Project On

“SINGLE AXIS SMART SOLAR TRACING SYSTEM USING ARDUINO AND SERVO MOTOR”

B. Sc. Engg. in Electronics and Communication Engineering
Department of ECE
East West University, Dhaka
Bangladesh

Submitted By,

Tanvir Ahmed	**Asadur Rahman**
ID: 2013-1-55-017	**ID: 2013-1-55-10**

Under the supervision of
Dr Md. Habibur Rahman
Professor
Department of Electrical and Electronic Engineering
University Of Dhaka

DECLARATION

We hereby declare that we carried out the work reported in this project in the Department of Electronics and Communications Engineering, East West University, under the supervision of **Dr. Md. Habibur Rahman**. We solemnly declare that to the best of our knowledge, no part of this report has been submitted elsewhere for award of any degree. All sources of knowledge used in this report have been duly acknowledged.

………………………..

Asadur Rahman

ID: 2013-1-55-010

..……………………..

Tanvir Ahmed

ID: 2013-1-55-017

CERTIFICATE

This is to certify that the project entitled **“Single Axis Smart Solar Tracking System Using Arduino and Servo Motor ”** being submitted by **Asadur Rahman and Tanvir Ahmed** of Electronics and Communications EngineeringDepartment, East West University, Dhaka in partial fulfillment for the award of the degree of Bachelor of Science in Electronics and Telecommunication Engineering, is a record of major project carried out by them. They have worked under my supervision and guidance and have fulfilled the requirements which, to my knowledge, have reached the requisite standard for submission of this dissertation.

…………………………………

Dr. Md. Habibur Rahman
Professor
Dept. ofElectrical and Electronics Engineering

ACKNOWLEDGEMENT

We would like to express our gratitude to our advisor Dr. Md. Habibur Rahman, Professor, Dept. of Electrical and Electronic Engineering, University of Dhaka for his guidance and support throughout this project work. He has been a constant source of inspiration to us throughout the period of this work. He has shared his valuable time and knowledge throughout the project period and checked our daily progress. We consider ourselves extremely fortunate for having the opportunity to learn and work under his supervision over the entire period.

Finally, we would like to thank our Chairman sir and department for giving us this chance to complete the project with all the facilities needed for it.

………………………..
Asadur Rahman
ID: 2013-1-55-010

……………………..
Tanvir Ahmed
ID: 2013-1-55-017

ABSTRACT

In this project a single axis solar tracking system has been developed by which more energy from the sun can be harnessed. In this project, an Arduino Uno, which is an Atmel microcontroller-based board, has been used as the main controlling unit. To detect the position of the sun on the sky, two LDRs have been used and to rotate the orientation of the Solar PV panel a servo motor has been used.The sensors and servo motor have properly been interfaced with the Arduino board. The servo motor has been mechanically coupled with the PV panel. The driving program has been written using the Arduino IDE. The whole system has been assembled together and its performance has been tested. This tracker changes the direction of the solar panel based on the direction of the sun facing to the panel successfully. Single axis solar tracker tracks the sun on daily basis and makes the solar panel more efficient.

TABLE OF CONTENTS

CHAPTER 4: SOLAR TRACKING DESIGN: HARDWARE………………. 25

CHAPTER 1

INTRODUCTION

1.1 OBJECTIVES

The project was carried out to satisfy two main objectives: Design a system that tracks the sunlight for solar panels. The aim of the project is to keep the solar photovoltaic panel perpendicular to the sun throughout the year in order to make it more efficient. The single axis solar photovoltaic panel takes astronomical data as reference and the tracking system has the capability to always point the solar array toward the sun and can be installed in various regions with minor modifications.

1.2 LITERATURE REVIEW

This section includes the literature review of a few papers among which we have studied about dual axis solar tracking in brief.

The project demonstrates the design and implementation A laboratory-scale single axis solar tracking system. By using the laboratory-scale system, the system becomes portable and convenient to be allocated at the suitable workplace for solar tracking process. In this project, microcontroller was used as an integrated control unit and the plant was actuated by the DC geared motor [4].

This paper describes in detail about the design, development and fabrication of two Prototype Solar Tracking Systems mounted with a single-axis and dual-axis solar tracking controllers. The solar tracking system-Tilted Single Axis Tracker and Azimuth-Altitude Dual Axis Tracker are designed in this project. LDR had been used as sensing unit for the projects. The control circuit for the systems was based on Atmega8 Microcontroller which was programmed to detect the sunlight through the LDR sensors and then actuate the DC geared motor using L293D motor driver to position the solar panel where it can receive the maximum sunlight [5].

After studying and analyzing a number of research papers, it is found that most of the tracking systems done are single axis tracking. Many of them are costly according to their framing design and use of components. Their tracking system can track daily change of sun position but not seasonally. Commercially tracking system can be made more efficient discarding the economic issue.

CHAPTER-2

SOLAR RADIATION & PHOTOVOLTAIC

2.1 CONCEPTS ON SOLAR RADIATION

Before we start talking about the solar tracking systems, at first we will discuss about some basic concepts relating to solar radiation and some important values to understand the results of this project.

The sun, at an estimated temperature of 5800 K, emits high amounts of energy in the form of radiation, which reaches the planets of the solar system. Sunlight has two components, the direct beam and diffuse beam. Direct radiation (also called beam radiation) is the solar radiation of the sun that has not been scattered (causes shadow). Direct beam carries about 90% of the solar energy, and the "diffuse sunlight" that carries the remainder. The diffuse portion is the blue sky on a clear day and increases as a proportion on cloudy days. The diffuse radiation is the sun radiation that has been scattered (complete radiation on cloudy days). Reflected radiation is the incident radiation (beam and diffuse) that has been reflected by the earth. The sum of beams, diffuse and reflected radiation is considered as the global radiation on a surface. As the majority of the energy is in the direct beam, maximizing collection requires the sun to be visible to the panels as long as possible.

2.2 Declination Angle

The declination of the sun is the angle between the equator and a line drawn from the center of the Earth to the center of the sun. The declination is maximum (23.45^0) on the summer/winter (in India 21 June and 22 December) The declination angle, denoted by δ, varies seasonally due to the tilt of the Earth on its axis of rotation and the rotation of the Earth around the sun. If the Earth were not tilted on its axis of rotation, the declination would always be 0°. However, the Earth is tilted by 23.45° and the declination angle varies plus or minus this amount. Only at the spring and fall equinoxes is the declination angle equal to 0°.

