



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



Sudan University Of science And Technology

College of Engineering

Biomedical Engineering Department

**DESIGN OF ROBOTIC ARM USES IN HOT LAB
OF NUCLEAR MEDICINE**

تصميم ذراع آلي يستخدم في مختبرات الطب النووي

**This Project Submitted In partial Fulfillment for the
Requirement of the Degree of B.S.c (honor) Degree in
Biomedical Engineering**

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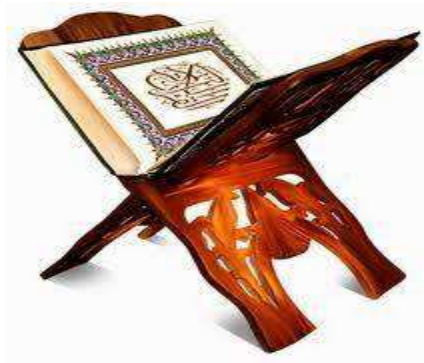
الآية

قَالَ تَعَالَى:

﴿ يَتَأَيُّهَا الَّذِينَ ءَامَنُوا إِذَا قِيلَ لَكُمْ تَفَسَّحُوا فِي الْمَجَالِسِ فَأَفْسَحُوا
يَفْسَحَ اللَّهُ لَكُمْ وَإِذَا قِيلَ أَنْشُرُوا فَأَنْشُرُوا يَرْفَعِ اللَّهُ الَّذِينَ ءَامَنُوا
مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ ﴾

المجادلة: ١١

صدق الله العظيم



Dedication

*Every challenging work needs self-efforts as well as guidance
of elders especially those who were
very close to our heart.*

*Our humbles effort we dedicate to our sweet and
loving*

Fathers & mothers.

*Whose affection, love, encouragement and prays
of day and night make us able to get such
success and honor.*

*Along with all hard working and respected
Teachers.*

Acknowledgement

We are indebted to a number of individuals for the help, support, and guidance they have provided to help this work to be done, to them we dedicate all thanks and grate fullness, Special thanks for our supervisor Dr. Eltahir Mohammed Hussein.

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List of Abbreviations

IFR	International Federation of Robotics
USB	Universal serial bus
AC	Alternating Current
DC	Direct Current
V _{in}	voltage input
GND	Ground
ICSP	In- circuit serial programming
FTDI	Future Technology Devices International
Emf	Electromagnetic field
Pwm	pulse-width modulated
UART	Universal asynchronous receiver/ transmitter
VCC	Collector supply <i>voltage</i>
RXD	Receive data
TXD	Transmitted data
<i>DOF</i>	Degree of freedom
<i>DH</i>	<i>Denavit Hartenberg</i>
FPGA	Field Programmable Gate Array
FR4	Flame retardants
GUI	Guide

VHDL	<i>VHSIC Hardware Description Language</i>
I/O	Input /Output
RIA	Radioimmunoassay
ICRP	International commission on radiological protection
NCRP	National council on radiological protection
ALARA	As Low As Reasonably Achievable

List of symbols

F	Force
T	Torque
M	Mass
G	Gravity
L	Length
W	Weigh
Ω	Resistance
H	Henry
V	Volt

Abstract

The aim of this project is to improve the safety level in hot labs of Nuclear medicine by assign the job of preparation radiopharmaceutical application, and signal send from android application to Arduino.

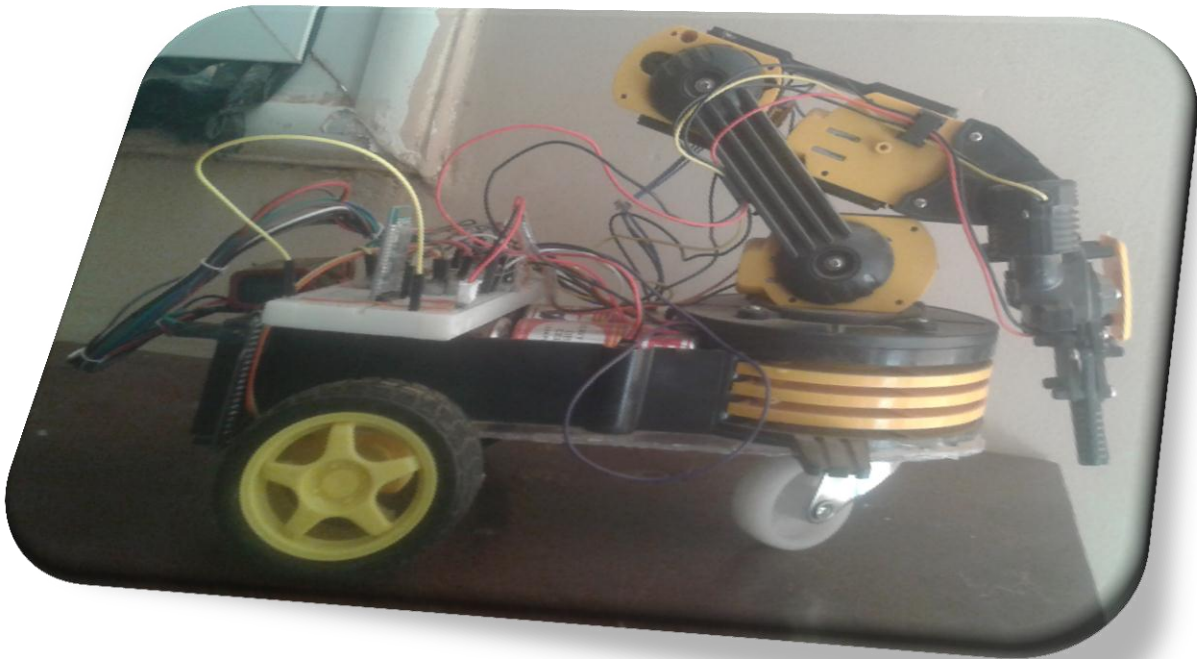
The proposed work described the hardware and software to operate the system. Finally obtained results are of acceptable values.

المستخلص

يقدم هذا المشروع تصميم وتطبيق يحسن مستوى الحماية في مختبرات تحضير العينات الاشعاعية في الطب النووي وذلك باستخدام الذراع الألي الذي يؤدي الي تجهيز جرعة اشعاعية لحماية الانسان من التعامل مع المواد المشعة مباشرة وتتم السيطرة علي الذراع باستخدام برنامج الاردوينو والموبايل بحيث يتم نقل الاشاره من التلفون الي الاردوينو ويتم مراقبه حركة الذراع الألي. واخيرا النتائج المستخلصة مقبولة.

Chapter One

Introduction



Chapter One

Introduction

1-1 General view

When mentioning robots, many people will think about machines with hands and feet. However, this kind of machines often appears in scientific movies, entertainment, exhibitions and toy stores. They are very different from industrial robots. Industrial robots are abbreviated as IR. Most of them are simple apparatus, sometimes they are called robotic arms.

Robotic arms are used in performing simple up-and-down motion, to take and pick out components from machines. However, a lot of machines can be entirely controlled by programs to do different types of jobs, such as, searching, transportation, targeting, assembly and inspection.

Many types of robotics are designed and developed to achieve a complex, sensitive, accurate and hard works such as chemical reactions (hot lab) for purpose of control robot, which works inside a radiation regions in nuclear medicine.

For radiation safety issue, nuclear medicine facilities are divided into two parts: i) controlled area, and ii) supervised area. Hot lab is named as controlled area/room where radionuclides are always stored.

The workers have to work in the hot lab, they spend most of their time for patient dose preparation. Therefore, keeping exposure below the radiation protection issue in the hot lab is an important factor.

1-2 Problem statement

Radiation can interfere with the body and potentially cause harm, it can potentially cause somatic and genetic effects including development of cancer and congenital anomalies.

The effects and dangers of some forms of radiation are not completely known. It is very difficult to detect all reasons. Some health effects of ionizing radiation are well known, yet some other are controversial. Workers in nuclear medicine can be exposed to many different forms of radiation.

1-3 objectives

There are two objectives for this research:

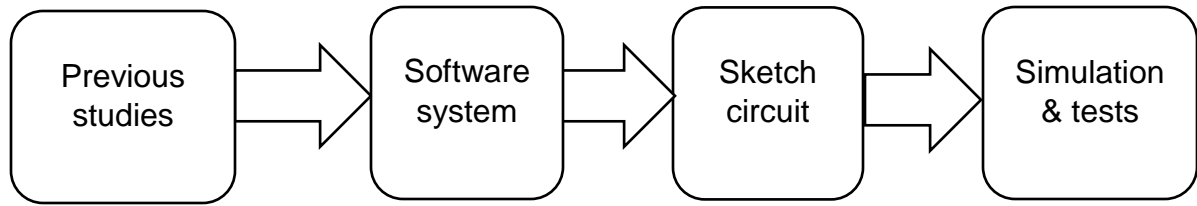
General objective is design and to implement of robotic arm uses in hot lab of nuclear medicine.

Specific objectives are to:

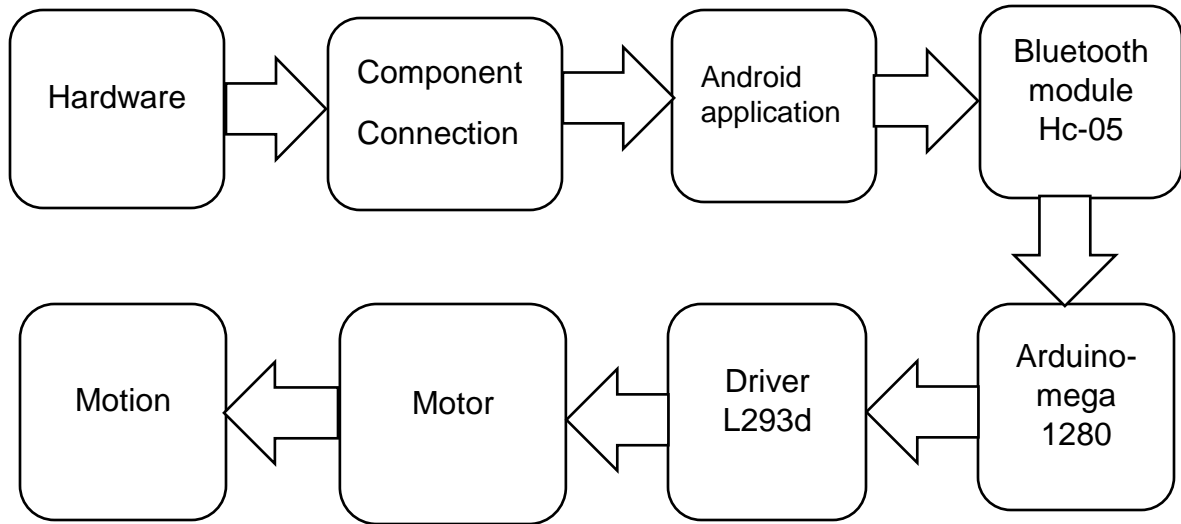
- 1-Prevent from contact with radiation and increase distance from it.
- 2-prevent uncontrolled spread of contamination.
- 3-provide high efficiency system and low power consumption.

1-4 Methodology

Several stages were taken to design and implementation the project. The first stage data were collected about the design and compared between the previous studies to provide optimal design. The second stage include software and hardware systems, the block diagram explain stages of methodology.



Block diagram 1-1: Explain the software phase.



Block diagram 1-2: Explain the hardware phase.

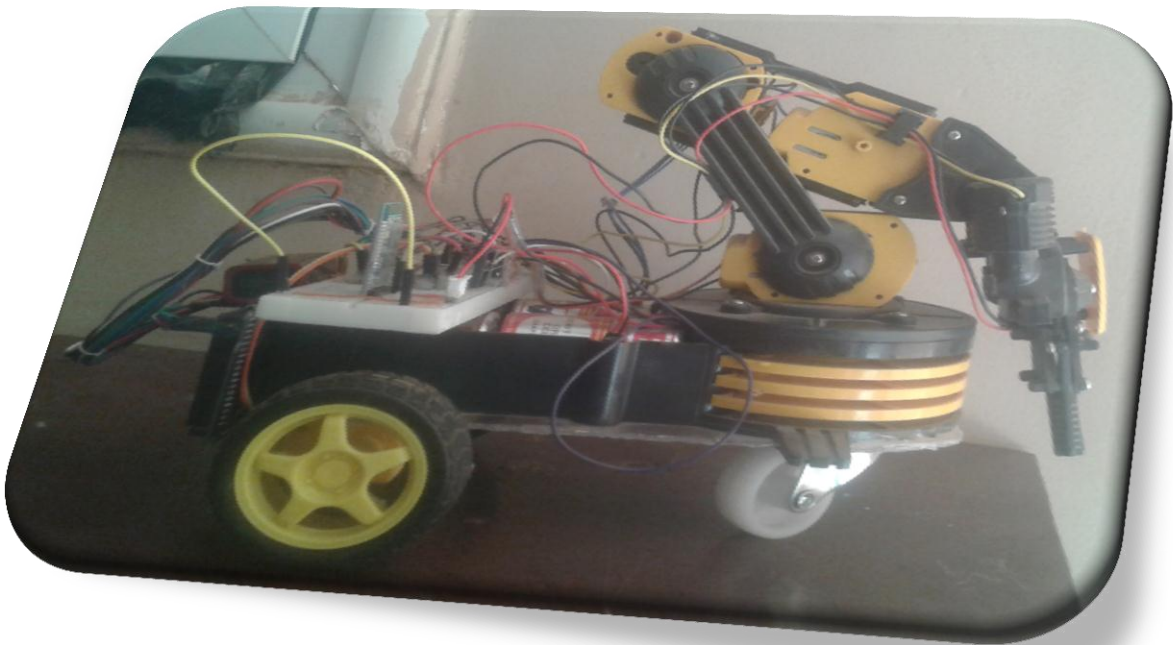
1-5 Thesis layout

This research consist of six chapters

Chapter one is an introduction. The previous studies describe chapter two. Chapter three is theoretical background. The proposed system is discussed in chapter four. Chapter five describe results and discussion. Finally conclusion and recommendation described in chapter six.

