Sudan University of Science and Technology

College of Engineering

School of Electrical and Nuclear Engineering

DESIGN OF A SPIDER ROBOT

تصميم عنكبوت آلي

A Project Submitted In Partial Fulfillment for the Requirements of the Degree of B.Sc. (Honor) In Electrical Engineering

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الآيـــــــة

قال تعالى :

اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ (1) خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ (2) اقْرَأْ
وَرَبُّكَ الْأَكْرَمُ (3) الَّذِي عَلَّمَ بِالْقَلَمِ (4)عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ (5)
كَلَّا إِنَّ الْإِنْسَانَ لَيَطْغَى (6) أَنْ رَآَهُ اسْتَغْنَى (7) إِنَّ إِلَى رَبِّكَ
الرُّجْعَى (8)أَرَأَيْتَ الَّذِي يَنْهَى (9) عَبْدًا إِذَا صَلَّى (10) أَرَأَيْتَ
إِنْ كَانَ عَلَى الْهُدَى (11) أَوْ أَمَرَ بِالتَّقْوَى (12) أَرَأَيْتَ إِنْ كَذَّبَ
وَتَوَلَّى (13) أَلَمْ يَعْلَمْ بِأَنَّ اللَّهَ يَرَى (14) كَلَّا لَئِنْ لَمْ يَنْتَهِ لَنَسْفَعَا
بِالنَّاصِيَةِ (15) نَاصِيَةٍ كَاذِبَةٍ خَاطِئَةٍ (16) فَلْيَدْعُ نَادِيَهُ (17) سَنَدْعُ
الزَّبَانِيَةَ (18) كَلَّا لَا تُطِعْهُ وَاسْجُدْ وَاقْتَرِبْ (19).

سورة العلق

DEDICATION

We gratitude shall be submitted first to "Allah" who Always helps and care for us.

We feel always indebted to "Allah" the most kind and merciful.

To our parent who gives us force and support us forever, and feeling us secure, who light our life and always say to us (it's possible).

To our brothers, sisters and college.

.

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ABSTRACT

Today commercial and industrial robots are in widespread use, performing jobs more cheaply or with greater accuracy and reliability than humans. They are also employed for jobs that are too dirty, dangerous or boring to be suitable for humans.

Robots are widely used in manufacturing, assembly and packing, earth and space exploration, surgery, weaponry, laboratory research and mass production of consumer and industrial goods .As robotic technology develops and becomes cheaper domestic robots for cleaning or mowing the lawn are available, along with robotic toys for children of all ages.

The main objective of this research is to study the main components of the robot, the system is communicated by using a transmitter and a receiver, the robot motion is controlled by using DC motor and sensing devices and design the moving parts of the robot such as legs and belts to achieve the normal operation of the robot in forward, backward, left and right directions.

المستخلص

في الآونة الاخيرة اصبحت الروبوتات الصناعية والتجارية تستخدم على نطاق واسع لاداء وظائف متعددة بتكلفة قليلة وبقدر كبير من الدقة والموثوقية اكثر من البشر ،حيث تستخدم في التصنيع والتجميع والتعبئة والتغليف واستكشاف الارض والفضاء والجراحه والاسلحة والبحوث المعملية وانتاج كميات كبيرة من البضائع الاستهلاكية والصناعية ، كما تطورت لتصبح وسيلة ارخص في اعمال التنظيف بجانب الالعاب الربوتيه للاطفال في جميع الاعمار .

الهدف الاساسي لهذا البحث دراسة المكونات الاساسية للروبوت وربط النظام باستخدام جهاز ارسال واستقبال ، ويتم التحكم في حركة الروبوت بواسطة محرك تيار مستمر واجهزة استشعار ، وتم تصميم الاجزاء المتحركة للروبوت مثل الارجل والسيور لتحقيق الحركة الفعلية للروبوت الى الامام والخلف واليمين واليسار .

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LIST OF SYMBOLS

W	Weight ,Kg
T	Torque , N.m
N	Reactions ,N
L	Dimension ,mm
θ	Angle ,Degree
Lb	length of belt ,mm
D	Diameter , mm
V	Velocity ,m/minute

LIST OF ABBREVIATIONS

CM	The Center of Mass
CPU	Central Processor Units
ALU	Arithmetical Logical Unit
SFR	Special Function Register
PSW	Processor Status Word
ROM	Read Only Memory
OTP	One Time Programmable ROM
UVEPROM	Ultra- Violet Erasable Programmable ROM
RAM	Random Access Memory
EEPROM	Electrically Erasable Programmable ROM
DC	Direct Current
VR	Variable-Reluctance
PM	Permanent Magnet
HB	Hybrid
IDE	Integrated Development Environment
CNC	Computer Numerical Control
MCLR	Memory Clear
PC	Personal Computer
GPR	General Purpose Registers
AC	Alternating Current
SR	Speed Ratio
IC	Integrator Circuit

CHAPTER ONE

INTRODUCTION

1.1 Background

Robots are available in many types according to their field of application. Industrial robots are used in industrial manufacturing environments; Household robots include many quite different devices such as robotic vacuum, cleaners, and robotic pool cleaner's, Medical robots are useful in medicine and medical institutions and etc..

1.2 Problem Statement

Robot is becoming the most important system used in automation due to their high accuracy, dependability and faithfully; so robotic system should have to be studied, constructed and operated.

1.3 Objectives

Robots systems represented in block diagram summarize the overall robot components. These components together perform the operation of the robot. Robot construction consists of a controller inputs and outputs devices, the motion of the spider robot need mathematical calculation to perform the require movement. Wireless camera is used for detection.

1.4Methodology

Spider robot is controlled by PIC16F84A microcontroller which programmed with micro C language and sensed with apposition sensor. The output actuator represents a servo motor and display unit. These together represent a spider model.

1.5 Project Outline

This research consists of five chapters. Chapter one deal with background, problem statement, objectives and methodology. Chapter two explains the robot block diagram and general component of robot. Chapter three represents programming language, four includes transmitter and receiver diagram and main component of spider robot .Chapter five involves conclusion and recommendations.

CHAPTER TWO

ROBOT'S HARDWARE

2.1 Introduction

In the robot's hardware processing there are many requirements and conditions achieve a stable robot walking; those requirements are presented on the mechanical structure design and the electronic design. The mechanical structure design attempts an adequate robot's proportions because mass distributions, center of mass location and the actuators selection are important stage on the mechanical structure design and have direct impact on robot's performance. The Center of Mass (CM) is the point in a system of bodies or an extended at which the mass of the system may be considered to be concentrated and external force may be considered to be applied .The CM is determined during the mass distribution process. The electronic design should be fast enough to perform the control algorithms and handle some sensors.

A robotic hardware design is composed by the actuators, microcontrollers' boards and force sensors. The actuators must be strong enough to carry out the robot's weight and maintain a good relationship between its weight and torque. A microcontroller has been designed in particular for monitoring and/or control tasks. It includes processer,memory,various interface controllers, one or more timer, interrupt controller, input/output pins and bit operation (change one bit within a byte without touching the other bits).Robots need sensors to deduce the events which happened in their world and react to changing situations [1].

2.2The Robot Block Diagram

There are many types of robots such as industrial robot, medical robot, service robot, military robot, etc.To represent a block diagram of a robot considering an industrial robot block diagram as shown in Figure 2.1.

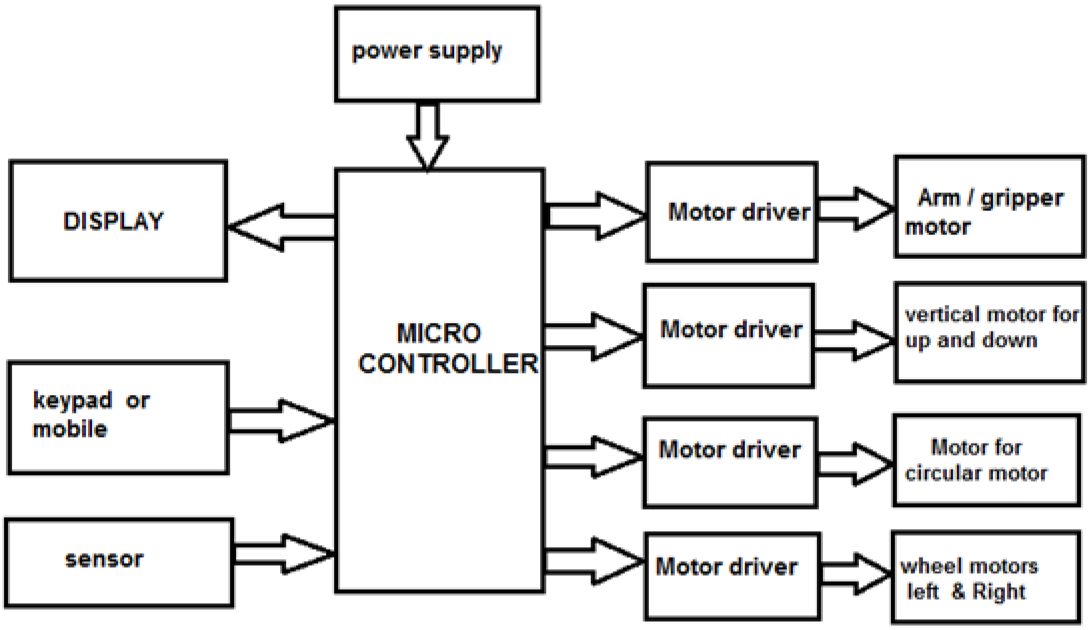

Figure 2.1: Industrial robot block diagram

2.2.1 The microcontroller

It is small devices, with lots of circuitry inside them, having few connections for external communication. The main diagram of microcontroller is shown blow in Figure 2.2.

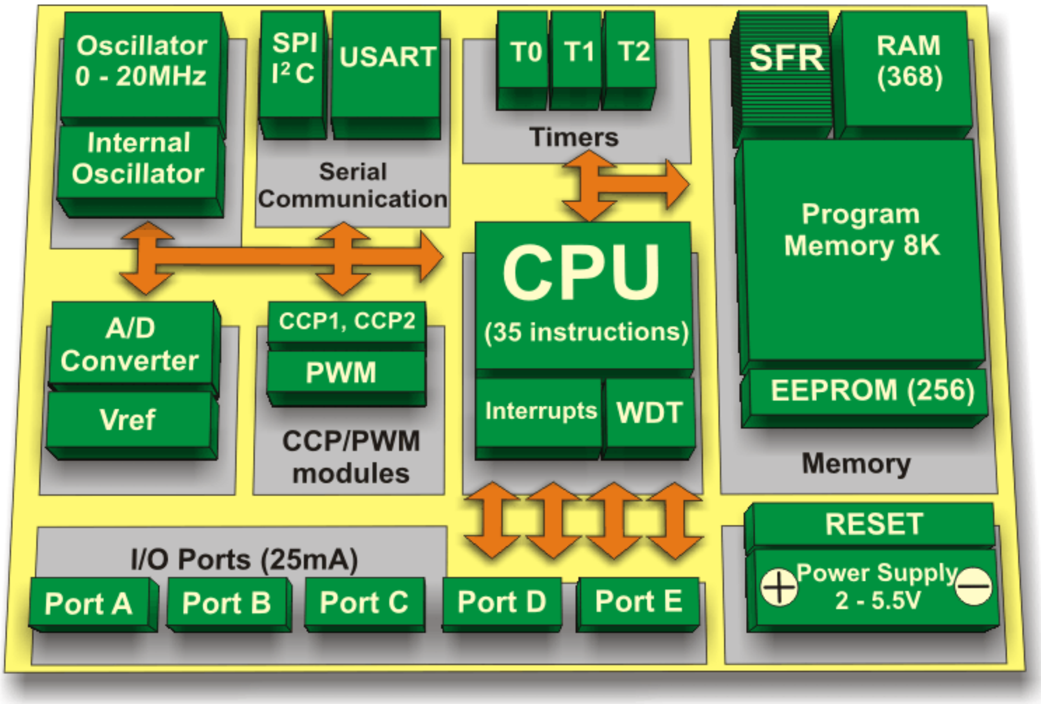

Figure 2.2: Microcontroller block diagram

Central Processor Units (CPU):

As its name indicates, this is a unit which monitors and controls all processes inside the microcontroller. It consists of several smaller units, of which the most important can be represented as shown in the block diagram in Figure 2.3.

