=r3=r4=1;
 Lcd8_Init();
Lcd8_Display(0x80,"HUMAN AID ",16);
 Lcd8_Display(0xc0," ROBOT HAND ",16);
 Delay(65000); Delay(65000);
 Lcd8_Command(0X01);
Lcd8_Display(0xc0," PROCESSING",16);
while(1)
{
if(S1==0)
{
r1=0;
r2=1;
Lcd8_Display(0xc0," UP ",16);
```

```
}
if(S2==0)
{
r1=1;
r2=0;
Lcd8_Display(0xc0,"  DOWN ",16);
}
if(S3==0)
{
r3=0;
r4=1;
Lcd8_Display(0xc0," GRIP ",16);
}
if(S4==0)
{
r3=1;
r4=0;
Lcd8_Display(0xc0,"  UN GRIP   ",16);
}
if(S5==0)
{
r1=r2=r3=r4=1;
Lcd8_Display(0xc0," stop ",16);
}
```

8. Reliability Testing:

The reliability test was performed using different components weighting between 50 to 1345 grams. 10 trails of experiment were carried out for each weight and the observed results are tabled as below.

Table 6: Reliability test for50 gram component

Load	No. of Trail	Pick	Move	Place
50g	1	0	0	0
	2	1	0	0
	3	0	0	0
	4	1	1	1
	5	1	0	0
	6	0	0	0
	7	0	0	0
	8	1	1	0
	9	1	1	1
	10	0	0	0

** 1-accepted & 0-rejecte

$$pick = \frac{No.of\ occurance}{No.of\ possible}$$

$$pick = \frac{5}{10}\times 100 = 50\%$$

$$move = \frac{3}{5}\times 100 = 60\%$$

$$place = \frac{2}{3}\times 100 = 66\%$$

Total reliability=50+60+66=58.66%

Table 7: Reliability test for using different loads

S.No	Load (g)	No. of Trail	Pick %	Move %	Place %	Total reliability
1	100	10	80	87	57	74
2	175	10	60	50	66	58
3	205	10	60	66	75	67
4	350	10	60	66	75	67
5	455	10	60	50	66	58
6	580	10	70	42	66	59
7	680	10	60	50	0	37
8	615	10	40	75	66	60
9	965	10	50	0	0	16
10	1345	10	40	0	0	13

9. Software Analysis:

Based on the link length and valve of the joint, Roboanalyzer software can predict the force, velocity, acceleration and work volume also the position and trajectory of the end effector can be traced.

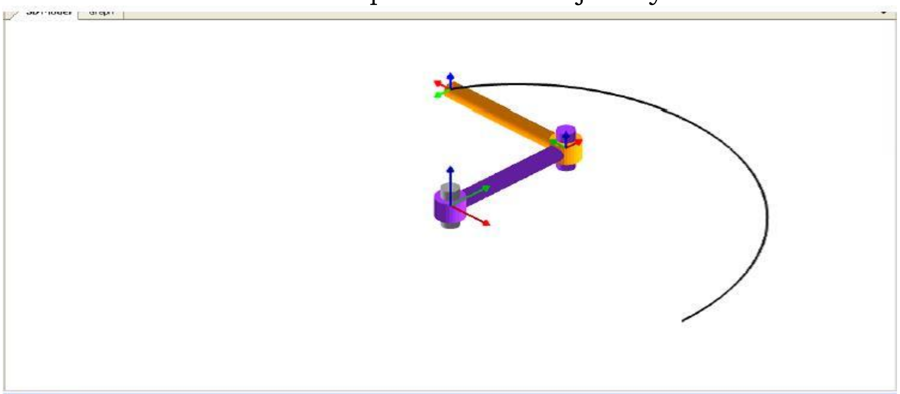


Figure 10: Joint and Link

Length of the link (X-axis) Vs time (Y-axis) for position of the link in all co-ordinates namely X, Y, Z coordinates.