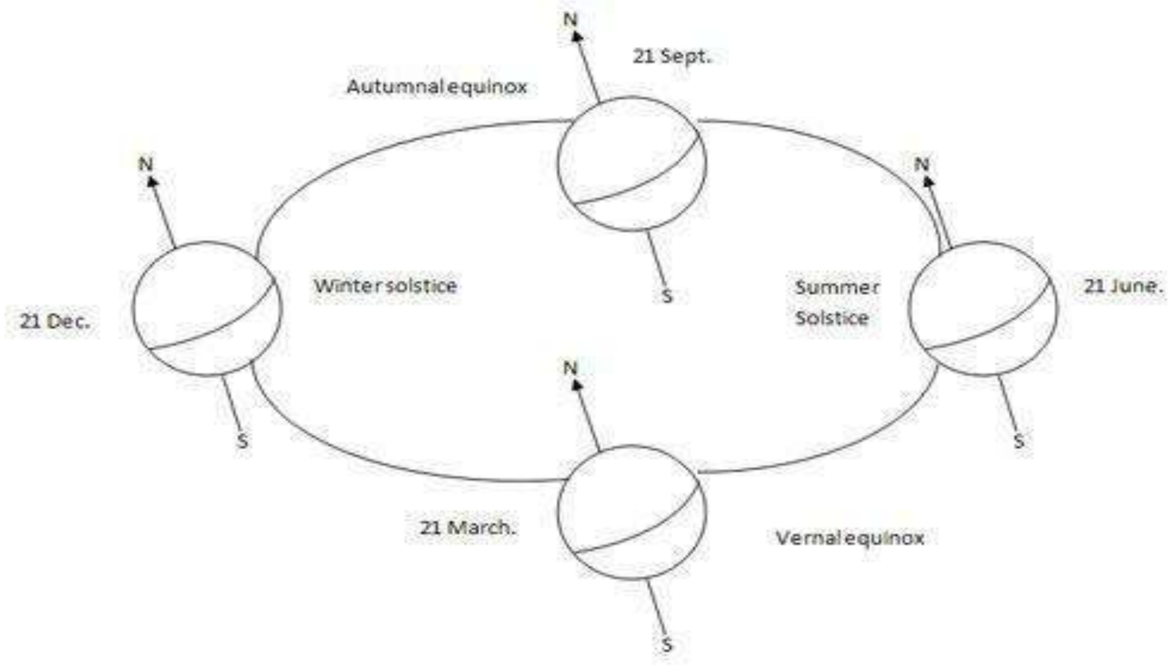


Figure 2.1: The Declination Angles

2.3 Hour Angle

The Hour Angle is the angular distance that the earth has rotated in a day. It is equal to 15 degrees multiplied by the number of hours from local solar noon. This is based on the nominal time, 24 hours, required for the earth to rotate once i.e. 360 degrees.

Solar hour angle is zero when sun is straight over head, negative before noon, and positive after noon.(here noon means 12.00 hour)

2.4 Solar Altitude (θ_z)

The solar altitude is the vertical angle between the horizontal and the line connecting to the sun. At sunset/sunrise altitude is 0 and is 90 degrees when the sun is at the zenith. The altitude relates to the latitude of the site, the declination angle and the hour angle.

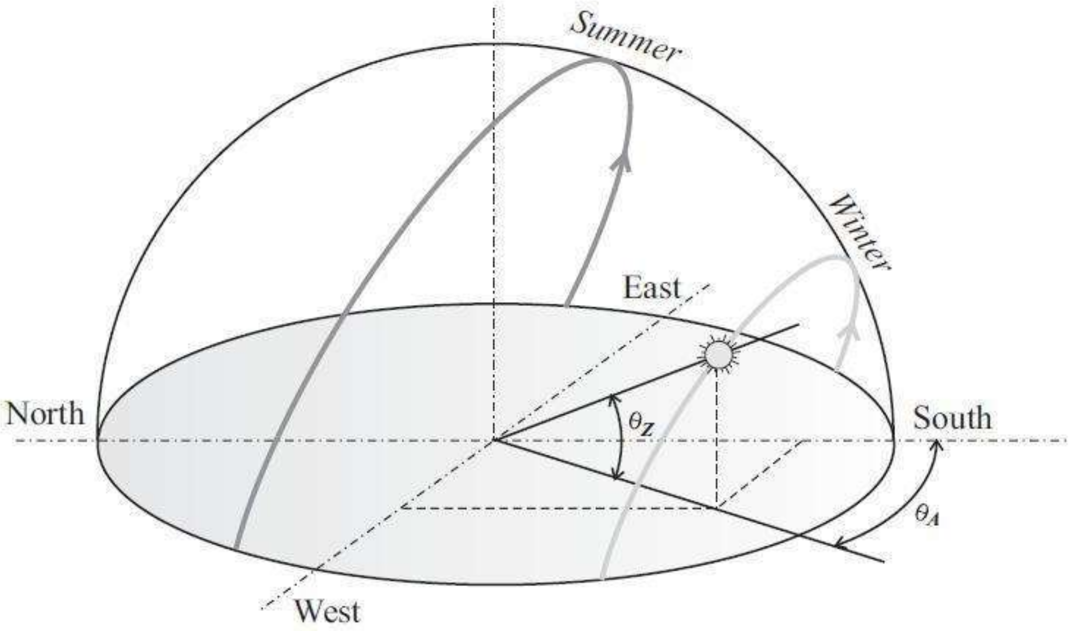


Figure 2.2:Solar altitudes and azimuths typical behavior of sun path

2.5 Solar Azimuth (θ_A)

The azimuth angle is the angle within the horizontal planemeasured from true South or North.The azimuth angle is measured clockwise from the zero azimuth. For example, if you're in the Northern Hemisphere and the zero azimuth is set to South, the azimuth angle value will be negative before solar noon, and positive after solar noon.

2.6 INSOLATION

Insolation is a measure of solar radiation energy received on a given surface area and recorded during a given time. It is also called solar irradiation and expressed as hourly irradiation if recorded during an hour, daily irradiation if recorded during a day, for example. The unit recommended by the World Meteorological Organization is MJ/m^2 (mega joules per square meter) or J/cm^2(joules per square centimeter).Practitioners in the business of solar energy may use the unit Wh/m^2 (watt-hours per square meter). If this energy is divided by the recording time in hours, it is then a density of power called irradiance, expressed in W/m^2 (watts per square meter). Over the course of a year the average solar radiation arriving at the top of the Earth's atmosphere at any point in time is roughly 1366 watts per square meter. The Sun's rays are attenuated as they pass through the atmosphere, thus reducing the irradiance at the Earth's surface to approximately 1000 $W\ m^{-2}$ for a surface perpendicular to the Sun's rays at sea level on a clear day. The insolation of the sun can also be expressed in Suns, where one Sun equals 1000 W/m^2 .

2.7 PROJECTION EFFECT

The insolation into a surface is largest when the surface directly faces the Sun. As the angle increases between the direction at a right angle to the surface and the direction of the rays of sunlight, the insolation is reduced in proportion to cosine of the angle; see effect of sun angle on climate.This 'projection effect' is the main reason why the Polar Regions are much colder than equatorial regions on Earth. On an annual average the poles receive less insolation than does the equator, because at the poles the Earth's surface are angled away from the Sun.

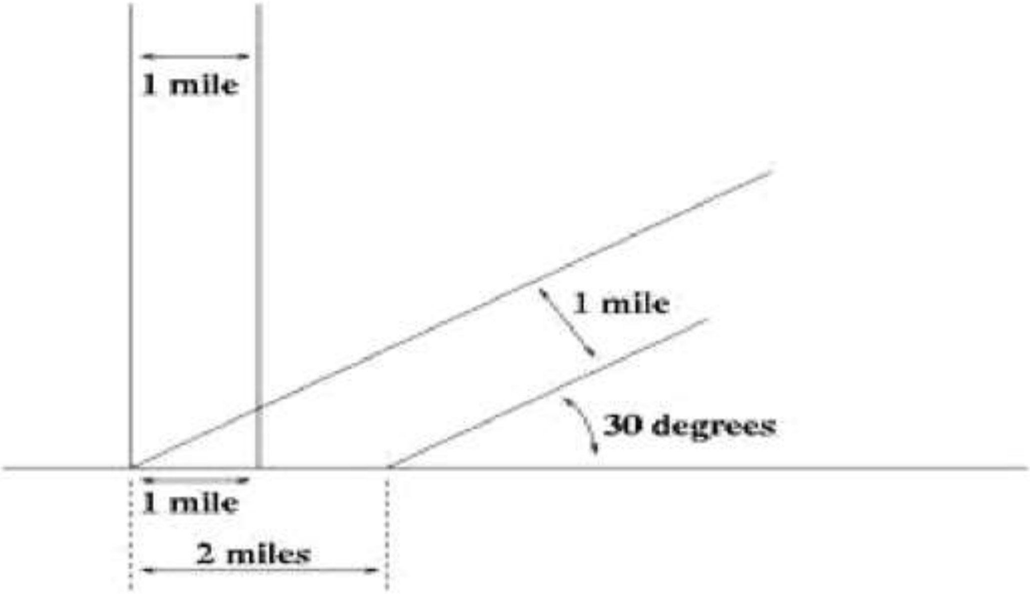


FIG 2.3: Projection effect

2.8 LATITUDE

To trace the sun path from a place on the earth surface another important parameter is Latitude that is a geographic coordinate which specifies the north– south position of a point on the earth surface. Latitude is expressed by the Greek alphabet “phi”(φ). Latitude is an angle which ranges from 0° at the Equator to 90° (North or South) at the poles. Lines of constant latitude, or parallels, run east–west as circles parallel to the equator.

