Final Year Project Report

MIMIC MEDICAL ARM

B.S Biomedical Engineering, Batch 2004

PROJECT SUPERVISOR
Engr. Faraz Shaikh
Assistant Professor
SSUET

PROJECT ADVISOR
Engr. M. Iqbat Bhatti
Assistant Professor
SSUET

PREPARED BY

Zohiab Gulzar (Technical Team Leader)	2004-BM-12
M. Fawad Baig	2004-BM-08
Syed Danial Fouz	2004-BM-30
M. Saad Khan	2004-BM-43
Shehla Gul Khan Durrani	2004-BM-49

DEPARTMENT OF BIOMEDICAL ENGINEERING
Sir Syed University of Engineering & Technology
University Road, Karachi-75300

Sir Syed University
of Engineering & Technology

Department of Biomedical Engineering

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بسم الله الرحمن الرحيم

GROUP MEMBERS

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   2004-BM-08
3. Syed Danial Fouz
   2004-BM-30
4. M. Saad Khan
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SSUET

DEDICATION

We dedicated our hard efforts to our

Loving parents and well – wishing teachers,

Who sacrificed their lives to groom us

With precious knowledge and

Experience.

ACKNOWLEDGEMENT

In the name of ALLAH the most beneficent and ever merciful, then for his grace which gave us a bit of knowledge from the ocean of knowledge and also provides us the means, strength and divine help in completion of final year project and completion of project report titled as MIMIC MEDICAL ARM.

At the beginning we would like to thank to all those people who help and guided us so that we could complete this target on time. We are grateful to Mr.Faraz Sheikh(Assistant Prof.) supervisor, dept. of Biomedical Engineering Sir Syed University of Engineering and Technology, Karachi. He was our internal advisor who motivated and directed us in a very appropriate direction for his relentful efforts to give this project a proper shape.

Secondly we want to express appreciation and sincere gratitude to our advisor M. Iqbal Bhatti (Assistant Prof.) dept. Of Biomedical Engineering, Sir Syed University of Engineering and Technology. He was source of inspiration and gave us right end, proper guidance from the beginning of the projects to the successful completion of the project and completion of this report.

Furthermore we are thankful to our parents whose love and encouragement was the motive behind the completion of this project. Finally we are thankful to all those who cared to answer our queries and send us relevant information concerning the project which proves very useful and in formatives.

GROUP MEMBERS

PREFACE

In the world today there is a race of technology among them designing of robotic arm is the hot issue these days in a developing country like Pakistan.

Biomedical Engineering has a vast and challenging inter disciplinary domain in which each branch of engineering integrates just like the three orthogonal areas of a cube. This project is one of its types and can be used in remote operations via Biotelemetry one can use this project within the distance of 200m to perform remote operation, to work with patients suffering with spread able disease, as sign language interpretation etc. The summery of chapters are as follows;

CHAPTER # 01

Contains the brief introduction and theoretical background of the designing of robotic arm available.

CHAPTER # 02

Defines the complete system requirements of the project.

CHAPTER # 03

Contains the brief introduction of operating circuitry and components to be used in the development of project.

CHAPTER # 04

Describes the mechanical model of the project design.

CHAPTER # 05

Defines the function of each operating unit of the project to perform the mimic motion.

CHAPTER # 06

Describes all the working of the project.

CHAPTER # 07

Shows pictures of the project.

CHAPTER # 08

Contains all medical and industrial applications of the project.

CHAPTER # 09

Defines the control algorithm of the project including both hardware and software.

CHAPTER # 10

Contains details of project management, task division, time limit and work plan.

SYNOPSIS

The aim of this project is to design a robotic arm that mimics the human arm accurately as much as possible. It should be done so that the system proves to be redundant and reliable moreover it consists of;

1. A MASTER ARM, which is a wearable arm containing sensors that senses the joint movements of human arm.

2. A SLAVE ARM, which is a robotic arm that mimics the human arm.

3. A wire less bio telemetry system that can transfer the signals efficiently from the master arm to slave arm

CERTIFICATE

This is to certify that this group of final year Biomedical Engineering (Batch 2004 – 07) has successfully completed their project on “ MIMIC MEDICAL ARM “ and submitted the final year project report to the Department of Biomedical Engineering, Sir Syed University of Engineering and Technology, Karachi as a partial requirement for the award of the degree of Bachelor of Engineering in Biomedical Engineering assigned to them as prescribed by Sir Syed University of Engineering and Technology (SSUET), Karachi.

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SHEHLA GUL KHAN DURRANI	2004-BM-49

CHAIRMAN:
M. A. Haleem
Biomedical Engineering Dept.
SSUET KARACHI.

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PROJECT ADVISOR:

Engr. M. Iqbal Bhatti

Assistant prof.

SSUET KARACHI.

CONTENTS

CHAPTER # 01

INTRODUCTION

1.1 OBJECTIVE:

“MIMIC MEDICAL ARM”, as the title indicates the objective was to design a robotic arm that IMITATES and accurately analyze human arm behavior.

1.2 HISTORY:

Robotics is the science and technology of robots, their design, manufacture, and application. Robotics requires a working knowledge of electronics, mechanics, and software. Although the appearance and capabilities of robots vary vastly, all robots share the features of a mechanical, movable structure under some form of control.

The structure of a robot is usually mostly mechanical and can be called a kinematics chain (its functionality being akin to the skeleton of a body). The chain is formed of links (its bones), actuators (its muscles) and joints which can allow one or more degrees of freedom. Most contemporary robots use open serial chains in which each link connects the one before to the one after it. These robots are called serial robots and often resemble the human arm so called a ROBOTIC ARM.

In the modern world there are robotic arms that perform different tasks like gripping the objects, lifting different loads etc that were initially controlled by remotes, sound and other modes of operations depending on the requirement.

1.3 DESCRIPTION OF PROJECT

Uses of robots in the field of medicine are becoming more popular for healthcare by performing different tasks via telemetry and owing to their advantages over conventional methods. The earlier projects do not include the advancement of mimicry such as those that mimic the mechanical structure, actions and movements of human arm, are comparatively rare. However, the development and use of such structures in robotic arm is an active area of research.

MIMIC MEDICAL ARM focuses on remotely controlling a robotic arm in 3D space by sensing the actual human arm and imitates accurately the movements of human arm. Many research works has been done on designing of robotic arm according to the task but MMA not only mimic the human arm movement in a real time but also used in teleoperations. Also the previous generations on the design of robotic arm consisted of 1 DOF and 3 DOF but MMA has 6 degrees of freedom including the movement of all three joints of each finger.

CHAPTER # 2

SYSTEM REQUIRMENTS

2.1 BACKGROUND

The first step before the construction of human arm model we need to analyze the human arm movement to know the basic principle of anatomy in order to design a generic vision model of human arm that imitates human arm accurately.

The upper limb starts with the shoulder joint at humorous. Elbow is the center joint of arm and there are three bones creating movement at the elbow joint: humorous, ulna, and radius. The humorous is the longest bone of the upper extremity extended from the shoulder to the elbow. The forearm, connected from the humorous, consists of the ulna and the radius. The upper end of the ulna is curved with the end of humorous to allow flexion and extension or hinge joint at elbow . Fig. 1 shows the range of motion of the flexion – extension, which is about 150 degrees measured from the stretched arm in flexion (at elbow),the extension can be 0 degree or approximately 10 degrees below neutral anatomical position, [1].