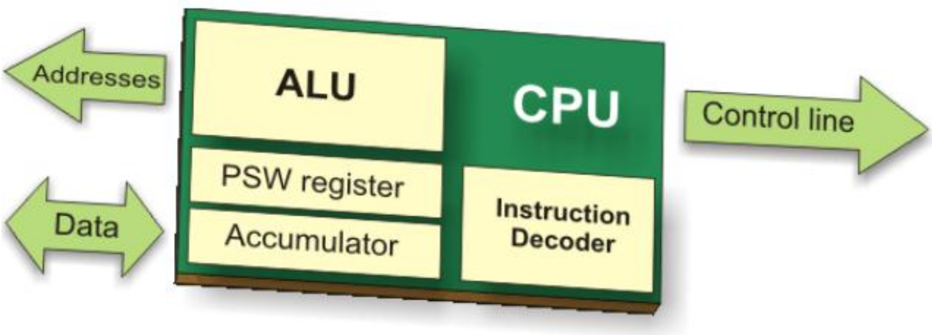

Figure 2.3: The microcontroller block diagram

- Instruction Decoders a part of electronics which recognizes program instructions and runs other circuits on the basis of that. The “instruction set” which is different for each microcontroller family expresses the abilities of this circuit.
- Arithmetical Logical Unit (ALU) performs all mathematical and logical operations upon data.
- An accumulator a Special Function Register (SFR) closely related to the operation of ALU. It is a kind of working desk used for Storing all data upon which some operation should be performed (addition, shift/move etc.). It also Stores results ready for use in further processing.
- Processor Status Word (PSW) is one of SFRs; called Status Register is closely related to the accumulator. It shows at any moment the “status” of a number stored in the accumulator (Number is greater or less than zero etc.).

Memory:

Memory is part of the microcontroller used for data storage. The Figure 2.4 shows memory components.

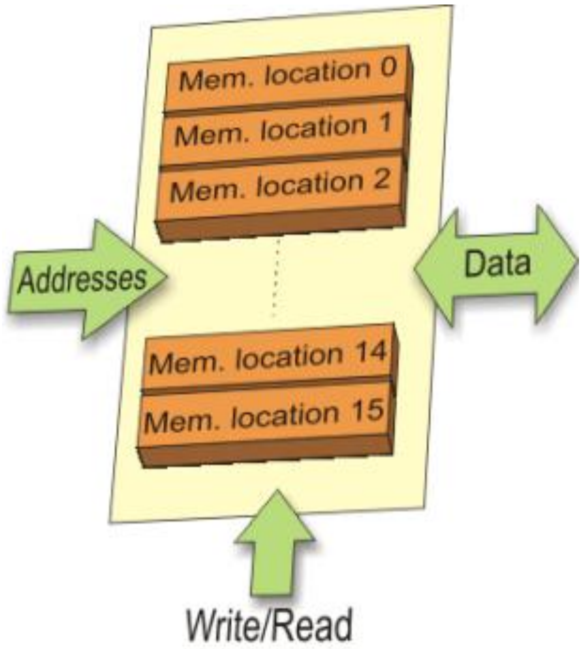

Figure 2.4: Memory components

Memory components are exactly like that. Each memory address corresponds to one memory location. The content of any location becomes known by its addressing. Memory consists of all memory locations and addressing is nothing but selecting one of them. The types of memories are:

- Read Only Memory (ROM).
- Masked ROM.
- One Time Programmable ROM (OTP) ROM.
- Ultra- Violet Erasable Programmable ROM (UV) EPROM.
- Flash memory.
- Random Access Memory (RAM).
- Electrically Erasable Programmable ROM (EEPROM).

Input and Output device:

Each microcontroller has one or more registers called "port" connected to the microcontroller pins. One of more important feature of I/O pins is maximal current they can give or get. For the most microcontrollers, current obtained from one pin is sufficient to activate a LED or other similar low-current consumer (10-20 m A) [2].

2.2.2 Power supply

The robot may be powered by a variety of methods; one of these methods is batteries because they are cheap, relatively safe, small and easy to use. They are composed of one or more cells, each containing a positive electrode, negative electrode, separator and electrolyte. The battery is an essential component of electrical system and it used to start engines and auxiliary power units. Cells can be divided into two major classes: primary and secondary. Primary cells are not rechargeable and must be replacing once the reactants are depleted, Secondary cells are rechargeable and require a dc charge source to restore reactants to their fully charged state. Batteries operate by converting chemical energy into electrical energy through electrochemical discharge reactions [9].

2.2.3 Sensor

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. There are different types of sensor such as: temperature sensor, photoelectrical sensor, etc.

Temperature sensor:

Temperature is a physical parameter that is measured in units of degrees. It is a critical part of any process to measure accurate temperature. The typical applications requiring accurate temperature measurements include medical applications, biology research, electrical or electronic studies, materials research, and thermal characterization of electrical product.The figure (2.5) represents the temperature sensor circuit.

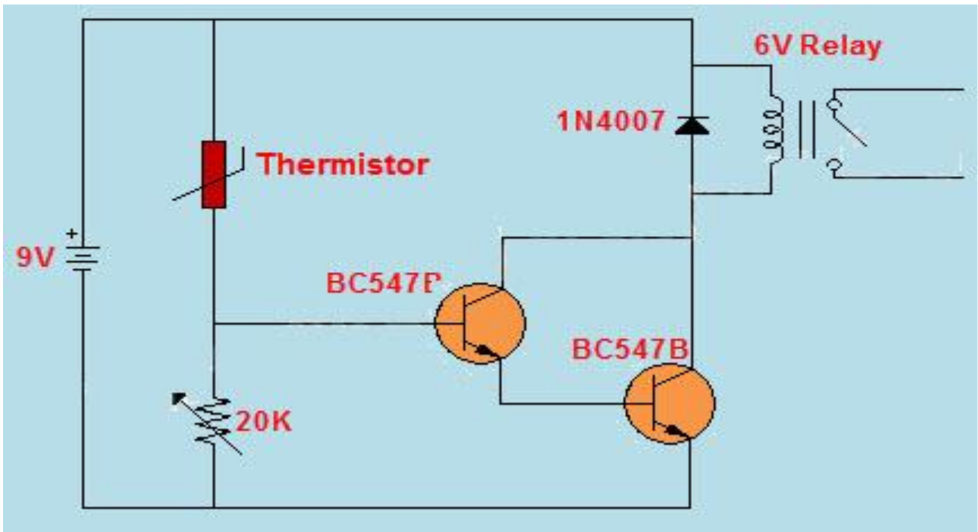

Figure 2.5: Temperature sensor circuit

A temperature sensor is device which used to measure amount of heat energy that allow to detect a physical change in temperature, producing either a digital or analog output ,it is consists of two basic physical types:

a) Contact temperature sensor types:

These types are required to be in physical contact with the object being sensed and use conduction to monitor changes in temperature. They can be used to detect solids, liquids or gases over a wide range of temperatures.

b) Non-contact temperature sensor types:

These types of temperature sensor are required to be in physical non-contact with the object being sensed and use conduction to monitor changes in temperature. They can be used to measure temperature of only solids and liquids. It is not possible to use them on gases because of their transparent nature.

Photoelectric sensor:

It is a device used to detect the distance, absence, or presence of an object by using a light transmitter, often infrared, and a photoelectric receiver. They are used extensively in industrial manufacturing [3].

2.2.4 Actuators

An actuator is a type of motor that is responsible for moving or controlling a mechanism or system. It operated by a source of energy, typically electric current or pneumatic pressure and hydraulic fluid, and converts that energy into motion. An electric actuator is powered by a motor that converts electrical energy into mechanical torque. A mechanical actuator functions by converting rotary motion into linear motion to execute movement. It involves gears, rails, pulleys, chainand other device to operate. Performance metrics for actuators include speed, acceleration and force Speed should be considered primarily at a no-load pace, since the speed will invariably decrease as the load amount increases. The rate the speed will decrease will directly correlate with the amount of force and the initial speed. Two main metrics should be considered for force in actuators static and dynamic loads, static load is the force capability of the actuator while not in motion; dynamic load is the force capability of the actuator while in motion. Most actuators used into robots are: DC motor, stepper motor, servo motor, etc.

Dc motors:

These are the most common motors available, connected to a power supply by two wires. The direction of a DC motors can be changed by reversing the polarity of the motor supply voltage. DC motors draw a large amount of current and as a result cannot be wired straight from a control system such as pic. There are four types of dc motors such as: Permanent Magnet, series, shunt and compound motors.

a) Permanent magnet motor:

The permanent magnet motor uses a magnet to supply field flux. It has excellent starting torque capability with good speed regulation. A disadvantage of permanent magnet DC motors is they are limited to the amount of load they can drive. These motors can be found on low horsepower applications; also the torque is usually limited to 150% of rated torque to prevent demagnetization of the permanent magnets. The Figure 2.6 shows the permanent magnet motor.

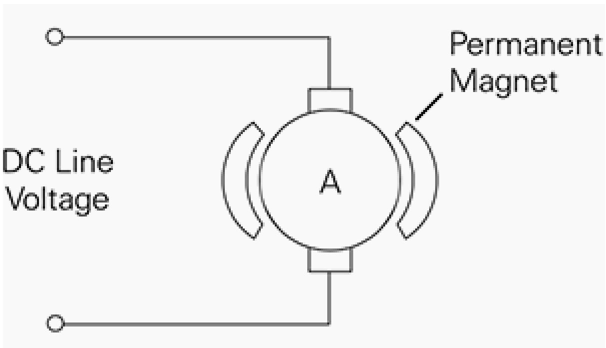

Figure 2.6: Permanent magnet motor

b) Series Motors:

In a series DC motor the field is connected in series with the armature. The field is wound with a few turns of large wire because it must carry the full armature current. Series motors cannot be used where a constant speed is required under varying load. Additionally, the speed of a series motor with no load increases to the point where the motor can become damaged. Some load must always be connected to a series-connected motor. Series-connected motors generally are not suitable for use on most variable speed drive applications. The Figure 2.7 represents the series motor.