2.8.1 LATITUDE DETERMINATION ON THE EARTH

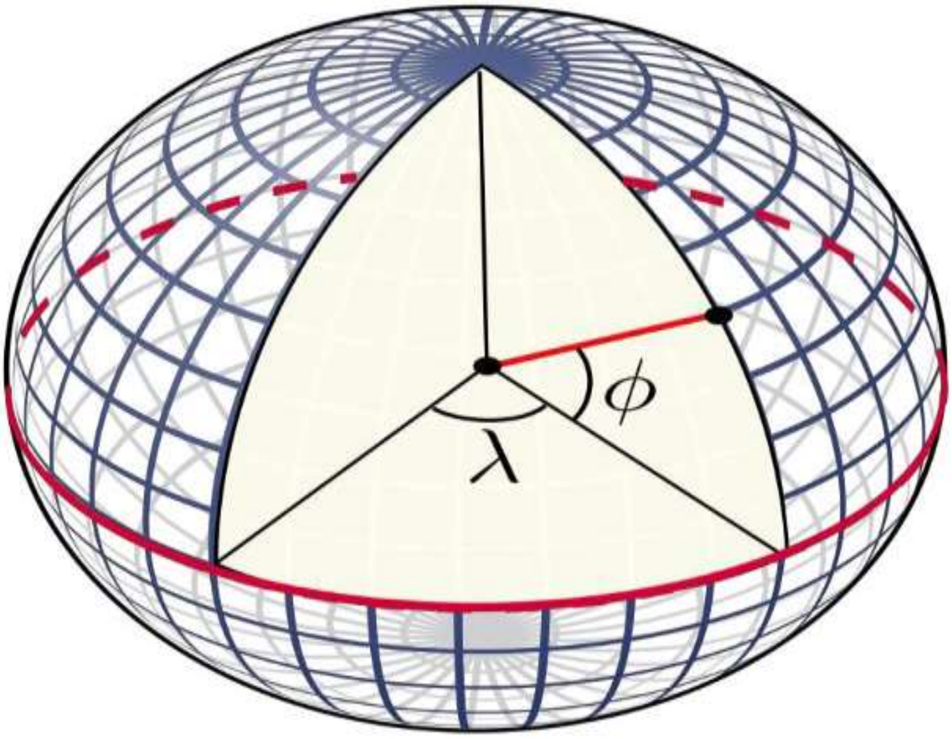


Fig 2.4: Latitude and Longitude determination

The graticule formed by the lines of constant latitude and constant longitude is constructed with reference to the rotation axis of the Earth. The primary reference points are the poles where the axis of rotation of the Earth intersects the reference surface. Planes which contain the rotation axis intersect the surface in the meridians and the angle between any one meridian plane and that through Greenwich (the Prime Meridian) defines the longitude: meridians are lines of constant longitude. The plane through the center of the Earth and orthogonal to the rotation axis intersects the surface in a great circle called the equator. Planes parallel to the equatorial plane intersect the surface in circles of constant latitude; these are the parallels. The equator has a latitude of 0°, the North Pole has a latitude of 90° North (written 90° N or +90°), and the South Pole has a latitude of 90° south (written 90° S or −90°). The latitude of an arbitrary point is the angle between the equatorial plane and the radius to that point. The latitude that is defined in this way for the sphere is often termed the spherical latitude to avoid ambiguity with auxiliary latitudes defined in subsequent sections.

2.8.2 LATITUDE’S NAME ON THE EARTH SURFACE

On the earth’s surface four latitude positions are used as the reference of determining than any other position of the earth’s surface.

Table 2.1: Earth’s latitude positions

Arctic Circle	66° 34′ (66.57°) N
Tropic of Cancer	23° 26′ (23.43°) N
Tropic of Capricorn	23° 26′ (23.43°) S
Antarctic Circle	66° 34′ (66.57°) S

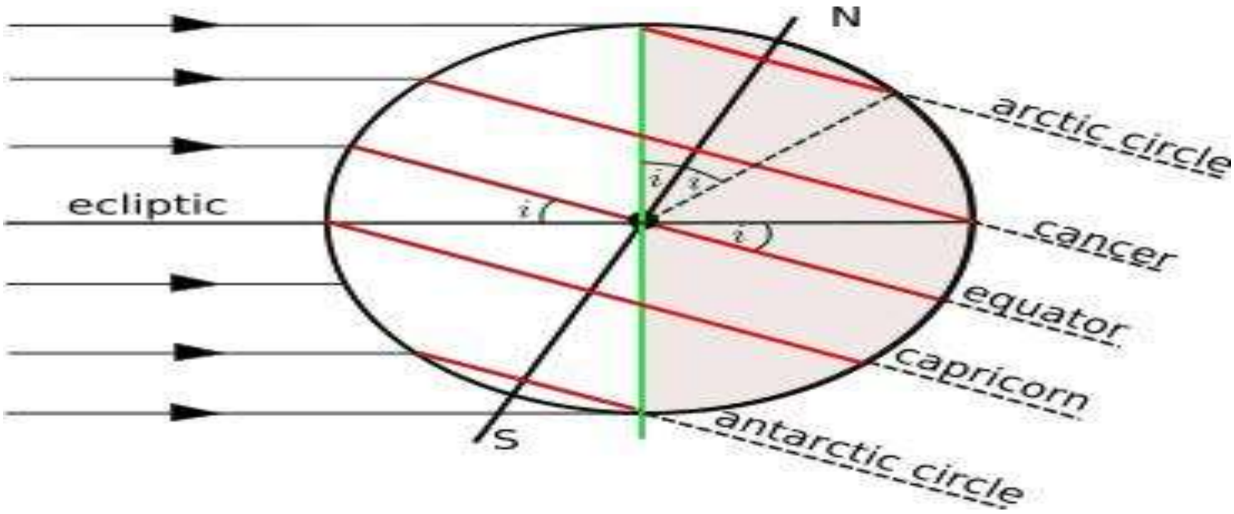


Fig 2.5: Name of the Latitude on the Earth surface

The plane of the Earth's orbit about the sun is called the ecliptic and the plane perpendicular to the rotation axis of the Earth is the equatorial plane. The angle between the ecliptic and the equatorial plane is called variously the axial tilt, the obliquity, or the inclination of the ecliptic, and it is conventionally denoted by “I”. The latitude of the tropical circles is equal to i and the latitude of the polar circles in the complement. The axis of rotation varies slowly over time and the values given here are those for the current epoch.

The time variation is discussed more fully in the article on axial tilt. The figure shows the geometry of a cross section of the plane normal to the ecliptic and through the centers of the Earth and the Sun at the December solstice when the sun is overhead at some point of the Tropic of Capricorn. The south polar latitudes below the Antarctic Circle are in daylight whilst the north polar latitudes above the Arctic Circle are in night. The situation is reversed at the June solstice when the sun is overhead at the Tropic of Cancer. Only at latitudes in between the two tropics is it possible for the sun to be directly overhead.