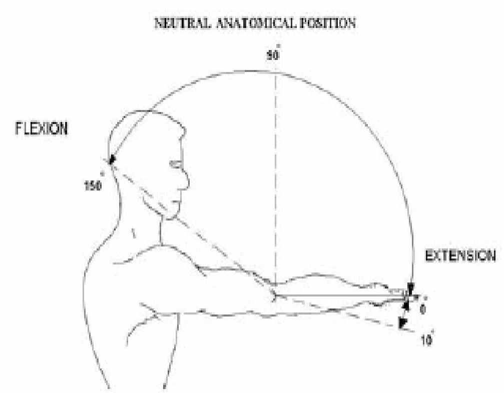
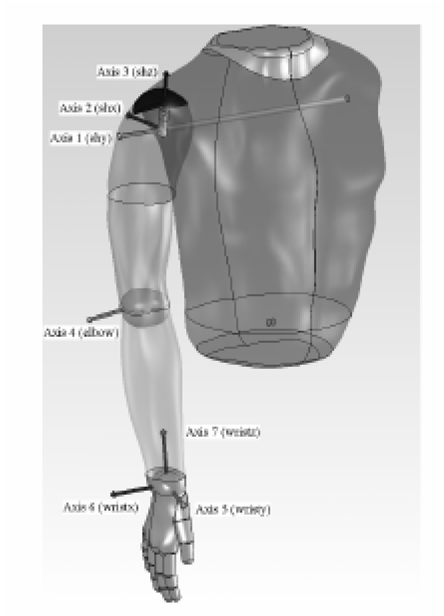


Fig. 1. Flexion-Extension range of motion

2.2 KINEMATIC AND DYNAMIC REQUIREMENT

To better understand the kinematics and dynamic requirements of an exoskeleton arm for functional use, a pilot study was first performed to see the motions of the human arm during the activities of daily living. Results of joint position and joint torque distribution of the entire database about each axis are plotted below. [2]



2.3 DEGREE OF FREEDOM (DOF)

In robotics, degrees of freedom are often used to describe the number of directions that a robot can pivot or move a joint. A human arm is considered to have 7 DOF. A shoulder gives pitch, yaw and roll, an elbow allows for pitch, and a wrist allows for pitch, yaw and roll.

In three dimensions, the six DOFs of a rigid body are sometimes described using these nautical names:

Moving up and down (heaving);

Moving left and right (swaying);

Moving forward and backward (surging);

Tilting up and down (pitching);

Turning left and right (yawing);

Tilting side to side (rolling);

The MMA model not only has all these degrees of freedom but it includes the wrist and movements of all finger joints.[2]

The exoskeleton achieves 99% of the ranges of motion required to perform daily activities

Joint	Motion	ADL ROM (deg)	EXO ROM (deg)
Shoulder	Flx-Ext	110	180
	Abd-Add	100	180
	Int-Ext Rot	135	166
Elbow	Flx-Ext	150	150
Wrist	Flx-Ext	115	120
	Rad-Uln Dev	70	60
	Pron-Sup	150	155

RANGE OF MOTION AT SHOULDER:

- Active range of motion
- Passive range of motion (normal range shown in degrees)
  - Abduction - 180
  - Adduction - 45
  - Flexion - 90
  - Extension - 45
  - Internal rotation - 55
  - External rotation - 40

RANGE OF MOTION AT ELBOW JOINT:

- Active range of motion
- Passive range of motion (normal range shown in degrees)
  - Flexion - 135

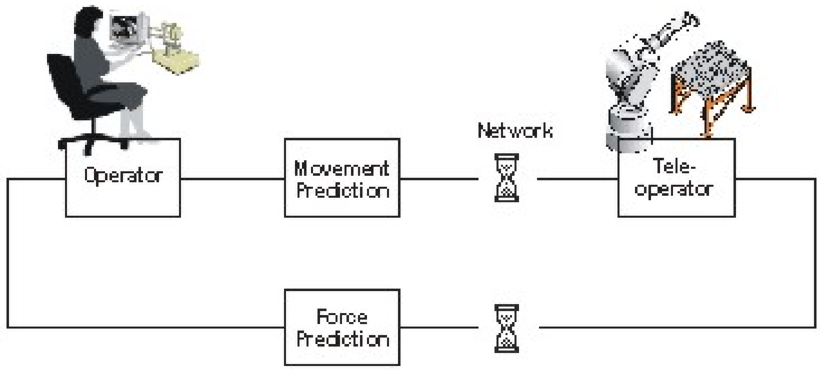
        - Extension - 0
        - Supination - 90
        - Pronation - 90

RANGE OF MOTION AT WRIST:

- Active range of motion
- Passive range of motion
    - Wrist (normal range shown in degrees)
        - Flexion - 80
        - Extension - 70
        - Ulnar Deviation - 30
        - Radial Deviation - 20
    - Fingers
        - Flexion and extension at the MCP joint
            - Flexion - 90
            - Extension - 30 - 45
        - Abduction - 20
        - Adduction - 0
    - Thumb:
        - Abduction - 70
        - Adduction - 0 (dorsal adduction)
        - Opposition (touch 5th digit)

2.4 TELEOPERATION:

Teleportation / Telemetry is a standard term in use both in research and technical communities and is by far the most standard term for referring to operation at a distance. The key feature of MIMIC MEDICAL ARM design is that it can be operated at distance via telemetry for teleportation. Teleportation indicates operation of MIMIC MEDICAL ARM at a distance. It is similar in meaning to the phrase "remote control" can be applied to a whole range of circumstances in which this robotic arm or MMA is operated by a person from a distance.



In Biotelemetry MIMIC MEDICAL ARM serves as a Slave Device – Replacing the virtual environment with a real robotic arm , the operator may use the Master arm to control MIMIC MEDICAL ARM in a teleportation (master / slave) mode, where the MIMIC MEDICAL ARM reflects back to the user the forces generated as the slave robot interacts with the environment. The MIMIC MEDICAL ARM shows a stable and high performance within a distance of 200 m.[3]

Figure 2b

The above figure shows the patient in France while the surgeons are operating the patient via telemetry from New York

CHAPTER # 3

OPERATING CIRCUITRY

MAJOR COMPONENTS

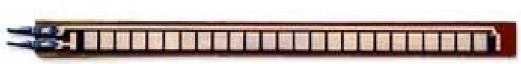
3. 1 SENSING CIRCUITRY

3.1.1 BEND SENSORS:

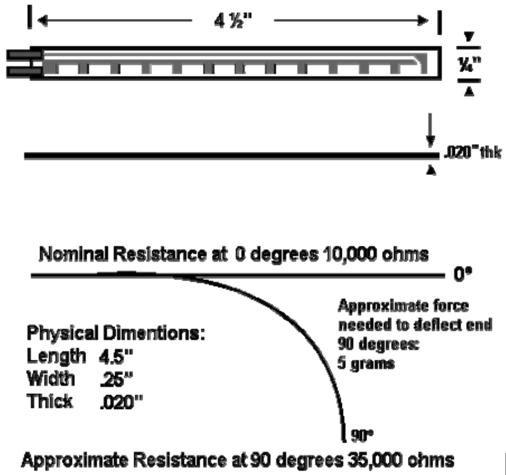
The bend sensor is composed of tiny patches of carbon that change resistance when bent. Its maximum resistance is between 30k and 40k ohms, proportional to how far it's bent. Its nominal resistance is 10k ohms. Resistor and wire assembled, ready for immediate connection to the Make Controller.