Chapter Two

Previous Studies



ChapterTwo

Previous Studies

2-1 Review:

Aakashk.sancheti: This paper,presents a thought and a way to eradicate the buttons, joysticks and replace them with some other more intuitive technique, that is, controlling the complete Robotic Arm by the operators hand movement or motion or gesture. In this paper the completely electronic (i.e. without mechanical sensors) way of achieving the above stated goal is discussed. This is achieved by using MEMSACCELEROMETER technology (that is used in smart phones for tilt sensing), showing the diversity of the application of the same technology [1].

JamshedIqbal, Razaulislam and Hamza khan: In this paper, the behavior of physical system in many situations may better be expressed with an analytical model. Robot modeling and analysis essentially involve its kinematics. For robotic manipulators having high Degrees Of Freedom (DOF) with multiple degrees in one or more joints, an analytical solution to the inverse kinematics is probably the most important topic in robot modeling. This paper develops the kinematic models a 6 DOF robotic arm and analyzes its workspace. The proposed model makes it possible to control the manipulator to achieve any reachable position and orientation in an unstructured environment. The forward kinematic model is predicated on DenavitHartenberg (DH) parametric scheme of robot arm position placement. Given the desired position and orientation of the robot end-effector, the

realized inverse kinematics model provides the required corresponding joint angles. The forward kinematic model has been validated using Robotics Toolbox for MATLAB while the inverse kinematic model has been implemented on a real robotic arm. Experimental results demonstrate that using the developed model, the end-effector of robotic arm can point to the desired coordinates within precision of 0.5cm. The approach presented in this work can also be applicable to solve the kinematics problem of other similar kinds of robot manipulators [2].

Sie Deen Lau: This report is focused on the examination of two industrial robot applications. The first is a robotic assembly using passive compliant devices and the second is a contact force control application. For each problem an end-effector device was designed, built and tested using a robotic manipulator with five degrees of freedom. The devices are presented together with the experimental results [3].

Aram Azad and Tarik Rashid: This paper aims at furnishing basic definitions for robotics in the span of man-made intelligence. Simple robotics and their faculties such as sensors and actuators are included in the definition. Moreover, intelligent and non-intelligent types of robotics are described in this research work. We generally focus on non-intelligent robotics (program-based robotics) and the setbacks designers can encounter. The methods and designs of an arm robot generally encompass three components: namely, the mechanical assembly of the arm robot, the electronic circuit, and software design employing Prolog software programming language.

Our design concentrates generally on programming an arm robot to manipulate its movements. In our case study programming an arm robot we delineate probable resolutions to setbacks we encountered without going intensely into theory, and we demonstrate a stable design for resolving these setbacks via a flowchart[4].

StylianiosKavousanakis, Anthony H.Jones,Stefan Kenway and Guowu Wei: This paper presents the development of a low-cost module-based 7-DoF robotic arm. Structure design of the robot arm is introduced and its kinematics is formulated based on product of exponentials representation. By using 3D printing system, the proposed robotic arm is then fabricated and assembled, and integrated with servo motors and Arduino low-level control kits, a functionally feasible prototype is developed. Tests are subsequently carried out so as to check the performance of the proposed robotic arm and to identify errors and defects for improving and optimizing the design. Integrating with MATLAB Robotic Toolbox and Arduino low-cost control platform, the robotic arm presented in this paper can be used for the purpose of mechanisms and robotics education in the courses such as robotic kinematics, automation and control, and robotic programming and planning[5].

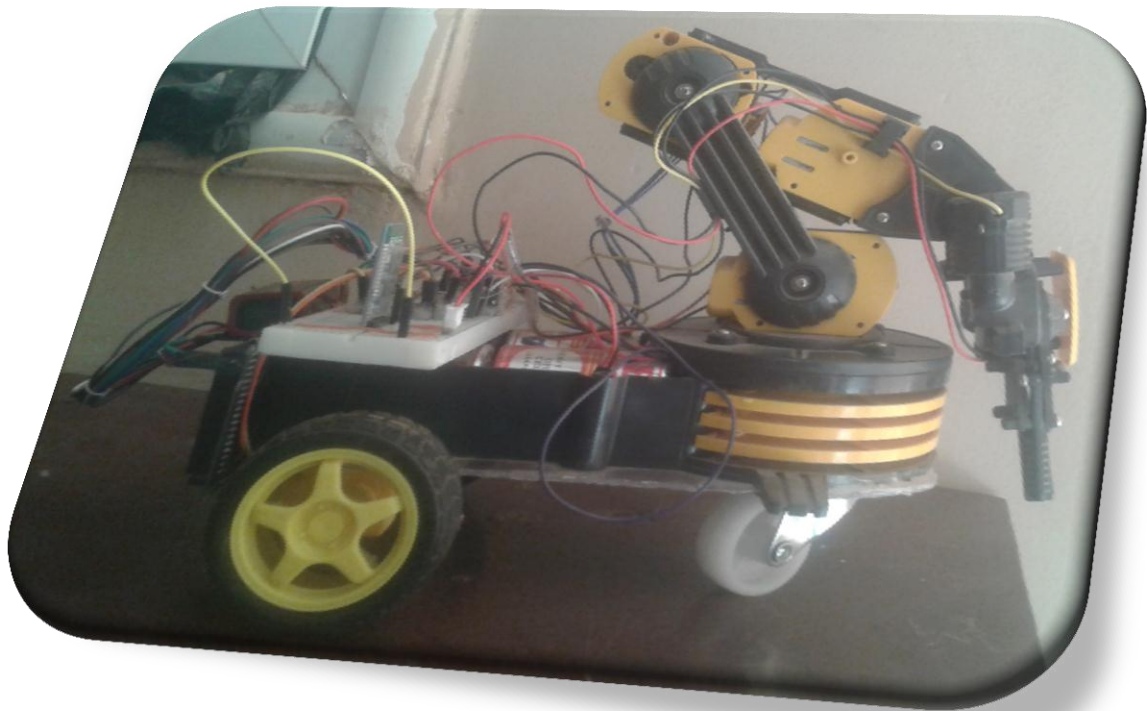
Mohammed Ibrahim Mohammed Ali:In this paper, the design, implementation and control of modified design of a six degrees of freedom (DOF) LYNX-6 robotic arm FPGA-based controller is introduced. In LYNX-6 arm, the lengths of the arms are modified and we used FR4 material to achieve the lightweight requirements of the arm structure. LYNX-6 arm has 5 DOF plus a grip movement (5+1). It is also similar to human arm from the number of joints point of

view. Servomotors are controlled by pulse-width modulated (PWM) signals that control the position of the servo actuator. To position the robotic arm in 3D space, the angle of each joint must be set. A MATLAB GUI is designed to pick the desired (X, Y, Z) coordinates from the user, check the robot domain, perform the inverse kinematics algorithm and send the angles data serially through wireless module to FPGA controller to generate the necessary pulse-width modulated signals for the motors. The controller architecture is implemented on a Xilinx spartan3 FPGA evaluation board using VHDL. FPGA with its large number of I/O pins and parallel processing capabilities is suitable for interfacing and controlling the six motors at the same time. The proposed FPGA-based controller offered flexible, standalone, and compact design with high system reliability [6].

Sharun Mendonca, Khalid Mohammed Zulqurnain, and K.M.AbdulRazack: In this project, work is carried out on the robotic arm which is controlled using an Arduino ATMEGA-328 micro-controller via android app. Servomotors are used for the link movements and DC motors are used for the base movement. The benefits of this work are visual movement of the device, text-to-speech recognition, compact in size and economical. The prototype developed is more user friendly and less cost. It will perform the desired operation very smoothly. The system can be controlled within a range of 15 meters using any android smart phone, which will be more applicable in applications such as bomb defusing, remote pick and place, cleaning applications [7].

Chapter Three

Theoretical Background



Chapter Three

Theoretical background

3-1 Introduction

A robotic arm is a robot manipulator, usually programmable, with similar functions to a human arm. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain.

The business end of the kinematic chain of the manipulator is called the end effectors and it is analogous to the human hand. The end effectors can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application. The robot arms can be autonomous or controlled manually and can be used to perform a variety of tasks with great accuracy. The robotic arm can be fixed or mobile (i.e. wheeled) and can be designed for industrial or home applications [8].

This report deals with a robotic arm whose objective is to imitate the movements of a human arm using accelerometers as sensors for the data acquisition of the natural arm movements. This method of control allows greater flexibility in controlling the robotic arm rather than using a controller where each actuator is controlled separately. The processing unit takes care of each actuator's control signal according to the inputs from accelerometer, in order to replicate the movements of the human arm [8]. The robots have to interact with their environment, which is an important objective in the development of robots. This interaction is commonly accomplished by means of

some sort of arm and gripping device or end effectors. In the robotic arm the arm has a few joints, similar to a human arm, in addition to shoulder, elbow, and wrist, coupled with the finger joints; there are many joints [9].

3-2 Types of robots

3-2-1 Industrial robots

In general, robotics can be divided into two areas, industrial and service robotics. International Federation of Robotics (IFR) defines a service robot as a robot which operates semi-or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations. These robots are currently used in many fields of applications including office, military tasks, hospital operations, dangerous environment and agriculture. Besides, it might be difficult or dangerous for humans to do some specific tasks like picking up explosive chemicals, defusing bombs or in worst case scenario to pick and place the bomb somewhere for containment and for repeated pick and place action in industries. Therefore, a robot can be replaced human to do work [8].

3-2-2 Intelligent robots

Most robots work according to program or are remotely controlled by human operator. Now there are a new generation of robots appearing which have been described as intelligent.

Intelligent robots have a range of sensors attached to them as well as their own powerful onboard processor, and significant memory capacity. All of which enables them to reproduce the capacities of the human senses.

Just like us, this allows robots to gather information about their environment and enables them to start making decisions for themselves.

3.3 The proposed robotic arm model

Learning basic robotic technology and build your own wired control robot arm with five motors and five joints. With its five –switch wired controller the robot features base rotation, elbow and wrist motion, and a functional gripper. The five motors operate the grab, release, lift and lower.

3-3-1 Specifications

Power source: four batteries to robotic arm (one battery 1.5v) and one battery used to arduino 9v.

Power consumption: 2400 mA.

Weight: 658 g (without batteries and load).

Maximum load: 100 g.

Base rotation: 270 degree left and right.

Base motion: 180 degree.

Elbow motion: 300 degree.

Wrist motion: 120 degree.

Gripper: 0-1.77.

3-4 Calculated torque

Torque means measure of how much force are acting on an object reasons that object to rotate. Torque is denoted by T. Torque (T) is defined as a moving “force” and is calculated using the following equation: $T = F * L$
.....(1) Where T is torque F means calculated force and L is denoted the length from a pivot point. The force is accelerating on an object due to gravity ($g = 9.81 \text{ m/s}^2$) multiplied by its mass.

$$F=M*g.....(2)$$

Mass (M), and gravity (g),the force (F) is also considered of an object's weight (W)

$$W=M*g.....(3)$$

The torque required to hold a mass at a given distance from a pivot point is showing therefore

$$T=(M*g)*L.....(4)$$

The length L is the perpendicular length from a pivot point to the force. This equation can found by similar doing a torque balance about a point.

