Palestine Polytechnic University

Electrical Engineering Department

Design of satellite dish positioning control system

By

Noor Adi ***Jihad Ghatass*** ***Kefah Abukebash***

Supervisor:

Dr: Osama Ata

Submitted to the College of Engineering
In partial electronics and communication for the degree of Bachelor in Electrical Engineering

Dec 2014

Abstract

The recent snow storm in Palestine caused many satellite receiver dishes to move from their designated positions and accumulate snow in them.
Consequently satellite receiver services were disrupted; displaying "no signal" on TV screen.

We propose a satellite dish positioning control system, capable of monitoring and controlling any misalignment of the dish orientation through azimuth and elevation motor that received command from a microcontroller connected to the system. Furthermore the system operates a heater that melts the snow on the dish using sensors such as humidity and temperature or weight.

الملخص

العاصفة الثلجية التي ضربت فلسطين في الاونة الاخيرة كانت سببا لظهور فكرة المشروع , حيث ان تراكم الثلوج على لواقط الاقمار الصناعية ادى الى تغير موقعها , السبب الذي ادى الى انقطاع البث التلفازي وظهور " لا يوجد اشارة " على اجهزة التلفاز .

في هذا المشروع نهدف الى عمل تطبيق لحل مشكلة ضياع الاشارة عن طريق اعادة توجيه الاقط الصناعي بطريقة الية , باستخدام نظام كامل لتحريك افقي وعمودي , بالاضافة الى وجود نظام تسخين مرتبط مع مجسات لتخلص من مشكلة تراكم الثلج على اللاقط الصناعي .

يقوم هذا المشروع على اساس تصميمي تطبيقي بحثي ، حيث يقوم هذا المشروع باستخدام نظامين احداهما لتحريك الافقي والاخر لتحريك العمودي , حيث يعتمد بشكل رئيسي على موقع اللاقط للقمر الصناعي , ومدى انحرافه عن قيم معينة محفوظة مسبقا في متحكم دقيق يستخدم كمرجع للاحداثيات الافقية والعمودية .

ويندرج هذا المشروع ضمن مجال الاتصالات الميكروية واللاسلكية والتحكم الألي بالاقط الصناعي.

Table of Contents

Table of Figures

Table of tables:

Chapter One
Introduction

1.1 Overview

1.2 Introduction

1.3 Project motivations

1.4 Main idea

1.5 Objectives

1.6 Idea and approach

1.7 Block diagram

1.8 Requirements

1.9 Challenges

1.10 Related works

1.11 Project Plan

1.12Estimated Cost and Budget

1.13 Report Content

1.1 Overview

In this chapter, we provided general literature information that is so important to address our project. This includes an explanation of the main idea, motivations, and the project objectives. After that we gave a look for some related works to our project.

1.2 Introduction

Satellite broadcasting of television is a major source of revenue for the satellite communications industry. Geostationary satellites have carried television program since their inception for commercial service in the late 1960s. The first time that a GEO satellite was used extensively for video transmission was for the Tokyo Olympic Games in 1968, which were broadcast live in the United States using a link through an early Intelsat satellite over Pacific Ocean. Satellite radio broadcasting commenced in 2001 from Sirius satellites in elliptical orbits and two XM satellites in GEO. The signals are transmitted in X-band at 12 GHz and are aimed primarily at automobiles, which is where most people listen to the radio [1].

From here, this project is an important application to solve the problem of the signal loss on TV screens. Snow storms and strong wind cause satellite dishes to move and change their original position and direction, besides the accumulation of snow on them. The benefits of the project are to decrease the cost of repair and maintenance and sustain the best signal quality.

1.3 Project motivations:

The system focuses on these motivations:

- Build an Integrated system to help overcome the signal loss on TV due to any misalignment.
- Reduce the cost on irregular maintenance.
- Overcome the problem of snow accumulating on the satellite dish.

1.4 Main idea:

The project aims to build a system, which would be used for adjusting the position of the dish automatically. This system consists of two motors that would enable the dish to move both in horizontal and vertical direction.

1.5 Objectives:

We aspire to achieve several objectives:

1) Reduce the maintenance cost.
2) Get the best quality of TV signal automatically.

1.6 Approach:

The project idea is to auto correct for horizontal and vertical misalignments of the satellite dish.

The project aims to build a system, which would be used for adjusting the position of the dish automatically. This system consists of two motors that would enable the dish to move both in horizontal and vertical directions.

This process is classified three main parts; the first part is to adjust the vertical location of the dish .In this step we aim to use closed loop position control system containing DC motor connected to an encoder. The second part is adjusting the horizontal location by the use of a similar system with a difference in the type of the motor. For the electrical part we will use an optical encoder to give the current position of the dish which is connected to the microcontroller used to save reference positions to specific satellites. The third part is the heating system which contain weight and humidity sensors .These would be connected to the microcontroller that give command to the heater to work and melt the snow accumulated on the dish.

1.7 Requirements:

1.7.1 Hardware:

1. Motors (servo & linear).
2. Optical encoder.
3. Arduino Microcontroller.
4. Sensors (Humidity &weight).
5. Heater.

1.7.2 Software:

C is a general purpose programming language. It has imperative, object-oriented and generic programming features, while also providing the facilities for low level memory manipulation.

It is designed with a bias for systems programming (e.g. embedded systems, operating system kernels), with performance, efficiency and flexibility of use as its design requirements. C has also been found useful in many other contexts, including desktop applications, servers, performance critical applications , and entertainment software.

The Arduino programming language is a simplified version of C/C++. If you know C, programming the Arduino will be familiar.

1.8 Challenges:

We anticipate to face challenges throughout our project . These are :

1. Availability of electronic chips.
2. Programming languages suitable in microcontroller.
3. Dealing with stepper motors to adequately rotate the dish.
4. Having the right position in accurate way .

1.9 Related works:

1.9.1 Dish Positioning Control by IR Remote

This project is designed to develop a dish positioning system which can be operated by using a conventional TV remote control handset. The main application of using a dish is to receive signal from satellites and other broadcasting sources. In order to position the dish to the exact angle and receive the optimum signal at a particular frequency, it needed to be adjusted manually [2].

We have many differences between the previous project and our project, we will mention them as the following:

1) Project[2] used an IR remote to control the dish in our project automatic positioning is used

2) In a related project they used dish de ice (consisting of heater)to melt the snow that accumulated on it .This kind of dishes does not exist in Palestine markets. so we will use humidity and weight sensors for this purpose.
3) In other related work they use a remote control to move the dish in horizontal and vertical way .

1.10 Project Plan:

The project contains the following stages:

Stage 1: Design the dish base.

Designing the dish base using AutoCAD program to assure movement in both direction horizontal and vertical.

Stage 2: Fabricate the dish base.
Get the base done by the CNC specialist.

Stage 3: Buying the project component .
Buying the project component that will use in our project .

Stage 4: Assembly the project components.
Assembly the project component together , firstly the base with motors and encoders .

Stage 5: Documentation and writing
Writing and preparing the documentation of the project was start from the first stage. and continue till the end of the end of the project.

Week / Task	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Stage1	■	■												
Stage2	■	■	■	■	■									
Stage3				■	■	■	■	■	■	■				
Stage4			■	■	■	■	■	■	■	■	■	■	■	■
Stage5												■	■	■

Table 1.1: Summary of the Project Plan for second semester

1.11 Estimated Cost and Budget:

The whole estimated cost will be approximately 850 JD, and the table below shows the cost of each hardware component.

Equipment	Number	Price /Unit	Total price
Dish	1	15 JD	15 JD
Base of dish	1	400 JD	400 JD
Humidity sensor	1	25 JD	25 JD
Microcontroller	1	70 JD	70 JD
Weight sensor	1	60 JD	60 JD
Linear dc motor	1	25 JD	25 JD
Heater	1	5 JD	5 JD
Receiver	1	20 JD	20 JD
Heads	1	10 JD	10 JD
Servo dc motor	1	100 JD	50 JD
Optical encoder	1	120JD	120 JD
			850 JD

Table 1.2: Estimated cost and budget

1.12 Report contents:

This project is mainly divided into four chapters, each of them describes specific part of the project as following:

Chapter One: includes the introduction, provides a general overview about the project, its objectives, importance, related works, challenges, time planning, estimated cost and at the end the report contents.

Chapter Two: discusses the theoretical background. It starts with general information about the project, motors, optical encoder, and then discusses the important aspects of the system including Arduino microcontroller, sensors.

Chapter Three: presents the general system design concepts. It includes system objectives, general system block diagram, description of system design ' components and operation'.

Chapter Four: lays down the hardware design implementation of the satellite dish positioning control system.

Chapter Five :describe the connection of the system and the software of the project.

Chapter Two

Literature Review

2.1 Overview

2.2 Theoretical background

2.3 Summary

2.1 Overview

In this chapter, we mention the basic theoretical information about some technologies to be used in our project .These will be taken advantage of and used appropriately.

We will talk about the Satellite dish, motors , microcontroller and some sensors. In addition, we present a brief overview about some similar ideas to our project.

2.2 Theoretical background

2.2.1 Satellite dish:

A satellite dish is a telecommunications device used to send and receive microwave signals. It is a parabolic shaped antenna used for data transmission and broadcasting.

The primary function of a satellite dish is to convert microwave signals into electric signals that can be used by a computer, television and other devices. The low-frequency signals can be received by the larger dishes, whereas small dishes are used for higher frequency signal. since size of dishes here antenna gain is related to the satellite.

Satellite dishes are used for all kinds of data communication. The signals can be sent anywhere without having miles of cables[3].

2.2.1.1 Principle of satellite dish:

The satellite service provider receives programming from various sources, and then beams a compressed digital signal containing its entire channel lineup through a satellite dish to a satellite in geosynchronous orbit. This means that the satellite maintains its position relative to the Earth, moving at the same speed as the Earth's rotation. If we couldn't put satellites into geosynchronous orbit, satellite television wouldn't exist. That's because the customer needs to align his or her own satellite dish so that is aimed at the correct satellite overhead. If the satellite moved in relation to the Earth, the customer would have to continuously adjust the aim of his or her satellite dish, and sometimes the satellite would move to the other side of the Earth and no amount of adjustment would result in a signal[4].

The orbiting satellite acts as both a **receiver** and a **transmitter**. It receives the feed of channels from the service provider, and then transmits that information back in a beam toward the Earth. The customer dish acts as an **antenna**. The dish picks up the signals and sends them to a receiver **set-top box** (STB) .Figure (2.1) show principle of satellite broadcasting[5].