The single layer Bend Sensor® product allows for the measurement of mechanical movement, air flow, water flow, or even vibration. In addition, it has been tested to over 35 million cycles without failure. It can be used as a range of motion sensor, or as a very durable, very reliable switch in most harsh environments. The breadth of applications for our sensor is limited only by one's imagination. The Bend Sensor® product consists of a coated substrate, such as plastic, that changes in electrical conductivity as it is bent. Electronic systems connect to the sensor and measure with fine detail the amount of bending or movement that occurs. The single layer design of the Bend Sensor® eliminates many of the problems associated with conventional sensors such as dust, dirt, liquids, and heat and pressure affects. Over-laminates or over-molding may also be applied to the sensors for added environmental protection. Flex point Sensor Systems offers standard designs, and can also help you design a sensor that meets the dimensions and requirements of your application. Virtual reality data gloves - mount bend sensors on the fingers.[4]

The flex sensor may be bent greater that 360 degrees depending upon the radius of the curve. Operating temperature is -45F to 125F.



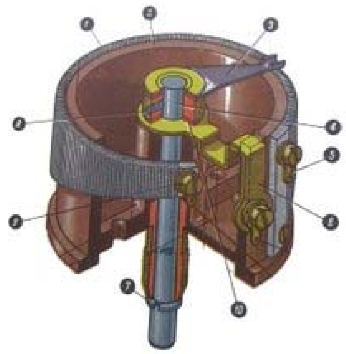
The sensor measures 1/4 inch wide, 4 1/2 inches long and only .019 inches thick.



[4]

3.1.2 POTENTIOMETER:

A potentiometer is a variable resistor that can be used as a voltage divider.Originally a potentiometer was an instrument to measure the potential (or voltage) in a circuit by tapping off a fraction of a known voltage from a resistive slide wire and comparing it with the unknown voltage by means of a galvanometer.The present popular usage of the term potentiometer (or 'pot' for short) describes an electrical device which has a user-adjustable resistance. Usually, this is a three-terminal resistor with a sliding contact in the center (the wiper). If all three terminals are used, it can act as a variable voltage divider. If only two terminals are used (one side and the wiper), it acts as a variable resistor. Its shortcoming is that of corrosion or wearing of the sliding contact, especially if it is kept in one position.[4]

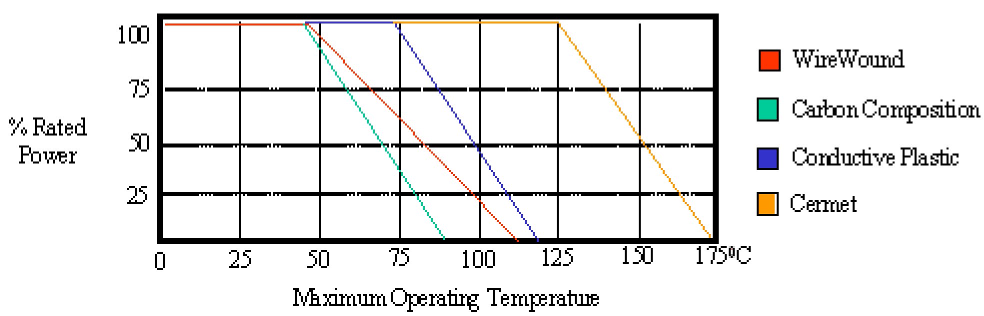


[4]

A potentiometer with a resistive load, showing equivalent fixed resistors for clarity.

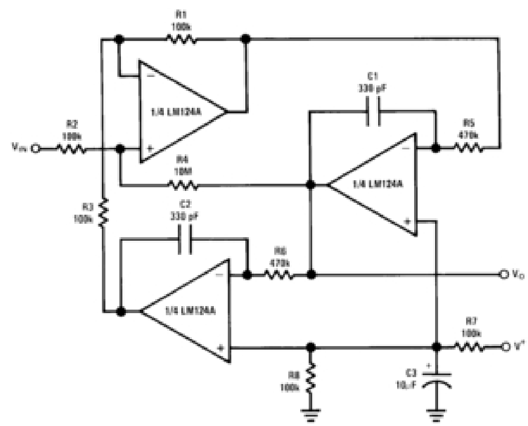
$$V_L = \frac{R_2 R_L}{R_1 R_L + R_2 R_L + R_1 R_2} \cdot V_s$$

Potentiometer Temperature Range / Derating



3.1.3 OP AMP LM324 :

The LM324 series are low-cost, quad operational amplifiers with true differential inputs. They have several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3.0 V or as high as 32 V with quiescent currents about one-fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

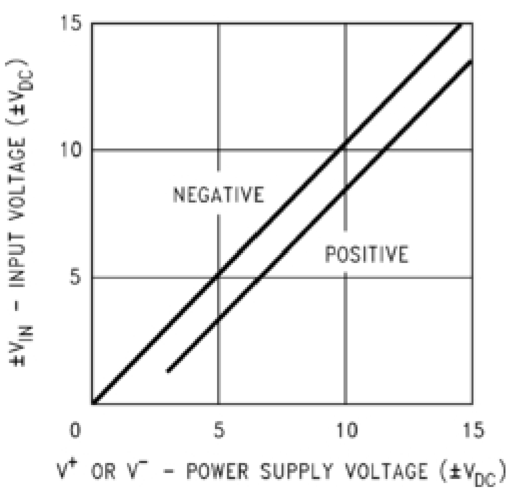


Parametric Table

Gain Bandwidth	1 MHz
Channels	4 Channels
Input Output Type	Vcm to V-, Not R-R Out
Slew Rate	0.5 Volts/usec
Supply Current Per Channel	0.18 mA
Supply Min	3 Volt
Supply Max	32 Volt
Offset Voltage max, 25C	3, 7 mV
Gain Bandwidth	1 MHz
Channels	4 Channels
Input Output Type	Vcm to V-, Not R-R Out
Slew Rate	0.5 Volts/usec

Supply Current Per Channel	0.18 mA
Supply Min	3 Volt
Supply Max	32 Volt
Offset Voltage max, 25C	3, 7 mV
Max Input Bias Current	200, 500 nA
Output Current	20 mA
Voltage Noise	40 nV/√Hz
Shut down	No
Special Features	Undefined
Function	Op Amp
Temperature Min	0, 0.0 deg C
Temperature Max	70 deg C

Typical Performance

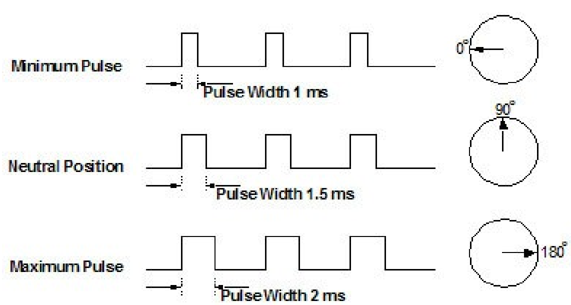


3.1.4 DC SERVO MOTOR:

[4]

Servos are DC motors with built in gearing and feedback control loop circuitry. And no motor drivers required! Servos are extremely popular with robot, RC plane, and RC boat builders. Most servo motors can rotate about 90 to 180 degrees. Some rotate through a full 360 degrees or more. However, servos are unable to continually rotate, meaning they can't be used for driving wheels (unless modified), but their precision positioning makes them ideal for robot arms and legs, rack and pinion steering, and sensor scanners to name a few. Since servos are fully self contained, the velocity and angle control loops are very easy to implement,

The standard time vs. angle is represented in this chart:



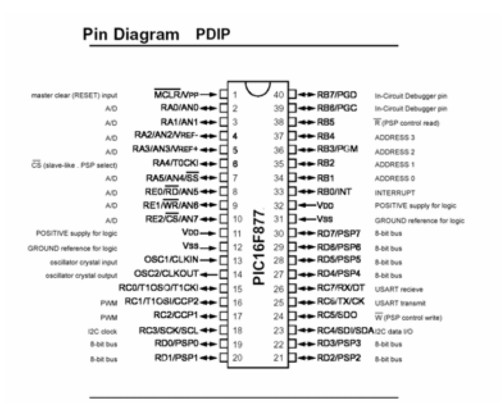
The servo turn rate, or transit time, is used for determining servo rotational velocity. This is the amount of time it takes for the servo to move a set amount, usually 60 degrees.[4] For example, suppose you have a servo with a transit time of 0.17sec/60 degrees at no load. This means it would take nearly half a second to rotate an entire 180 degrees

3.1.5 PIC microcontroller :

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC was originally an acronym for "Programmable Intelligent Computer".[1]


[1]

PICs are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.[1]



[1]

3.1.6 89C52 MICROCONTROLLOR:

The AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer Bytes of Flash programmable and erasable read only memory (PEROM).

Is manufactured using Atmel's high-density nonvolatile memory technology
Compatible with the industry-standard 80C51 and 80C52 instruction set
The on-chip Flash allows the program memory to be reprogrammed in-
Conventional nonvolatile memory programmer; By combining a versatile
With Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer
Which provides a highly-flexible and cost-effective solution too many embedded
Applications.[5]

Specifications

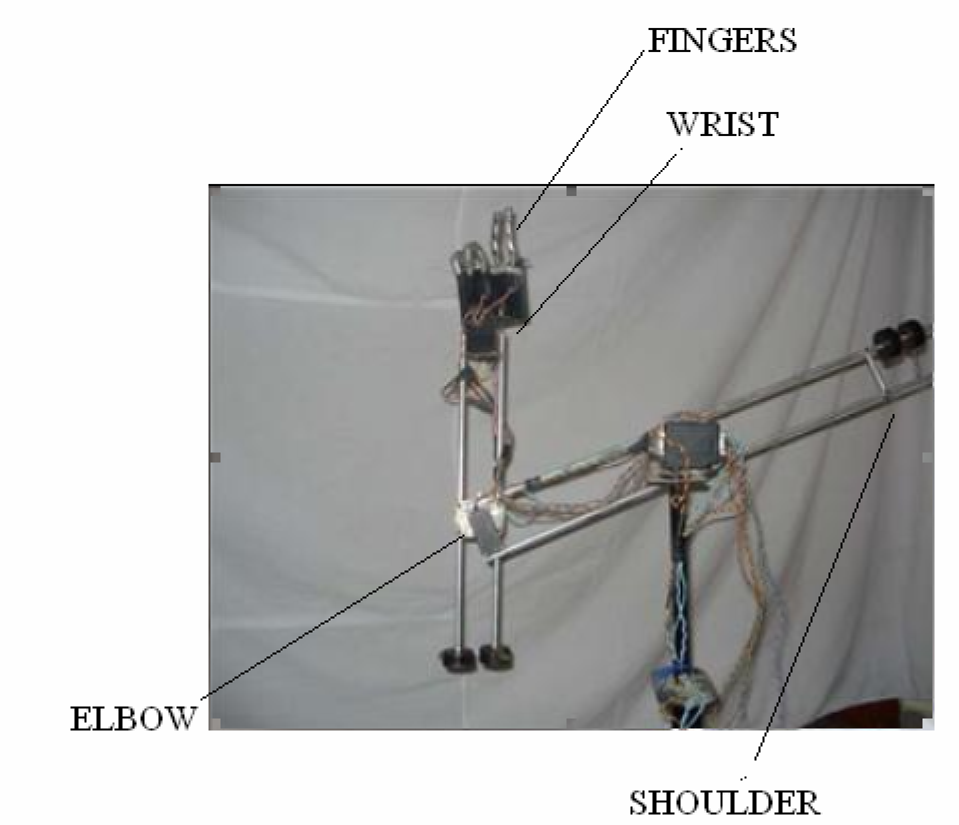
- 89C51 or 89C52 Processor
- 4K or 8K Flash (89C51/52)
- Small footprint: 1.625 by 2.25 inches
- 12 MHz or 18 MHz Operation
- 8051 software compatible
- All MPU lines brought out on connectors
- 93LC66 with 512 bytes EEPROM
- DS1232 Micro Monitor w/watchdog timer
- On-board voltage regulator
- Prototype area for custom circuitry
- Program Using Allen Systems' PB-51/11

CHAPTER # 4

MECHANICAL MODEL

4.1 MECHANICAL STRUCTURE:

The design and development of a high performance robotic arm is a process with numerous competing factors. The mechanism weight and its stiffness exist at opposite ends. Contributing to these underlying requirements are factors such as the operational workspace, desired joint torques, motor placement, link design, and additional requirements emerge regarding comfort and safety of operation.



Also the selection of material used is more important because it effects the structure, properties and working of project directly ,mostly we have used aluminum and nylon due to their low cost and reliability.

MOTOR USED

Part #	Company	Motor Dimensions	Operating Voltage	Torque
S3114	Futaba FINGERS	0.86 x 0.43 x 0.78" (21.8 x 11 x 19.8mm)	6V 4.8V	23.5 oz-in (1.7 kg-cm) 20.8 oz-in (1.5 kg-cm)
S3305	Futaba WRIST	0.8 x 0.39x 1.5" (20 x 10x 38 mm)	6V 4.8V	124 oz-in (8.9 kg-cm) 99 oz-in (7.1 kg-cm)
S3801	Futaba ELBOW	2.4"-1.2"-2.0"	6V 4.8V	194oz-in(14.0 kg-cm) 156oz-in(11.2 kg-cm)
HS-755MG	Hitec SHOULDER	2.32" x*1.14"x1.96"	6V 4.8V	199.97oz.in (14.4kg.cm) 166.64oz.in (12kg.cm)
CS-80	Hobbico SHOULDER	2.59" x1.18" x2.26"	6V 4.8V	343 oz-in (24.7 kg-cm) 275 oz-in (19.8 kg-cm)