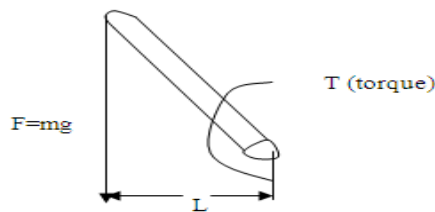


Figure 3-1: Torque balance

$$\Sigma T = 0 = F*L - T.....(5)$$

Therefore, replacing the force (F) with mass and gravity (m*g) we can find out the same equation above. This is the more accurate way to find out the torque by using the torque balance.

$$M*g*L = TA(6)$$

In order to estimate the torque required at each joint, we can must chose the worst case scenario.

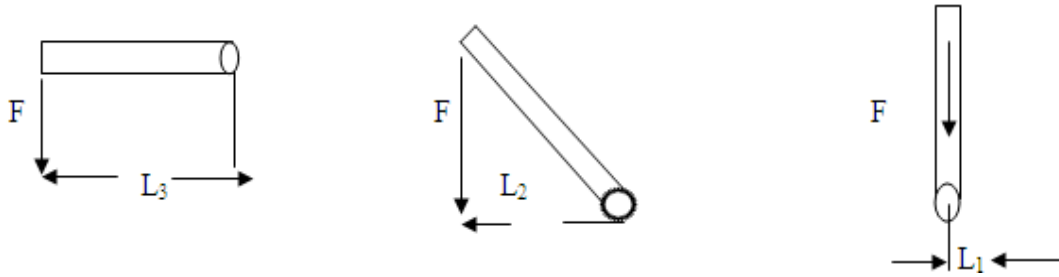


Figure 3-2: Required torque at each joint

From the above figure we can see a link of required length L is rotate clockwise. Only for perpendicular component of the length (L) between the pivot point and force (F) is taken into account. We can observe that the distance of length (L) is decreasing from length L_3 to length L_1 . Since from the torque equation the length (L) or distance multiplied by the force (F), the greatest value will be obtained by using L_3 , The force (F) does not change. We can rotate the link counterclockwise similarly and observe the same effect. The weight of the object (load) being held as Indicated in the Figure 4 by A_1 , which is multiplied by the distance its center of mass and the pivot point gives the torque required at the pivot. The tool takes into the consideration that the links may have a significant weight (W_1 , W_2) and its center of mass is located at roughly the center of its length (L). The torque caused by this difference masses must be added. The torque required at the first joint is therefore [10].

$$T_1 = L_1 * A_1 + L_1 * W_1 \text{ ("A" is weight of the actuator or the load.)} \dots\dots(7)$$

We may consider that the actuator weight A_2 which is as shown in the diagram below is not included when calculating the torque at that point. This is because by the length (L) between its center of mass and the pivot point is zero. The torque required at the 2nd joint must

be re-calculated with the new lengths, which is as shown in the following figure. (The applied torque shown in green color like T1 and T2).

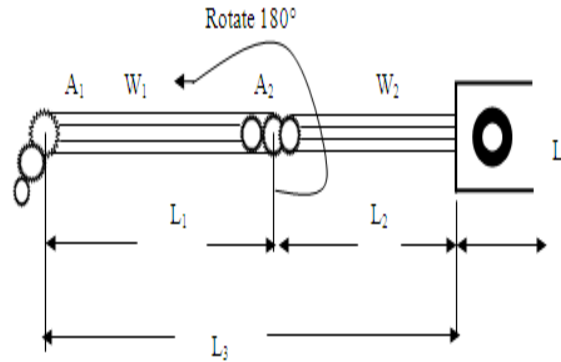


Figure 3-3: Calculation of applied torque

$$T2=L3*A1+L1*W1+L2*A2+L4*W2 \dots\dots\dots(8)$$

Knowing that the link weight (W2, W2) are located in the center point of the lengths, and the distance between the actuators (L1 and L3 shown in the diagram above) we can re-write the equation as follows:

$$T2= (L1+L2)*A1+ (L1+L3)*W1+ (L2)*A2+ (L2)*W2 \dots\dots\dots(9)$$

Only for the tool requires that the user enter the lengths (L) of the each link, which would be L1 and L3 above so the equation is showing accordingly. The torques at each subsequent of the joint can be found similarly, by re-calculating the lengths between each new pivot point and each weight [10].

3-5 Arduino

Arduino an accepted open-source single-board microcontroller, successor of the open-source wiring platform designed to formulate the process of using electronics in multidisciplinary function more easily to get. With the help of the wiring-based language (syntax and libraries) similar to C++, Arduino hardware is programmed using

some simplifications and modifications, and a Processing based integrated development environment.

The Arduino can be powered via the USB connection or with an external power supply and the power source is selected automatically. External (non-USB) power can come from either an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and VIN pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. Therefore, the recommended range is 7 to 12 volts[9].

The most important parts on the Arduino board:

- USB connector
- Power connector
- Automatic power switch
- Digital pins
- Analog pins
- Power pins
- Reset switch

3-5-1 Types of Arduino

3-5-1-1 Arduino uno

The Arduino Uno is a microcontroller board based on the atmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller;

simply connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDIUSB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

3-5-1-2 Arduino mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input and output pins of which 14 can be used as PWM outputs, 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an alternating current (AC) to direct current (DC) adapter or battery to get started [11].

3-6 DC motor

The direct current (DC) motor is one of the first machines devised to convert electrical energy to mechanical power. DC motors (machines) consist of one set of a current carrying conductive coil, called an armature, inside another set of a current carrying conductive coils or a set of permanent magnets, called the stator. The input voltage can be applied to armature terminal (armature current controlled DC motor), or to carrying conductive coils terminals (field current controlled DC motor)[12]. This current will generate lines of flux around the armature and affect the lines of flux in the air gap between two coils, generating two magnetic fields, the

interaction between these two magnetic fields (attract and repel one another) within the DC motor, results in a torque which tends to rotate the rotor (the rotor is the rotating member of the motor). As the rotor turns, the current in the windings is commutated to produce a continuous torque output resulting in motion. DC machines are characterized by their versatility. By means of various combinations of shunt-, series-, and separately-excited field windings, they can be designed to display a wide variety of volt-ampere or speed-torque characteristics for both dynamic and steady-state operation. Because of the ease with which they can be controlled, systems of DC machines have been frequently used in many applications requiring a wide range of motor speeds and a precise output motor control. The selection of motor for a specific application is dependent on many factors, such as the intention of the application, correspondingly allowable variation in speed and torque and ease of control [12].

A dc motor is widely used for control purposes because of its stability and straight forward characteristics. For effective analytical purposes, mathematical models are indispensable. The separately excited dc motor is the simplest of all dc motors and it is the one most commonly found in industrial applications [13].

3-6-1 Mathematical model of DC motor:

The separately excited DC motor is described by the following equations:

$$K F \omega_p(t) = - R_a i_a(t) - L_a [di_a(t)/dt] + V_t(t) \quad (1)$$

$$KF\dot{\omega}_p(t) = J[d\omega_p(t)/dt] + B\omega_p(t) + TL(t) \quad (2)$$

Where,

$\omega_p(t)$ - rotor speed (rad/s)

$V_t(t)$ - terminal voltage (V)

$i_a(t)$ - armature current (A)

$TL(t)$ - load torque (Nm)

J - Rotor inertia (Nm^2)

KF - torque & back emf constant (Nm/A)

B - Viscous friction coefficient (Nms)

R_a - armature resistance (Ω)

L_a - armature inductance (H)

From these equations mathematical model of the DC motor

Can be created. Where,

T_a - Time constant of motor armature circuit, $T_a=L_a/R_a$ (s).

T_m – Mechanical time constant of the motor $T_m=J/B$ (s).

3-7 Motor driver L293

The L293 is an integrated circuit motor driver that can be used for simultaneous, bi-directional control of two small motors. The L293 is limited to 600 mA, but in reality can only handle much smaller currents unless you have done some serious heat sinking to keep the case temperature down.

The L293 comes in a standard 16-pin, dual-in line integrated circuit package. There is an L293 and an L293D part number. Pick the "D" version because it has built in fly back diodes to minimize inductive voltage spikes [14]. The L293 and L293D are quadruple high-current half-H drivers. The L293 IS designed to provide

bidirectional drive currents of up to 1A at voltage from 4.5V to 36V. The L293D is designed to provide bidirectional drive currents of up to 600-MA at voltages from 4.5V to 36V.

Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high voltage loads in positive-supply applications.

On the L293D, external high-speed output clamp diodes should be used for inductive transient suppression. A Vcc1 terminal, separate from Vcc2, is provided for the logic inputs to minimize device power dissipation. The L293 and L293D are characterized for operation from 0° C to 70° C [15].

3-8 HC Serial Bluetooth

HC Serial Bluetooth product consists of Bluetooth serial interface module and Bluetooth adapter. Bluetooth serial module is used for converting serial port to Bluetooth.

This module has two modes: master and slaver device. The device named after even number is defined to be master or slaver when out of factory and can't change to the other mode. But for the device named after odd number, users can set the work mode (master or slaver) of the device by AT commands. The main function of Bluetooth serial module is replacing the serial port line, such as: One connects to Bluetooth master device while the other one connect to slaver device. Their connection can be built once the pair is made. This Bluetooth connection is equivalently liked to a serialport line connection including RXD, TXD signals. And they can communicate with each other [15].

3-9 Hot Laboratory in Nuclear Medicine

The term „hot-laboratory“ (hot-lab) is used to describe the facility where large quantities of volatile radioisotopes such as, unsealed sources of ionizing radiation and generators, are handled. Usually this is done in a small side room off a main laboratory. This is where all the radioactive work in a nuclear medicine department takes place. Hot lab is an exclusively reserved facility which is designated controlled area persons working with unsealed radioactive sources must be protected not only from radiation emitted by the sources but also from ingestion, absorption or inhalation of radioactive material. Procedures to minimize the intake of radioactive nuclides into the body depend on the facilities available within an institution and vary from one institution to another[16].

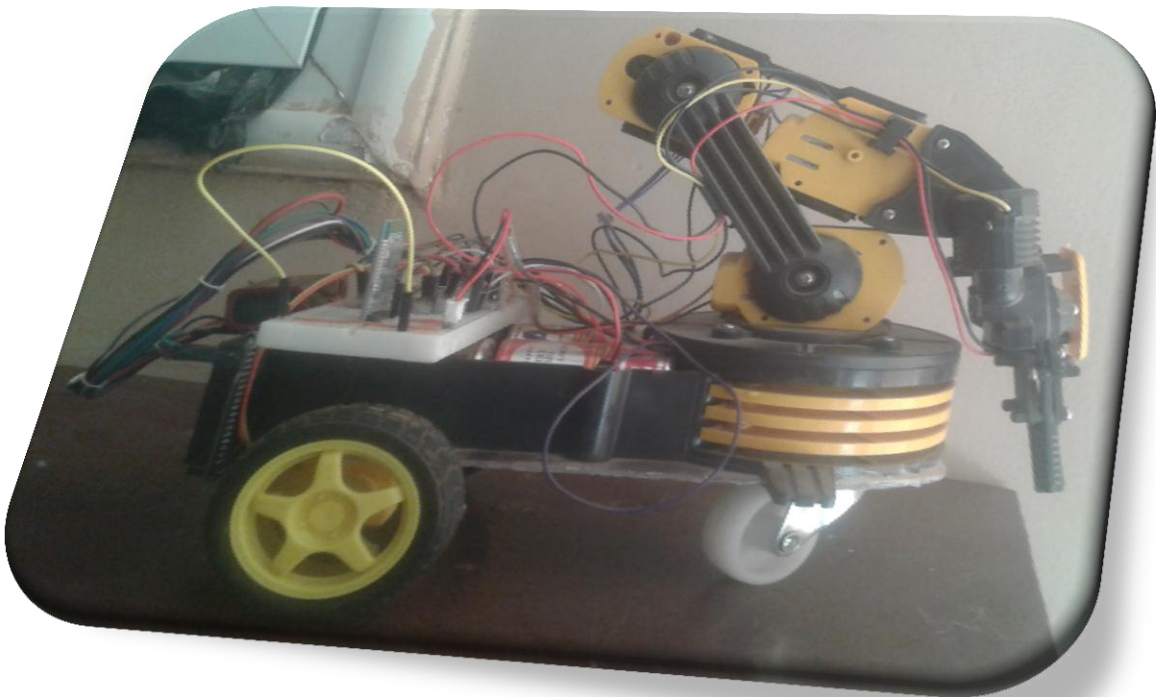
Guidelines for the safe use of radioactive materials are included publications by individuals and by advisory groups such as the ICRP and NCRP [16].

The processing analysis of highly radioactive substances and components materials requires sophisticated and extensive laboratory infrastructure that ensures safety and security, as well as educate scientific/technical personnel who can optimally and reliably use the facilities. The sources of ionizing radiation exposure should be handled on a “As Low As Reasonably Achievable” (ALARA) basis and for that every reasonable effort to maintain exposures to ionizing radiation below the dose limits should be made by improving the hot lab facility A table top bench shield was made indigenously earlier for

the „hot-lab“ of our department where the radiation workers of nuclear medicine dispense and prepare radiopharmaceuticals for the patients[16].