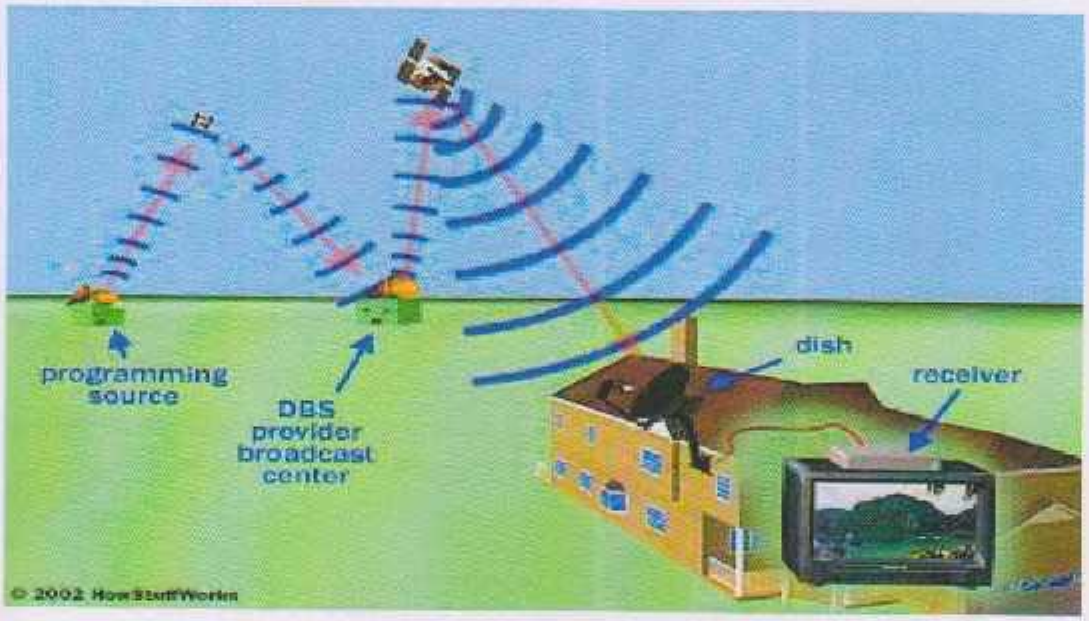


Figure 2.1 Satellite broadcasting

2.2.1.2 Satellite orbits:

Four different types of satellite orbits have been identified depending on the orbit shape and diameter of each orbit (see figure 2.2):

1. GEO (Geostationary Earth Orbit) at 36,000 kms above earth's surface.

2. LEO (Low Earth Orbit) at 500-1500 kms above earth's surface.

3. MEO (Medium Earth Orbit) or ICO (Intermediate Circular Orbit) at 6000-20000 kms above earth's surface.

4. HEO (Highly Elliptical Orbit)[6].Figure (2.2) show orbits type and distance.

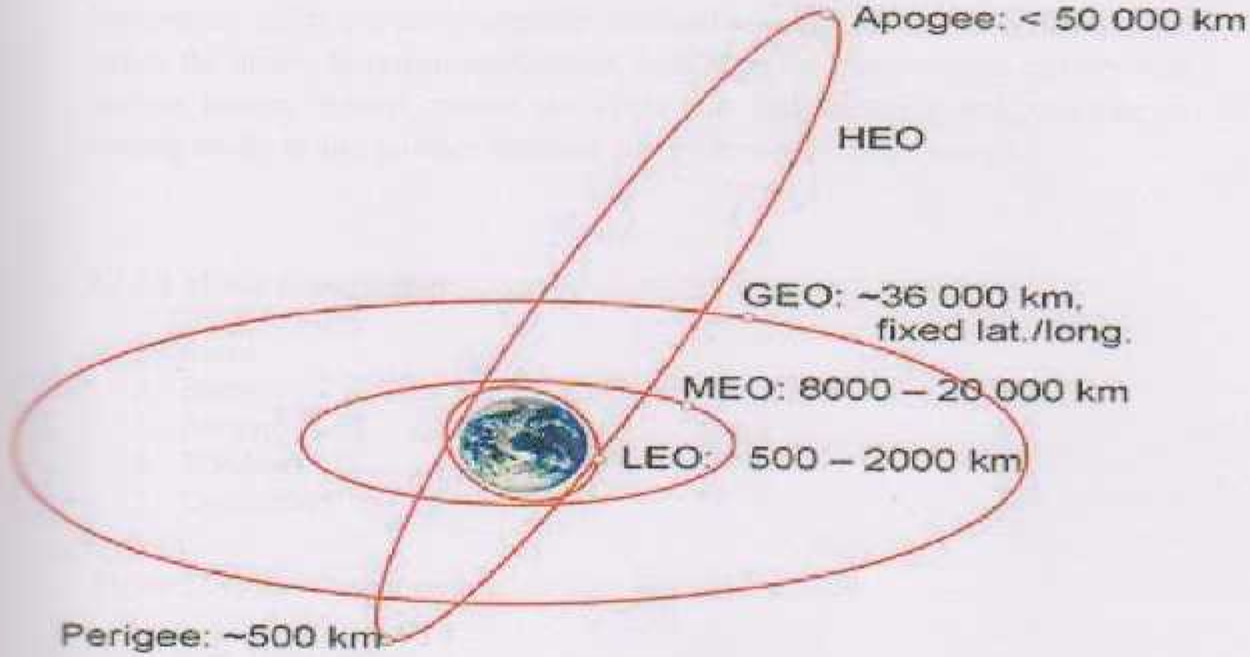


Figure 2.2 Satellite orbits

Most of the satellite are in the GEO orbit that is 36000km above the earth. In Palestine the most common satellite are Nile Sate, Arab Sat, Hotbird Sat, and Turk Sat. These satellite are located at 40° Vertical so they are at the same orbit , the difference is in degree of oriented from west to east. The figure2.3 show orbits and distribution of satellites.

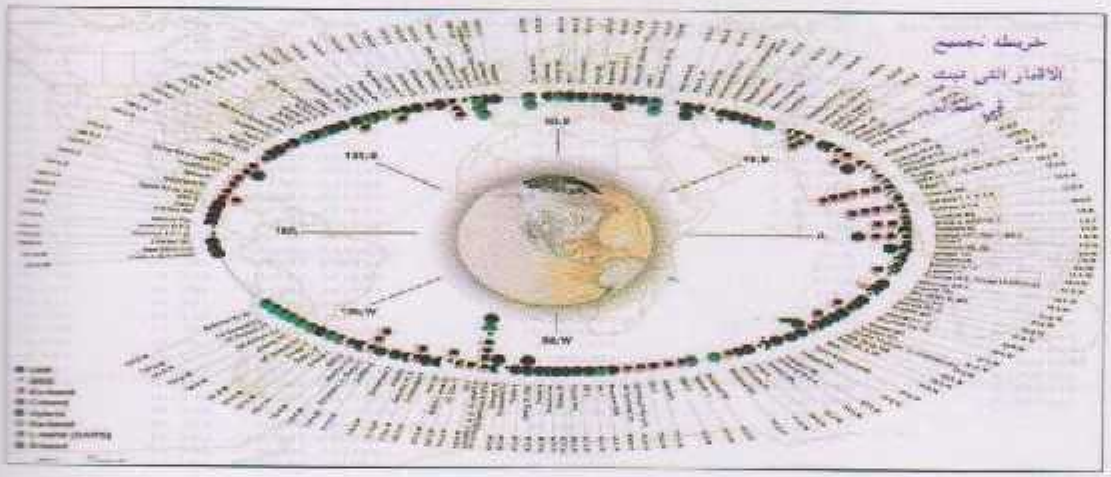


Figure 2.3 Satellite distribution around the world

2.2.2 Motor:

An electric motor: is an electric device that converts electrical energy into mechanical energy.

In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes to also produce electrical energy from mechanical energy.

2.2.2.1 Motor construction:

1. Rotor.
2. Stator.
3. Air gap.
4. Windings.
5. Commutator.

Figure (2.4) show motor parts

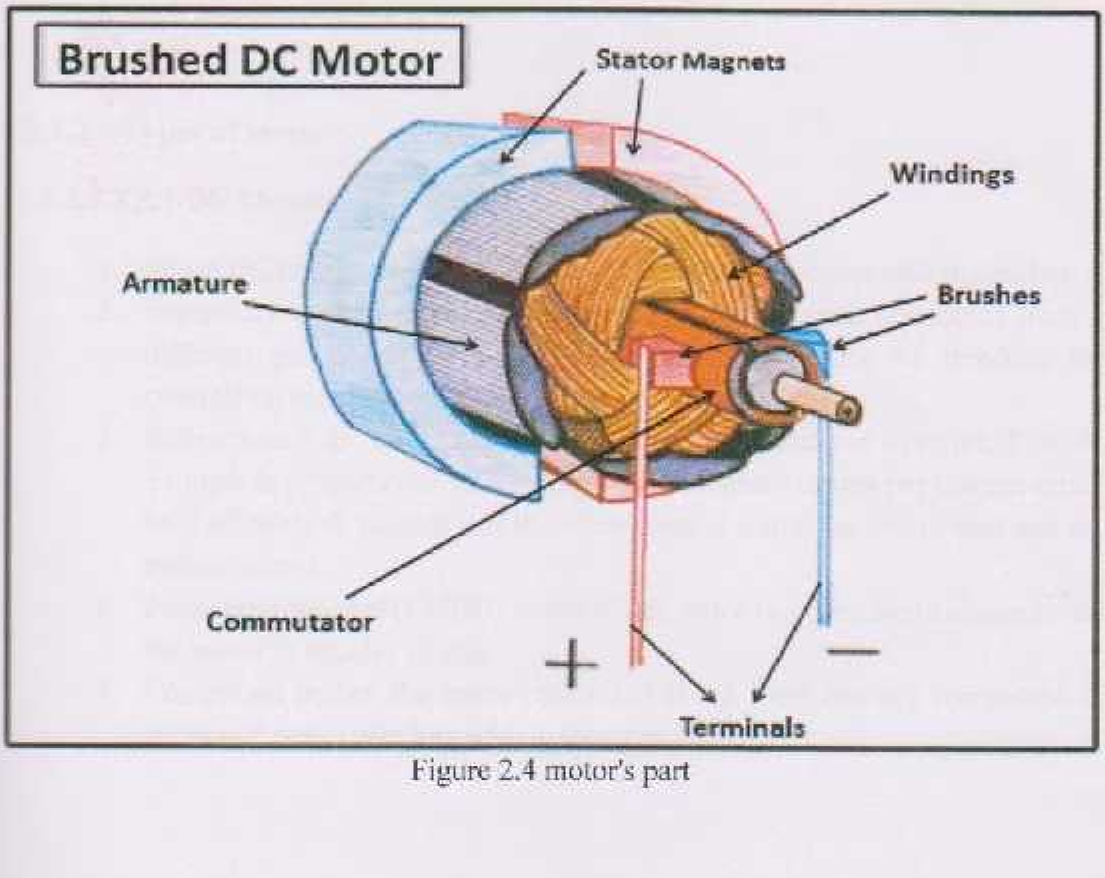


Figure 2.4 motor's part

2.2.2.2 Motor supply and control:

2.2.2.2.1 Motor supply:

Motors supply divided into two types:

1. A DC motor is usually supplied through slip ring commentator.
2. AC motors' commutation can be either slip ring commutator or externally commutated type, can be fixed-speed or variable-speed control type, and can be *synchronous* or *asynchronous* type. *Universal motors* can run on either AC or DC.

2.2.2.2.2 Motor control:

1. Fixed-speed controlled AC motors are provided with direct-on-line or soft-start starters.
2. Variable speed controlled AC motors are provided with a range of different power inverter, variable-frequency drive or electronic commutator technologies.