CHAPTER # 5

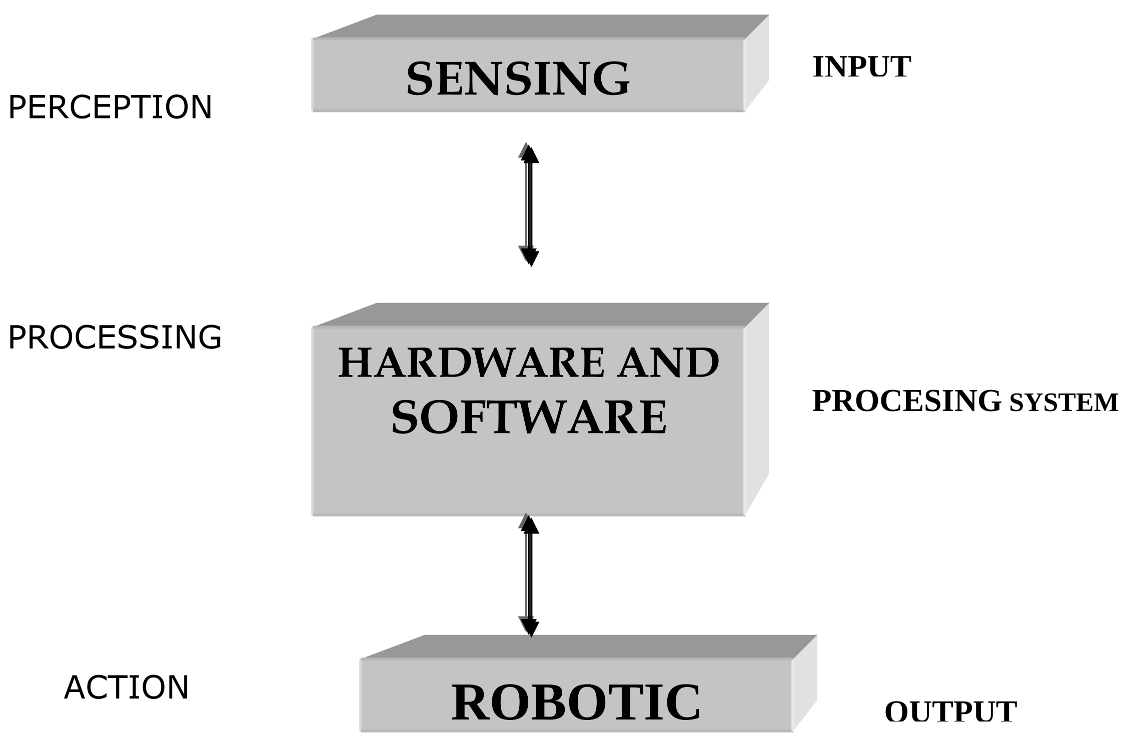
OPERATING UNITS

MIMIC MEDICAL ARM DESIGN:

The MMA comprises of three different subsystems each of which is performing an important task.

1. Perceptron unit
2. Processing unit
3. Actuator unit

The Mimic Medical Arm is a medical Application with three-tier architecture.



5.1 PERCEPTION SUBSYSTEM:

It is the MASTER ARM of the MIMIC MEDIVAD ARM and is made up of an easily wearable arm glove for sensing the movements, ease the subject. This wearable glove contains potentiometers and light weight flex sensors which sense the movements at each joint of human arm with respect to degree of rotation and speed.

The Flex Sensor is a unique component that changes resistance when bent. An inflexed sensor has a nominal resistance of 10,000 ohms (10 K). As the flex sensor is bent the resistance gradually increases. When the sensor is bent at 90 degrees its resistance will range between 30-40K ohms.

The flex sensor may be bent greater that 360 degrees depending upon the radius of the curve. Operating temperature is -45F to 125F.

5.2 COMMUNICATION SUBSYSTEM:

The data collected by perception subsystem is wirelessly sent using the wireless transceivers working in ISM Band to the Mimic Robotic Arm. The use of wireless link is to utilize MMA for remote operations. Few Sensors that are worn by Subject that senses the movement of the Human Arm. the signals received through sensors are processed and received by the Robotic Arm causing the Robotic Arm to move

5.3 ROBOTIC ARM SUBSYSTEM:

It is the final subsystem of the project and is the SLAVE ARM of the MIMIC MEDICAL ARM we have designed a SLAVE ARM (robotic arm) that resembles the human arm having gripper, wrist joint, elbow joint and the shoulder joint. Its function is to copy the movements of MASTER ARM (human arm)where the use of DC servo motors mimic the behavior of the sensed data coming from the subject perception unit and also to control the movement of gripper, wrist joint, elbow joint and shoulder joint. Servos are DC motors with built in gearing and feedback control loop circuitry. And no motor drivers required. Servos are extremely popular with robot, RC plane, and RC boat builders.

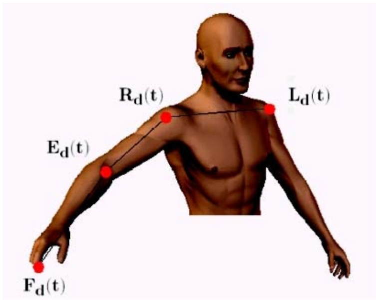
CHAPTER # 6

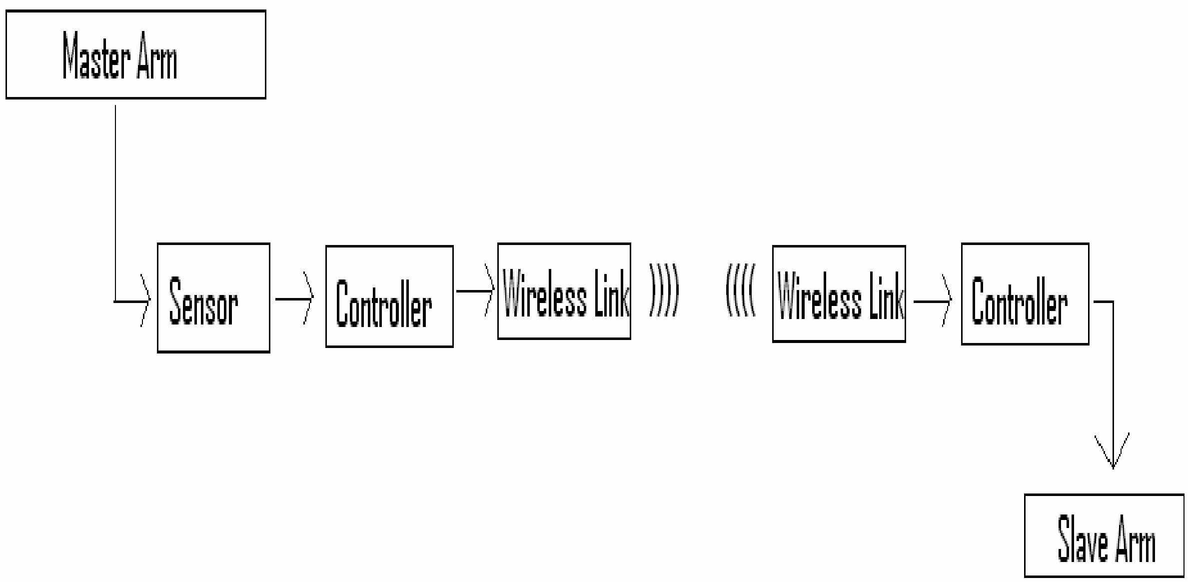
WORKING OF MIMIC MEDICAL ARM

METHODOLOGY:

The systems methodology follows a particular discipline and start from the Sensing system. The sensing structure, a wearable glove containing sensors at all joint movements worn by the user. Joint movements cause bending of sensors and the bend sensors change their resistance on bending and give voltage as their output which is sensed and this sensing gives information about the environment or the robot itself (e.g. : the position of its joints or its end effectors).This information is processed to calculate the appropriate signals to the actuators (motors) for this these sensed signals are sent to PIC 16F877 microcontroller and to the analog to digital (ADC) converter and via telemetry this data is transmitted to the receiver module The transmitter digitizes analog physiological signal, converts into serial form, forms a digital data packet by summing data and synchronization information and transmits the packets via an FM transmitter. The receiver side amplifies and pulse-shapes the received data packet, separates the data and synchronization information, converts serial data into parallel form and then into analog signal. A special coding method provides high noise immunity and proper synchronization between transmitter and receiver.