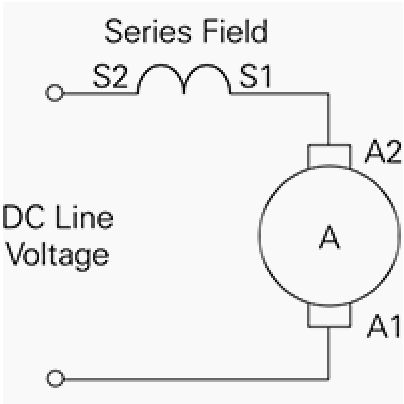

Figure 2.7: Series motor

C) Shunt motors:

In a shunt motor the field is connected in parallel (shunt) with the armature windings. The shunt-connected motor offers good speed regulation. The field winding can be separately excited or connected to the same source as the armature. An advantage to a separately excited shunt field is the ability of a variable speed drive to provide independent control of the armature and field. The Figure 2.8 explains the shunt motors.

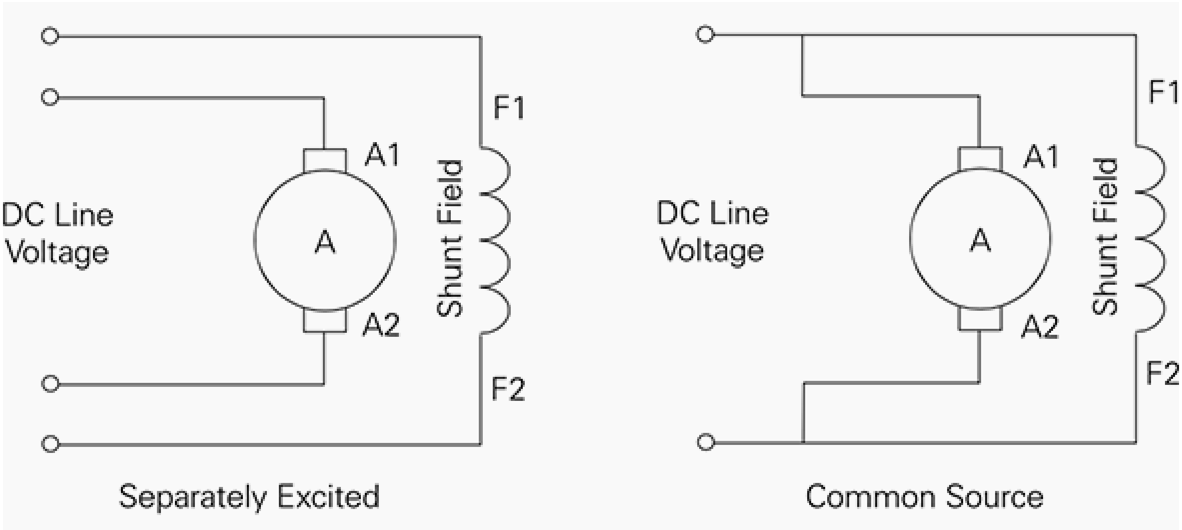

Figure 2.8: Shunt motor

d) Compound motors:

Compound motors have a field connected in series with the armature and a separately excited shunt field. The series field provides better starting torque and the shunt field provides better speed regulation. However, the series field can cause control problems in variable speed drive applications and is generally not used in four quadrant drive. Figure 2.9 explains the compound motors.

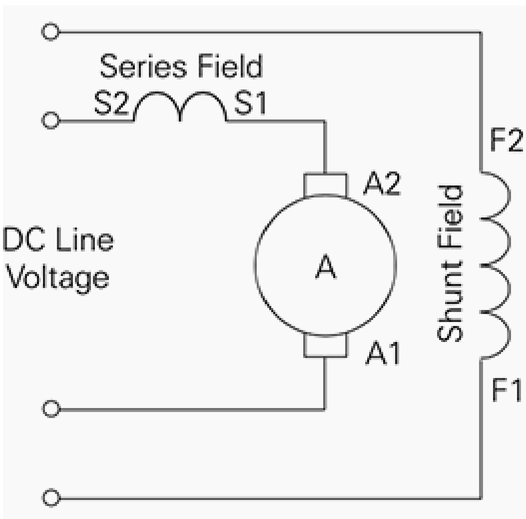

Figure 2.9: Compound motor

Stepper motor:

Stepper motors have several electromagnetic coils that must be powered sequentially to make the motor run. It can be made to reverse direction and controlled by sequential turning on and off the coils. The shaft of stepper motor moves between discrete rotary positions that correspond to the particular coil that was last energized because precise position controllability stepper motor are excellent for application that require high positioning accuracy. The types of stepper motors:

a)Variable-Reluctance (VR):

This type of stepper motor has been around for a long time. It is probably the easiest to understand from a structural point of view. Figure 2.10 shows a cross section of a typical V.R. stepper motor. This type of motor consists of a soft iron multi-toothed rotor and a wound stator. When the stator windings are energized with DC current the poles become magnetized. Rotation occurs when the rotor teeth are attracted to the energized stator poles.

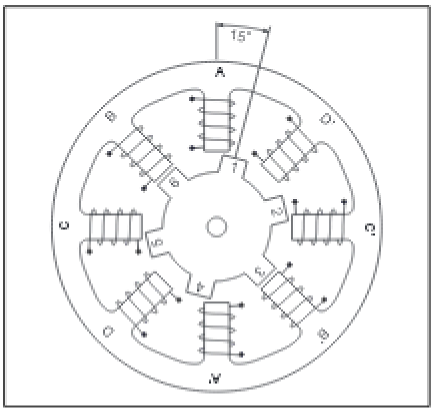

Figure 2.10: Variable – Reluctance motor

b) Permanent Magnet (PM):

Often referred to as a “tin can” or “can stock” motor the permanent magnet step motor is a low cost and low resolution type motor with typical step angles of 7.5to 15 (48 – 24 steps/revolution) PM motors as the name implies have permanent magnets added to the motor structure. The rotor no longer has teeth as with the VR motor. Instead the rotor is magnetized with alternating north and south poles situated in a straight line parallel to the rotor shaft. These magnetized rotor poles provide an increased magnetic flux intensity and because of this the PM motor exhibits improved torque characteristics when compared with the VR type. The Figure 2.11 explains the permanent magnet.

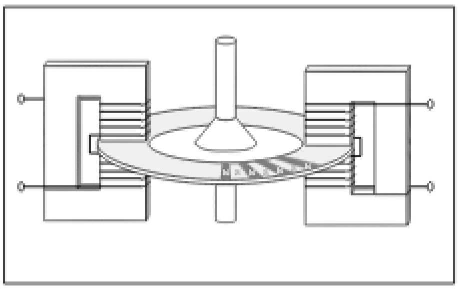

Figure2.11: Permanent magnet motor

c) Hybrid (HB):

The hybrid stepper motor is more expensive than the PM stepper motor but provides better performance with respect to step resolution, torque and speed. The hybrid stepper motor combines the best features of both the PM and VR type stepper motors. The Figure 2.12 illustrates the hybrid motor

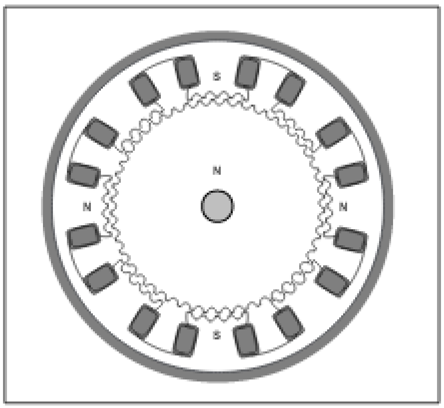

Figure2.12: Hybrid motor

Servo motor:

The servo motors offer the smooth and great control. They can be told to rotate to specific points, making them ideal for applications that require precise movement. The rotation of a servo is limited; most rotate from 90 degree to 180 degree through some can complete a full rotation. And the torque and control make them suitable for powering robotic. Servos motors are made up of a number of components that are housed neatly in a self-contained unit .They contain a motor, gearbox and driver controller, allowing them to be controlled directly from a microcontroller. Servos have three wires connected to them. Two of wires are for the power supply and the third cable feeds straight from the MC [4].

2.2.5 Display device:

It is an output device for presentation of information in visual or tactile form. When the input information is supplied as an electrical signal, the display is called an electronic display. There are many methods to display such as: segment displays, full-area two dimensional displays (television sets, computer monitors, etc), etc [9].

CHAPTER THREE

ROBOT'S SOFTWARE

3.1 Introduction

The various software components are developed by different programmers to successfully achieve the deployment of autonomous robots; the robotic community has relied on architectures and tools to enforce number of good software engineering practices. The software components are organized in levels or layers .Most of the time these layers correspond to different temporal requirements, or to different abstraction requirements designed as electronic. so electronic devices today are the blend of hard ware and software such as a microcontroller electronic integrated circuits. The microcontroller revolutionized the world of electronics such as controlling in remote control, air condition, microwave oven, DVD player ,television or cell phone and industrial automation including automatic, handling the job nicely assembly lines ,robots and quality control system [4].

3.2 Programming languages

A computer program is a sequence of instruction, written to perform a specified task on computer. A computer requires programs to function, typically executing the program's instruction in central processor. A programming language is a computer language engineered to create a standard from commands. These commands can be interpreted into a code understood by a machine .Programs are created through programming languages to control the behavior and output of machine through accurate algorithms, similar to the human communication process.

There are three main levels of computer programming language Machine language, assembly language, a high level language and other more [5].

3.2.1 A machine language

The lowest level programming language except for computers that utilize programmable microcode, it is the only languages understood by computers and it is the almost impossible for humans to use because they consist entirely of number [5]. For example to jumping to address 1024 the programming for this operation is

[Op target address]

2 1024

Decimal

000010 00000 00000 00000 10000 00000

Binary

3.2.2The assembly language

Assembly language is the most basic programming language available for any processor. With assembly language, a programmer works only with operation implemented directly on the physical CPU. Assembly language is the most powerful computer programming language available, and it gives programmer the insight required to write effective code in high – level language [5]. The samples for this language explain in following programming:

```
        MVI B, FFH
NEXT        DCR B
        MVI C, COUNT
```

```
DELAY   DCR C
        JNZ DELAY
        MOV A, B
        OUT PORT
        JMP NEXT
```

3.2.3 A high level language

High-level language is computer programming language that isn't limited by the computer, designed for a specific job, and is easier to understand. It is more like human language and less like machine language .however, in order for computer to understand and run a program created with a high-level language, it must be compiled into machine language.