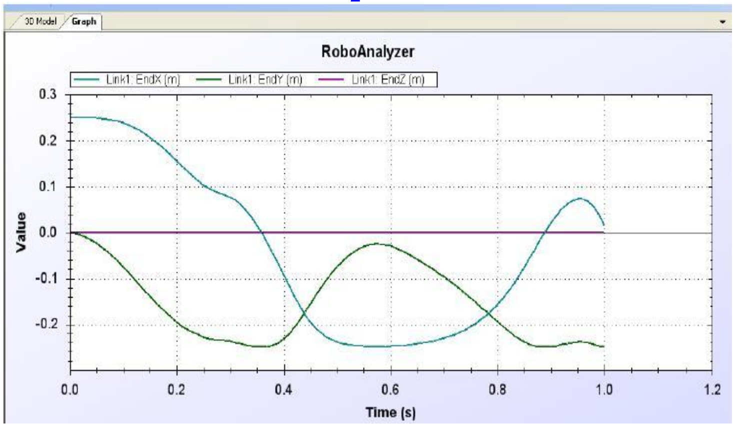


Figure 10.1: Link 1

Similar to link 1, link2 can be obtained in a form of graph as shown below

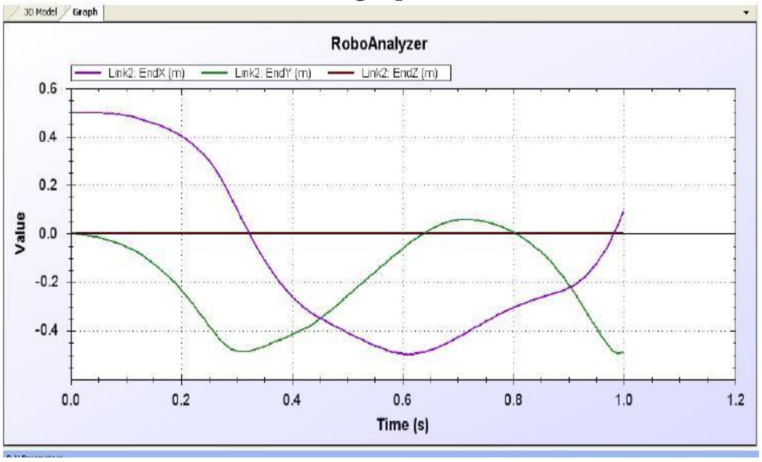


Figure 10.2: Link 2

Position of joint 1 was obtained in the form of graph for the values of degree of joint and time.

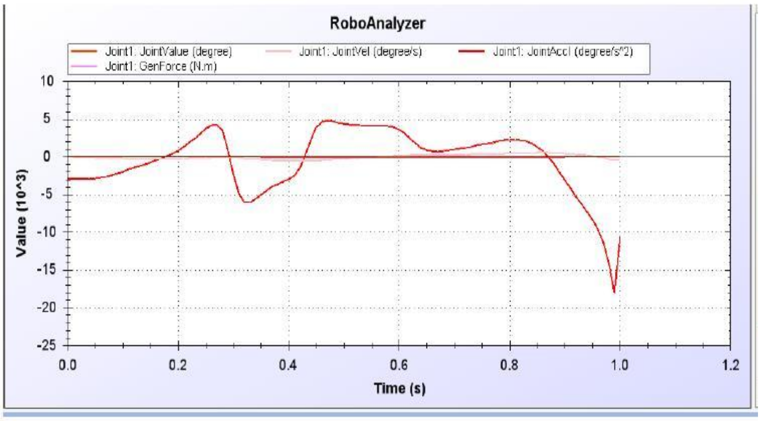


Figure 10.3: Joint 1

Similar to joint 1, other joint2 such as in a form of graph as shown below

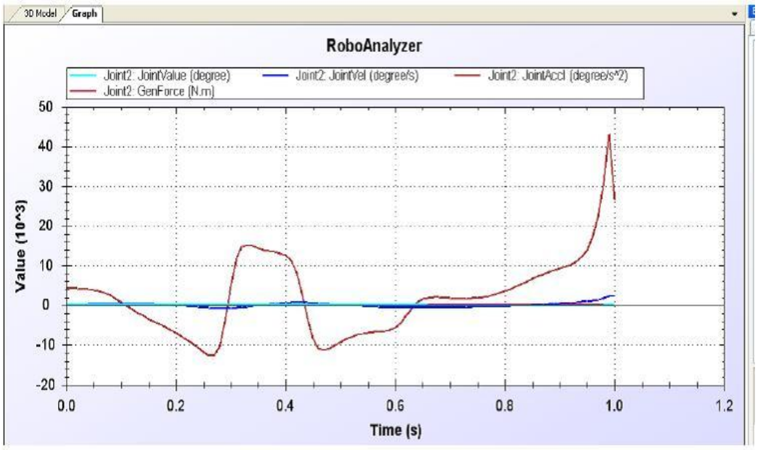


Figure 10.4: Joint 2

The figure 10.1, 10.2,10 .3 and 10.4 shows the variation in position of the links with respect to the three different axes when the angle of the link is varied causing the end effector to move in space. The links are moved in a path with varied speed and acceleration such that the trace of the end effector in the space is shown in the form of a graph.