2.8.3 LONGITUDE

Alike Latitude, Longitude is another geographic coordinate system that specifies the east-west position of a point on the Earth's surface. It is an angular measurement, usually expressed in degrees and denoted by the Greek letter lambda (λ). Meridians that are the lines running from the North Pole to the South Pole connect points with the same longitude.By convention, one of these, the Prime Meridian, which passes through the Royal Observatory, Greenwich, England, was allocated the position of zero degree longitude.

The longitude of other places is measured as the angle east or west from the Prime Meridian, ranging from 0° at the Prime Meridian to +180° eastward and −180° westward. Specifically, it is the angle between a plane containing the Prime Meridian and a plane containing the North Pole, South Pole and the location in question. This forms a right-handed coordinate system with the z axis (right hand thumb) pointing from the Earth's center toward the North Pole and the x axis (right hand index finger) extending from Earth's center through the equator at the Prime Meridian. Longitude is given as an angular measurement ranging from 0° at the Prime Meridian to +180° eastward and −180° westward.

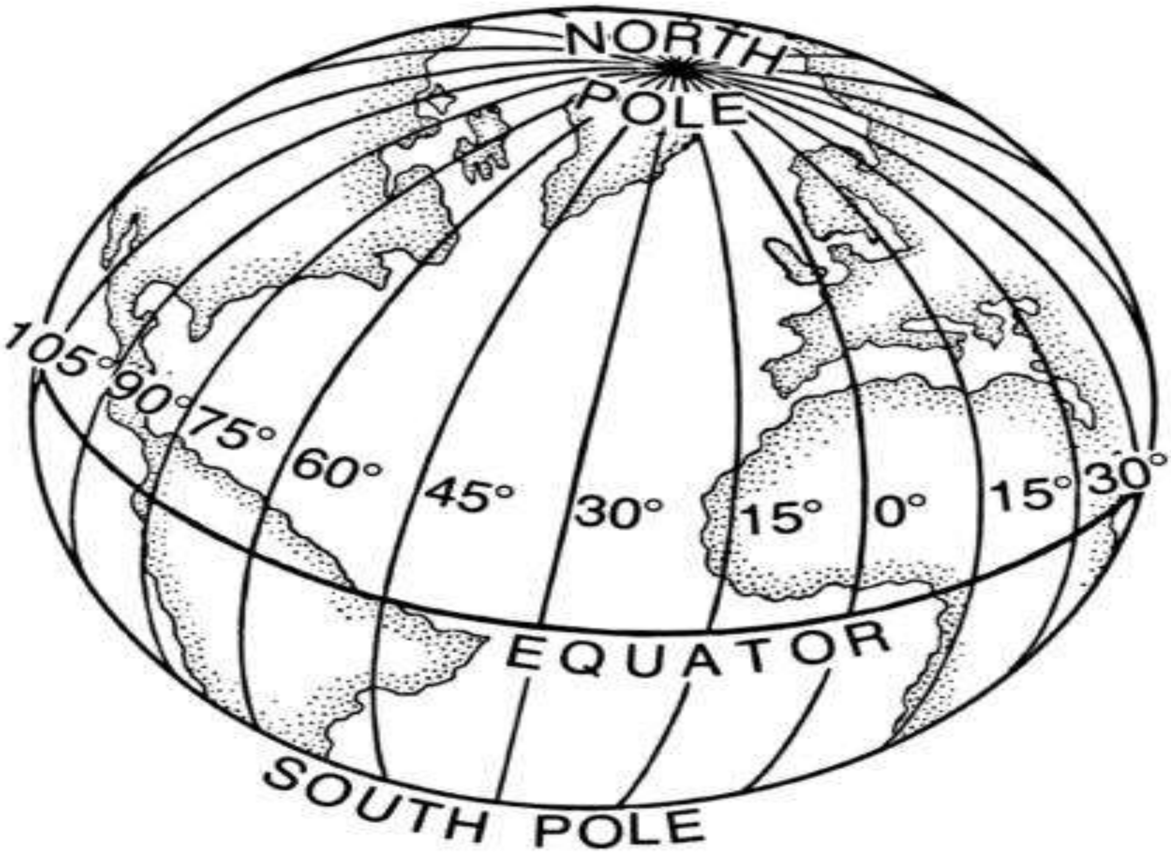


Fig2.6: Concept of Longitude

2.9 WORKING OF PHOTOVOLTAICS

Photo voltaic are the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity. A solar cell (also called photovoltaic cell or photoelectric cell) is a solid state electrical device that converts the energy of light directly into electricity by the photovoltaic effect. Crystalline silicon PV cells are the most common photovoltaic cells in use today.

A number of solar cells electrically connected to each other and mounted in a support structure or frame are called a photovoltaic module. Modules are designed to supply electricity at a certain voltage, such as a common 12 volts system. The current produced is directly dependent on how much light strikes the module. Multiple modules can be wired together to form an array. In general, the larger the area of a module or array, the more electricity will be produced. Photovoltaic modules and arrays produce direct-current (DC) electricity. They can be connected in both series and parallel electrical arrangements to produce any required voltage and current combination.

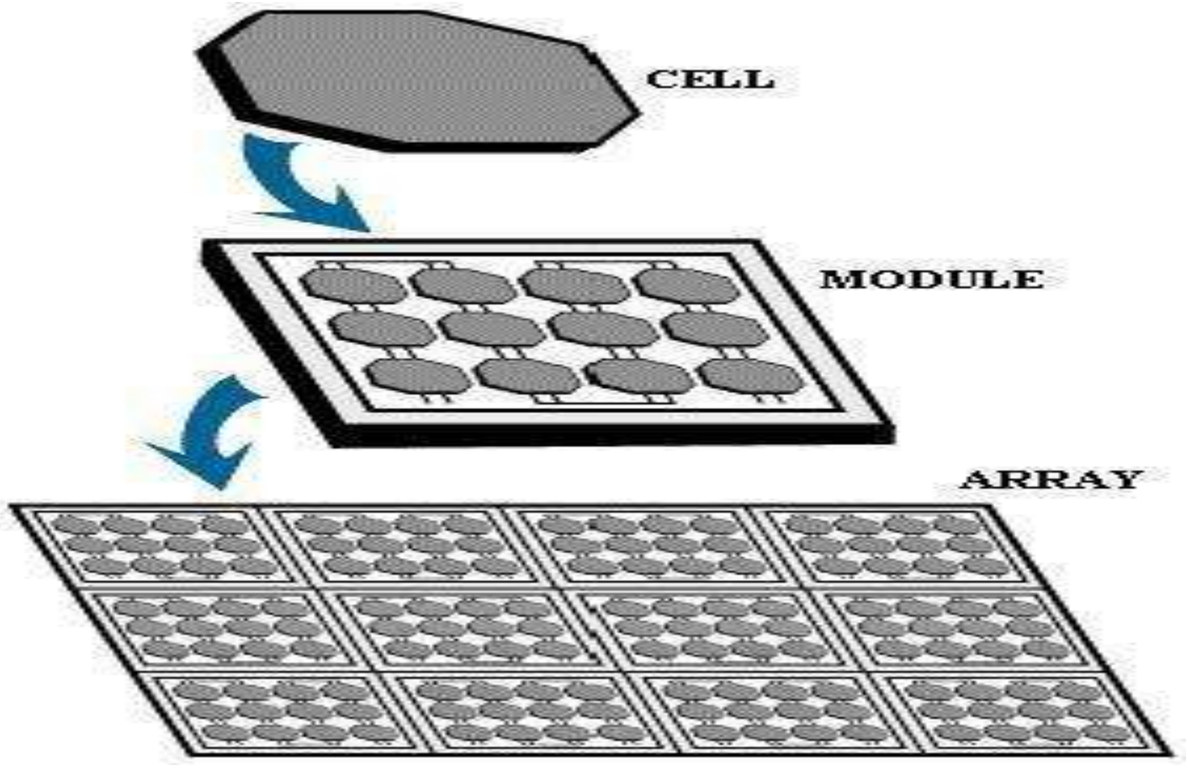


Figure 2.7: Photovoltaic panel or array

CHAPTER-3

SOLAR TRACKER

3.1 INTRODUCTION

Solar Tracker is a Device which follows the movement of the sun as it rotates from the east to the west every day. The main function of all tracking systems is to provide one or two degrees of freedom in movement. Trackers are used to keep solar collectors/solar panels oriented directly towards the sun as it moves through the sky every day. Using solar trackers increases the amount of solar energy which is received by the solar energy collector and improves the energy output of the heat/electricity which is generated. Solar trackers can increase the output of solar panels by 20-30% which improves the economics of the solar panel project.