There are many high-level languages such as BASIC, C, C++, JAVA and Pascal. Example for a high level language written by C language as follows:

```
// sum the numbers 1...100 //
int i=1;
int sum=0;
  while (i<=100)
{
sum+=I;
i++;  }
```

In plus the microcontroller can be programmed by micro C for PIC microcontroller, and Bascom language for at mega microcontroller

3.3 Micro C

The creation of PIC BASIC followed the great success of Basic stamp (small plate with PIC16F84 and serial EEPROM that compose the whole microcontroller system) as its modification. PIC BASIC enables the programs written for the original Basic stamp to be translated for the direct execution on the PIC16xxx, PIC17Cxxx and PIC18Cxxx members of the microcontroller's family. By means of PIC BASIC it is possible to write programs for the PIC microcontrollers of the following families PIC12C67x, PIC14C000, PIC16C55x, PIC16C6x, PIC16C7x, PIC16x84, PIC16C9xx, PIC16F62x, PIC16C87x, PIC17Cxxx and PIC 18Cxxx. On the contrary, the programs written in PIC BASIC language cannot be run on the microcontrollers possessing the hard ware stack in two levels as for example the case of PIC16C5x family (that implies that by using the CALL command any subroutine can be called not more than two times in a row).For the controllers that are not able to work with PIC BASIC there is an adequate substitution. For example, instead of PIC16C54 or 58, can use pin compatible chips PIC16C554, 558, 620 and 622 also operating with PIC BASIC without any difference in price. Currently, the best choice for application development, using PIC BASIC are microcontrollers from the family : PIC16F87x, PIC16F62X and of course the famous PIC16F84. With this family of PIC microcontrollers, program memory is created using FLASH technology which provides fast erasing and reprogramming, thus allowing faster debugging. By a single mouse click in the programming software, microcontroller program can be instantly erased and then reloaded without removing chip from device. Also, program loaded in FLASH memory can be stored after power supply has been turned off. The older PIC microcontroller series (12C67x, 14C000, 16C55x, 16C6xx, 16C7xx and 16C92x) have program memory created using EPROM/ROM technology, so they Basic for PIC Microcontrollers can either be programmed only once (OTP version with ROM memory) or have glass window (JW version with EPROM memory), which allows erasing by few minutes exposure to UV light. OTP versions are usually cheaper and are used for manufacturing large series of products. Besides FLASH memory, microcontrollers of PIC16F87x and PIC16F84 series also contain 64 -256 bytes of Internal EEPROM memory, which can be used for storing program data and other parameters when power is off. PIC BASIC has built -in READ and WRITES instructions that can be used for loading and saving data to EEPROM. In order to have complete information about specific microcontroller in the application should get the appropriate Data Sheet or Microchip CD – ROM [2].

3.4 Bascom

BASCOM is an Integrated Development Environment (IDE) that supports the 8051 family of microcontrollers and some derivatives as well as Atmel's AVR microcontrollers. Two products are available for the various microcontrollers - BASCOM-8051 and BASCOM-AVR.In a microcontroller project one needs to know the hardware base like the microcontroller with internal and connected peripherals, and the software used like IDE handling, programming and debugging. There are two families of BASCOM:

3.4.1 8051 family

The 8051 is an accumulator-based microcontroller featuring 255instructions. A basic instruction cycle takes 12 clocks; however, some manufacturers redesigned the instruction-execution circuitry to reduce the instruction cycle. The CPU has four banks of eight 8-bit registers in on-chip RAM for context switching. These registers reside within the 8051's lower 128 bytes of RAM along with a bit-operation area and scratchpad RAM.

These lower bytes can be addressed directly or indirectly by using an 8-bit value [5].

3.4.2AVR family

AVR microcontrollers were designed together with C-language experts to ensure that the hardware and software work hand-in-hand to develop a highly efficient,high - performance Code.The family of AVR microcontrollers includes differently equipped controllers - from a simple 8-pin microcontroller up to a high-end microcontroller with a large internal memory. Also computer numerical control machine can be programmed by different types of code programming such as G code and M code [5].

3.5 Computer Numerical Control Programming

Is the general term used for a system which controls the functions of a machine tool using coded instructions processed by a computer .This manual covers the stages involved producing the coded instructions, used by the CNC unit to make the component, These coded instructions are called the part program, each part program contains a number of different codes, the most important being the collection of G and M codes. Essentially, these form the basic language used to describe how a component will be manufactured, the order in which to carry out machining tasks, when to change tools, how far to cut into the material etc...[6].

3.5.1G codes

Preparatory functions, called G codes, are used to determine the geometry of tool movements and operating state of the machine controller; functions such as linear cutting movements, drilling operations and specifying the units of measurement. They are normally programmed at the start of a block. A G code is defined using the G address letter and a two digit number as follows, G Ø, Ø (Address, two digit number)[6].

3.5.2M code

Miscellaneous functions, called M codes, are used by the CNC to command on/off signals to the machine functions. i.e., MØ3spindle forward (CW), MØ5 - spindle stop, etc.....The functions allocated to lower M code numbers are constant in most CNC controls, although the higher M code number functions can vary from one make of controller to the next. An M code is defined using the M address letter and a two digit number as follows MØ,Ø (Address ,Two digit number).Artificial intelligence programming is represented in Prolog programming language[6].

3.6Prolog programming

It is a declarative programming language that means, when implementing the solution to a problem, instead of specifying how to achieve a certain goal in a certain situation, specify what the situation (rules and facts) and the goal (query) are and let the Prolog interpreter derive the solution for us. Prolog is very useful in some problem areas, such as arterial intelligence, natural language processing, databases, but pretty useless in others, such as graphics or numerical algorithms [5].

CHABTER FOUR

SYSTEM APPLICATION

4.1 Introduction

The spider robots are controlled by the wireless controller. They move with eight legs, four legs in the front and four legs at the back. Every two legs are connected with axis of rotation continuously interleaved with serrated commander by timing belt. This Serrated commander connected to the axis of servo motor modified to be constant current driver to ensure the continuity of rotation. It can walk forward, backward and can maneuver to right or left direction.

Mechanical system has been used to move the legs with mechanism prompt return. It is the system which converts circular motion to linear motion through the links and connecting rods. These links and connecting rods have been designed to conform to the legs movement. Before the design the numbers of legs, links and the speed of the motor have been determined. This spider moves very smoothly. In the moment there are four legs touch the ground and provide with fortitude and other four legs be in the air and so on. Spider contains wireless camera installed in the constant current motor and moves 360 degrees slowly in order to provide the camera by vision accurate degree.

4.2 System Components

The main block diagram of the spider robot represent in two block diagrams, the first is transmitter circuit and the other one is receiver circuit as shown in Figures 4.1 and 4.2 respectively.

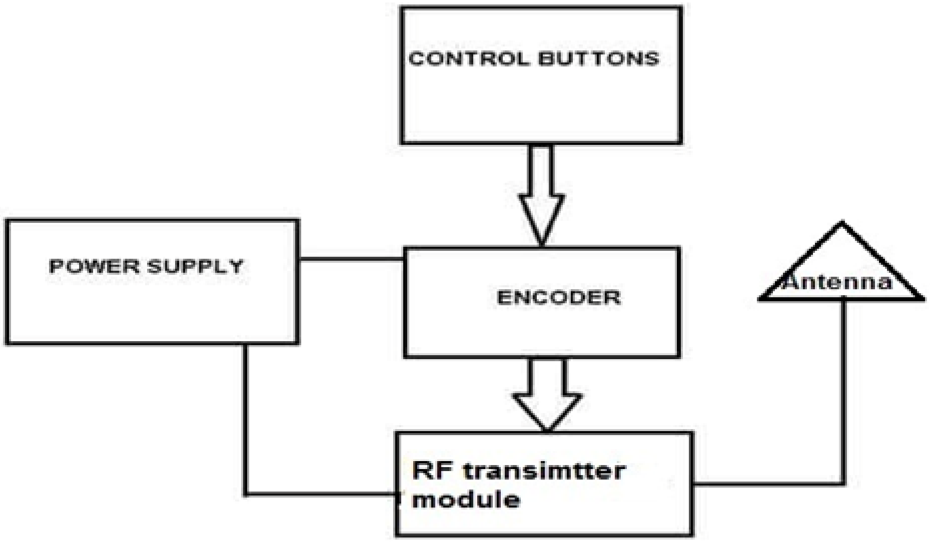

Figure 4.1: Transmitter circuit

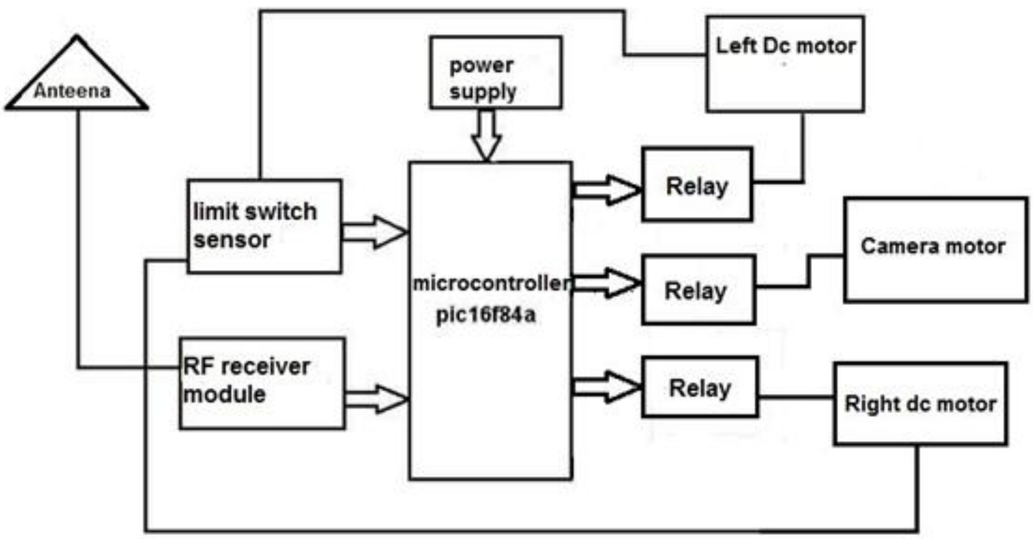

Figure 4.2: Receiver circuit

The main component of the spider robot are: the microcontroller PIC16f84A, wireless camera, limit sensor, servo motor, relays, joints ,belts and end effectors.

4.2.1The microcontroller PIC16F84A

PIC16F84A product by microchip company ,it is widely common and supported by location that interest of microcontroller projects, 16F84A instead of 16F84 with the only difference being that the A-version runs at 20MHz using a 20MHz crystal, the non-A version runs at10MHz crystal. It consists of EEPROM, FLASH and RAM, timer to count and time and word length 1024 bit. The most useful feature of this microcontroller is that its flash based so it can be re-programmed many times.There are also many other similar chips with different (RAM/EPROM/internal peripherals), such as the 16F88, 1FF628, 16F627 have the same pin out and are cheaper. Features of PIC16F84A have been represented in the Table 4.1.