2.2.2.2.3 Types of motor :

2.2.2.2.3.1 DC Motors:

1. Shunt DC motor: The rotor and stator windings are connected in parallel.
2. Separately excited motor: the rotor and stator are each connected from a different power supply, this give us another degree of freedom for controlling the motor over the shunt.
3. Series motor: the stator and rotor windings are connected in series. Thus th e torque is proportional to I^2 so it gives the highest torque per current ratio over all other dc motors.It is therefore used in starter motors of cars and el evator motors .
4. Permanent Magnet (PMDC) motors: The stator is a permanent magnet, so the motor is smaller in size.
5. Compound motor: the stator connected to the rotor through compound of shunt and series winding add up together [7] .

2.2.2.2.3.1.a DC Servo Motors:

The motors which are utilized as **DC servo motors**, generally have separate DC source for field winding and armature winding. The control can be archived either by controlling the field current or armature current. Field control has some specific advantages over armature control and on the other hand armature control has also some specific advantages over field control. Which type of control should be applied to the **DC servo motor**, is being decided depending upon its specific applications [8].

2.2.2.2.3.1.b Linear Dc Motors:

A **linear motor** is an electric motor that has had its stator and rotor "unrolled" so that instead of producing a torque (rotation) it produces a linear force along its length. The most common mode of operation is as a Lorentz-type actuator, in which the applied force is linearly proportional to the current and the magnetic field .

Many designs have been put forward for linear motors, falling into two major categories, low-acceleration and high-acceleration linear motors. Low-acceleration linear motors are suitable for maglev trains and other ground-based transportation applications. High-acceleration linear motors are normally rather short, and are designed to accelerate an object to a very high speed.[9]

2.2.2.2.3.2 AC Motors:

1. Induction Motor: So called because voltage is induced in the rotor (thus no need for brushes), but for this to happen,the rotor must rotate at a lower sp eed than the magnetic magnetic field to allow for the existence of an induced voltage.
2. Synchronous Motor: So called because rotor tries to line up with the rotati ng magnetic field in the stator. It has the stator of an induction induction motor, and the rotor of a dc motor, stepper motor is an example of this type of motors .

2.2.2.2.3.2.a Stepper motor:

Stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements the shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied. Figure (2.5) show stepper motor [10] .

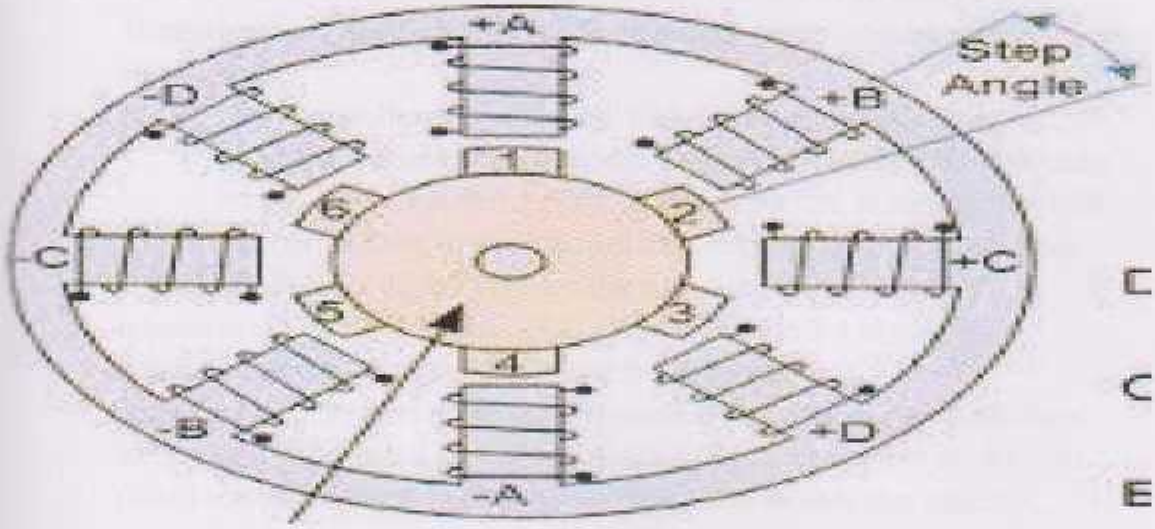


Figure 2.5 stepper motor

2.2. 3 Microcontroller:

A microcontroller (sometimes abbreviated µC, uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications[11].

2.2. 3.1 Microcontrollers modules:

1. Processor Core: The CPU of the controller. It contains the arithmetic logic unit, the control unit, and the registers (stack pointer, program counter, accumulator register, register file , . . .).
2. Memory: The memory is sometimes split into program memory and data memory. In larger controllers, a DMA controller handles data transfer between peripheral components and the memory.
3. Interrupt Controller: Interrupts are useful for interrupting the normal program flow in case of (important) external or internal events .In conjunction with sleep modes, they help to conserve power.
4. Timer/Counter: Most controllers have at least one and more likely 2-3 Timer/Counters, which can be used to timestamp events, measure intervals, or count events.
    a. Many controllers also contain PWM (pulse width modulation) outputs, which can be used to drive motors or for safe breaking (antilock brake system, ABS). Furthermore the PWM output can, in conjunction with an external filter, be used to realize a cheap digital/analog converter.
5. Digital I/O: Parallel digital I/O ports are one of the main features of microcontrollers. The number of I/O pins varies from 3-4 to over 90, depending on the controller family and the controller type.
6. Analog I/O: Apart from a few small controllers, most microcontrollers have integrated analog/digital converters, which differ in the number of channels (2-16) and their resolution (8-12 bits). The analog module also generally features an analog comparator. In some cases, the microcontroller includes digital/analog converters.
7. Interfaces: Controllers generally have at least one serial interface which can be used to download the program and for communication with the development PC in general. Since serial interfaces can also be used to communicate with external peripheral devices, most controllers offer several and varied interfaces like SPI and SCI.
8. Watchdog Timer: Since safety-critical systems form a major application area of microcontrollers, it is important to guard against errors in the program and/or the hardware. The watchdog timer is used to reset the controller in case of software "crashes".
9. Debugging Unit: Some controllers are equipped with additional hardware to allow remote debugging of the chip from the PC. So there is no need to download special debugging software which has the distinct advantage that erroneous application code cannot overwrite the debugger[12] .Figure (2.6) show microcontroller basic layout.

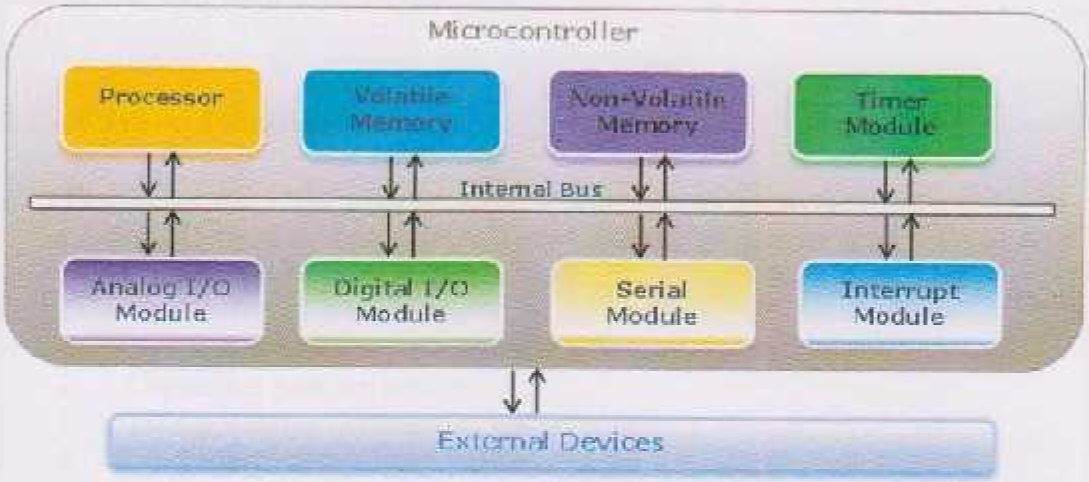


Figure 2.6 microcontroller basic layout

2.2. 4 Sensors:

Sensors are very important organs of any measurement system. They collect data from the surroundings/ physical parameter and provide electrical signal as the input to the systems. Amongst wide variety of sensors operating on different sensing principles and used in different applications, position sensors play an important role in different systems. Whether it is fly-by-wire aircraft systems, drive-by-wire cars, bullet trains taking round curves, injection molding machines, packaging machines, medical equipments, and so on, position sensors finds their applications, of course in different ways.

2.2. 4.1 Position Sensors:

Most common way of classifying the wide spectrum of sensors is based on the specific application of the sensor. Sensor used for measuring humidity is termed as humidity sensor, the one used for measurement of pressure is called pressure sensor, sensor used for measurement of liquid level is called level sensor and so on though all of them may be using the same sensing principle. In a similar fashion, the sensor used for measurement of position is called a position sensor.

Position sensors are basically sensors for measuring the distance travelled by the body starting from its reference position. How far the body has moved from its reference or initial position is sensed by the position sensors and often the output is given as a fed back to the control system which takes the appropriate action. Motion of the body can be rectilinear or curvilinear; accordingly, position sensors are called linear position sensors or angular position sensors[13].

2.2.4.2 Types of Position Sensor:

Position sensors use different sensing principles to sense the displacement of a body. Depending upon the different sensing principles used for position sensors, they can be classified as follows:

1. Resistance-based or Potentiometric Position sensors
2. Capacitive position sensors
3. Linear Voltage Differential Transformers
4. Magnetostrictive Linear Position Sensor
5. Eddy Current based position Sensor
6. Hall Effect based Magnetic Position Sensors
7. Fiber-Optic Position Sensor
8. Optical Position Sensors

2.2.4.2.a Potentiometric Position Sensors:

Potentiometric position sensor use resistive effect as the sensing principle. The sensing element is simply a resistive (or conductive) track. A wiper is attached to the body or part of the body whose displacement is to be measured. The wiper is in contact with the track. As the wiper (with the body or its part) moves, the resistance between one end of the track and the wiper changes. Thus, the resistance becomes a function of the wiper position. The change in resistance per unit change in wiper position is linear.

Resistance, proportional to wiper position, is measured using voltage divider arrangement. A constant voltage is applied across the ends of the track and the voltage across the resistance between the wiper and one end of the track is measured. Thus, voltage output across the wiper and one end of the track is proportional to the wiper position[14].

The conductive track can be made linear or angular depending upon the requirements. The tracks are made from carbon , resistance wire or piezo resistive material. Figure (2.7) show type of potentiometer .

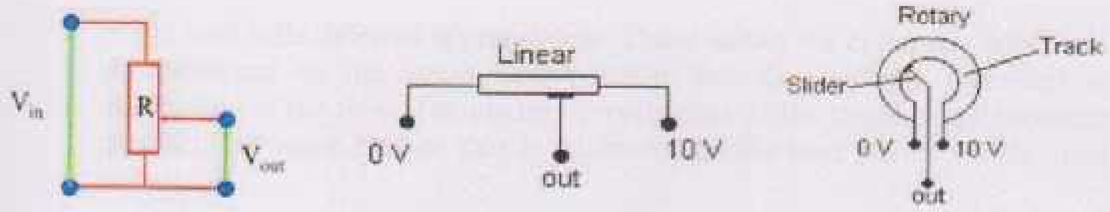


Figure 2.7 potantiometer types

2.2.4.2.b Digital Encoders:

A digital optical encoder is a device that converts motion into a sequence of digital pulses. By counting a single bit or by decoding a set of bits, the pulses can be converted to relative or absolute position measurements. Encoders have both linear and rotary configurations, but the most common type is rotary. Rotary encoders are manufactured in two basic forms: the absolute encoder where a unique digital word corresponds to each rotational position of the shaft, and the incremental encoder, which produces digital pulses as the shaft rotates, allowing measurement of relative position of shaft. Most rotary encoders are composed of a glass or plastic code disk with a photographically deposited radial pattern organized in tracks. As radial lines in each track interrupt the beam between a photometer-detector pair, digital pulses are produced[15].