3.2 NEED FOR SOLAR TRACKER

The sun travels through 360 degrees east-west a day, but from the perspective of any fixed location the visible portion is 180 degrees during a 1/2 day period. Local horizon effects reduce this somewhat, making the effective motion about 150 degrees. A solar panel in a fixed orientation between the dawn and sunset extremes will see a motion of 75 degrees on either side, and thus, according to the table above, will lose 75% of the energy in the morning and evening. Rotating the panels to the east and west can help recapture these losses. A tracker rotating in the east-west direction is known as a single-axis tracker.

The sun also moves through 46 degrees north-south over the period of a year. The same set of panels set at the midpoint between the two local extremes will thus see the sun move 23 degrees on either side, causing losses of 8.3% A tracker that accounts for both the daily and seasonal motions is known as a dual axis tracker.

The energy contributed by the direct beam drops off with the cosine of the angle between the incoming light and the panel. The table no. 2.1 shows the Direct power lost (%) due to misalignment

Table no-3.1: Direct power lost (%) due to misalignment (angle *i*)

Misalignment (angle *i*)	Direct power lost (%)=1-cos(i)
0^0	0
1^0	.015
3^0	.14
8^0	1
23.4^0	8.3
30^0	13.4
45^0	30
75^0	>75

3.3 TYPES OF SOLAR TRACKERS

There are two types of tracking systems they are

- Passive tracking
- Active tracking

3.3.1. PASSIVE TRACKING SYSTEMS

The passive tracking system realizes the movement of the system by utilizing a low boiling point liquid. This liquid is vaporized by the added heat of the sun and the center of mass is shifted leading to that the system finds the new equilibrium position.

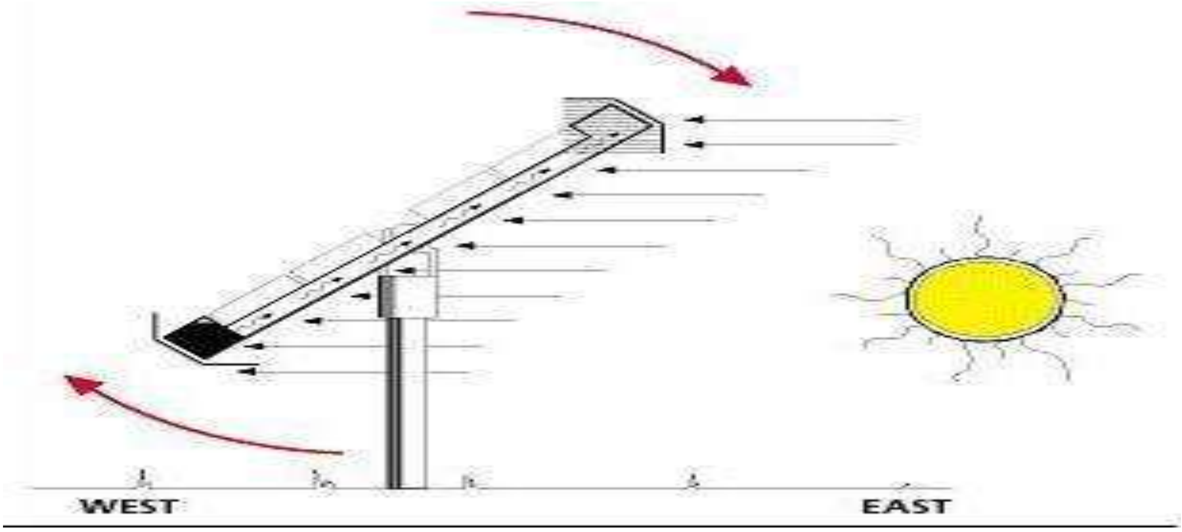


Figure 3.1: Passive tracking system

3.3.2.ACTIVE TRACKING SYSTEMS

The two basic types of active solar tracker are single-axis and double-axis.

(a)Single axis trackers

The single axis tracking systems realizes the movement of either elevation or azimuth for a solar power system. Which one of these movements is desired, depends on the technology used on the tracker as well as the space that it is mounted on. For example the parabolic through systems utilize the azimuthally tracking whereas the many rooftop PV-systems utilize elevation tracking because of the lack of space. A single-axis tracker can only pivot in one plane – either horizontally or vertically. This makes it less complicated and generally cheaper than a two-axis tracker, but also less effective at harvesting the total solar energy available at a site. Trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. Since the motors consume energy, one wants to use them only as necessary.

Single axis trackers have one degree of freedom that acts as an axis of rotation. There are several common implementations of single axis trackers. These include horizontal single axis trackers (HSAT) and vertical single axis trackers (VSAT).

Figure 3.2: Single axis solar tracker

A horizontal-axis tracker consists of a long horizontal tube to which solar modules are attached. The tube is aligned in a north-south direction, is supported on bearings mounted on pylons or frames, and rotates slowly on its axis to follow the sun's motion across the sky. This kind of tracker is most effective at equatorial latitudes where the sun is more or less overhead at noon. In general, it is effective wherever the solar path is high in the sky for substantial parts of the year, but for this very reason, does not perform well at higher latitudes. For higher latitude, a vertical-axis tracker is better suited. This works well wherever t he sun is typically lower in the sky and, at least in the summer months, the days are long.

(b)Dual Axis Trackers

Dual axis trackers as shown in the figure 2.6 have two degrees of freedom that act as axes of rotation. Double-axis solar trackers, as the same suggest, can rotate simultaneously in horizontal and vertical directions, and s o are able to point exactly at the sun at all times in any location.

Dual axis tracking systems realize movement both along the elevation- and azimuthally axes. These tracking systems naturally provide the best performance, given that the components have high enough accuracy as well.

Figure 3.3:Dual-axis solar tracking

CHAPTER-4

SOLAR TRACKING DESIGN & COMPONENTS DESCRIPTION

4.1 BLOCK DIAGRAM OF THE SYSTEM

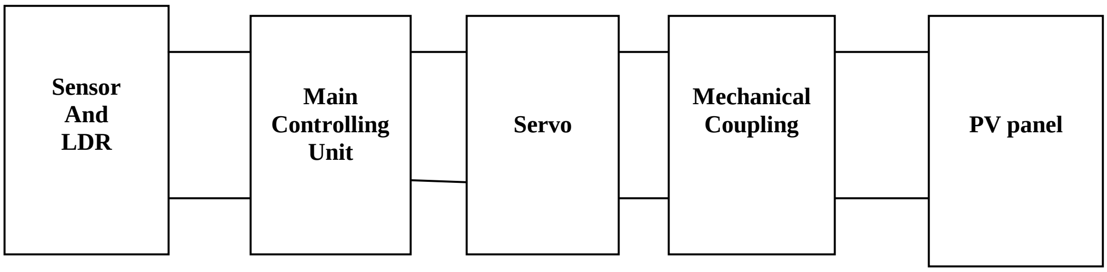


Fig 4.1: Block diagram of the proposed solar tracking system

From the above illustration, we can see that there are 5 major parts in my control system:

1. Sensors
2. Arduino
3. Servo
4. Mechanical coupling
5. PV panel

4.2 MATERIAL USED FOR TRACKER DESIGN

This section presents background information on the main subsystems of the project. Specifically, this section discusses light sensor photocell and servo motor theory in order to provide a better understanding as to how they relate to the solar tracker. The automatic solar tracker that we designed is a single axis tracker, which will track the sun on vertical axes. To achieve this, we had to build a prototype that consisted of many individual parts. Some of the key hardware that we have used are:

- Servo
- Sensor(LDR)
- Battery
- Register
- Arduino Uno

In order to make the system completely automatic, all this hardware had to be linked together. The function and working principle of each of these hardware uses are described below in details.