Chapter Four

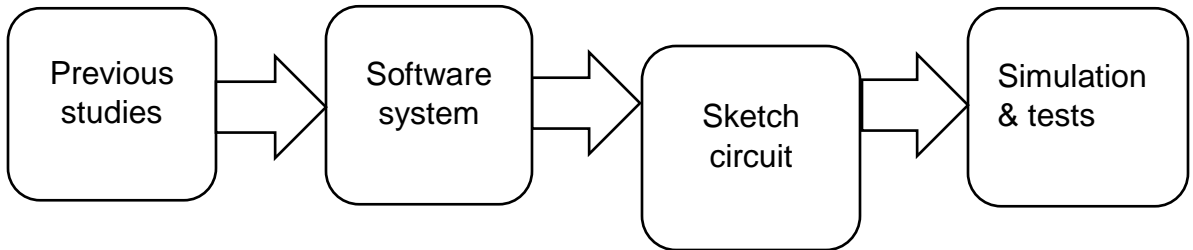
The Proposed System



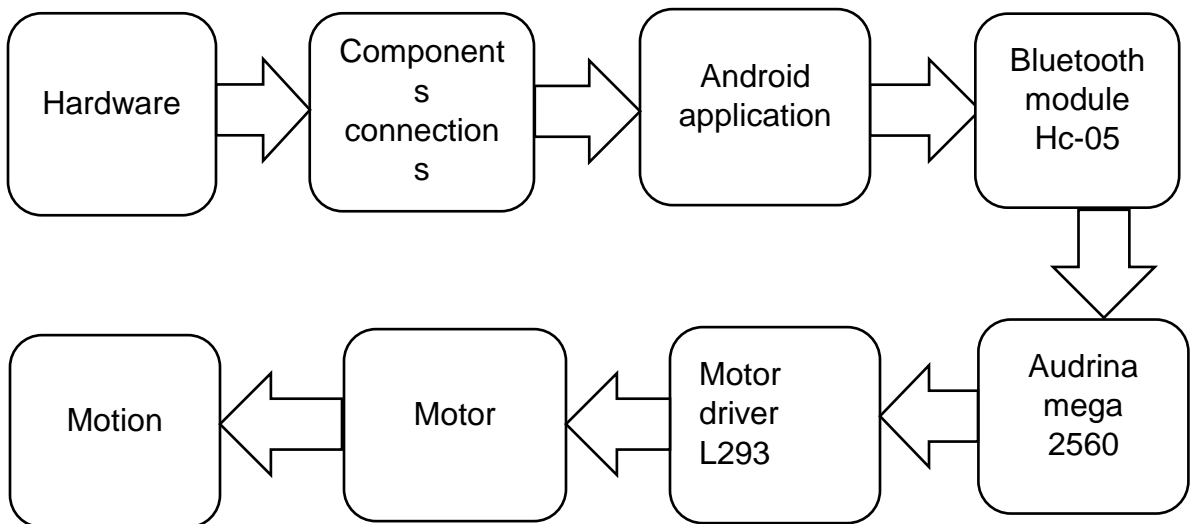
Chapter Four

The proposed system

Several stages were taken to design and implementation the project. Block diagram below explain the main stage to achieve it.



Block diagram 4-1: Explain the software phase.



Block diagram 4-2: Explain the hardware phase.

4-1 Introduction

For designing and implementation the project, at the first reflexed to the previous studies and compared between it to select and treat the problems in them, in order to produce perfect design and avoid all problems in previous studies.

Before to design the project, data collected about hot lab (working area) from different sources *and how to bring and preparing the radiopharmaceutical dose to different purposes of diagnosis, and analysis the hazard in hot lab to high hazard room for preparation, dispensing radiopharmaceutical and temporary storage of waste, medium hazard room for storage of radionuclide's and low hazard room for measuring samples Radiochemical work (RIA) offices.* Data collected about hot lab (working area) in order to make the design convenient to hot lab (working area).

When data had sufficient to design, the phase of software system had done to simulate the circuit and test for it. Hardware phase had done to connect components together and given the complete design.

4-2 Software system

Software system is programs use to sketch and implement the circuit, also to simulate the circuit after sketch it.

Many problems had met design during software to simulate circuit and changed multi-components to arrive for the end and optimal simulation to design. Some of this problems, which met in software (simulation), at the first microcontroller (PIC16f877A) had chosen to design, but microcontroller is very complicated and difficult, and to let design very simple and easy to treat, if meet any problem, arduino uno had chosen to replace the microcontroller for programming the design, but the number of pins, which required to connect between the arduino uno, driver L293D, board and Bluetooth

module (HC-05) is less in arduino uno than required to connect all components together in circuit.

Arduino mega 1280 had chosen to simulate and connect components together, because it contains enough pins to connect all components together.

When microcontroller (PIC16F877A) had chosen, proteus-7 program used to sketch circuit, but programmability and sketching with microcontroller is very difficult and complicated (although it give better design more than arduino). To sketch circuit with arduino mega 1280 proteus-7 program is not benefit, because it was not contained some component such as arduino mega 1280. Proteus-8 used and downloaded arduino library to be able to sketch circuit.

From above below (proteus simulation), software simulation includes arduino mega 1280, Bluetooth module Hc-05, multi-wires, four driver L293D and eight dc motors. Code was prepared during sketching circuit to simulate it.

4-2-1 Code used

Code divided into four parts. The first part defines the motors names and the corresponding pins numbers that connect with them. Second part determines the status or mode of motors. Motor usually gave specific output when we entering voltage to it. The third part explains the digital signal that enter for each motor when the digital signal was high (1), motor will givespecific motion according to digital signal which came from arduino mega. And when digital signal was low (0), motor will stop and don't give any motion. The fourth part explains the arduino mega stop and arduino mega dose not send

any digital signal the all motors will be low (0), and don't give any motion.

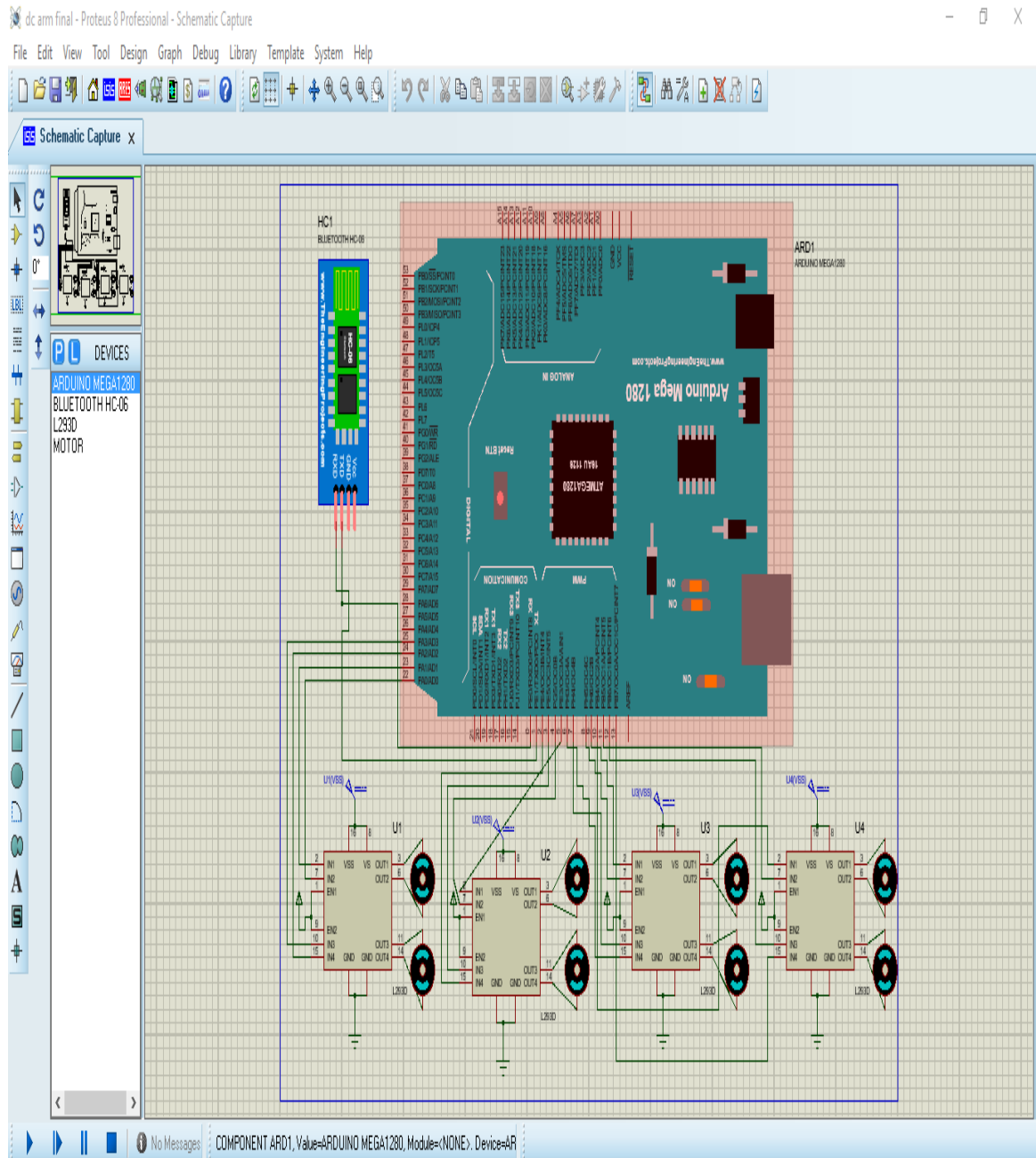
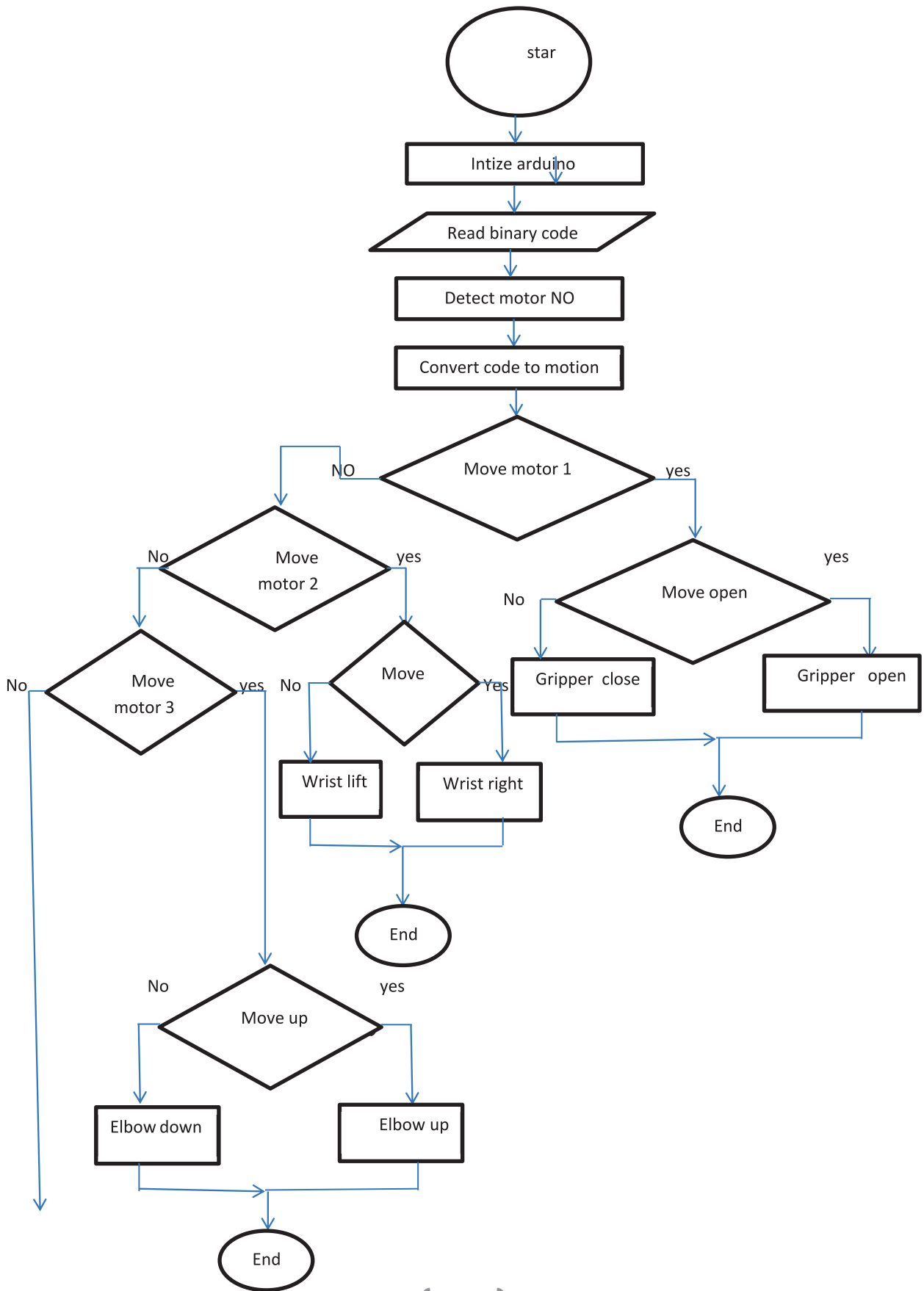
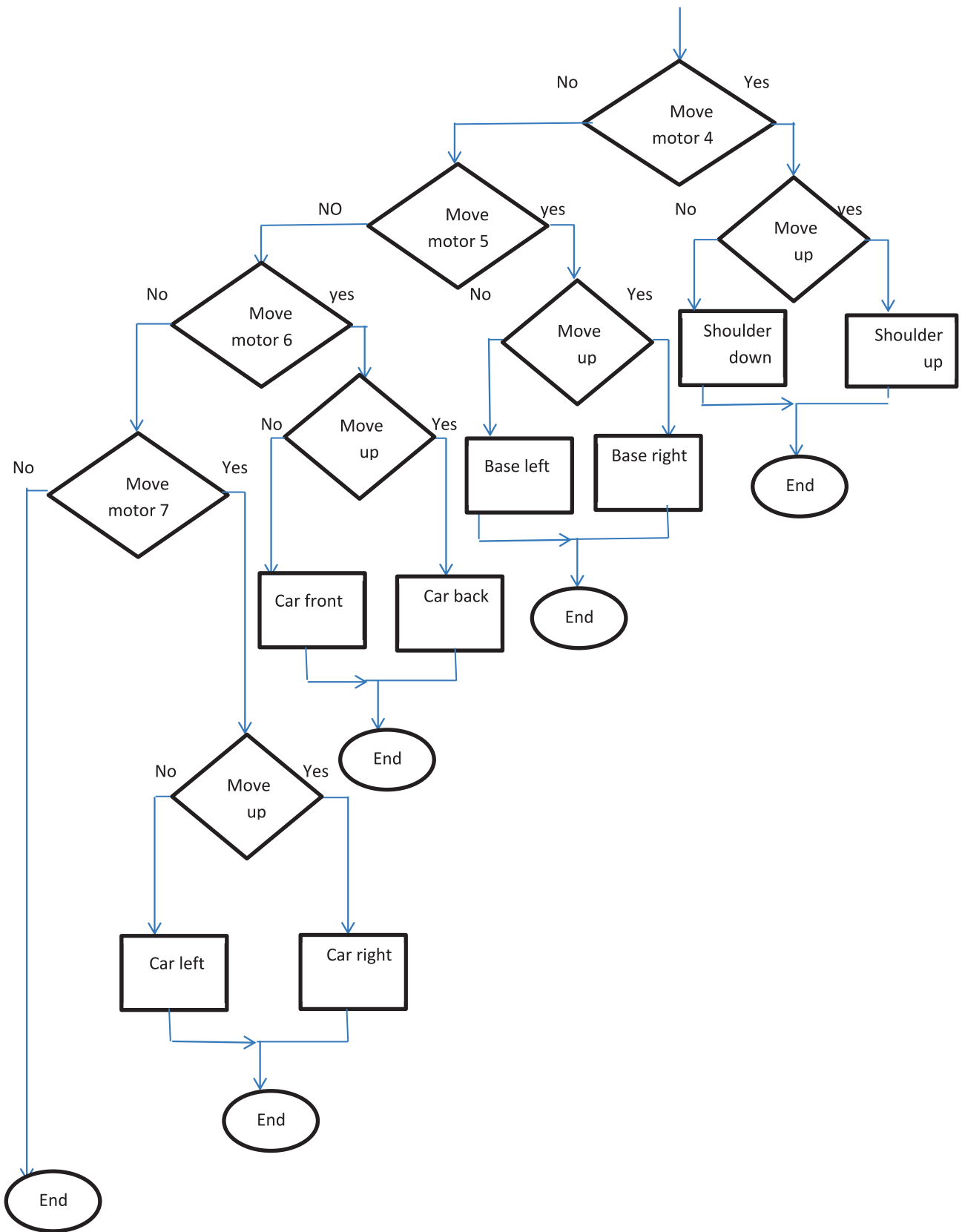