2.2.4.2.c Optical absolute encoders:

The optical encoder's disc is made of glass or plastic with transparent and opaque areas. A light source and photo detector array reads the optical pattern that results from the disc's position at any one time. This code can be read by a controlling device, such as a microprocessor or microcontroller to determine the angle of the shaft.

The absolute analog type produces a unique dual analog code that can be translated into an absolute angle of the shaft[16].

2.2.4.3 Strain gauge load cell (weight sensor):

Strain gauge load cells are the most common in industry. These load cells are particularly stiff, have very good resonance values, and tend to have long life cycles in application. Strain gauge load cells work on the principle that the strain gauge (a planar resistor) deforms/stretches/contracts when the material of the load cells deforms appropriately. These values are extremely small and are relational to the stress and/or strain that the material load cell is undergoing at the time. The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on the load cell[17]

2.3 Summary

In this chapter we mentioned the basic theoretical information about the parts to be used in our project, discussed their operating principles and took a historical round in some of them.

Chapter Three

Conceptual Design

3.1 Overview

3.2 Theoretical design

3.3 System function

3.4 Basic operation

3.5 Summary

3.1 Overview:

After what has explained in the previous chapter about the theoretical background, this chapter describes the general block diagram of the whole system, and the system elements.

We show linear and servo motors requirement equations , also explained Usage of hardware and software to achieve the aim of the project. Where hardware will be built using the sensors and microcontroller. Also, the explanation will include the work design methodology.

3.2 Theoretical design :

In this section we will talk about linear motor requirement equations and also DC servo requirement equations as follow :

3.2.1 Linear Motor requirements equations:

In order to determine the correct motor for a particular application it is necessary to be familiar with the following relations:

3.2.1.1 EQUATIONS OF MOTION:

Basic kinematic equation: $xo + vot = a \times t^2/2$

a = acceleration (g's)

x = stroke (inch [m])

t = time (seconds)

v = velocity (in/sec [m/sec])

g = gravitational acceleration (in/sec2[m/sec2])

3.2.1.2 NEWTON'S SECOND LAW:

Newton's Second Law provides a simple method of converting between forces, payloads, and accelerations. It states:

$F = m \times a$ $F = m \times a \times g = 10 \times .64 = 6.4\text{N}$

where,

F = Force Lbs N

m = payload Lbs kg

a = acceleration g's g's

g = gravitational accel

3.2.1.3 DUTY CYCLE:

The duty cycle of a motor is defined as the time the motor receives power during a cycle divided by the total time of the cycle. When a linear motor receives power for more than thirty (30) seconds, it is operating at a duty cycle of 100%

$$\text{Duty Cycle} = \frac{\text{time on}}{\text{time on} + \text{time off}} \times 100\% = 10\%$$

3.2.2 DC Servo motor requirement equations:

3.2.2.1 Linear to Rotary Formulas:

$$\frac{1}{2}(M \times V)^2 = \frac{1}{2}(J \times w)^2$$

$$F \times V = T \times w$$

$$F = M \times a \quad , \quad T = J \times a$$

M = Mass

V = Velocity

J = Inertia

w = Angular Velocity

F = Force

T = Torque

α = Acceleration

3.2.2.2Torque Conversion:

$$T(lb - ft) = \frac{\text{Force (lbs.) x Lead (in / rev)}}{24 \times (screw\ effciency) \times s \times \pi \times \zeta}$$

Where:

Force = Cutting force of load or

Friction load = Weight x (Coefficient of friction)

3.2.2.3 Inertia Conversion:

Linear to Rotary:

$$J(lb - ft - s) = \frac{\text{Weight (lbs.) x Lead (in / rev)}}{\text{1.8 x10 x (Screw effciency)}}$$

Rotary

J(lb-ft-s2) = Diameter4 (inches) x Length (inches)x6x 10-6 [For solid steel cylindrical screws]

J Reflected Through a Gear Ratio = N

$$J\ ref = \frac{\text{J Load}}{\text{N} \times \text{(R to effecincy)}}$$

3.2.2.4 RMS Torque:

$$T_{rms} = \sqrt{\frac{{T_1}^2 \times t_{1\times}{T_n}^2 \times t_n}{t_1 + t_2 + t_n}}$$

$T_1, T_2, T_n = Torques\ 1 - n, \qquad t_1, t_2, t_n = Times\ 1 - n$

3.2.2.5 Maximum Duty Cycle:

$$\frac{T_p}{T_c} = \sqrt{\frac{1 - e^{t_{on}} / duty\ cycle\ (TCT)}{1 - e^{t_{on}} / TCT}}$$

$$X = \frac{t_{on}}{t_{on} + t_{off}}$$

Where:

Tp = Output torque

Tc = Continuous torque rating

TCT = Thermal time constant

ton = Time on

toff = Time off

3.2.2.6 Constant Torque Acceleration:

$$T(lb - ft) = \frac{J(lb - ft - s^2) \times n(RPM)\pi}{30t(second)} + T\ Friction\ torque(lb - ft)$$

3.3 System Functions:

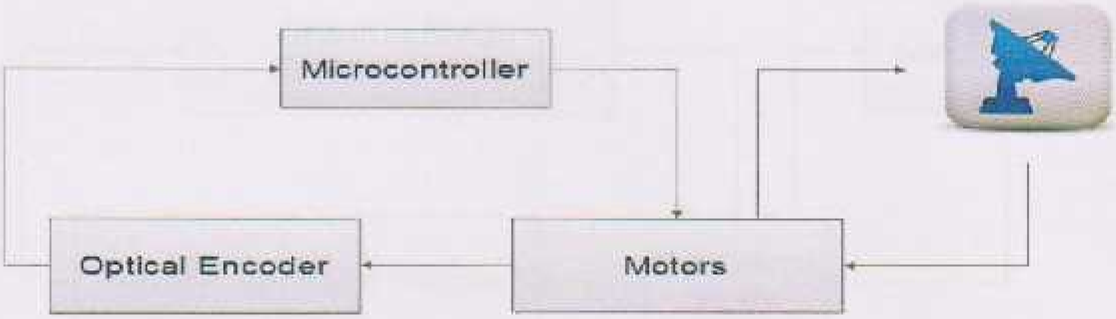
The project aim to build automatic system to correct any misalignment happened in satellite dish due to weather reasons , this will happened using vertical and horizontal systems that contain closed loop position system , also the use of heating system milt the snow that accumulate on the dish.

3.4 Basic operation:

Our project basic idea is auto correction the satellite dish after any misalignments, this would be shown in three stages as following :

3.4.1 Position control loop system:

The position control loop is characterized by the use of optical encoder and microcontroller . It creates a closed signal action flow between microcontroller and optical encoder connected to the motor , the optical encoder used to give the current angle of the satellite dish resulted by the movement of the motor shaft connected to the satellite dish Figure 3.4 shows block diagram of this stage .



3.4.1.1 Vertical System:

Basic component of vertical closed loop system ,see Figure 3.5:

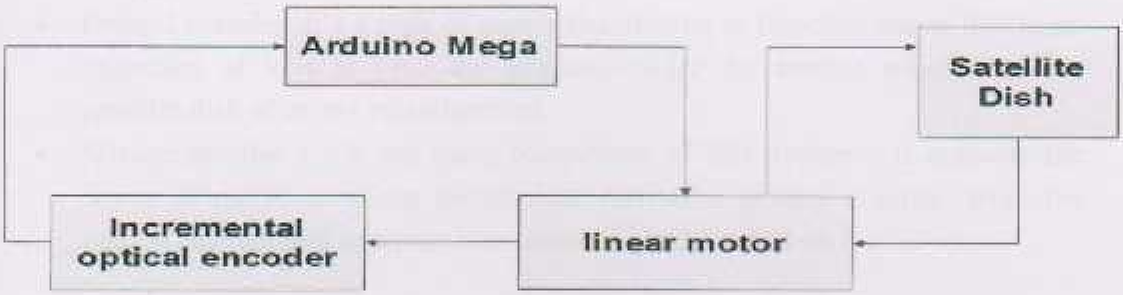


Figure 3.2 Block Diagram of Vertical system

- Incremental optical encoder : it gives the current position of satellite dish after any misalignment resulted from the movement of satellite dish
- Linear motor driver : it will be used to connect between the motor and controller .
- Linear motor : this is the mechanical part that will move the satellite dish specific angle .

3.4.1.2 Horizontal closed loop system:

The basic component of horizontal system as shown in the figure 3.3.

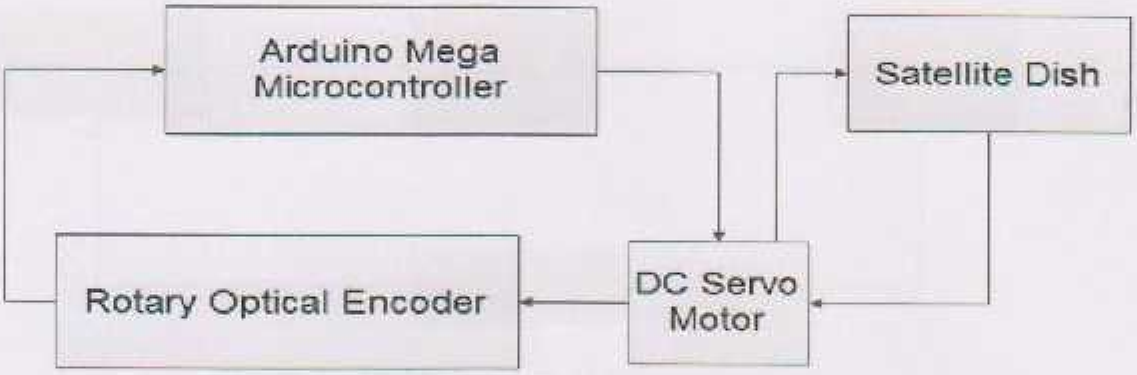


Figure 3.3 Horizontal system Block diagram

- Servo dc motor: This type give the accuracy we need in horizontal system , because any misalignment make a huge difference the location of the satellite dish to be oriented to other satellite . The Servo dc motor input is a command come from microcontroller to move the satellite dish in specific angle .
- Optical encoder: it's a type of sensor that belong to Encoder sensor ,the basic operation of it is to give the microcontroller the current position of the satellite dish after any misalignment.
- Microcontroller : it's the main component of this system , it controls the Servo dc motor to orient the satellite dish after getting a value from the optical encoder and compare it to threshold value saved on it .

3.4.1.3 Heating system :

Is an additional system that solve the problem of accumulating snow on the satellite dish by the use of heater and sensors as shown in the figure 3.7.