Table 4.1: PIC16F84A features

Parameter Name	Value
Program memory type	Flash
Program memory	1.75(kb)
Cpu speed	5(mips)
Ram bytes	68
Data EEPROM	64(bytes)
Timers	1x8-bit
Temperature range	40-85(c)
Operating voltage range	2-6 (v)
Pin count	18

The Pin diagram of PIC16F84A is represented in Figure 4.3

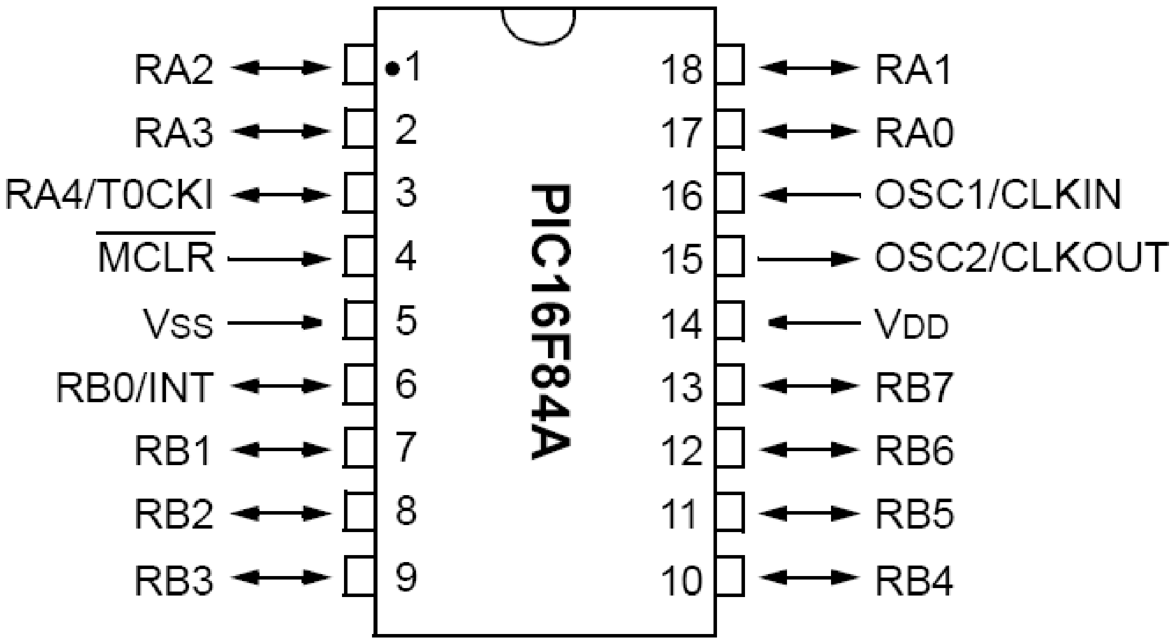

Figure 4.3:The pin diagram of PIC16F84A

The Pin configuration of PIC16F84A is shown in Table 4.2

Table 4.2: The pin configuration

Pin Number	Description
1	RA2 - Port A
2	RA3 - Port A
3	RA4/TOCK1 - Port A
4	MCLR - Master Clear Input
5	Vss – Ground
6	RB0/INT - Port B
7	RB1 - Port B
8	RB2 - Port B
9	RB3 - Port B

10	RB4 - Port B
11	RB5 - Port B
12	RB6 - Port B
13	RB7 - Port B
14	Vdd - Positive Power Supply
15	OSC2/CLKOUT - Oscillator Output
16	OSC1/CLKIN - Oscillator Input
17	RA0 - Port A
18	RA1 - Port A

The pin definition:

Pin 5: Vss– This is the ground pin of the IC and must be connected to the negative terminal of the battery.

Pin 14: Vdd– This is the supply pin of the IC and must be connected to the positive terminal of the battery. (Remember maximum you can use a 5 volt) .

Pin 4: MCLR – Memory Clear. This is an active low pin. That means, it performs its assigned function, when it is kept low (connected to the ground). Obviously, this pin is used to clear the temporary RAM memory. Always, when the controller is in operation, this pin is connected to positive supply.

Pins 15&16: Oscillator in/out –Maximum frequency you can use is 20MHz second!). They are very cheap, easy to use, accurate and small.

Pins 1,2,3,6,7,8,9,10,11,12,13,17&18: These are the 13 I/O pins. They are grouped into two groups. Port A which contains 5 pins (17,18,1,2&3) and Port B which contains 8 pins(6,7,8,9,10,11,12&13) [7].

-PIC16F84 Programming:

The chip can be programmed by using the same integrated circuit system programmer used for the other PIC chips.

The program:

```
Void clock ( )
{
Portb.f0=1;
Portb.f1=0;
Porta.f0=1;
Porta.f1=0;}
Void unclock ( )
{
Portb.f0=0;
Portb.f1=1;
Porta.f0=0;
Porta.f1=1;}
Void interrupt ( )
{
If (portb.f6==0)
Clock ( );
else
```

```
unClock( );

Intcon.f0=0;

}

Void main( ){

trisb=0xc0;

portb=0;

trisa=0;

porta=0;

intcon=0b10001000;

option_reg=0b1000000;

clock( );

}
```

PIC16F84A power Supply:

Figure 4.4 represented the 5 volt power supply unit.

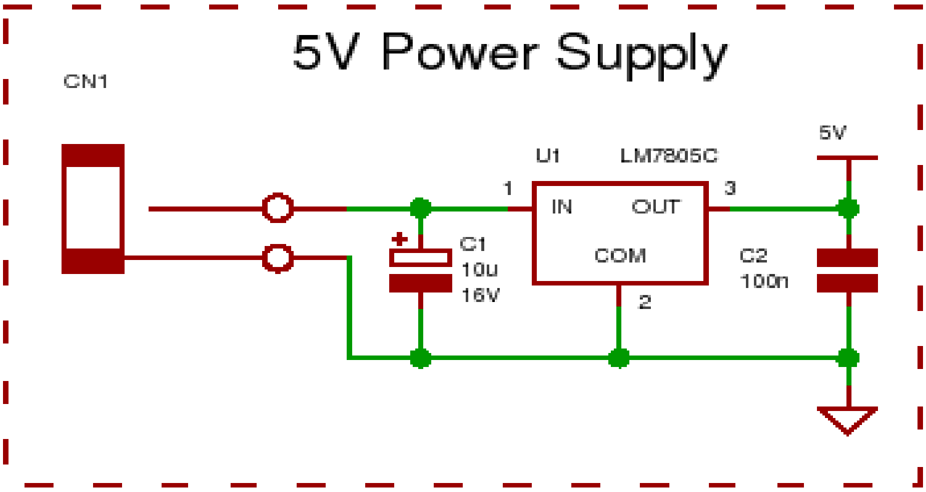

Figure 4.4: 5 volt power supply

It is best to use the 5V power supply circuit as it not only correctly regulates the dc voltage but it protects your PIC chip.

Central process unit (CPU):

To fetched instruction from memory and decode that instruction in to series of simple action and execute the instruction by caring out this action in sequential manner.

Arithmetic and logic unit:

To perform simple arithmetic and logic operation.

The Watchdog Timer:

Watchdog timer is an internal timer inside the chip. You can enable or disable the timer by programming. The main use of the timer is to reset the microcontroller when its program goes faulty or it enters into an infinite loop.

Registers:

There are two types of registers – General Purpose Registers (GPR) and Special Function Registers (SFR). It's obvious from the name that the general purpose registers are used to store any arbitrary value to operate on. The special function registers are used to perform some functions which control the device.

STATUS:

We use this register mainly for one purpose – to switch between the banks. When the fifth bit of this register is set, we are in bank 1, when the fifth bit is reset, we are in bank 0.

PORTA:

The five of the eight bits in the register corresponds to the 5 pins of port A (17, 18, 1, 2&3 pins). Here the least significant bit corresponds to RA_0.

PORTB:

The eight bits of this register corresponds to the 8 pins of port B (6, 7, 8, 9, 10, 11, 12&13 pins). Same is the case here – LSB is RB_0 and MSB is RB_7.

TRISA:

This register is used to set (decide) whether the ports A pins are input or output. Ones represent input and zeros represent outputs).

TRISB:

Similar is the case with TRISA register. It is used to configure port B pins as inputs/outputs.

W Register:

This is the general purpose register accessible by program. You can write values directly only into W register. It corresponds to a register (Accumulator) in the 8085 processor [2].

4.2.2 Wireless control

A wireless network consists of several components that support communications using radio or light waves propagating through an air medium. Some of these elements overlap with those of wired networks, but special consideration is necessary for all of these components when deploying a wireless network.

Robots using a handheld radio transmitter box that sends signals from an antenna on the top to a matching an antenna , radio signals can be travel mush further than infrared ones without inference , especially if the transmitters and antennas are large and powerful.

- **Wireless Network Infrastructures :**

The infrastructure of a wireless network interconnects wireless users and end systems. The infrastructure might consist of base stations, access controllers, application connectivity software, and a distribution system. These components enhance wireless communications and fulfill important functions necessary for specific applications.

- **Base Stations :**

The base station is interfaces the wireless communications signals traveling through the air medium to a wired network often referred to as a distribution system. Therefore, a base station enables users to access a wide range of network services, such as, e-mail access.

- **Distribution System :**

The distribution system, which often includes wiring, is generally necessary to tie together the access points, access controllers, and servers. In most cases, the common Ethernet comprises the distribution system[1].

- **Wireless camera :**

The Figure 4.5 shows the wireless camera.

Figure4.5: Wireless camera

A 1.2G Wireless Camera Kit is used to deserve unexpected thing from happening, a mini wireless camera suit for security supervise, surveillance supervise, and many other interesting filed in our life.Wireless transmission and reception, light weight, small size, low power consumption, High sensitivity, easy to install and operate, as well as to conceal. Table 4.3 represents the wireless camera specification.

Table 4.3: Wireless camera specification

CMOS color	0.9-1.2GHz/1/3
Wireless	Audio
Frequency control	adopt CPU frequency lock the wreath to control, with high frequency stability
Rule	PAL/CCIR NTSC/EIA
Effective picture element	PAL:628x582 NTSC:510x492
Horizontal definition	380 Line
Minimum Illumination	3 Lux
Scan Frequency	PAL/CCIR: 50Hz, NTSC/EIA: 60Hz
Sensitivity	18DB - AGL ON-OFF
Output power	50 - 300Mw
Distance	50 - 100M (without barrier and interference)
Electric power	DC9V
Current	200Ma
Size	25x35x15mm
Power Consumption	<400Mw

The other requirements of wireless camera:

-1x 1.2GHz Security Wireless CMOS Color Video Audio Camera.

-1x 1.2GHz Security Wireless Radio AV Receiver.

-1x power supply.

-1x LCD screen.

4.2.3Limit switch

A limit switch is a switch operated by the motion of a machine part or presence of an object .It used as a part of a control system for controlling machinery or to count objects passing a point and used in variety of applications and environments because it is ease of installation and reliability. A limit switch is an electromechanical device include an actuator mechanically linked to a set of contact , when an object comes into contact with the actuator the device operates the contacts to make or break an electric connection[3].