Figure 4-1: Explain proteus simulation





4-3 Android application

Code had finished and proteus sketch, android applications was prepared in mobile telephone to connect Bluetooth module HC-05 of proteus circuit with it, to make many tests in proteus simulation in order to make sure from motion of each motor works in proper way.



Figure4-2: Explain android application

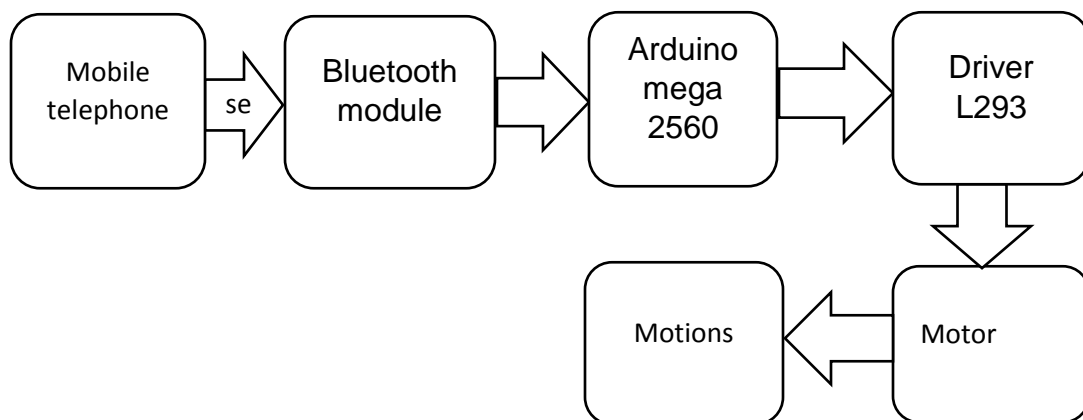
As showed from figure above the android application (control) contains seven keys. The first key is called car, which control in the direction and motion of car, the perpendicular directions to move car forward and backward. Horizontal directions to move car on the left direction or to right direction. The second key containfour directions, the perpendicular directions to move the base of robotic arm to left or right direction. And the horizontal directions to move the shoulder of arm to up and down. Third key to control in the motion of elbow in the arm to up or down as arrows explain. Fourth key to control in the motion of pitch in arms to move it up or down. Five key is not use called (roll), because at the firstwanted to design the robotic arm with six doff robotic arm, but it isn't available andbought robot with five doff robotic arm. The last key to control in motion of gripper in

roboticarm to catch sample or an untangled it in hot lab, (“O”) to catch sample and (“X”) to an untangled sample.



Figure4-3: Explain tests during simulation

The signal came from telephone mobile (controller), and received with Bluetooth module, which contains two pins TXD and RXD to send and receive the signal from arduino to it. It send signal to arduino mega, and then arduino translate it, and send it to specific driver motor L293 to give the desiremotion for the motor.



Block diagram 4-3: Explain the transmission of signal

4-4Hardware system

Software (simulation) and tests had finished, after sure from the circuit had worked in proper way, hardware system was starting to connect components together in order to give the end-design. Hardware system includes many stages, collecting components and bought it and then connection between it to give desired design.

4-4-1 Hardware architecture

- Arduino mega 2560.
- Bluetooth module HC-05.
- Board.
- Four driver L293.
- Two dc motors and three wheels.
- Wires.
- Battery 9v (called Kodak).

4-4-1-1 Arduino mega

The Arduino mega is a microcontroller board on the Atmega2560. It contains 54 digital input and output pins, 14 pins can be used as PWM (Pulsed-with modulated) 4 UARTs hardware serial ports, 16 analog inputs and 16 MHz crystal oscillator (or, addition to this pins Arduino mega 2560 consists button called reset , USB connection to connect it to battery called Kodak (12v) to get started, and an ICSP header.



Figure 4-4: explain the arduino mega 2580

4-4-1-2 HC-05 Serial Bluetooth

HC Serial Bluetooth product consists of Bluetooth serial interface module and Bluetooth adapter. Bluetooth serial module is used for converting serial port to Bluetooth. This module has two modes: master and slaver device. The device named after even number is defined to be master or slaver when out of factory and can't change to the other mode. The main function of Bluetooth serial module is replacing the serial port line, such as: One connects to Bluetooth master device while the other one connect to slaver device. Their connection can be built once the pair is made. This Bluetooth connection is equivalently liked to a serial port line connection including RXD, TXD signals. And they can communicate with each other.

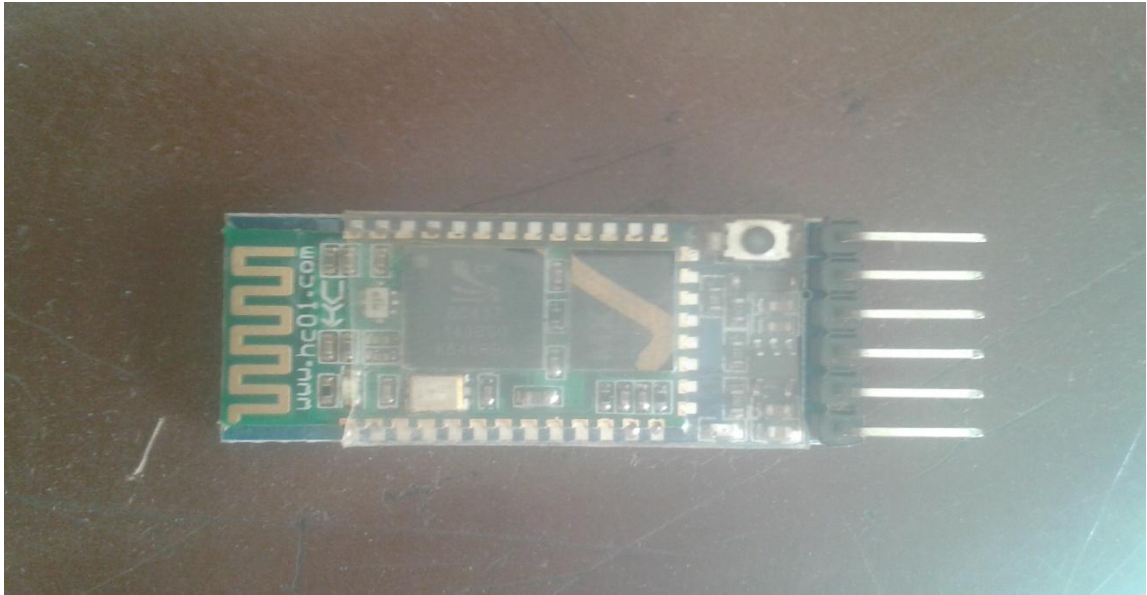


Figure 4-5: explain HC-05 serial Bluetooth

4-4-1-3 Dc motors

The selection of motor for a specific application is dependent on many factors, such as the intention of the application, correspondingly allowable variation in speed and torque and ease of control.

The direct current (DC) motor is one of the first machines devised to convert electrical energy to mechanical power. DC motors (machines) consist of one set of a current carrying conductive coil, called an armature, inside another set of a current carrying conductive coils or a set of permanent magnets, called the stator. The input voltage can be applied to armature terminal (armature current controlled DC motor), or to carrying conductive coils terminals (field current controlled DC motor). This current will generate lines of flux around the armature and affect the lines of flux in the air gap between two coils, generating two magnetic fields, the

interaction between these two magnetic fields (attract and repel one another) within the DC motor, results in a torque which tends to rotate the rotor (the rotor is the rotating member of the motor). As the rotor turns, the current in the windings is commutated to produce a continuous torque output resulting in motion. DC machines are characterized by their versatility. By means of various combinations of shunt-, series-, and separately-excited field windings, they can be designed to display a wide variety of volt-ampere or speed-torque characteristics for both dynamic and steady-state operation. Because of the ease with which they can be controlled, systems of DC machines have been frequently used in many applications requiring a wide range of motor speeds and a precise output motor control.

4-3-1-4 Motor driver L293d

Four drivers l293 used to operate seven dc motors, l293 driver is an integrated circuit motor driver that can be used for simultaneous, bi-directional control of two small motors.