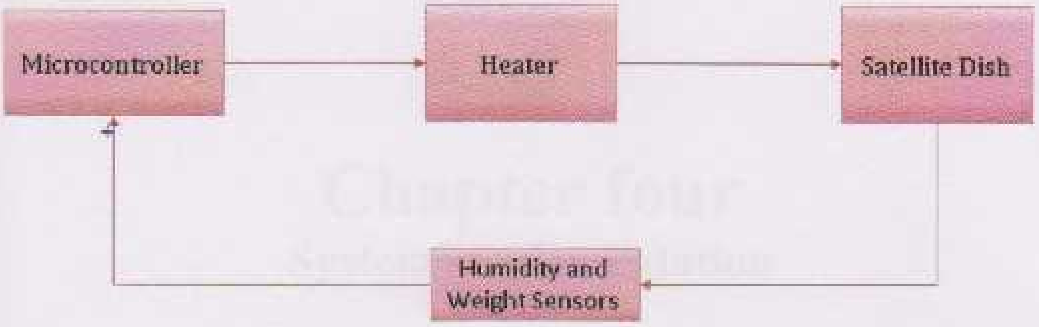


Figure 3.4 Block diagram of Heating system

The basic component of this system is :

- Humidity and Weight sensor: they used together because sensing a snowing weather need both , because snow can be described in weight and humidity , in this system they give the values to the microcontroller to give the command to the heater to start heating .
- Heater : it's a heating element connected to an automatic switch that connect and disconnect according to the command come from the microcontroller .

3.5 Summary:

In this chapter we described the basic mathematical equation that we will use to find parameters related to DC motors also describe the systems by block diagrams .

Chapter four

System Implementation

4.1 Introduction

4.2 Hardware Description

4.3 Summary

4.1 introductions

In this chapter the construction of the system would be shown. After collecting all the necessary information's related to the project and analyze them, the group started to build the system step by step , and until this time we finished the first part which is the general design circuit of system .

And this is what will be shown in the next section.

4.2 Hardware Description

In this section, a description for the hardware that will used, will be explained:

4.2.1. Microcontroller

Microcontroller is a Microchip programmable IC, that controls the inputs and outputs from each device, it will be used as the main subject that control the system for the goal to be achieved.

Figure 4.1 Arduino Mega

4.2.1.a Arduino Mega specifications:

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16

DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

4.2.2 Motor Driver

Figure 4.2 Motor driver.

4.2.2.a Driver Specification:

Driver: L298N

Driver power supply: +5V~+46V

Driver Io: 2A

Logic power output Vss: +5~+7V (internal supply +5V)

Logic current: 0~36mA

Controlling level: Low -0.3V~1.5V, high: 2.3V~Vss

Enable signal level: Low -0.3V~1.5V, high: 2.3V~Vss

Max power: 25W (Temperature 75 cesus)

Working temperature: -25C~+130C

Dimension: 60mm*54mm

4.2.3 Linear Motor :

Figure 4.3 linear motor

4.2.3.a Linear motor specifications:

Type LAS-1-1-50-24

Product Linear actuator

Max load 1200N

Max self locking 800N

Max speed 12mm\sec

Stroke 50mm

Power rating 24v, max 2A

Weight 0.64kg

Duty cycle max 10%

4.2.4 Incremental optical encoder :

Figure 4.4 incremental optical encoder

4.2.4.a Incremental encoder specification :

■Specifications

Item			Diameter ø50mm hollow shaft type of incremental rotary encoder	
Resolution(P/R)			(Note1) 60, 100, 360, 500, 512, 1024, 3200	
Electrical specification	Output phase		A, B, Z phase (Line driver output A, $\overline{A}$, B, $\overline{B}$, Z, $\overline{Z}$ phase)	
	Phase difference at output		Phase difference between A and B : $\frac{T}{4} \pm \frac{T}{8}$ (T=1cycle of A phase)	
	Control output	Totem pole output	•Low ⇒ Load current:Max. 30mA, Residual voltage : Max. 0.4VDC •High ⇒ Load current:Max. 10mA, Output voltage(Power supply 5VDC):Min. (Power supply−2.0)VDC, Output voltage(Power supply 12~24VDC):Min. (Power supply−3.0)VDC	
		NPN open collector output	Load current : Max. 30mA, Residual voltage : Max. 0.4VDC	
		Voltage output	Load current : Max. 10mA, Residual voltage : Max. 0.4VDC	
		Line driver output	•Low ⇒ Load current : Max. 20mA, Residual voltage : Max. 0.5VDC •High ⇒ Load current : Max. −20mA, Output voltage : Min. 2.5VDC	
	Response time (Rise/Fall)	Totem pole output	Max. 1μs	•Measuring condition ⇒ Cable length : 2m, I sink = Max. 20mA
		NPN open collector output	Max. 1μs	
		Voltage output	Max. 1μs	
		Line driver output	Max. 0.5μs	
	Max. Response frequency		200kHz	
	Power supply		•5VDC ±5%(Ripple P-P:Max. 5%) •12~24VDC ±5%(Ripple P-P:Max. 5%)	
	Current consumption		Max. 80mA (disconnection of the load), Line driver output:Max. 50mA (disconnection of the load)	
	Insulation resistance		Min. 100MΩ (at 500VDC megger between all terminals and case)	
	Dielectric strength		750VAC 50/60Hz for 1 minute(Between all terminals and case)	
	Connection		Cable outgoing type, 250mm cable outgoing connector type	
Mechanical specification	Starting torque		Max. 200gf·cm(0.02N·m)	
	Moment of inertia		Max. 800g·cm² (8×10^{-5} kg·m²)	
	Shaft loading		Radial : 5kgf, Thrust : 2.5kgf	
	Max. allowable revolution		(Note2) 3600rpm	
Vibration			1.5mm amplitude at frequency of 10 to 55Hz in each of X, Y, Z directions for 2 hours	
Shock			Max. 75G	
Ambient temperature			−10 to 70℃ (at non-freezing status), Storage : −25 to 85℃	
Ambient humidity			35 to 85%RH, Storage : 35 to 90%RH	
Protection			IP50 (IEC standard)	
Cable			ø5mm, 5P, Length : 2m, Shield cable(Line driver output : ø5mm, 8P)	
Accessory			Spring bracket	
Unit weight			Approx. 560g	
Approval			CE (Except for line driver output)	

※(Note1)Not indicated type is customizable.

※(Note2)Max. allowable revolution ≥ Max. response revolution [Max. response revolution(rpm) = $\frac{\text{Max. response frequency}}{\text{Resolution}}$ × 60 sec.]

Make sure that max. response revolution should be lower than max. allowable revolution when selecting the resolution.

Table 4.1 incremental encoder specification.

4.2.5 Servo Dc Motor:

Figure 4.5 servo dc motor

4.2.6 Load Cell (weight sensor)

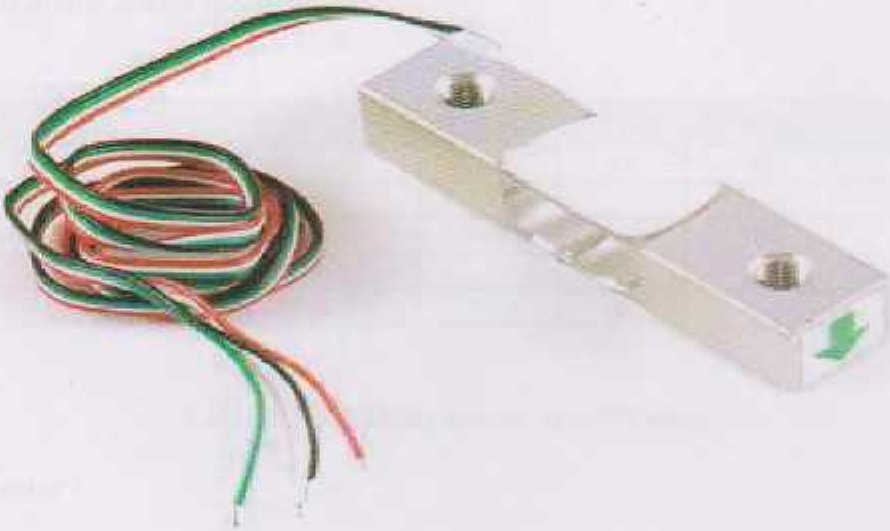


Figure 4.6

4.2.6.a Load cell Specification:

Type	Weight Range	Accuracy (FS)	Apps	Strength
Strain gauge	0-50k lbs 0-200 lbs. typ.	1%	Small scales	Small, inexpensive

Table 4.2 strain gauge specification.

4.2.7 humidity sensor:

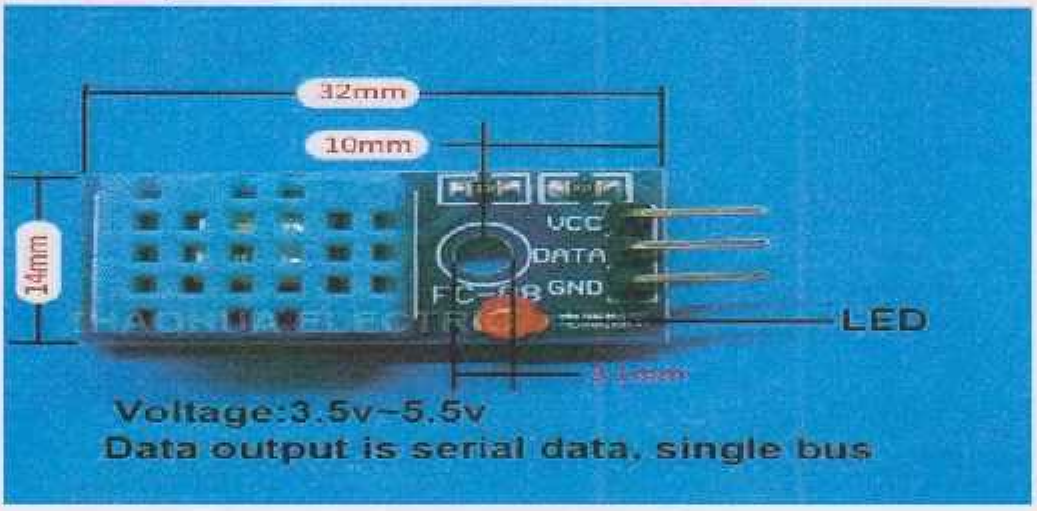


Figure 4.7 humidity sensor

4.2.7.a Humidity sensor specification:

Symbol	Quantity	Minimum	Typical	Maximum	Units
Vs	Supply Voltage		5.0	10	V
RH	Measuring Range	1		99	%
Ta	Operating Temperature	-40		100	°C
Tcc	Temperature Coefficient		0.23		T_{Decay}/°C
ta	Response time (33 - 76 % RH)		5		S

Table 4.3 humidity sensor specification

4.2.8 Heater :

Figure 4.8 heater

4.2.8.a Heater specification:

Max. operating voltage	Vmax 24 V DC
Rated voltage	VR 12 V DC
Breakdown voltage	VBD > 40 V
Curvature	< 0.05 mm
Operating temperature range	(V = 0) Top 40/+200 °C
Operating temperature range	(V = VR) Top 40/+100 °C
Tolerance of RR	ΔRR ±50 %

4.3 Summary:

In this chapter we showed specification and pictures for the parts of the project we used .