4.2.4Servo motor

The spider robot needs Dc motor with continuous rotation and high torque, so the servo motor should have to be modified. The interface of this motor is three lines one wire for control line, the second for power, and the third for the ground. The modification has been done by disconnecting the control line to achieve a continuous motion [7].

4.2.5Relay

A relay is usually an electromechanical device that is actuated by an electrical current. The current Flowing in one circuit causes the opening or closing of another circuit.

Relay is necessary to control circuit by a low power signal. All relays contain a sensing unit, the electric coil, which is powered by AC or DC current. When the Applied current or voltage exceeds a threshold value, the coil activates the armature, which operates either to close the open contacts or to open the closed contacts. When a power is supplied to the coil, it generates a magnetic force that actuates the switch mechanism. The magnetic force is, in effect, relaying the action from one circuit to another. The first circuit is called the control circuit the second is called the load circuit. It has different shape and the simplest one have only three contacts: common, normally open and normally close. The normally close contact will be connected to common contact when no power is applied to the coil, the normally open contact will be open when no power is applied to the coil .When the coil is energized the common is connect to the normally open contact and the normally closed contact is left floating. There are two basic classifications of relays: Electromechanical and Solid State. Electromechanical relays have moving parts, whereas solid state relays have no moving parts.

Relays include lower cost, no heat sink is required, multiple poles are available, and they can switch AC or DC with equal ease. Advantages of Solid State Relay long life, no moving parts, no contact bounce, and fast response. The drawback to using a solid state relay is that it can only accomplish single pole switching [3].

4.2.6 Joints

The rotary joint have two section one is fixed and other is rote about it. Most rotary joints cannot rotate through 360 degree as they are mechanically restrained by the arm construction and the servo motor. There are three types of links: small link, medium link and large link. Small link used to interface medium link to move in work space as shown Figure 4.6.

Figure4.6: Small link

Medium link used to interface large link to move in work space as represented in Figure 4.7.

Figure 4.7: Medium link

Large link is a main part in leg used to determine long step as illustrated in Figure 4.8.

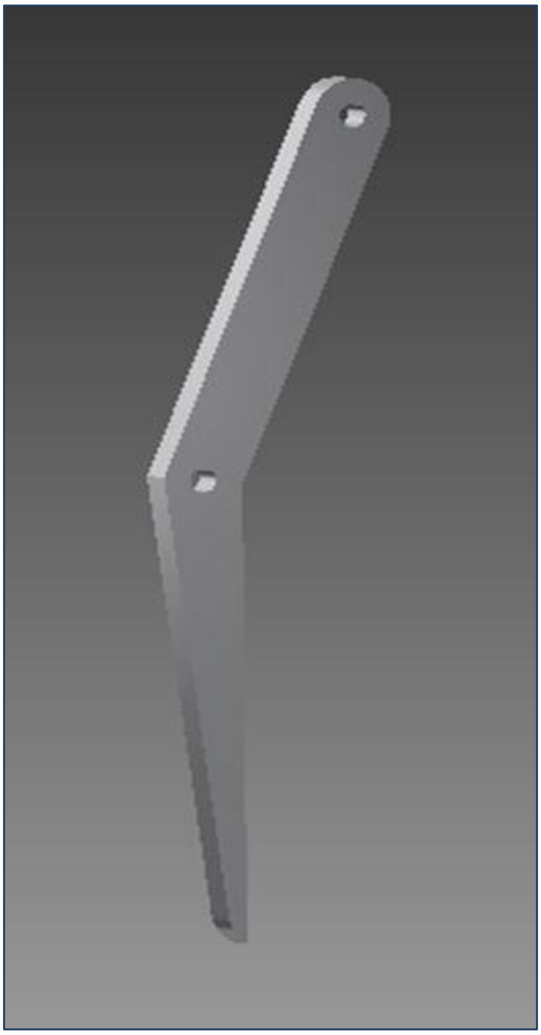

Figure 4.8: Large link

Figure 4.9 explain links and joints together to touch ground in position beginning moving.

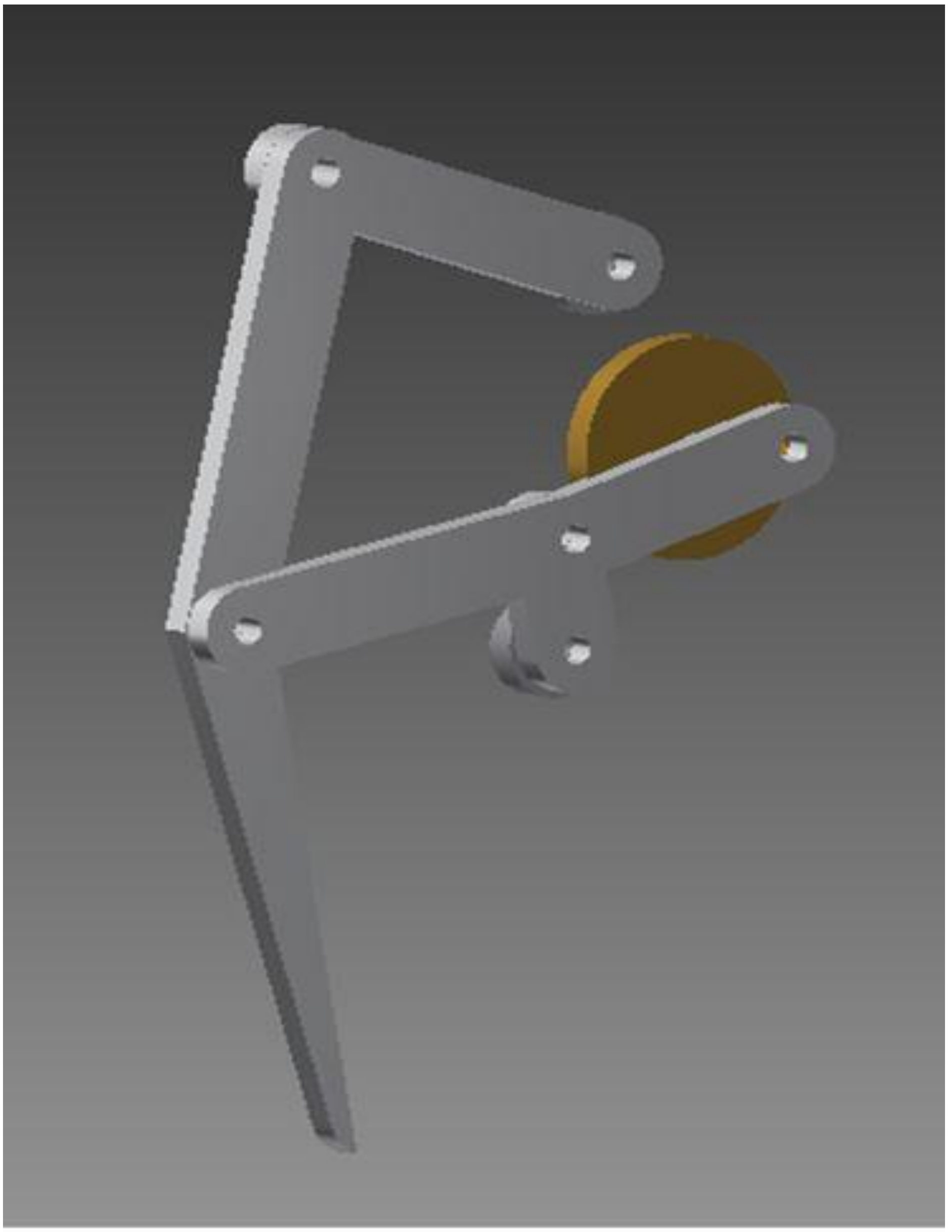

Figure 4.9: Link and joint for initial movement

Figure 4.10 shown links and joints together to rise leg from ground.

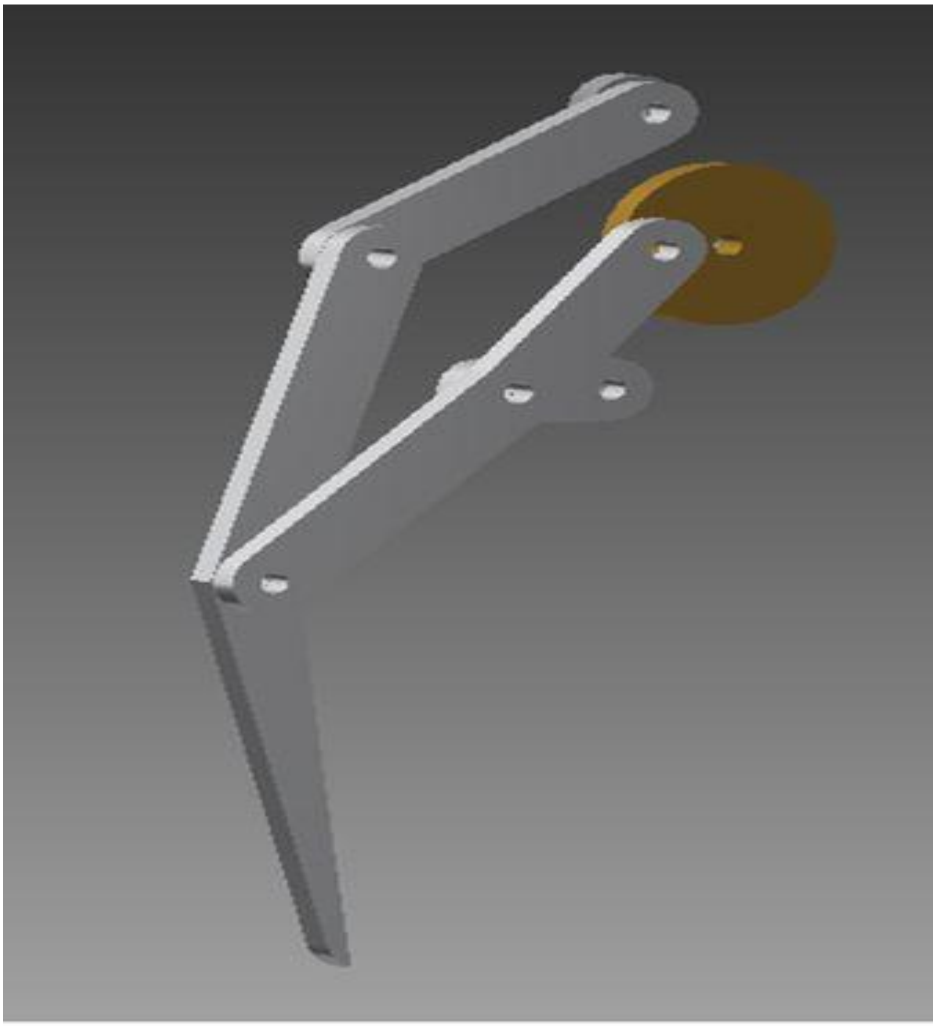

Figure 4.10: Link and joint for rising leg from ground

Figure 4.11 represents leg moving in work space.