4.2.1 SERVO MOTOR

Servo motors (or servos) are self-contained electric devices that rotate or push parts of a machine with great precision. By rotating a shaft connected to the engine throttle, a servo regulates the speed of a fuel-powered car or aircraft. Servos also appear behind the scenes in devices we use every day.The servo motor is actually an assembly of four things: a normal DC motor, a gear reduction unit, a position-sensing device (usually a potentiometer—a volume control knob), and a control circuit.The function of the servo is to receive a control signal that represents a desired output position of the servo shaft, and apply power to its DC motor until its shaft turns to that position. It uses the position-sensing device to determine the rotational position of the shaft, so it knows which way the motor must turn to move the shaft to the commanded position. The shaft typically does not rotate freely round and round like a DC motor, but rather can only turn 200 degrees or so back and forth.The servo has a 3 wire connection: power, ground, and control. The power source must be constantly applied; the servo has its own drive electronics that draw current from the power lead to drive the motor.The control signal is pulse width modulated (PWM), but here the duration of the positive-going pulse determines the position of the servo shaft. For instance, a 1.520 millisecond pulse is the center position for a Futaba S148 servo. A longer pulse makes the servo turn to a clockwise-from-center position, and a shorter pulse makes the servo turn to a counter-clockwise-from-center position. The servo control pulse is repeated every 20 milliseconds. In essence, every 20 milliseconds you are telling the servo, “go here.”To recap, there are two important differences between the control pulse of the servo motor versus the DC motor. First, on the servo motor, duty cycle (on-time vs. off-time) has no meaning whatsoever—all that matter is the absolute duration of the positive-going pulse, which corresponds to a commanded output position of the servo shaft. Second, the servo has its own power electronics, so very little power flows over the control signal. All power is draw from its power lead, which must be simply hooked up to a high-current source of 5 volts.Contrast this to the DC motor. On the Handy Board, there are specific motor driver circuits for four DC motors. Remember, a DC motor is like a light bulb; it has no electronics of its own and it requires a large amount of drive current to be supplied to it. This is the function of the L293D chips on the Handy Board, to act as large current switches for operating DC motors.Plans and software drivers are given to operate two servo motors from the HB. This is done simply by taking spare digital outputs, which are used to generate the precise timing waveform that the servo uses as a control input. Very little current flows over these servo control signals, because the servo has its own internal drive electronics for running its built-in motors.

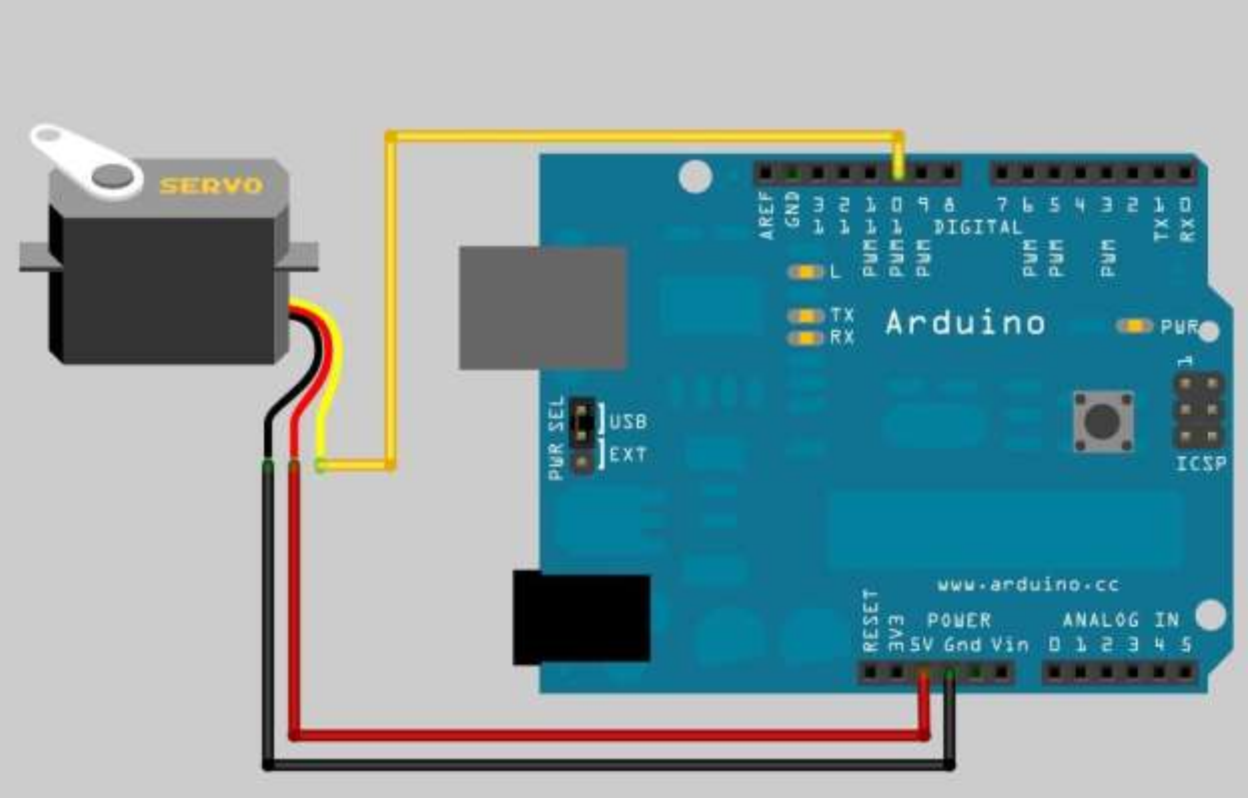


Fig 4.2: Servo Connection with Arduino.

4.2.2 LDR as Sun Position Sensor

LDR is a passive transducer hence we will use potential divider circuit to obtain corresponding voltage value from the resistance of LDR. LDRs resistance is inversely proportional to the intensity of light falling on it i.e. Higher the intensity or brightness of light the Lower the resistance and vice versa.