Chapter Five

Deign and Software Implementation

5.1 Introduction.

5.2 Project Design .

5.3 Summary.

5.1 Introduction:

In this chapter we will show the design and connection of the project component to the main piece of our project (microcontroller), also we will attach some codes that we used in the project.

5.2 Project design :

This will show hardware connections and also software if needed.

5.2.1 Satellite base design:

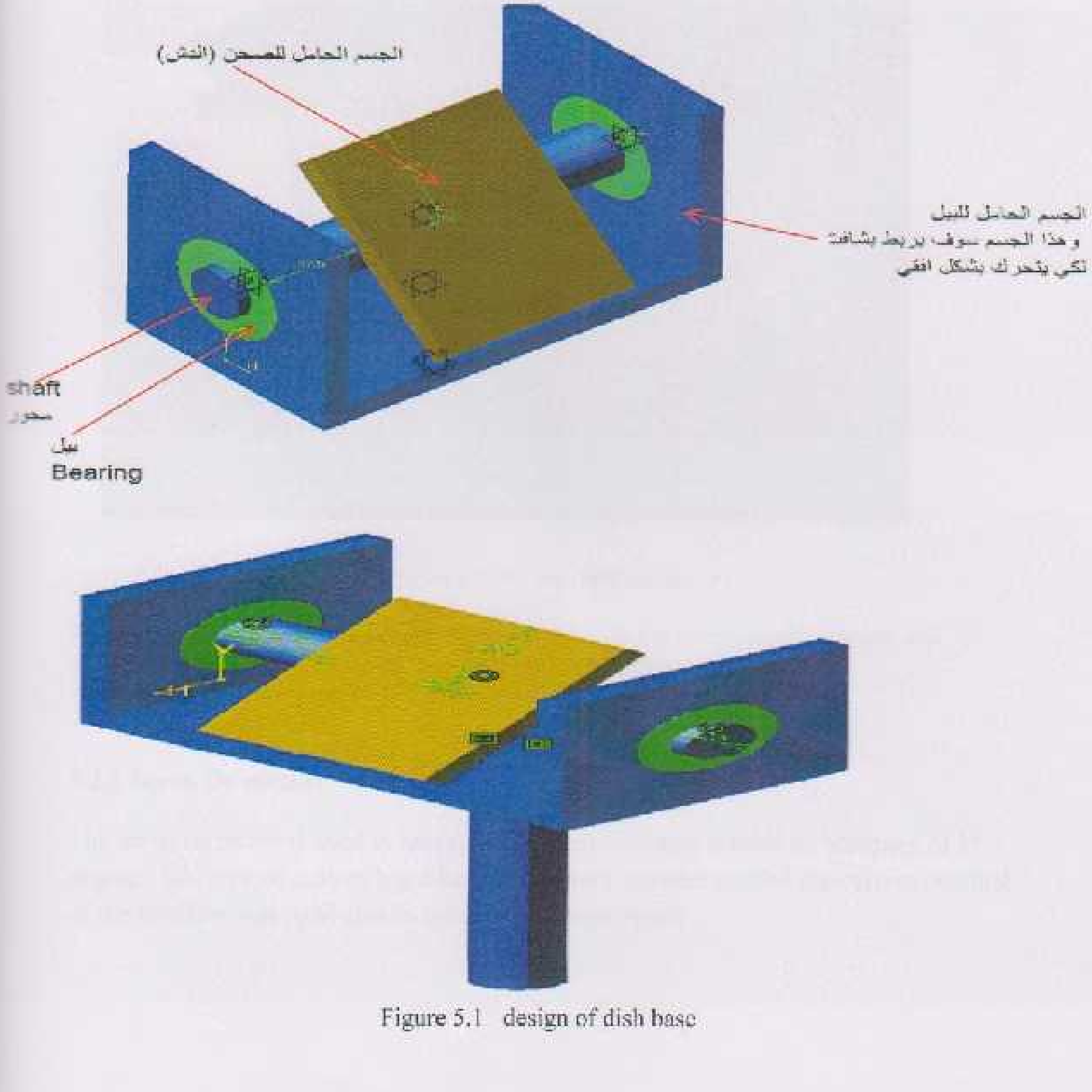


Figure 5.1 design of dish base

This figure shows the base of satellite dish designed using AutoCAD program , so that it moves in two direction vertically in a range of [-45,45] ,so that we will fixe it at the main orbit that posited at 40° degree, and horizontally at a range of [0°-180°] this range will include the main 4 satellites that we interested (Arab Sate, Nile Sate, Hotbaird, Turk Sate) .

5.2.1.a Satellite dish base final:

figure 5.2 dish base with motors

This figure shows the satellite dish base connected with the motors for the vertical and horizontal movement, also shows the encoders and the dish attached .

5.2.2 Servo Dc motor:

The servo dc motor is used in horizontal system , because it have an accuracy of 1° degree , this type of motors has a bullied in rotary encoder to give the current position of the satellite dish , and also to control the motor speed .

Figure 5.3 servo dc motor

5.2.2.a Servo motor connected to microcontroller :

This schematic diagram show how the servo driver will be connected to the microcontroller .

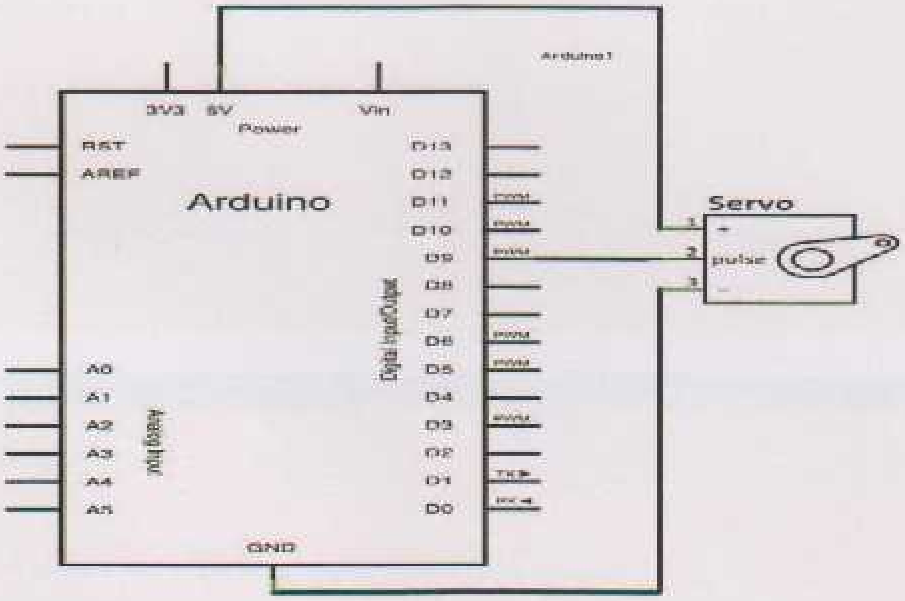


Figure 5.4 pins out of arduino with servo dc motor driver.

The following figure shows how we connect the servo motor driver to pwm pins (D8,D9).

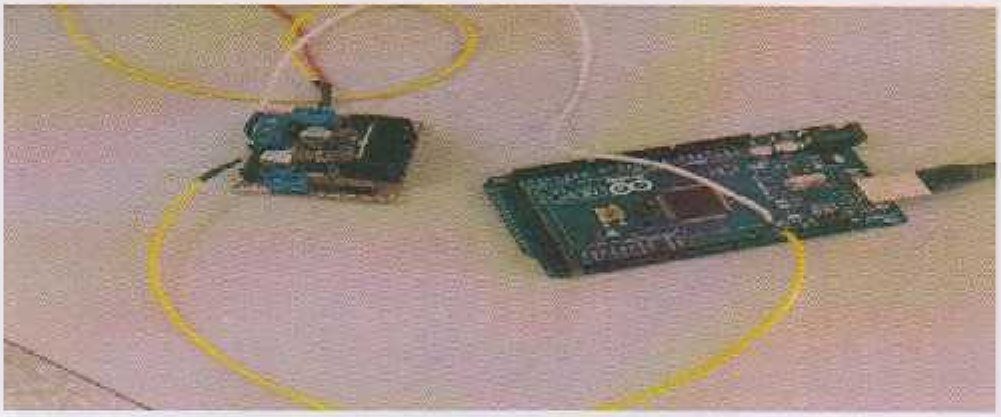


Figure 5.5 Arduino with Driver motors

5.2.2.b Software of Servo Dc motor:

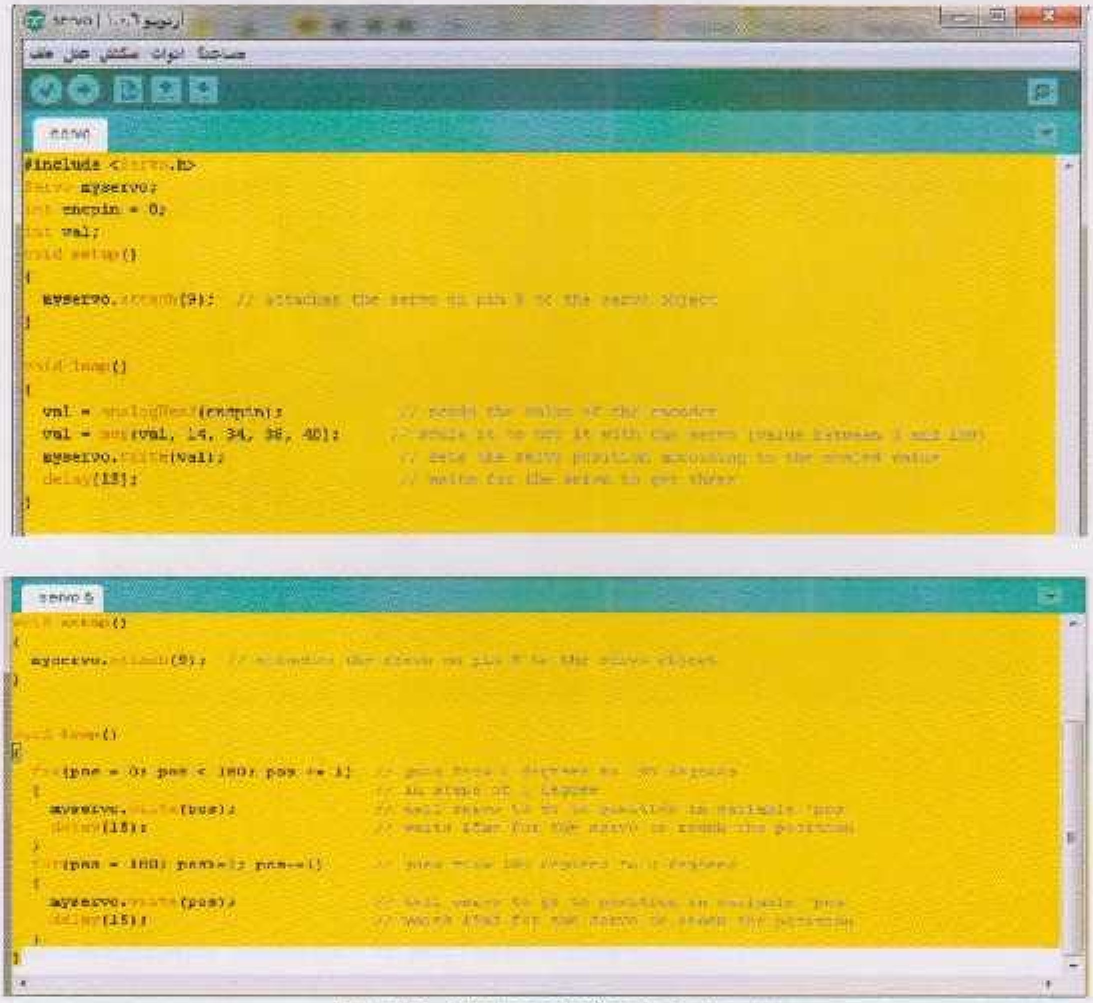


figure5.6 Arduino code for servo dc motor

5.2.3 Optical encoder :

Rotary and incrementally optical encoders are used in our project to give the current position of the satellite dish , they are connected to the base of satellite dish as shown .Figure 5.7.