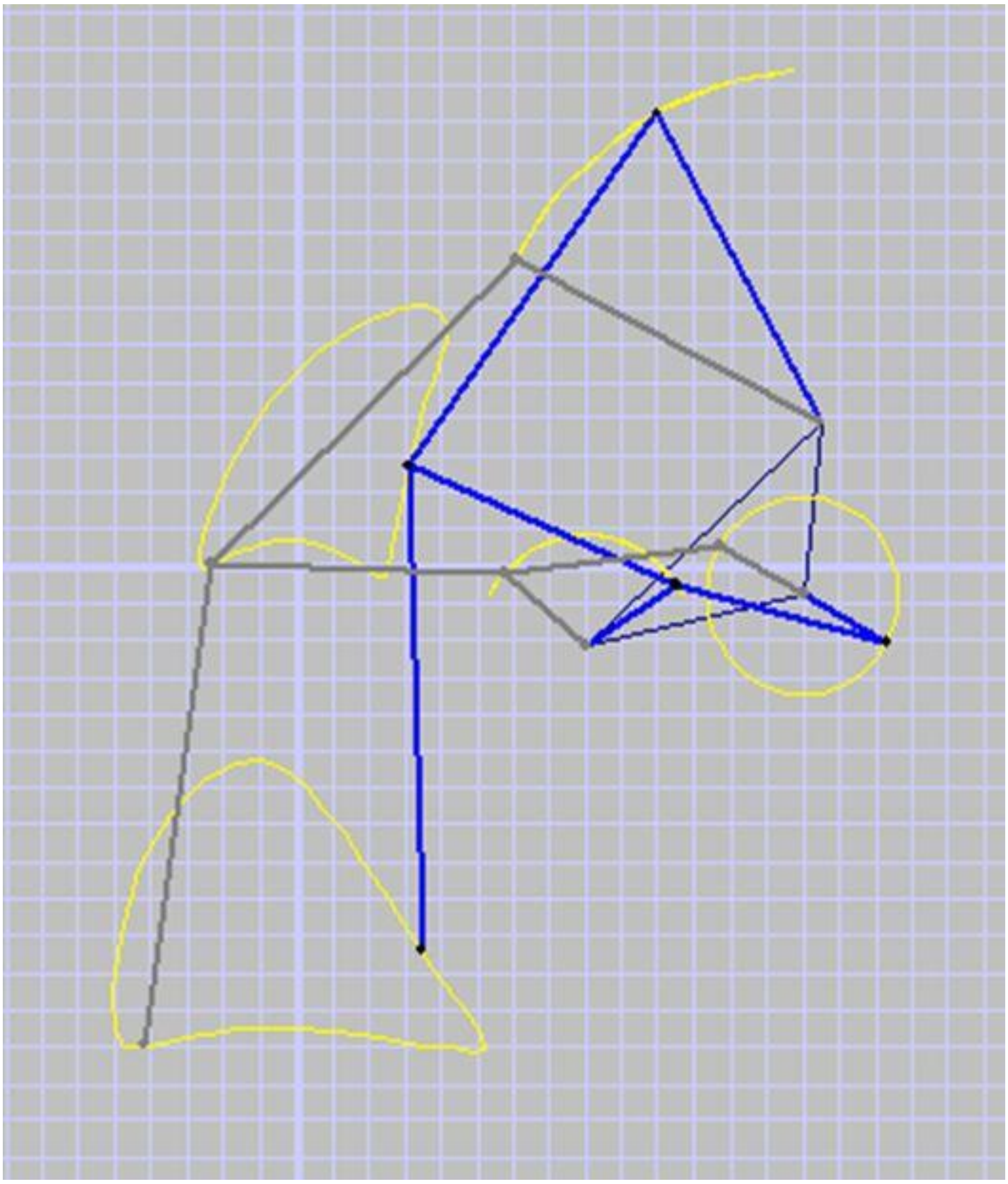

Figure 4.11: Leg moving

4.3Design Calculation

The design depends on legs and belts calculations to operate the system in normal conditions.

4.3.1Leg calculations

Octopod (8-legged) robots are most commonly configured in either two rows of 4 legs (4+4) or at 60 degrees from each other and equal distance [8].

The Figure 4.12 represents the 8 legs condition.

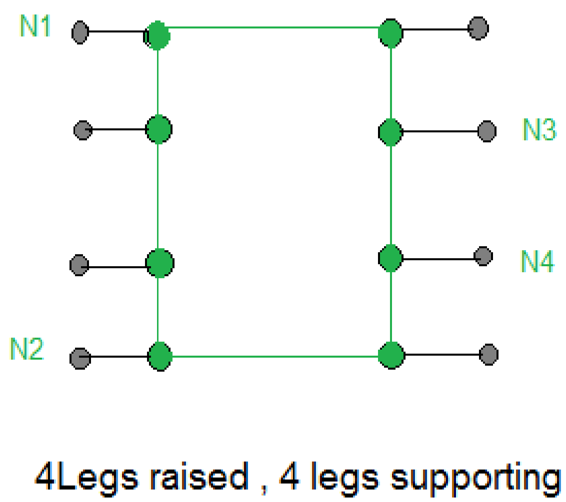

Figure4.12:Eight legs condition

The angles are taken between the horizontal and the link and it is assumed the legs are configured the same on both sides. The following assumptions must also be made in order to simplify the calculations and inputs required. The Figure (4.13) represents the angle of legs between two sides.

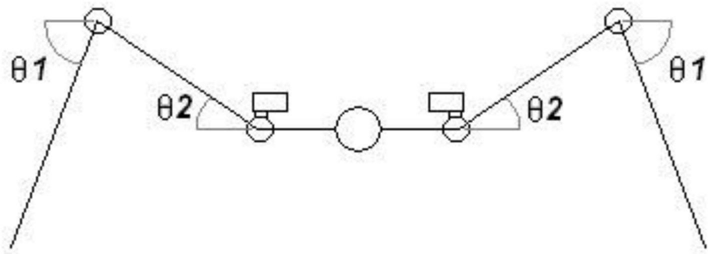

Figure 4.13: The angle of legs between two sides

Figure 4.14 shows legs as two rows of 4leg, all legs are identical

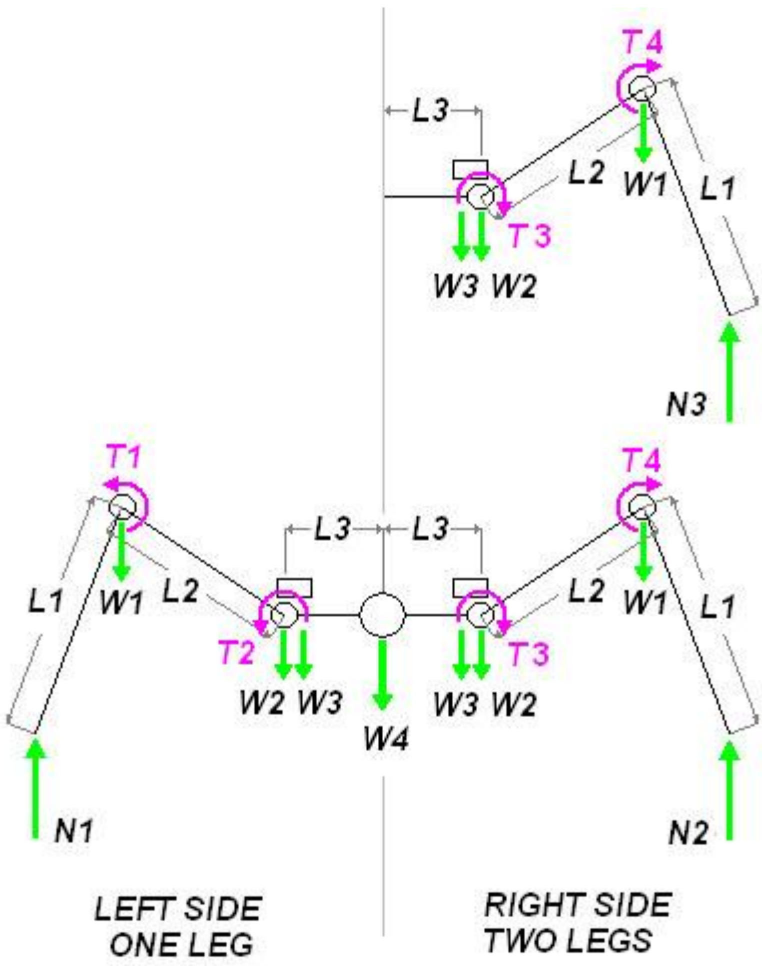

Figure4.14: Legs as two rows of 4leg

Where:

(W_1, W_2, W_3): weight of each actuator.

W_4: Weight acting at the center of mass.

(T_1, T_2, T_3, T_4): Torque acting at each joint.

(N_1, N_2) : Reactions.

(L_1,L_2,L_3): Dimension ,mm.

The weight W_4 acting at the center of the robot when 4 legs are raised is a combination of various parts the Table 4.4 represents weight.

Table 4.4: Weight table

Part	**Weight**
Battery	0.44 kg
Servo motor	0.035 kg
Leg	0.014 kg
Joint	0.003 kg
Chase	0.373 kg
Gear	0.005 kg

Table 4.5: Dimensions table

Part	**Tall**
Distance between two gears	39 mm
Distance between gear and motor	51 mm
Long joint	60 mm
Medium joint	34 mm

Calculation of legs:

W_{frame}=frame gear+ W_{shaft} +W_{joint} + W_{legs} +W_{servo} (4.1)

W_{frame}=0.37+0.04+0.04+0.24+0.008+0.112+0.07 = 0.88 Kg

$W_4=W_{frame}+W_{battery}+W_3$*legs (4.2)

W4=0.88+0.24+0.036=1.48 Kg

The weight of the robot is assumed to be evenly distributed on both legs on the right side, so the reaction forces, N_2 and N_3 are equal. Three legs must support the entire weight of the robot, as well as their own weight.

$N_1+2N_2 =W_4+8*(W_1+W_2+W_3)$ (4.3)

W_1=w long joint

W_1=0.002+0.001 = 0.003 kg

$W_2=W_{shaft}+W_{gear}$ (4.4)

W_2= 0.01+0.005=0.015 kg

$W_3=w_{shaft}+ w_{gear}$ (4.5)

W_3=0.01+0.005=0.015 kg

The value of the normal force N_2 can be found by doing a torque balance about N_1

$\sum T_{left\ foot} = -w_1*L_1 * \cos(\theta_1) - w_2*(L_1 * \cos(\theta_1)+ L_2 * \cos(\theta_2)) - w_3*(L_1 * \cos(\theta_1) + L_2 * \cos(\theta_2)) - w_4*(L_1 * \cos(\theta_1)+ L_2 * \cos(\theta_2)+ L_3) - 2w_3*(L_1 * \cos(\theta_1)+ L_2 * \cos(\theta_2)+ 2L_3) - 2w_2*(L_1 * \cos$

$(\theta_1)+ L_2 * \cos(\theta_2)+ 2L_3) - 2 w_1*(L_1 * \cos(\theta_1)+ 2L_2 * \cos(\theta_2)+ 2L_3) + 2 N_2*(2L_1 * \cos(\theta_1)+ 2L_2 * \cos(\theta_2)+ 2L_3)$ (4.6)

T left foot= (-0.003*6.1*0.5)-0.015(6.1*0.5+3.4*0.5)-0.015(6.1*0.5+3.4*0.5) -1.48(6.1*0.5+3.4*0.5+20)-2*0.015(2*20+6.1*0.5+3.4*0.5)-2*0.015(6.1*0.5+3.4*0.5+2*20)-2*0.003(6.1*0.5+2*3.4*0.5+2*20)+2*n2(6.1*2*0.5+2*3.4*0.5+2*20)

Although long, the equation uses only known variables, and since the combined torque about the left foot is zero, this equation will allow you to solve for N_2. This value is inserted into the equation above, to solve for N_1. Using conventional notation (counterclockwise is considered positive)

$-0.00915-0.07125-0.07125-36.63-1.3425-1.3425-0.2787+99N_2=0$

$99N_2=39.74535$

$N_2=0.4012$

$N_1+2N_2=W4+8*(W1+W2+W3)$

$N_1+2*N_2=1.48+8*(0.003+0.015+0.015)$

$N_1+2*N_2=1.744$

$N_1+2*0.0412=1.744$

N1=0.941N

4.3.2 Belt Calculation

Figure 4.15 represents gears with belt.