10. Conclusion:

The prototype of the robotic arm was fabricated and tested for pick and place applications and was found to be working effectively except for the case of tapered component handling, where the jaw structure makes it difficult to hold. As the less number of links and joints are used, the controlling of the hand is made easy. Velocity, acceleration and force were found using "Robo Analyzer" software. The position(x, y & z co-ordinates) of end effector were found using Forward kinematics

11. References:

1. Shweta Patil, Dr. Sanjay Lakshminarayan, Position Control of Pick and place Robotic Arm, Robotic and Electrical Engineering
2. M. H. Van Haaren, P. W. M. Van Zutven, Design of A Robot Arm, 2011
3. Wai Mar Myint, Theingi, Kinematic Control of Pick and place Robot Arm, Mechanical Engineering (2015)
4. R. A. D. M. P. Ranwaka, T. J. D. R. Perera, J. Adhuran, C. U. Samarakoon, R. M. T. P. Rajakaruna, Micro-Controller Based Robot Arm With Three Dimensional Reach, Mechatronics Engineering
5. C. R. Rocha, C. P. Tonetto, A. Dias, A Comparison between the Denavit-Hartenberg and the Screw-based Methods Used in Kinematic Modeling of Robot Manipulators, Robot and Computer Integrtd Manufacturing 27(2011)
6. Ravi K. Jain, Somajoyti Majjumder, Bhaskar Ghosh,Surajit Saha, Design and Manufacturing of Mobile micro Mnnipulation System With A Compliant Piezoelectric actuators Based Micro Gripper, Manufacturing system (2015)
7. H. S. Lee, S. L. Chang Development of a CAD / CAE / CAM System for a robot Manipulator, Materials Processing Technology ,(2003)
8. Hashim Iqbal, Tauseef Aized, Workspace Analysis and Optimization of Link of an 8 DOF Haptic Master Device, Robotics and Autonomus, (2014)
9. Faina, F. Bellas, F. Orjales, R. J. Duro an Evoluton Friendly Modular Architecture to Produce Feasible Robots, robotics and Autonomous (2015)
10. Guanglong Du, Ping Zhang, Markerless Human –robot Interface For Dual Robot Manipulators Using Kinect Sensor, Robotic and Computer-Integrated Manufacturing, (2014)
11. Maj Stenmark, Jacek Malec, Knowledge –Based Instruction of Manipulation Tasks for Industrial Robotics, Robotics and Computer –Integrated Manufacturing,(2015)
12. Alaa Hassan, Mouhammad Abomoharam, Design of a Single DOF Gripper Based on Four –Bar and Slider –Crank Mechanism for Educational Purposes,(2014)
13. Sarah Manzoor, Raza Ui Islam, Aayman Khalid, Abdul Samad, Jamshed Iqbal, An Open-Source Multi –DOF Articulated Roboic Educational Platform for Autonomous Bbject Manipulation, Robotic and Computer –Integrated Manufacturing ,(2014)
14. Ebrahim Mattar,A Survey of Bio-Inspired Robotics Hands Implementation; New Directions in Dexterous Manipulation, Robotics and Autonomous system,(2013)
15. Wan Muhamad Hanif Wan Kadir,Reza Ezuan Samin, Babul Salam Kader Ibrahim, Internet Controlled Robotic Arm, Robotics and Intelligent Sensors,(2012)