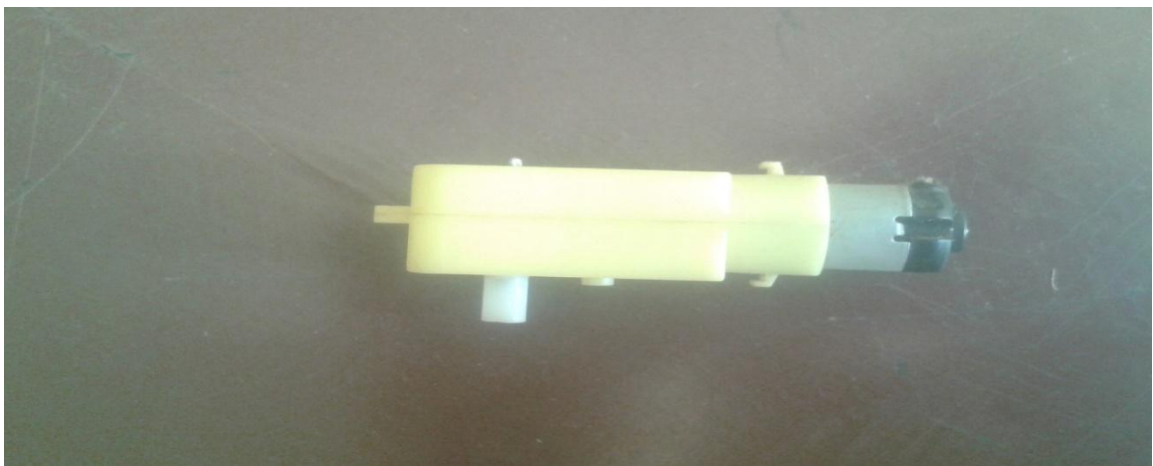


Figure 4-6: Explain the dc motor

Current enter to driver equal to 600mA. This means four driver used 2400mA to operate seven dc motors used in circuit.

The L293 contains 16-pin, dual-in line integrated circuit package, four pins for power, four for ground, four pin for connecting two dc motors and four pin for connecting with arduino. The L293 is quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1A at voltage from 4.5V to 36V.

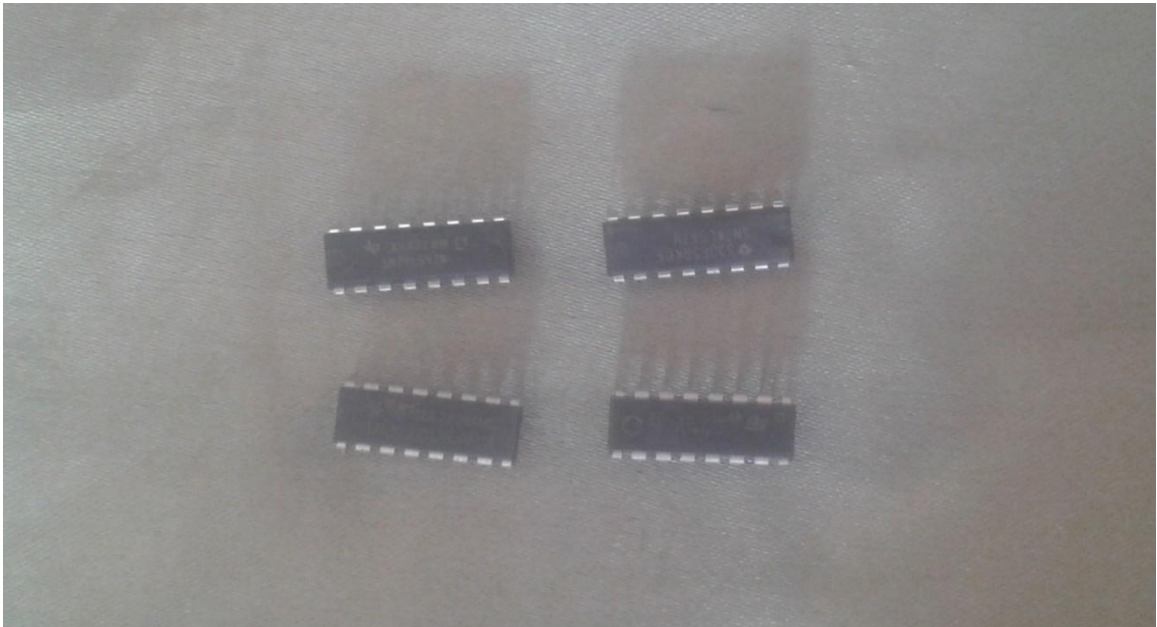


Figure 4-7: Explain motor driver L293

4-4-1-5 Wheels

In order to facility movement of robot arm inside the hot lab without any intervene from worker, two wheels used with two motors and third wheel to create car with three wheels to transport it. Carcrewed from three wheels and a piece of fiber to make surface

above car to put robot in it. Two wheels connected with two motors, each motor for one wheels as show from figure below:



Figure 4-8: Explain motor and wheel

Two wheels with two motors fixed back in the car to give desired motion to the car left, right, back and forward. Third wheel fixed forward the car, which does not contains motors, this make wheel play like axially to move according to movement of two wheels in the back like really car the movement come from wheels back. Welding and wires used to connect the motors and wheels with a piece offiber and scalderalso used to make holes in a piece of fiber in

order to connect it with motors and wheels as we show from figure below:

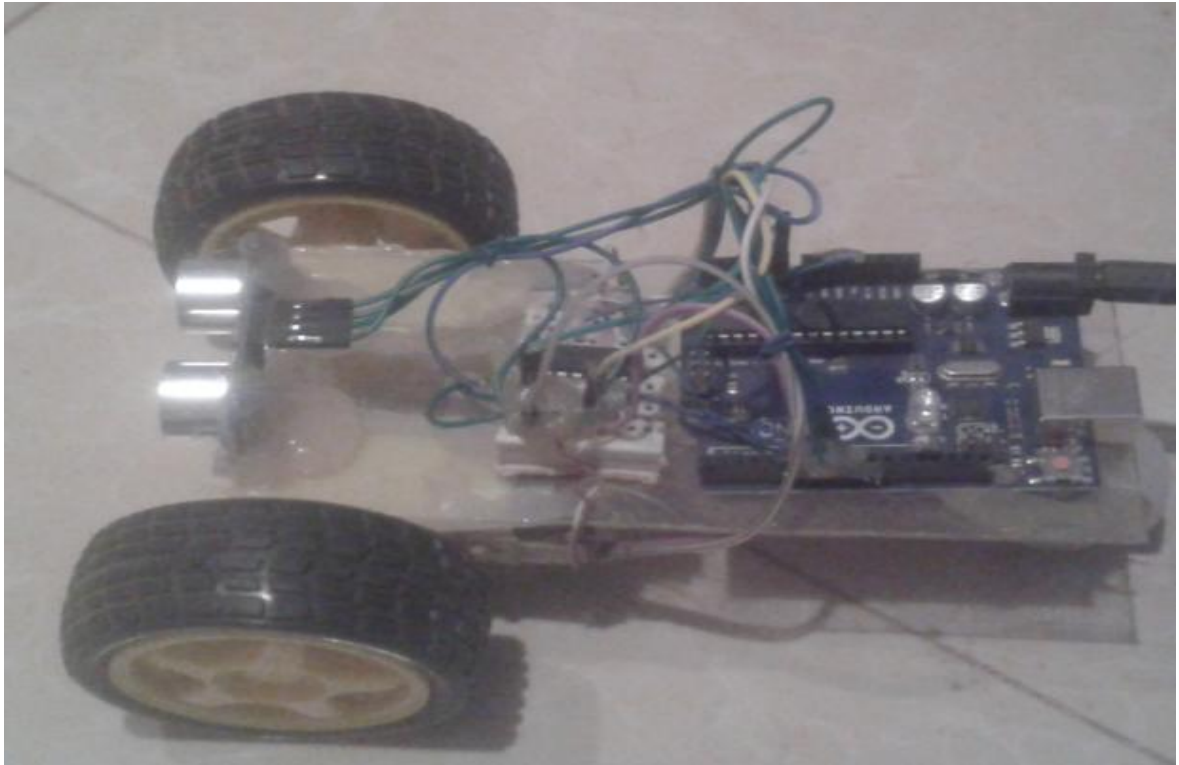


Figure 4-9: Explain the car with three wheels

4-4-1-6 Wires

Many wires had used to connect components together, also to transport the voltage and current from the power source to each components for starting operating and transmission the signal from Bluetooth to Arduino mega, driver until arrive to motors and give motion for it. Male to male wires had used to connect arduino with motors of car, four drivers l293, power source and Bluetooth module Hc-05. Addition to male to male wires, shorts wires used to plump parts of driver l293 to motors of robotic arm and to the ground

and source of power. Short wires and tall wires are used to plump the components together in the board. To avoid damage and fire in components which result from transport of electricity during process of operating waxier welding had used to forbid all above problem from take place and fix the components in proper way.

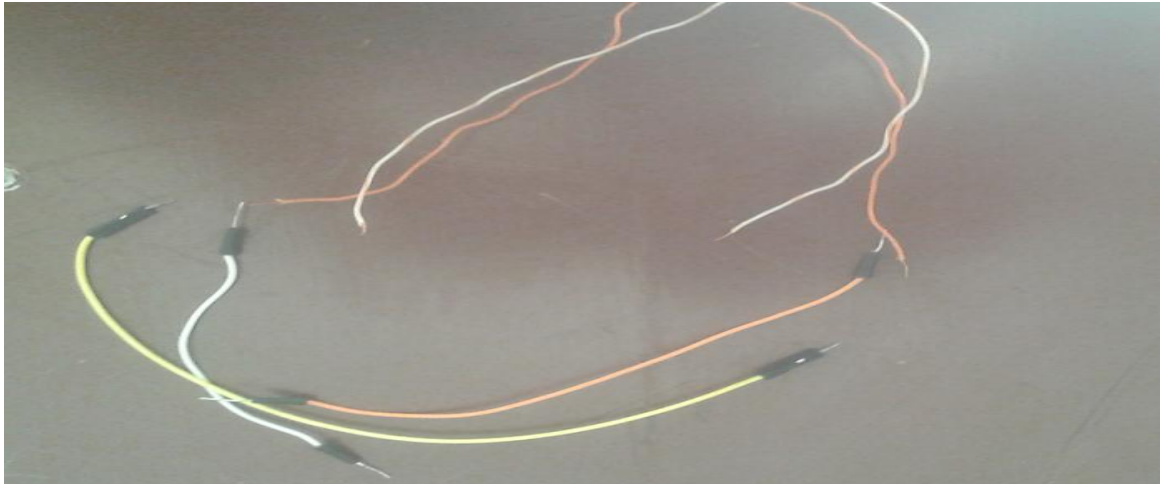


Figure 4-10: Explain types of wires

4-4-1-7 Powers sources

Four batteries used to feed motors of robotic arm and car for operating and give motion for it. This batteries called ABC, every battery from them could provide 1.5 voltage and all together give provide 6 voltage as total. Also four batteries could operate and plumb current and voltage for all component exception arduino, which it fed from external battery with 9 voltage separated from four batteries, which it called Kodak.

The Kodak battery provide 9 voltage for arduino, but arduino consist adapter, which divide the 9 voltage until arrive to arduino in 5 voltage, which required to operate the arduino in proper way. If this

value increase from limited, it will lead to damage in arduino and other components.



Figure 4-11: Explain the power sources

4-5 Method of Connection

When components had round, phase of connection between it started, at the first four drivers L293 had fixed in board and wires used to plumb 16 pins of each driver. As mentioned before four pins(3,7,11 and 14)in each side of driver used to connect driver with two motors of robotic arm(two pins for one motors), four pins(1,8,9 and 16) used to input 5 volts in each side, four pins(4,5,12 and 13) to ground in each side, and four pins(2,6,10 and 15)to connect driver with arduino. All this steps applied to four driverl293.

Each drivers could operate two motors, four drivers used to operate seven motors, five motors found in roboticarm and two motors which connected with two wheels of car. Addition to connect four drivers with arduino, Arduino had connected with Bluetooth from pins RXD and TXD, which found in Bluetooth and arduino.Seven

motors connected with arduino by using wires and plumb from drivers to arduino.