Figure 5.7 incremental encoder

Figure 5.8 rotary encoder

5.2.3.a Encoder connected to microcontroller :

The following schematic diagram shows how the microcontroller connected to the optical encoder. Figure 5.9.

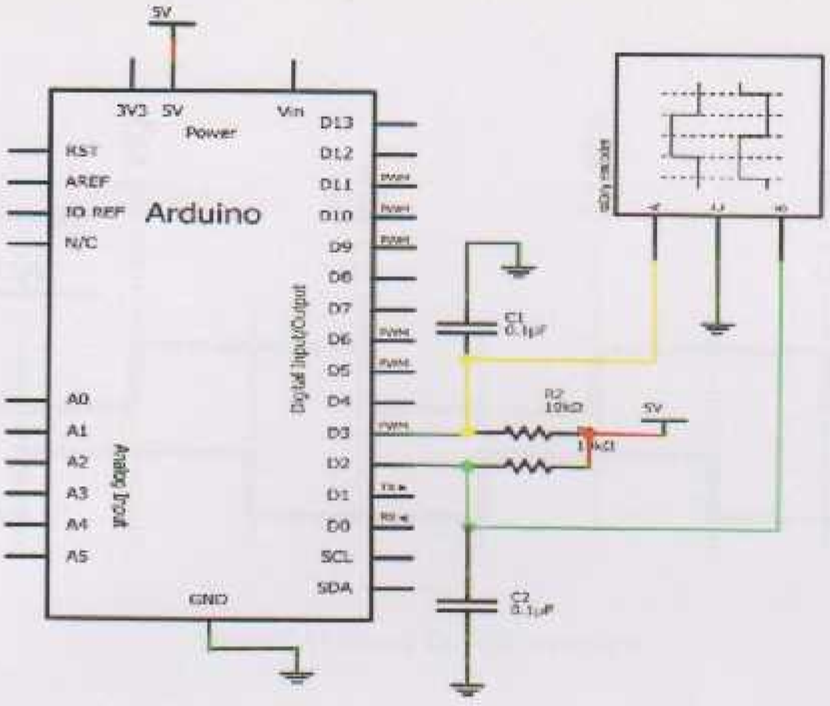


Figure 5.9 schematic diagram of encoder with Arduino.

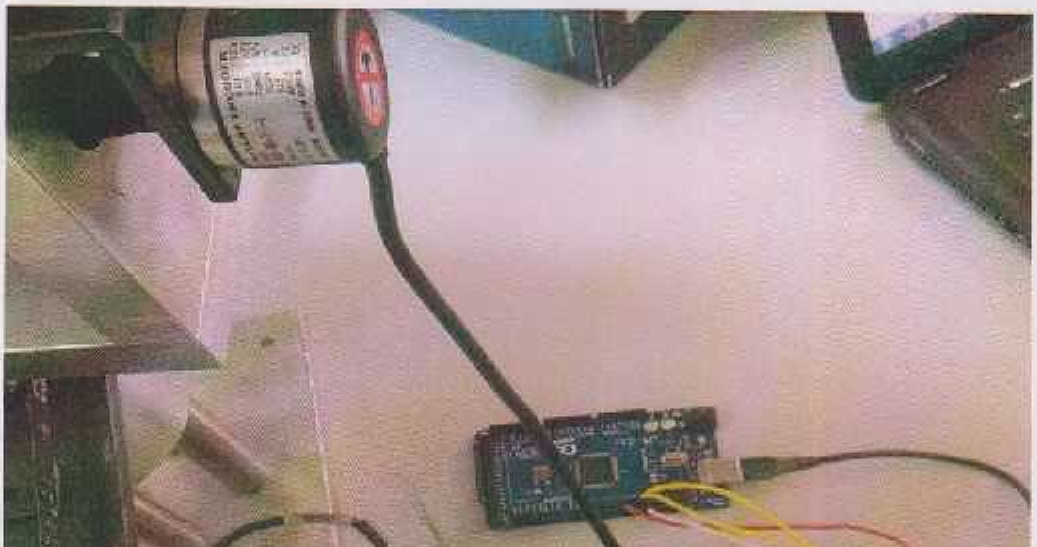


Figure 5.10 Encoder with Arduino Mega

To determine the position of the satellite dish encoder use two outputs(A,B) if B comes before A that mean the dish moved CW and if A is come before B that mean the dish moved CCW and with the number of pulses we can know exact position ,Figure 5.11 shows how encoder works.

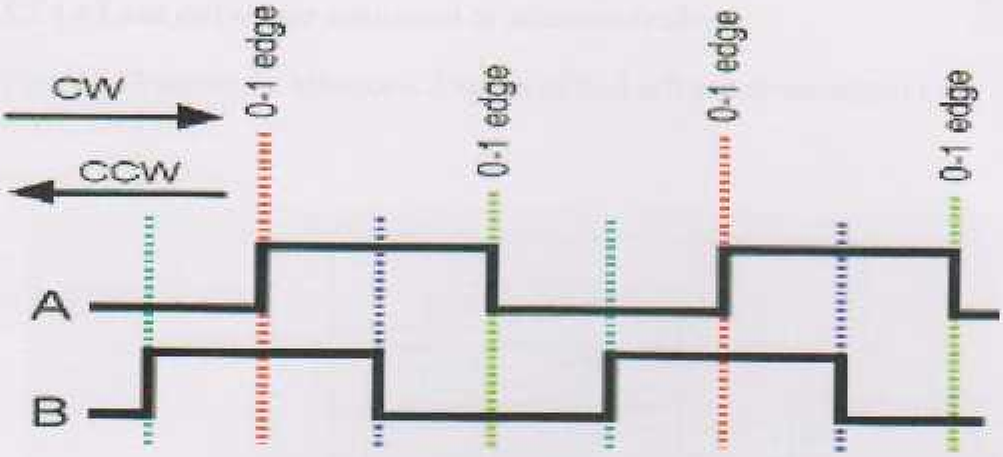


Figure 5.11 Rotary encoder waveform

5.2.3.b Software of Encoder:

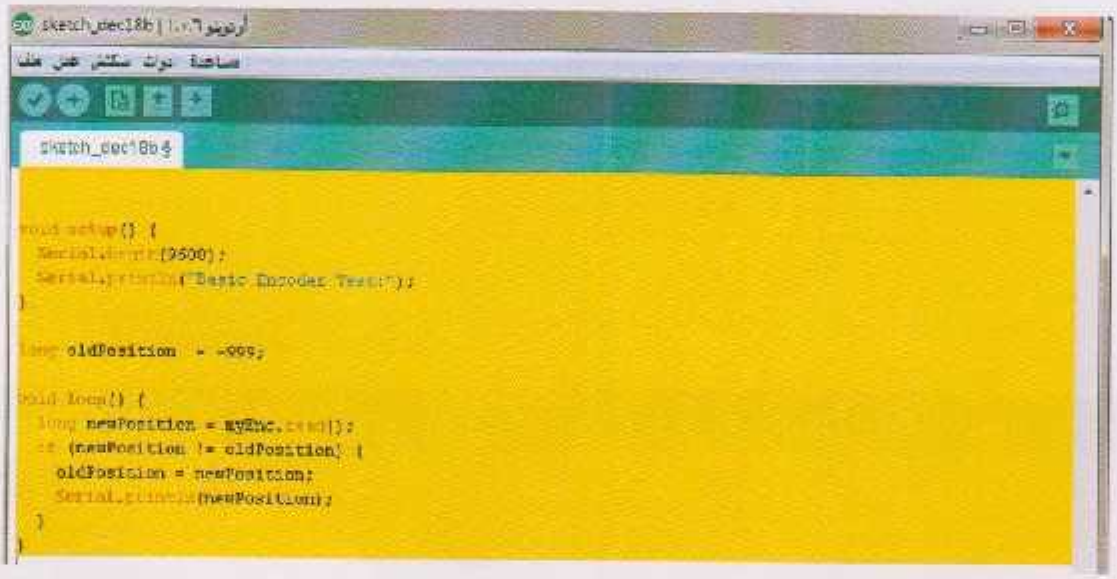


Figure 5.12 Encoder Arduino software

5.2.4 Load Cell (weight sensor):

We used load cell sensor to measure the weight of accumulated snow an the satellite dish , taking the dish weight as reference value = 1.300kg, this sensor will be connected an AND gate with humidity sensor .

5.2.4.a Load cell sensor connected to microcontroller:

Figure 5.13 shows the schematic diagram of load cell sensor connected to microcontroller .

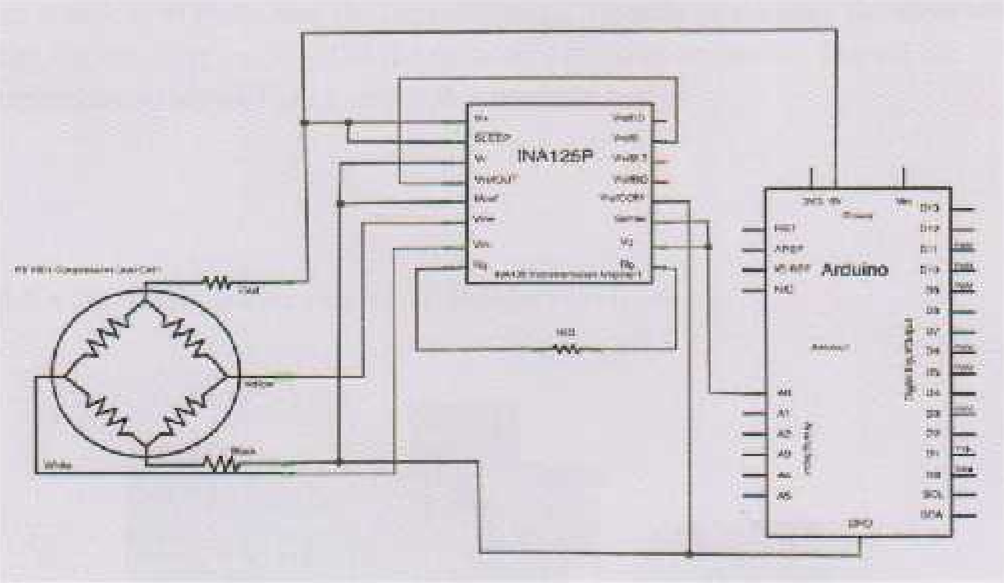


Figure 5.13 schematic diagram of Arduino with load cell

5.2.4.b Software of Load cell sensor:

Figure 5.14 load cell programming

5.2.5 Humidity sensor :

This sensor used measuring the humidity of the weather to simulate the snow weather, when the humidity reach <30% the snow will fall also we can not neglect the temperature so we will use a sensor that measure both.