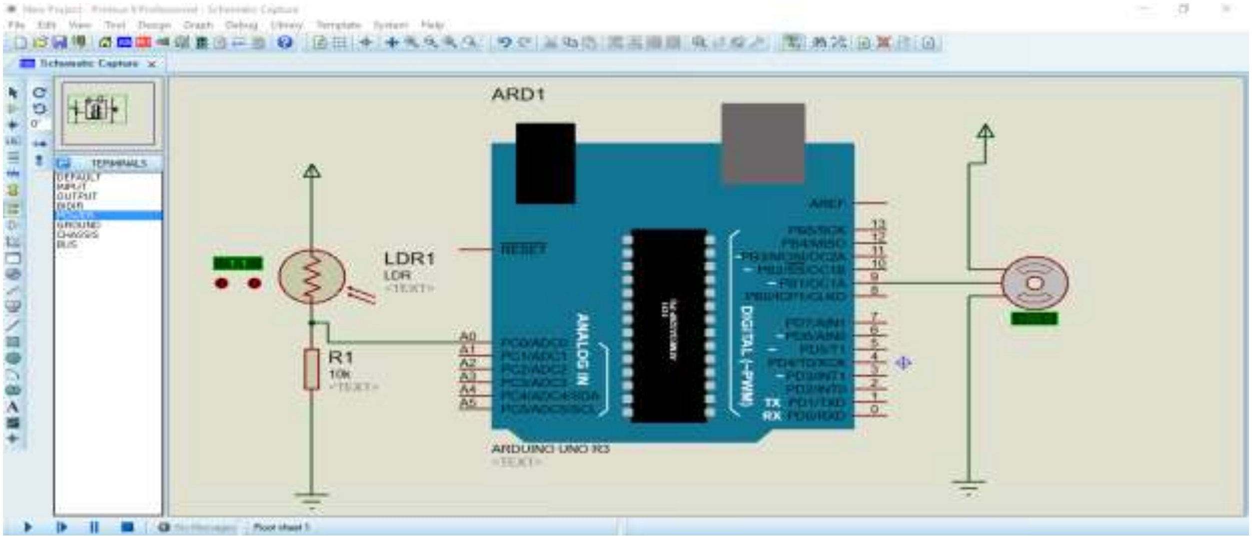


Fig4.3: LDR1 Connection

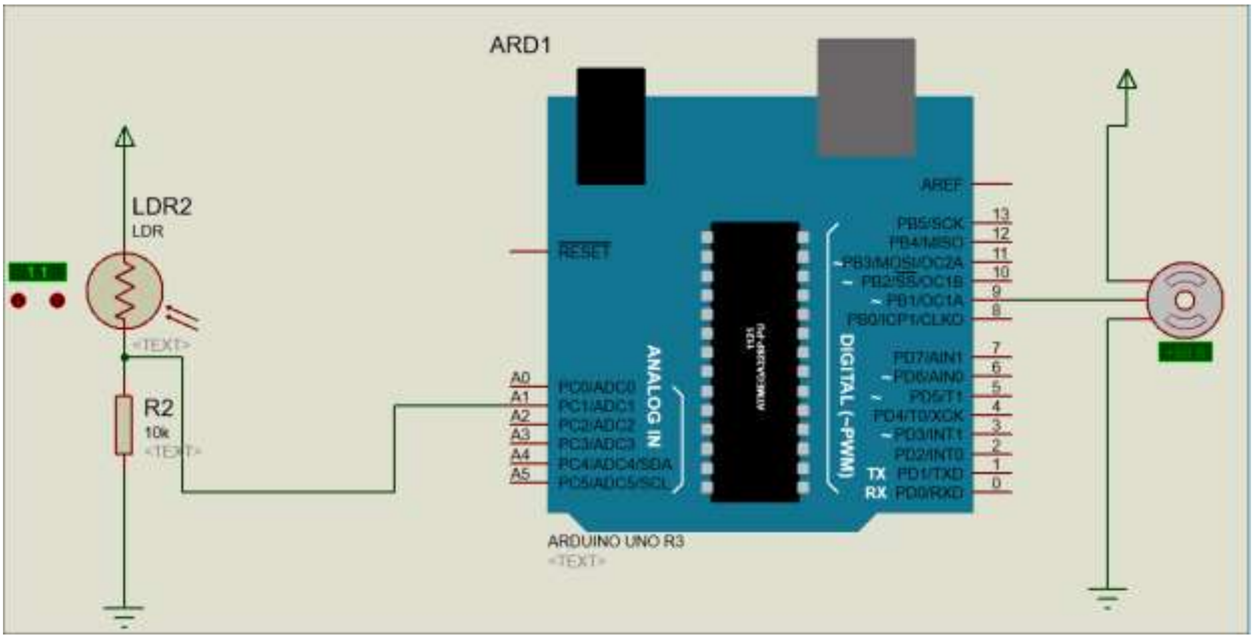


Fig4.4: LDR2 Connection

4.2.3 WORKING PRINCIPAL OF LDR IN DETAILED

A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material.

When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased. This is the most common working principle of LDR.

LDR’s are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When a light dependent resistor is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as 1012 Ω and if the device is allowed to absorb light its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular LDR.

Photocells or LDR’s are nonlinear devices. There sensitivity varies with the wavelength of light incident on them. Some photocells might not at all response to a certain range of wavelengths. Based on the material used different cells have different spectral response curves.

When light is incident on a photocell it usually takes about 8 to 12 ms for the change in resistance to take place, while it takes one or more seconds for the resistance to rise back again to its initial value after removal of light. This phenomenon is called as resistance recovery rate. This property is used in audio compressors.

Also, LDR’s are less sensitive than photo diodes and photo transistor. (A photo diode and a photocell (LDR) are not the same, a photo-diode is a p-n junction semiconductor device that converts light to electricity, whereas a photocell is a passive device, there is no p-n junction in this nor it “converts” light to electricity).

4.3 CONTROL UNIT (ARDUINO UNO)

Arduino UNO has been used as the control unit for the project.

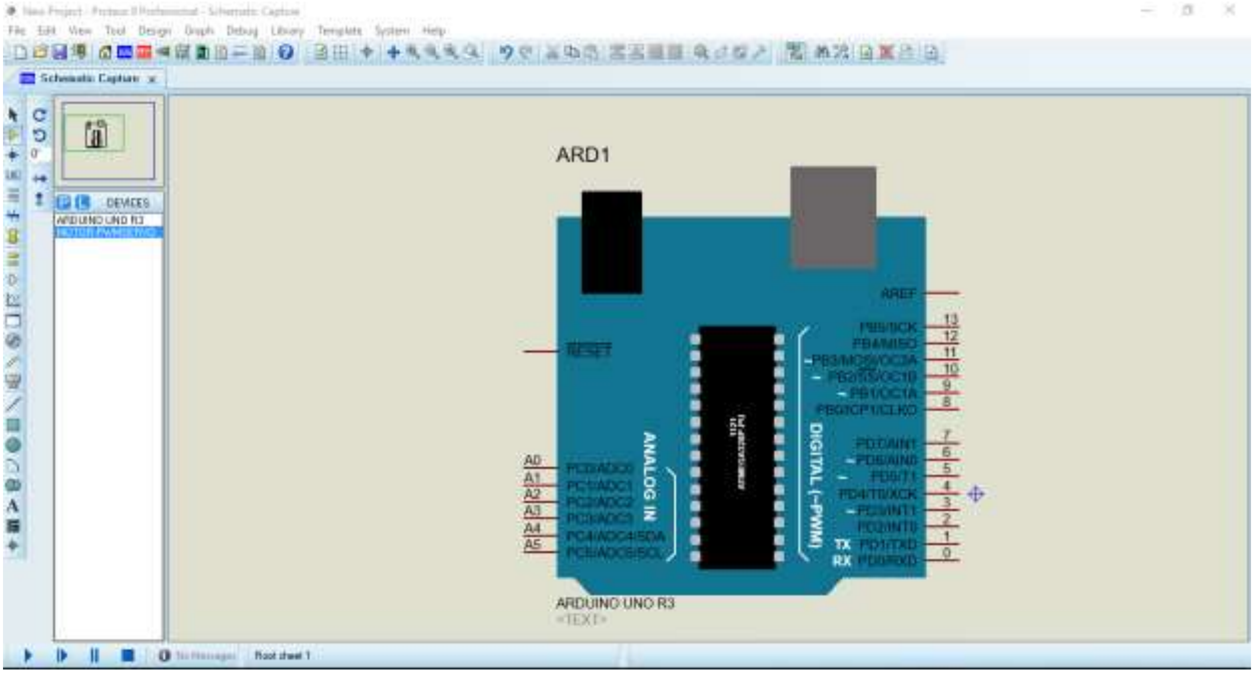


Fig4.6: Arduino Uno Connection

4.3.1 INPUT(ADC)

Arduino has an inbuilt 10-bit Analog to Digital converter(ADC), hence it can provide Digital values from 0-1023 (since 2^{10}=1024). We can also set the ADC reference voltage in Arduino, but here we’ll let it use default value. LDR’s has two pins, and to get voltage value from it we use potential divider circuit. In potential divider we get Vout corresponding to resistance of LDR which in turn is a function of Light falling on LDR. The higher the intensity of light, lower the LDR resistance and hence lower the Output voltage (Vout) And lower the light intensity, higher the LDR resistance and hence higher the Vout[20].