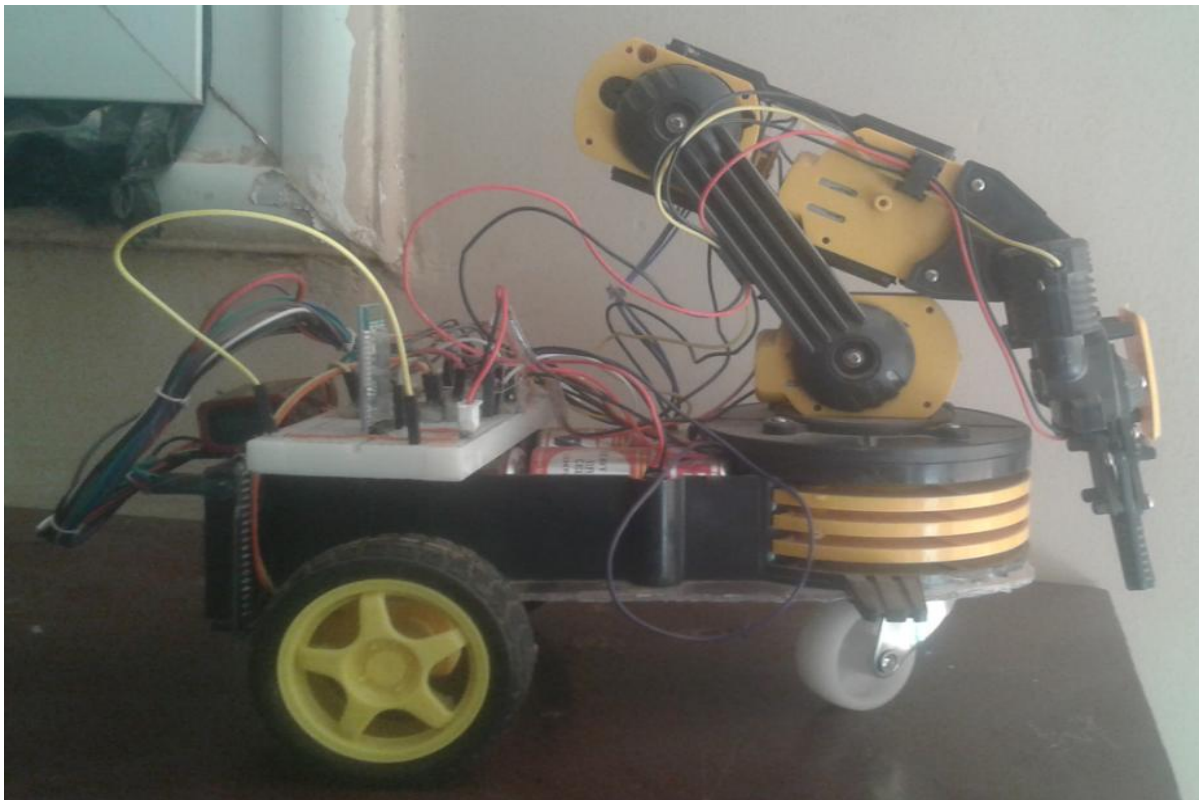


Figure 4-12: Explain the final design

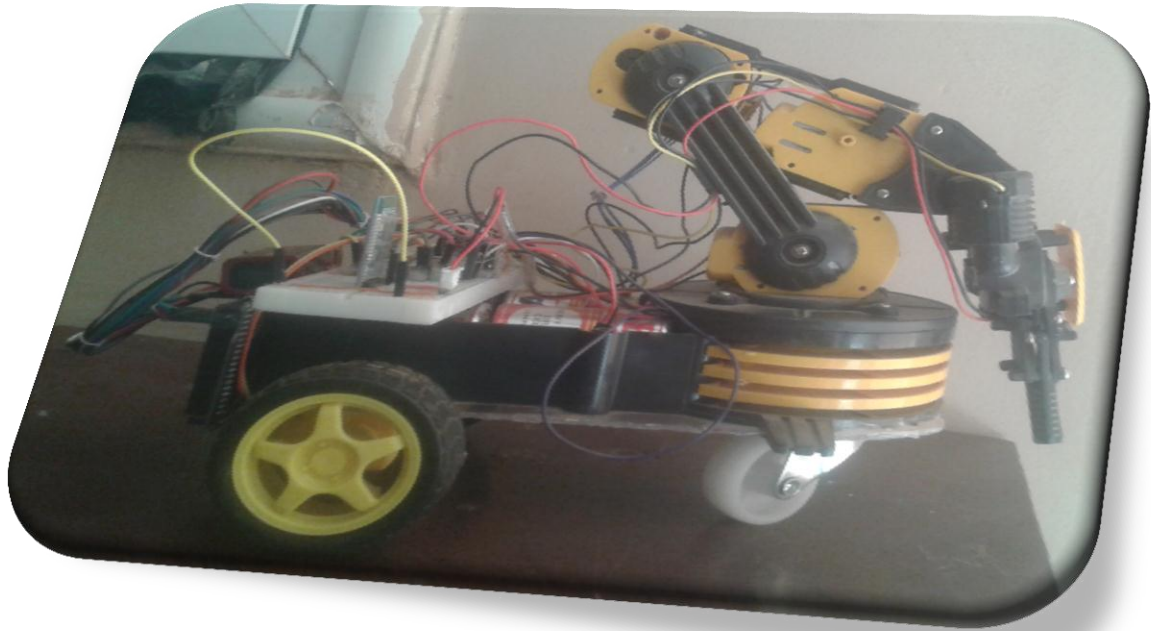
Connection of components had finished, and phase of operating started to move motors. The android application paired with Bluetooth module by inter password 1234 or 0000 to sure from connection between android and Bluetooth. When connection taken place, each key in andiron application pushed to test any motor motion. During test many problems had observed, some of this problems, the base motor moved in left direction andthe right direction did not response to signal from android application. After some revisions to the circuit connection, discovered that it found wire from arduino to driver of base was disconnected. Another problem

related with motors of car, which connected with wheels could move left and right motions, but did not move forward and backward. Code reviewed to modify programmability, after many tries and tests motors wheels could give backward, forward, left and right motions in proper way. Project had given all motions of motors in proper way and with many test achieved the desired objectives.

Design of this project set back 4000 pounds to buy the components, some of this components bought from Egypt and another bought from Tailand and Sudan.

Chapter Five

Results And Discussion



Chapter Five

Results and Discussion

5-1 Results

The obtained results were achieved the objectives of the main project which include:

1-prevent from contact with radiation and increase distance from it.

2-prevent uncontrolled spread of contamination.

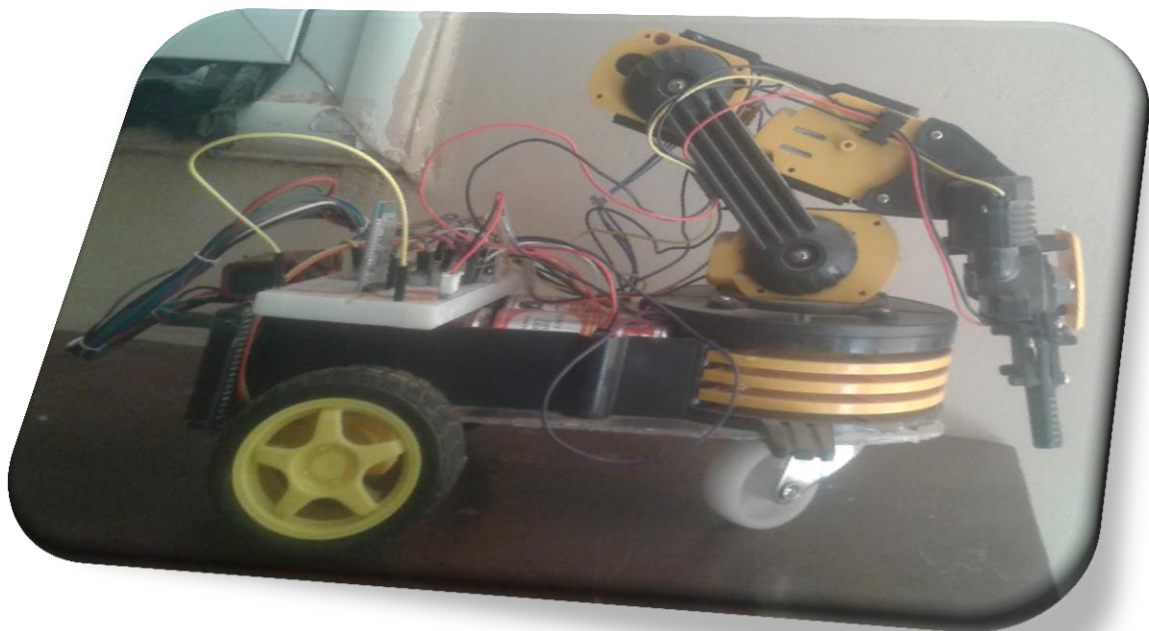
3-provide high efficiency system and low power system.

5-2 Discussion

After circuit had plumbed, the signal came from android application (controller) to Bluetooth module and then to arduino, which translate the signal to send it to specific motor drover, in order to give the motion for motor. And the obtained results are acceptable value.

Chapter Six

Conclusion And Recommendation



ChapterSix

Conclusion and Recommendation

6-1 Conclusion

The system has successfully designed in software and hardware phases. Results obtained are good value, and using android application can make the control from large distance is very easy and flexible in usage.

The system has many benefits:

- Optimize exposure of staff, patient and public, and increase distance from it.
- Reduce time in contact with radiation source.

In short period the use of our design observe improved in safety and protection from radiation source inside hot lab. Also observed that the design could achieve specific functions smoothly, easily and with 3high accuracy.

6-2 Recommendation

The recommendations are to

- 1- Add roll motor in robotic arm design to give it more flexibility.
- 2-Use sensor to detect the motion and recorded it for automatic control.
- 3- Use rechargeable batteries to feed robotic arm and sensor to detect the level of it.

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Appendix

A:

```
int Cmotor1f = 25;
```

```
int Cmotor1b = 24;
```

```
int Cmotor2f = 23;
```

```
int Cmotor2b = 22;
```

```
intARMBmotorf = 3;
```

```
intARMBmotorb = 2;
```

```
intSHmotorf = 5;
```

```
intSHmotorb = 4;
```

```
intELmotorf = 9;
```

```
intELmotorb = 8;
```

```
intPImotorf = 7;
```

```
intPImotorb = 6;
```

```
intROLmotorf = 11;
```

```
intROLmotorb = 13;
```

```
intGRmotorf = 10;
```

```
intGRmotorb = 12;
```

```
int state;
```

```
void setup() {
```

```
    // initialize the digital pin as an output.
```

```
    pinMode(Cmotor1f, OUTPUT);
```

```
    pinMode(Cmotor1b, OUTPUT);
```

```
    pinMode(Cmotor2f, OUTPUT);
```

```
    pinMode(Cmotor2b, OUTPUT);
```



```
pinMode(ARMBmotorf, OUTPUT);
pinMode(ARMBmotorb, OUTPUT);
pinMode(SHmotorf, OUTPUT);
pinMode(SHmotorb, OUTPUT);
pinMode(ELmotorf, OUTPUT);
pinMode(ELmotorb, OUTPUT);
pinMode(PImotorf, OUTPUT);
pinMode(PImotorb, OUTPUT);
pinMode(ROLmotorf, OUTPUT);
pinMode(ROLmotorb, OUTPUT);
pinMode(GRmotorf, OUTPUT);
pinMode(GRmotorb, OUTPUT);

// initialize serial communication at 9600 bits per second:
Serial.begin(9600);}

void loop() {
  if(Serial.available() > 0){
    state = Serial.read();}
  if (state == '5') {
    digitalWrite(Cmotor1f, HIGH);
    digitalWrite(Cmotor2f, HIGH);
    digitalWrite(Cmotor1b, LOW);
    digitalWrite(Cmotor2b, LOW); }

  else if (state == '6') {
    digitalWrite(Cmotor1b, HIGH);
    digitalWrite(Cmotor2b, HIGH);
```

```
digitalWrite(Cmotor1f, LOW);
    digitalWrite(Cmotor2f, LOW) }
else if (state == '7') {
    digitalWrite(Cmotor1f, LOW);
    digitalWrite(Cmotor2f, HIGH);
    digitalWrite(Cmotor1b, LOW);
    digitalWrite(Cmotor2b, LOW); }
else if (state == '8') {
    digitalWrite(Cmotor1f, HIGH);
    digitalWrite(Cmotor2f, LOW);
    digitalWrite(Cmotor1b, LOW);
    digitalWrite(Cmotor2b, LOW); }
else if (state == '2') {
digitalWrite(ARMBmotorf, HIGH);
digitalWrite(ARMBmotorb, LOW); }
    else if (state == '4') {
digitalWrite(ARMBmotorf, LOW);
digitalWrite(ARMBmotorb, HIGH); }
    else if (state == '1') {
digitalWrite(SHmotorf, HIGH);
digitalWrite(SHmotorb, LOW); }
    else if (state == '3') {
digitalWrite(SHmotorf, LOW);
digitalWrite(SHmotorb, HIGH); }
    else if (state == 'U') {
digitalWrite(ELmotorf, HIGH);
```

```
digitalWrite(ELmotorb, LOW); }
  else if (state == 'D') {
digitalWrite(ELmotorf, LOW);
digitalWrite(ELmotorb, HIGH); }
  else if (state == 'P') {
digitalWrite(PImotorf, HIGH);
digitalWrite(PImotorb, LOW); }
    else if (state == 'H') {
digitalWrite(PImotorf, LOW);
digitalWrite(PImotorb, HIGH); }
      else if (state == 'L') {
digitalWrite(ROLmotorf, HIGH);
digitalWrite(ROLmotorb, LOW); }
        else if (state == 'R') {
digitalWrite(ROLmotorf, LOW);
digitalWrite(ROLmotorb, HIGH); }
          else if (state == 'X') {
digitalWrite(GRmotorf, HIGH);
digitalWrite(GRmotorb, LOW); }
            else if (state == 'O') {
digitalWrite(GRmotorf, LOW);
digitalWrite(GRmotorb, HIGH); }
              else
                {
                  digitalWrite(Cmotor1f, LOW);
                  digitalWrite(Cmotor2f, LOW);
```

```
digitalWrite(Cmotor1b, LOW);
digitalWrite(Cmotor2b, LOW);
digitalWrite(ARMBmotorf, LOW);
digitalWrite(ARMBmotorb, LOW);
digitalWrite(SHmotorf, LOW);
digitalWrite(SHmotorb, LOW);
digitalWrite(ELmotorf, LOW);
digitalWrite(ELmotorb, LOW);
digitalWrite(PImotorf, LOW);
digitalWrite(PImotorb, LOW);
digitalWrite(ROLmotorf, LOW);
digitalWrite(ROLmotorb, LOW);
digitalWrite(GRmotorf, LOW);
digitalWrite(GRmotorb, LOW); }
//For debugging purpose
//Serial.println(state);}
```