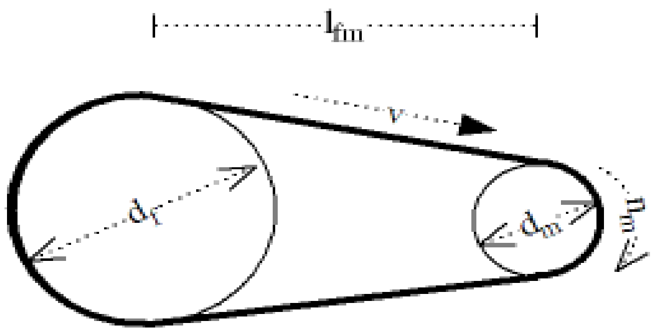

Figure 4.15: Gears with belt

Belt Length

Table 4.6: Dimension of gears and belt

Dm	20 mm
Df	20 mm
Lfm	39 mm
Motor velocity	55.56 rpm

The length of the belt can be calculated as

$$Lb = (dm * \pi / 2) + (df * \pi / 2) + (2*lfm) + ((df - dm)*2/(4*lfm)) \quad (4.7)$$

Where :

Lb≡ length of belt (mm)

DF ≡pulley diameter gear1 (mm)

Dm≡ pulley (sheave) diameter motor (mm)

$\pi = 3.14$

Lb = (20*3.14)/2 + (20*3.14)/2+ (2*39) + (20-20)*2/(4*39)

Lb=140.8mm

Lfm : center to center distance of fan and motor pulleys (mm, inches)

Belt Velocity-

The velocity at which a belt travels may be expressed as

$v = \pi * dm * (Nm / 12)$ (4.8)

Where:

V ≡velocity of belt (ft/min)

Nm≡ velocity motor (rpm)

0.18 sec --------→60 degree

X sec ------------→360 degree

X = 1.08 sec

X = 1.08 /60 = 0.018 minute

0.018 minute -----→1 cycle

1 minute-----------→Y

Y = 55.56 cycle.

Nm = 55.56 rpm.

$v = \pi * dm * nm / 12$

v = 3.14 * 20*(55.56/12) = 290.9 ft

V= 88.67 m/minute

Speed Ratio

Speed ratio can be calculated as

SR = (RF / Rs) (4.9)

Where:

SR≡ speed ratio

RF≡ revolutions per minute - fastest machine

Rs≡revolutions per minute - slowest machine

SR=1/1 =1

4.4The circuit diagram& operation

The main circuit contains a main switch and receiver circuit. The main switch is switch used to operate and stop the main circuit and all supplements. The receiver circuit contains of four relays each relay has five points, two of them for coil and remaining points for control.

Relays coils have been fed from receiver circuit outputs, when the transmitter circuit sends a signal, the receiver circuit receives the signal. Also in the receiver circuit the signal can be amplified and converted to current to operate the relay. The common point was fed from battery for all normally closed contacts of relays. The normally open contacts should have to be closed to operate the system. There are two relays to operate the servo motors; each of them is fed separately. To reverse the direction motion, the polarity of field coils must change. Also one relay is used to operate the servo motor to guide the camera .when the camera takes the picture ,it will be send by transmitter circuit .The receiver circuit receives the picture and display in the screen. The limit switch was connected in robot feet to avoid collides by another bodies. Before collides the switch changes his position and current will be cut off from the motors. In this case the direction motion will be reversed to return back. Control circuit which contain of the sending circuit. The sending circuit includes the integrator circuit(IC), capacitors, diodes and antenna and fed it from DC source. It sent the commands to receiver circuit by microwaves and includes many switches each used for specified purposes.

Figure 4.16 represent the circuit diagram.

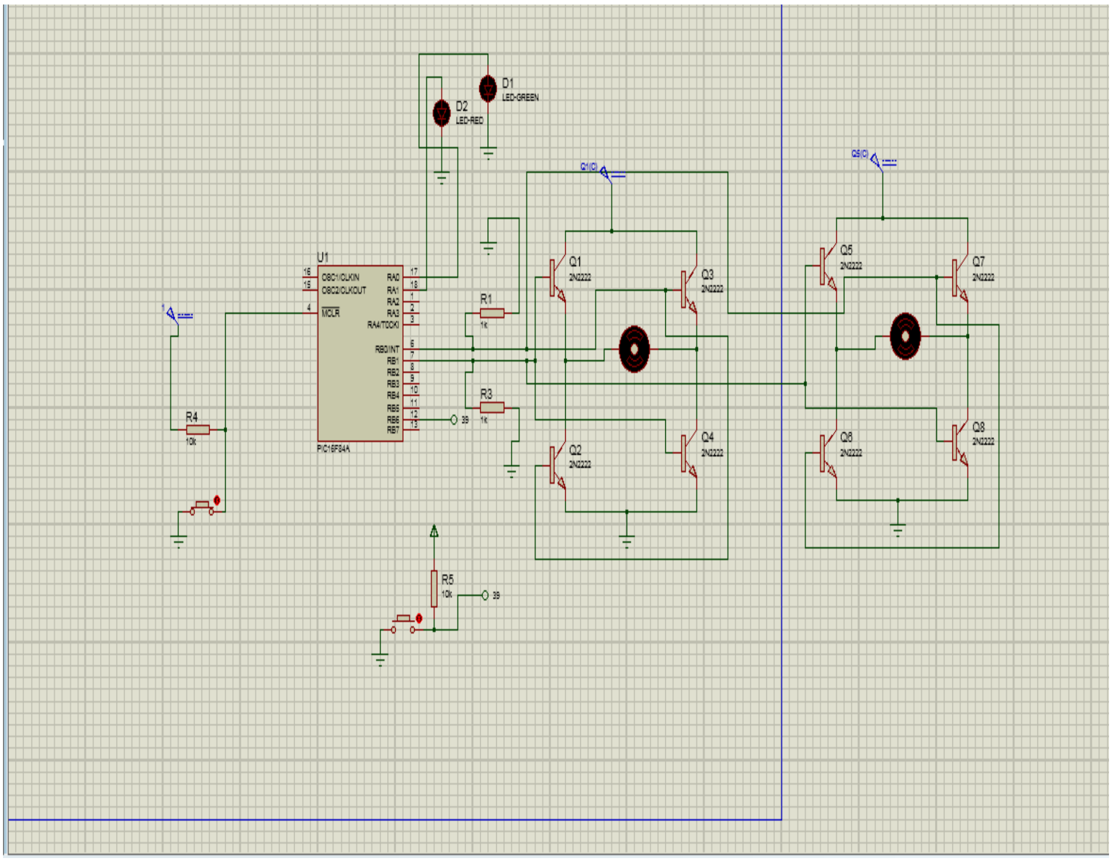

Figure 4.16: The circuit diagram

CHAPTER FIVE

CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusion

Spider robots solve many problems such as that occurred in dangerous zones, chemical areas and mines industries.

The mathematical leg calculations have be demonstrated according to the practical requirements.

5.2 Recommendations

Industrial robot is very useful in industrial application because they can improve production, work in continuous mode and can be reprogrammed to perform other tasks.

Robot can be controlled by other method of control devices.

REFERENCES

[1] Craig JJ, “Introduction To Robotic Mechanics and Control”, Edition , addision - Wesley, 1989.

[2]Myke predko, “123 pic microcontroller experiments for the Evil genius’’Mc Graw – Hill /TAB Electronic,2005.

[3]William D. NEFF (Eds.), “Contridutions to sensory physiology ”Academic press,1965.

[4]Thomas G.F.Gray ,“Computer software”, woodhead publishing, 1992.

[5]Lozano – perez ,T,“Robot Programming”,Proc,IEEE,1983.

[6]Alanoverby, “CNC machining Handbook:Building,programming and implementation”,Mc Graw-HillLTAB Electronic,2010.

[7]Vikram kapila , karolos Grigoriadis, “Actuator saturation control”,CRC press,2002.

[8]Jadran Lenarcic, “Advance in Robot Kinematics :Analysis and Design” ,oxford university press , 2008.

[9]www.diss.fu-berlin.de/.../03-Kapitel3.pdf,“”Robot'SHardwaredesign”,15/ 9/2015.

APPENDICES

TRANSISTORS C8050

Characteristic	symbol	Test Condition	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_C	$I_{c=100\mu A}$	-40	-	-	V
Collector-Emitter Breakdown Voltage	BV_C	$I_{C=}$-2mA	- -25	-	-	V
Emitter – Base Breakdown Voltage	BV_C	I_C=-100µA	-6	-	-	V
Collector cutoff current	I_{ca0}	$V_{CE=}$-35V	-	-	-100	Na
Emitter cutoff current	I_{E0}		-	-	-100	Na
Dc current Gain	$h_{ce}1$ $h_{ce}2$ h_{ce3}	V_{CE}=1V,I_C=5Ma V_{CE}=-1V, I_C=-1mA	45	170	300	-
Output Capacitance	C_{op}	V_{CS}=-10V,I_C=0	15	-	-	PF

TRANSISTOR BC546-D

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C=10mA,$I_{B=}$0)	$V_{(BR)}$COE	65	-	-	V
Collector –Base Breakdown Voltage	$V_{(BR)}$CBO	80	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)}$EBO	6	-	-	V
Collector cutoff current	I_{CES}	-	0.2	15	Na

TRANSISTOR 2N2222-D

Characteristic	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	V_{dc}
Collector-Base Voltage	V_{CBO}	75	V_{dc}
Emitter-Base Voltage	V_{EBO}	6.0	V_{dc}
Collector Current Continuous	I_C	600	mAdc
Total Device Dissipation @T_A=25ºC Derate above 25ºC	PD	625 5.0	mW mW/ºC
Total Device Dissipation @T_C=25ºC Derate above 25ºC	PD	1.5 12	W Mw/ºC
Operating and Storage Junction Temperature Range	$T_{j,}T_{Stg}$	- 55to+150	ºC