The MAX 3232 transceiver have a proprietary low dropout transmitter output stage enabling true RS – 232 performances. The MAX 3232 are guaranteed to run at data rates of 120kbps while maintaining RS – 232 outputs levels, saving the use of MAX 3232 from converting RS – 232 from serial port, now the signal is directly connected to the RT433F4 transceiver which is connected with 89C52 controller where a PWM module is sat via timers and through timers and PWM the motors are controlled and driven which moves the mechanical Robotic arm and by this technique each movement , executed by the MASTER is copied by the SLAVE with the same speed per degree and the rotation angle of the Human arm movement. For example when a subject moves his elbow joint at 0.2sec/60 degree and the angle of rotation is 40 degree, the robotic arm’s elbow joint will also move at 0.2sec/60 degree and 40 degree angle of rotation. We have tried to control the speed of the arm by selecting (using) high speed and high torque motors that are fixed in the joints of the robotic arm.

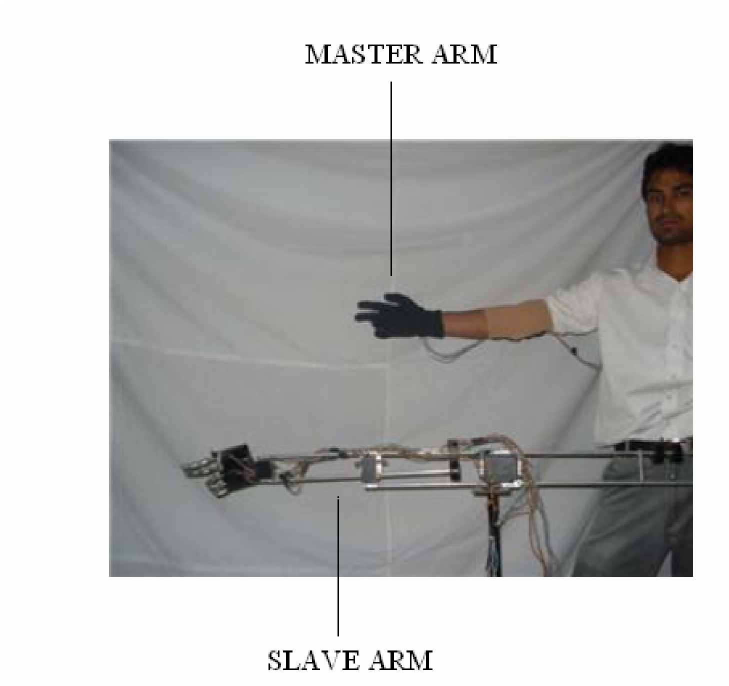

$R_d(t)$
$L_d(t)$
$E_d(t)$
$F_d(t)$


Master Arm
Sensor
Controller
Wireless Link
Wireless Link
Controller
Slave Arm

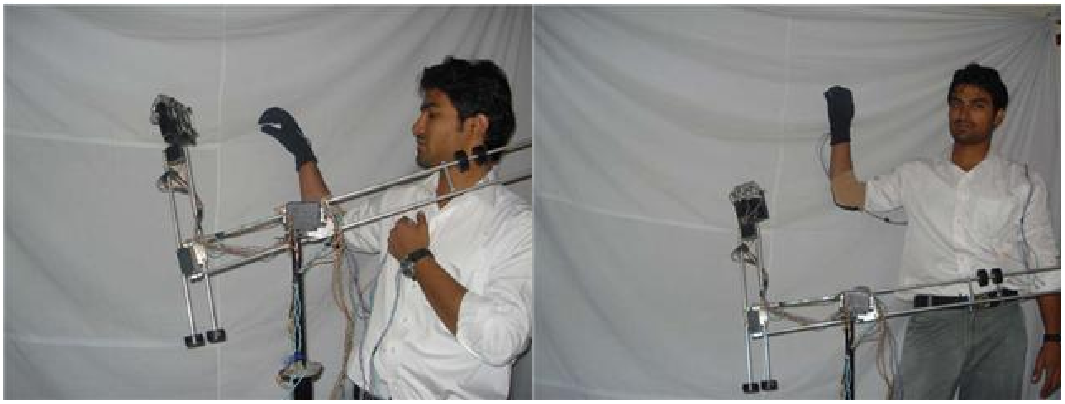
CHAPTER # 7

PICTURES OF PROJECT

PICTURES OF MIMIC MEDICAL ARM:



Above pictures showing the mimic motion



SHOWING FLEXION AT ELBOW JOINT

SHOWING FLEXION AT ELBOW JOINT AND MOVEMENTS OF FIBGER JOINTS

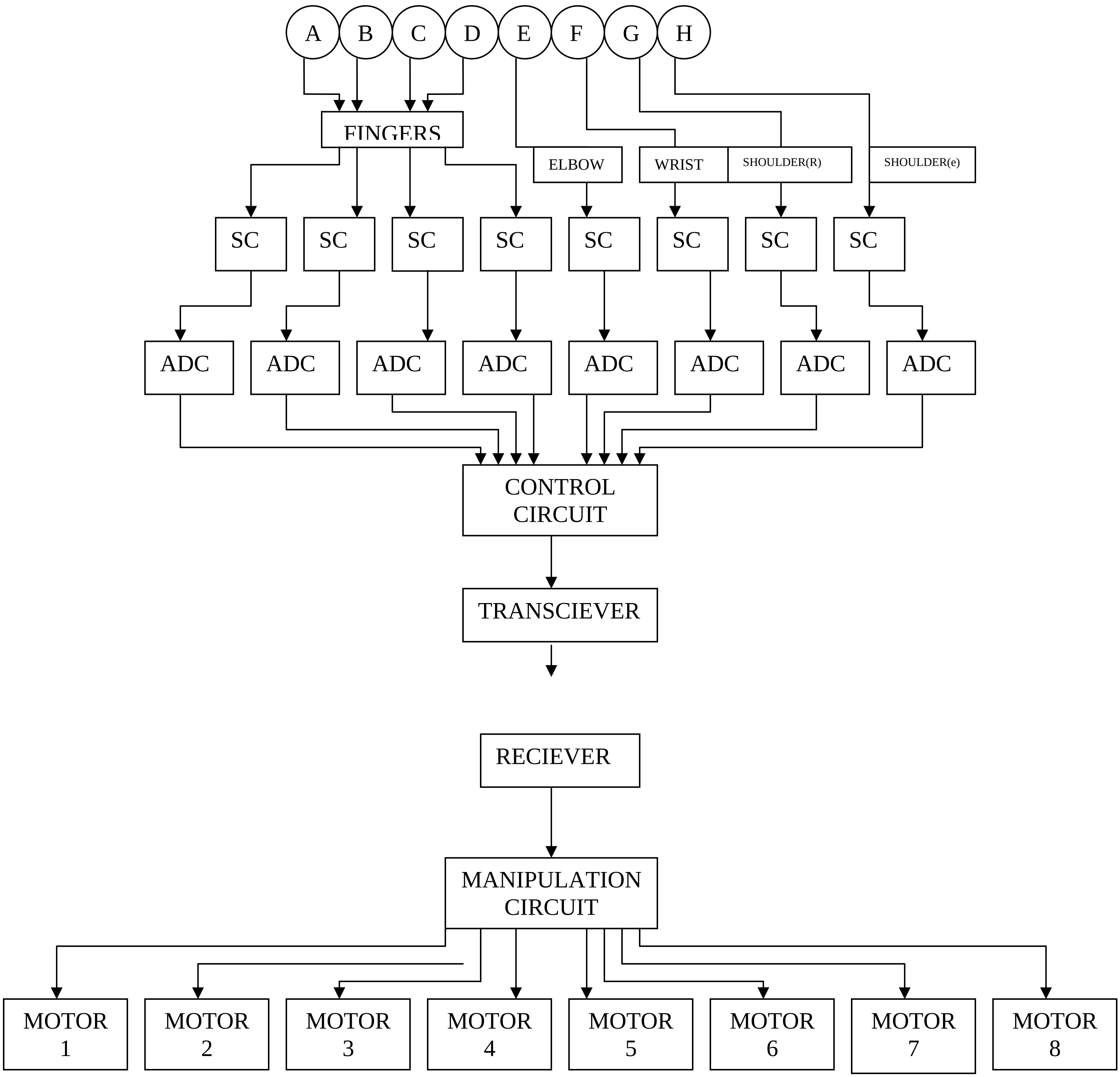
SHOWING EXTENTION

CHAPTER # 08

CONTROL ALGORITHM

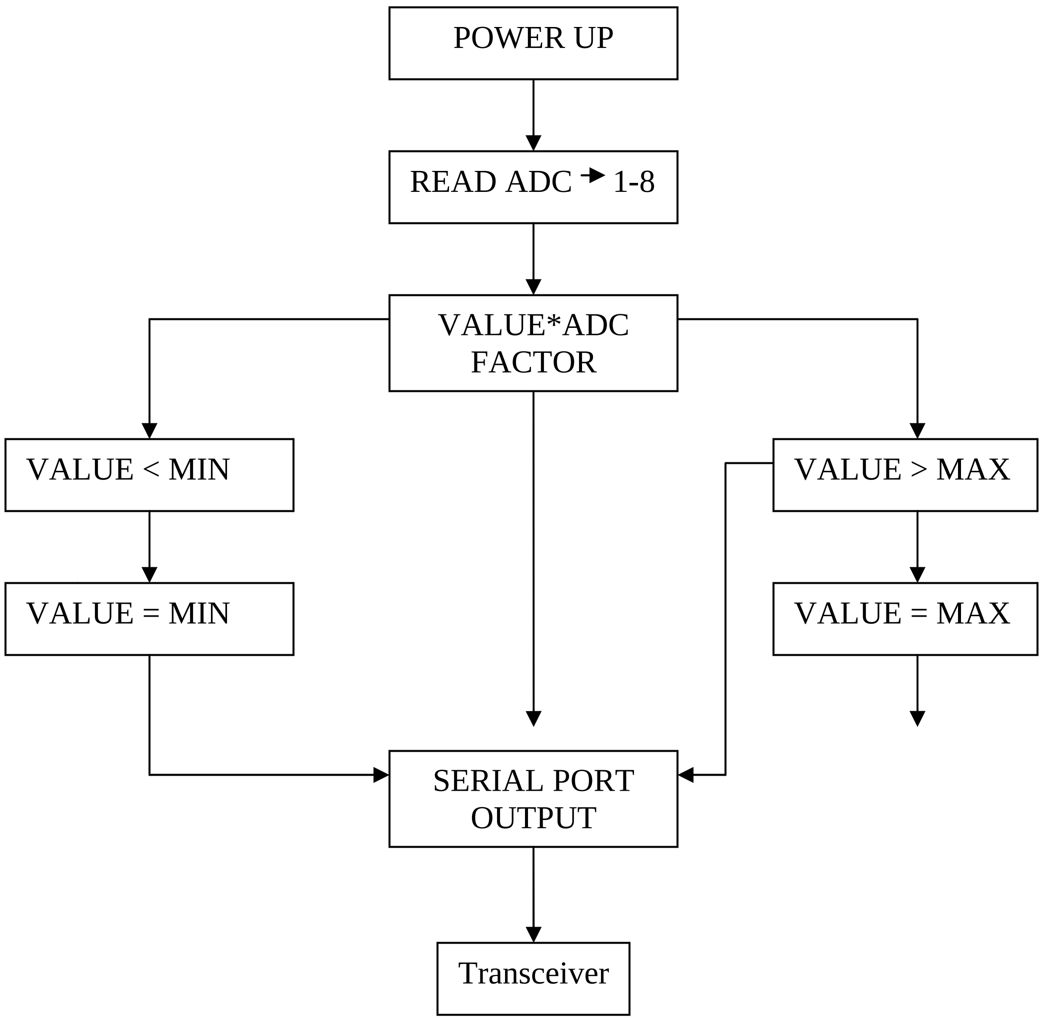
HARDWARE ALGORITHM:

SENSORS FROM BODY

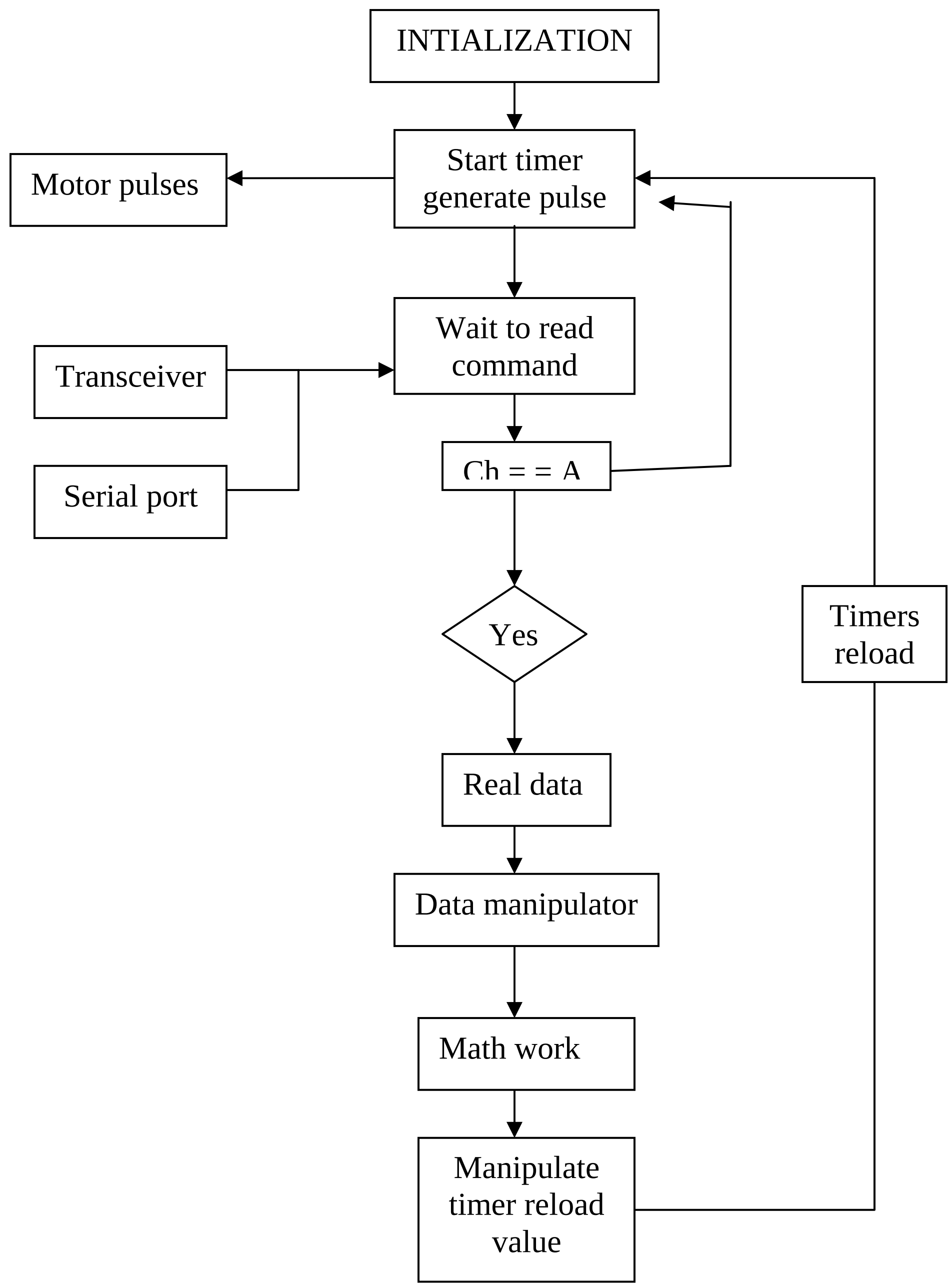


SOFTWARE ALGORITHM:

AT SENSING SIDE



AT SLAVE SIDE:



CHAPTER # 9

MEDICAL AND INDUSTRIAL APPLICATIONS

8.1 MEDICAL AND INDUSTRIAL APPLICATIONS OF THIS PROJECT

The MIMIC MEDICAL ARM can be used in following modes of operations:

1. To perform remote operations.
2. Useful while working with Bio hazardous materials.
3. To work with patients suffering from spread able diseases.
4. Handles heavy weights easily.
5. The sensing arm can also be used as sign language interpretation.
6. Helpful for the patients who do not have proper arm strength, physically weak persons such as elderly, injured or disabled.
7. Provides various advantages in the health care industries like medicine, chemical etc.
8. As a therapeutic and diagnostics device for physiotherapy.
9. As an assistive (orthotic) device for human power amplification.
10. As a hepatic device in virtual reality simulation.
11. As a slave device for teleportation.

CHAPTER # 10

PROJECT MANAGMENT

PROJECT MANAGEMENT:

In principle there is always more than one person working on one specific task. Our team has a designated leader who indicates the responsibilities of each squad member.
To handle the workload required for this project, the responsibilities were split between the group members.

The project management team was proposed as.

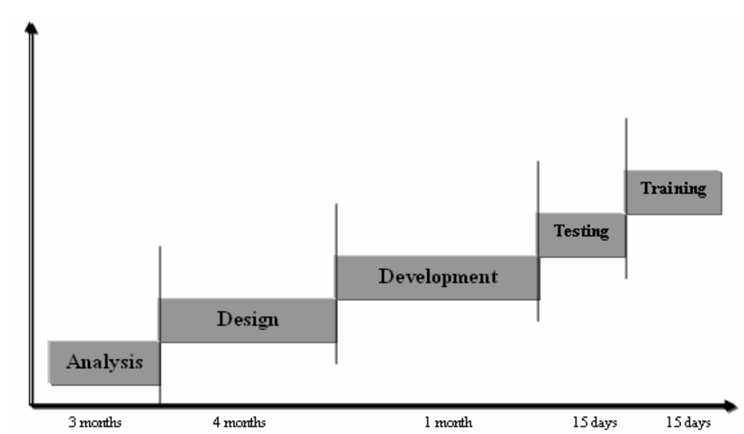
- SUPERVISOR – Engr. Faraz Sheikh, the team supervisor is responsible for supervising us towards the better way and sort out related problems internally.

- ADVISER – Engr. Muhammed Iqbal Bhatti, the team Adviser guide our team and advising the different areas of the project.

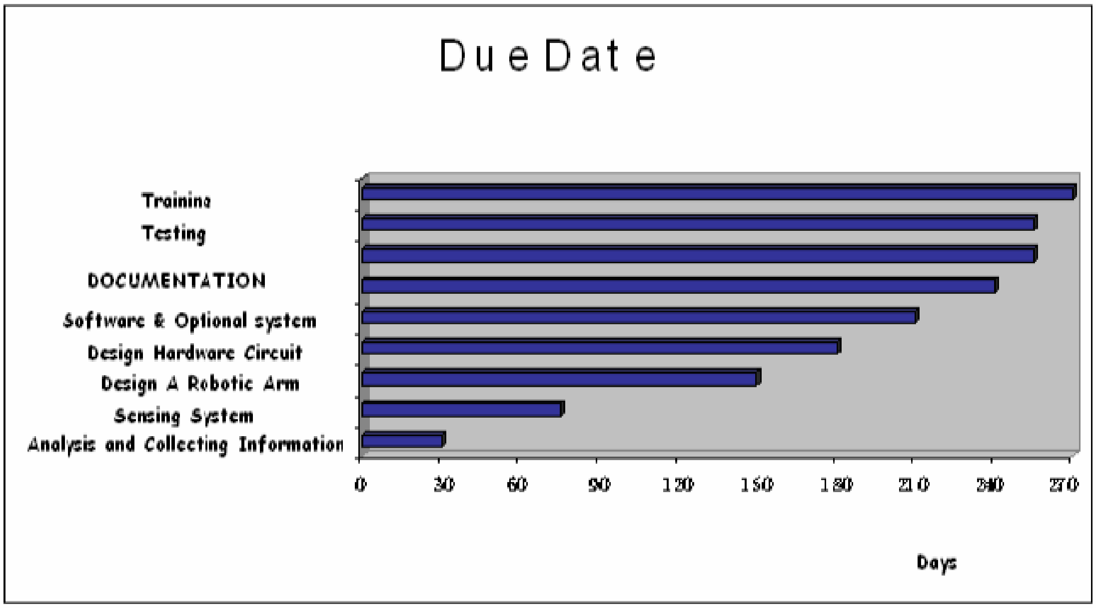
- CLIENT / PROJECT TEAM CONTACT – Mr. Zohaib Gulzar, the team contact person is responsible for managing all contacts between the development team and staff. To keep the project on schedule and avoid communication problems in project related issues must be manage through your contact person.
- PROJECT MANAGER & TEAM LEADER – Mr. Zohaib Gulzar (Roll No. 2004-BM-012), the project manager was responsible for internally managing the project to meet the production schedule and budget constraints and guide the team very efficiently and help the team member's problems and solving their respective task, keeping involved individually with every team member.
- SLAVE DEVELOPER -- Mr. Muhammad Fawad Baig (Roll No. 2004-BM-08) was responsible for the development of the SALVE (robotic arm).

- SENSING OF ROBOTIC ARM. –- Mr. Muhammad Saad Khan (Roll No. 2004-BM-043) was responsible to develop the sensing circuitry of the SLAVE (robotic arm).
- HARDWARE DEVELOPER & IMPLEMENTATON -- Mr. Syed Danial Fouz (Roll No. 2004-BM-030) was responsible to develop the hardware circuit and implement it on the Robotic Arm to achieve desired performance so as to attain the objective.
- ANALYSIS OF HUMAN HAND & DOCUMENTATION – Miss. Shehla Gull khan Durrani (Roll No. 2004-BM-049) was responsible for Developing and researching required Solution and all the necessary documents, like report operating Manual etc.

10.1 COMPLETION SCHEDULE



WORKING PLAN



CONCLUSION

In order to promote high performance while ensuring safe operations, the requirement for developing the 6 DOF robotic arm that mimics the human arm movements and used in teleportation must be realized and understood both from their technical as well as functional aspects. Additionally principles of physiological joints can assist in achieving a relatively high performance system. The selection of components, motors, potentiometers, bend sensors, transceiver, and material used are the few features that add to the performance and ease-of-use of the MIMIC MEDICAL ARM for teleportation.

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