B1:

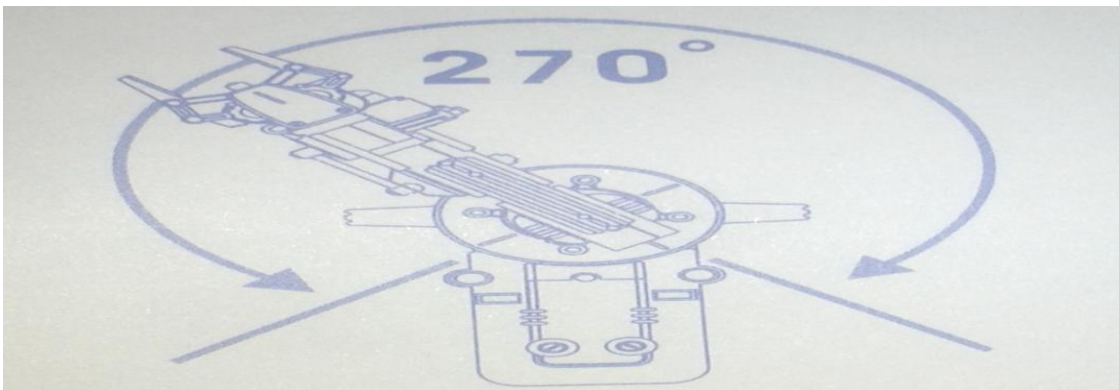


Figure (B1): Explain the base rotation in right side

B2:

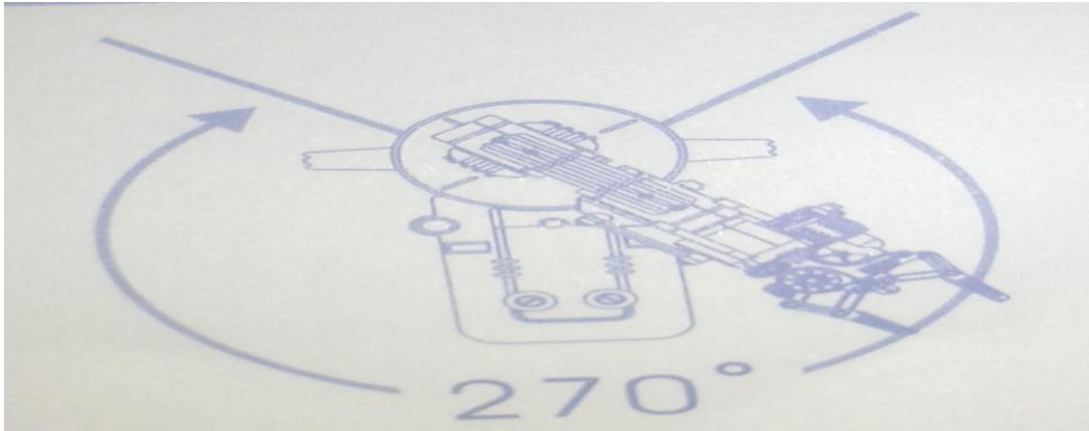


Figure (B2): Explain the base rotation in left side

B3:

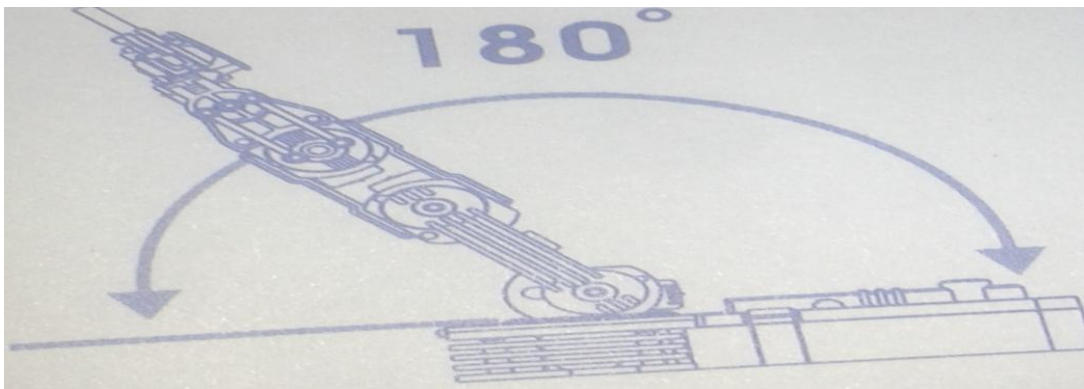


Figure (B3): Explain the base rotation

B4:



Figure (B4): Explain the elbow motion

B5:

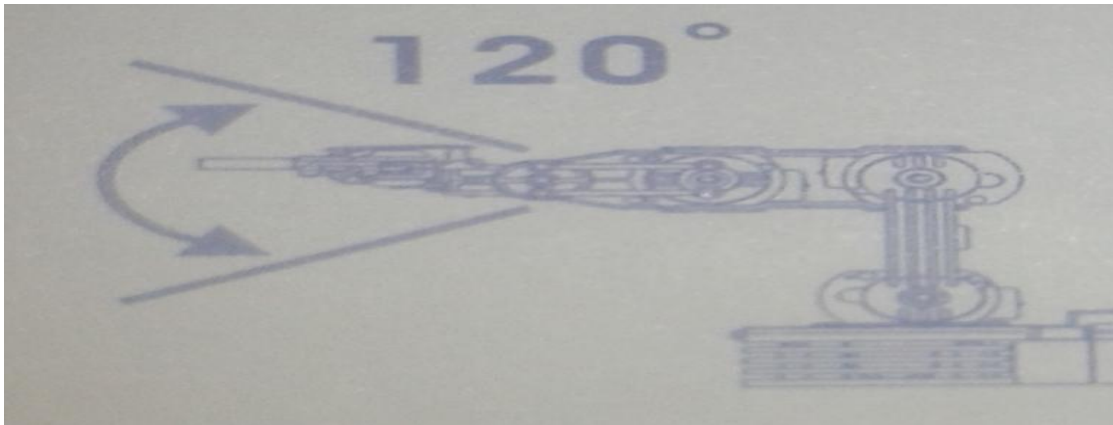


Figure (B5): Explain the wrist motion

B6:

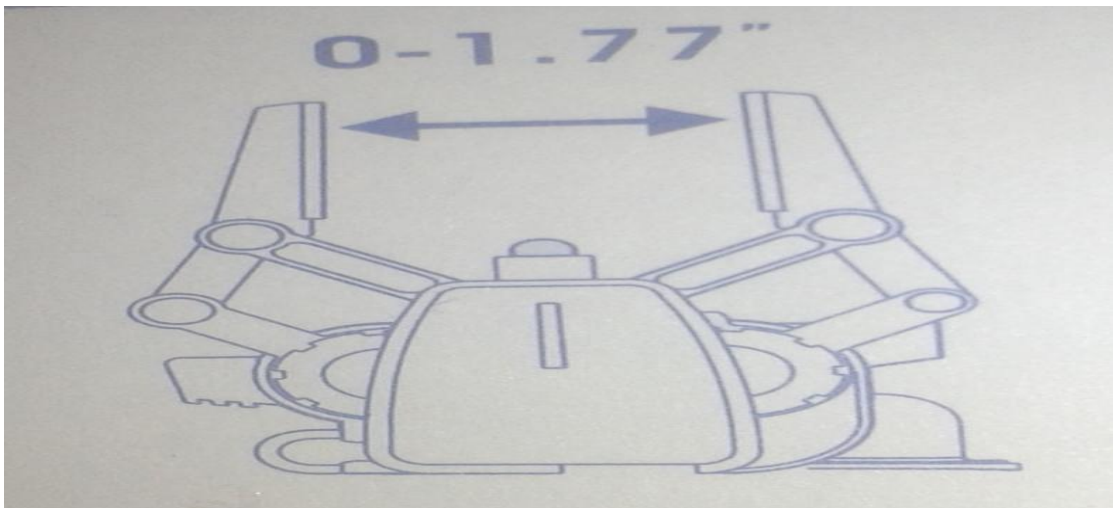


Figure (B6): Explain Gripper motion

C:

- Input voltage: 7-12 V (USB, DC plug, or Vin)
- Max output current per pin: 40 mA

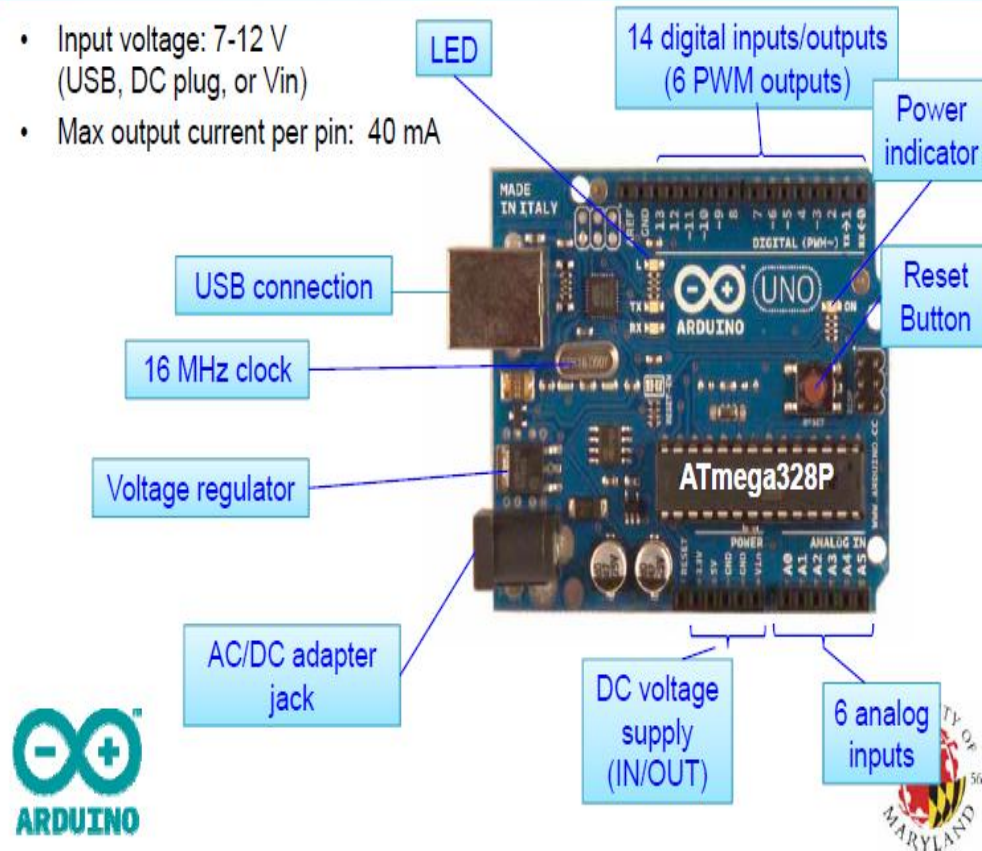


Figure (C): Arduino Atmega parts.