5.2.5.a Humidity sensor connected to microcontroller :

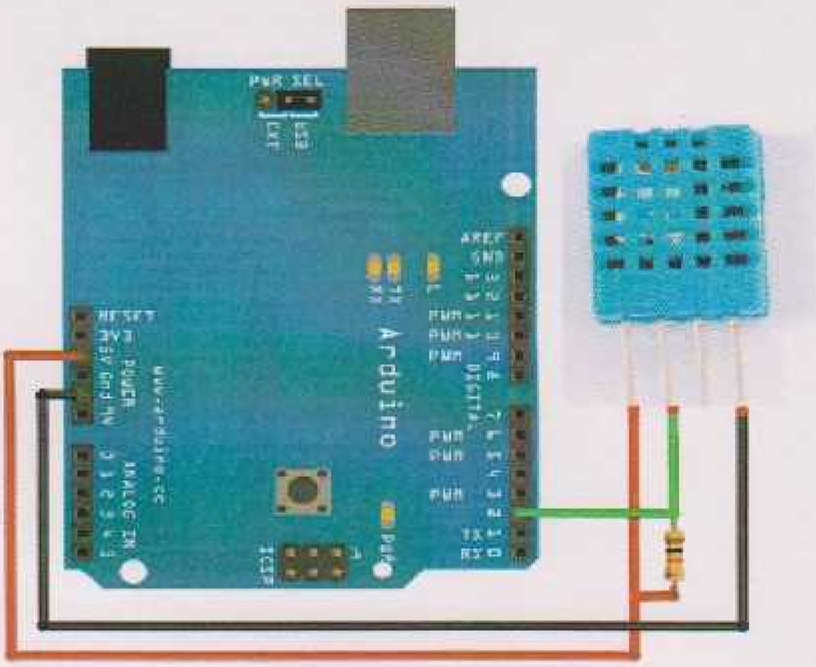


Figure 5.15 Arduino with humidity sensor

5.2.5.b Software of Humidity sensor:

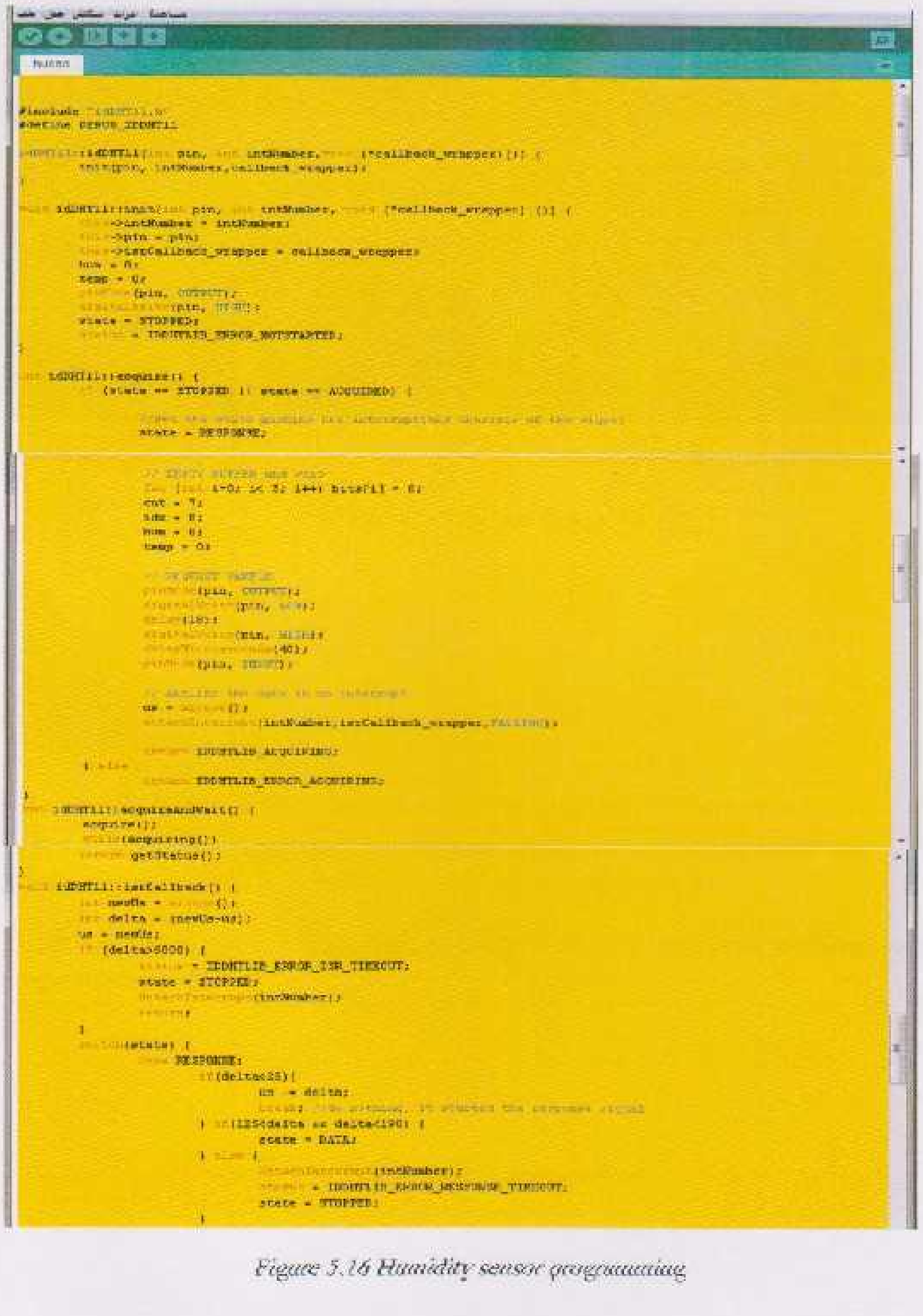


Figure 5.16 Humidity sensor programming

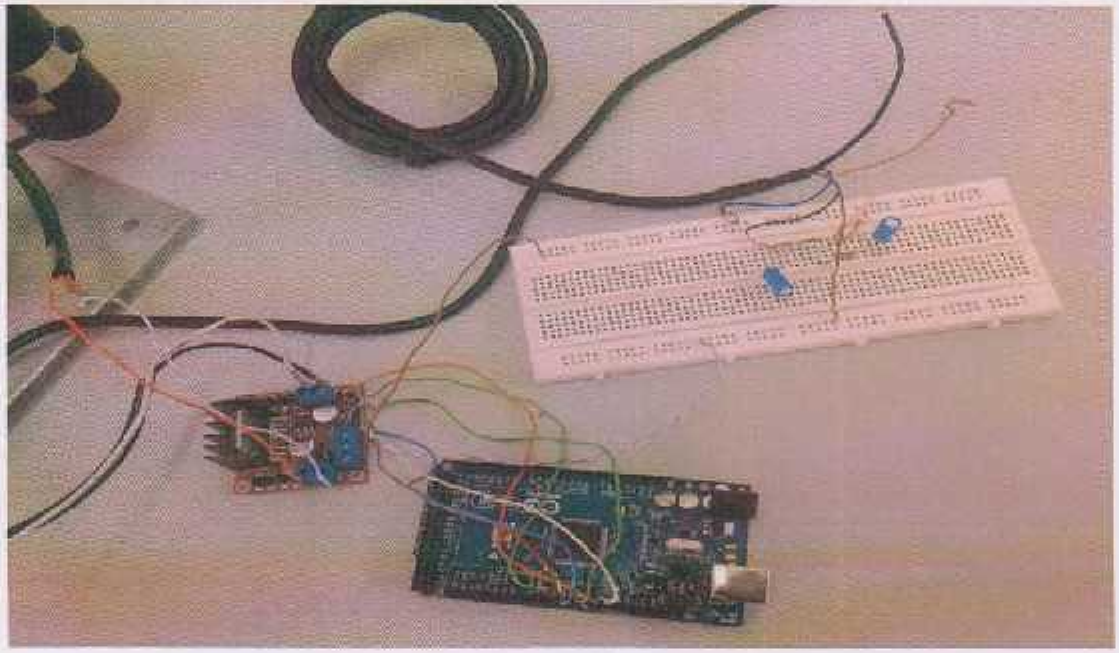


Figure 5.17 the final project

5.3 Summary:

In this chapter we mentioned the basic connection of our project ,also we added some programming codes .

References :

Refrences:

[1]: D. Ayansola Ogundele and Yinusa A. Adediran, " History of Satellite Broadcasting: Development and Advancement of Radio and Television Technology", white paper, Federal University of Technology, Minna,Nigeria,2010,pp 1-7.

[2]: *Dish* Positioning Control by IR Remote", white paper, http://www.edgefxkits.com/dish-positioning-control-by-ir-remote

[3]: [Online]Satellite Dish Definition : http://www.techopedia.com/definition/25279/satellite-dish .

[4]: Parod,C.(2005,January), DTH – HOW IT WORKS, pp1-1, http://www.scatmag.com/technical/techarticle-jan05.pdf

[5]: [Online] How Satellite HD works http://electronics.howstuffworks.com/satellite-hd.html

[6]: [Online] Different type of satellite orbits : http://www.globalcomsatphone.com/hughesnet/satellite/orbits.html

[7]: Allan R. Hambley," Electrical Engineering Principles and Applications", Chapter 16 http://vlab.ee.nus.edu.sg/~bmchen/courses/EG1108_DCmotors.pdf

[8]: [Online] Servo dc motor: http://www.electrical4u.com/dc-servo-motors-theory-and-working-principle.

[9]: [Online] linear motor http://www.usna.edu/EE/ee301/supplements/Linear%20Motors%20Supplement.pdf

[10]: [Online] Microcontroller : https://www.princeton.edu/~achaney/tmve/wiki100k/docs/Microcontroller.html

[11]: Byreddy Swetha1, T. Praveen Blesington2, Fazal Noor Basha2, B. BhanuMurthy ," DESIGN OF 32-BIT MICROCONTROLLER PROCESSOR IN SOC",white peaper, Department of ECE Engineering. KL University, Vijayawada, India, May 2013, Vol. 6, Issue 2, pp. 812-825.

[12]: [Online] Position Sensor:
http://www.car-san.com/product_pdfs/doc_20121010180524.pdf

[13]: [Online] Digital Encoder
http://mechatronics.mech.northwestern.edu/design_ref/sensors/encoders.html

[14]: [Online] Optical Encoder
http://ar.scribd.com/doc/82253339/Absolute-Rotary-Encoder

[15]: [Online] Strain gauge load cell
http://en.wikipedia.org/wiki/Load_cell

[16]: Norman S.Nise, control system engineering, sixth Edition, pp240-241.

[17]: Puneet Pahuja*, Sushil Kr. Singh and HR Rai, "Design of Position Control of DC Servo MotorUsing PI Controller", VSRD International Journal of Elecrical, Electronics & Communication Engineering, 2012,VSRD-IJEECE, Vol. 2 (4), 196-200.