4.3.2 OUTPUT(PWM): Arduino has an 8-bit PWM generator, so we can get up to256 distinct PWM signal. To drive a servo, we need to get a PWM signal from the board, this is usually accomplished using timer function of the microcontroller but arduino makes it very easy. Arduino provides a servo library in which we have to only assign servo angle (0-1800) and the servo rotates by that angle, all the PWM calculations are handled by the servo library and we get a neat PWM signal according to the desired angle.

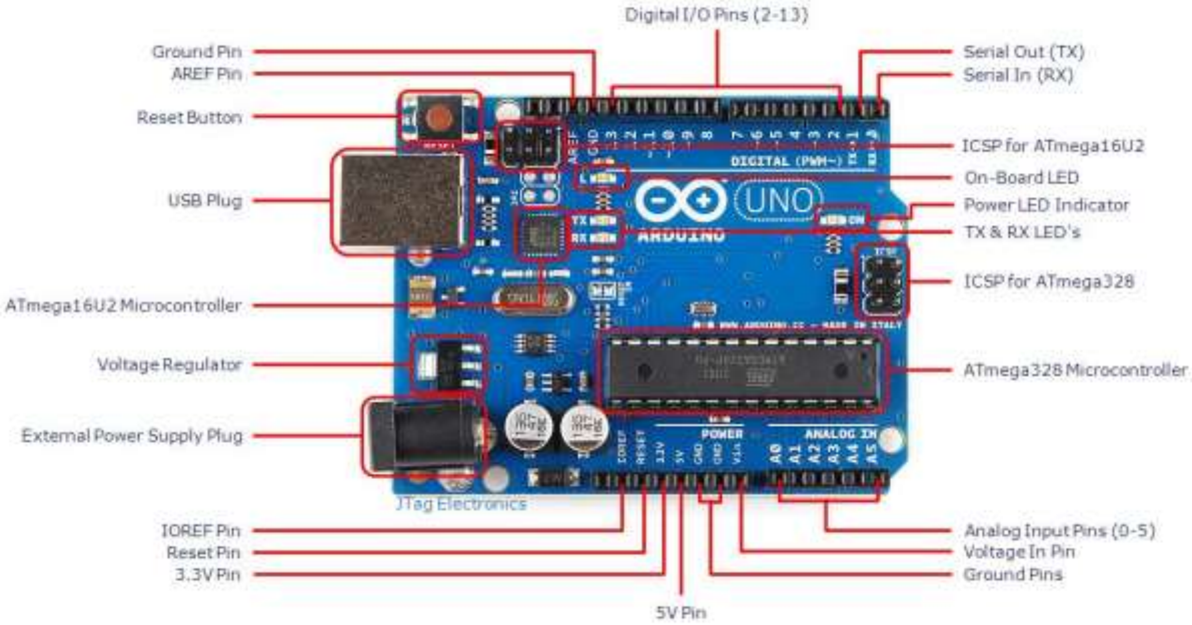


Fig 4.7: Arduino UNO

4.3.3 MICRO CONTROLLER

The ATMEGA-168 is a modified Harvard architecture 8-bit RISC single chip microcontroller which was developed by Atmel. It uses on-chip flash memory for program storage, as opposed to one-time programmable ROM, EPROM, or EEPROM used by other microcontrollers at the time.

FEATURES:

- Flash: 16KB
- EEPROM: 1024B
- SRAM: 512B
- Clock freq. : up to 20MHz
- Supply voltage: 2.8-5.5v
- Ext. Interrupt: 24
- PWM: 6

4.4 COMPONENTS ASSEMBLE

LDR

LDR has been used in the project that is responsible to sense sun light and send signal to Arduino to command solar panel. When lights fall on the LDRs, the intensity of lights are calculated by the average of the change of the resistance value of each LDR and after the measurement of the average of UP and DOWN mutual LDR's resistance the rotation direction of the Servo motors are change from either left to right or right to left.

SOURCE

We have used the 9v rechargeable battery to provide power to the system.

Servo

We have used a 5v 180 degree rotational servo motor

Arduino Uno

We have used an Arduino Uno for interfacing the servo motor and the LDRs

4.5 CONNECTION SETTING

According to the idea of the structure along with algorithm, the wire connection scheme is executed. Here in the structure two LDR is used, so for the analog read of Arduino Uno two wire is connected from A0 to A1, resistors are used to block any kind of short circuit connection between LDRs and ground.

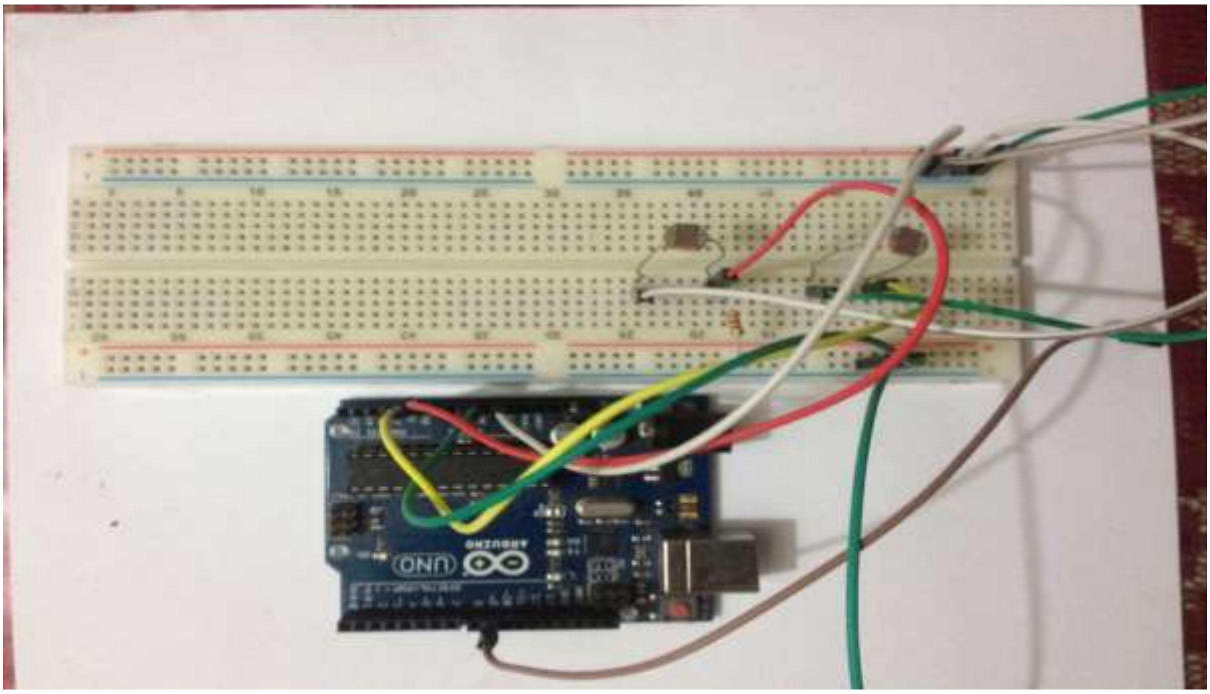


Fig 4.8: Arduino connection to breadboard

ARDUINO ANALOG CONNECTION

Two wires are connected with the analog pin of the Arduino Uno board from A0 and A1.

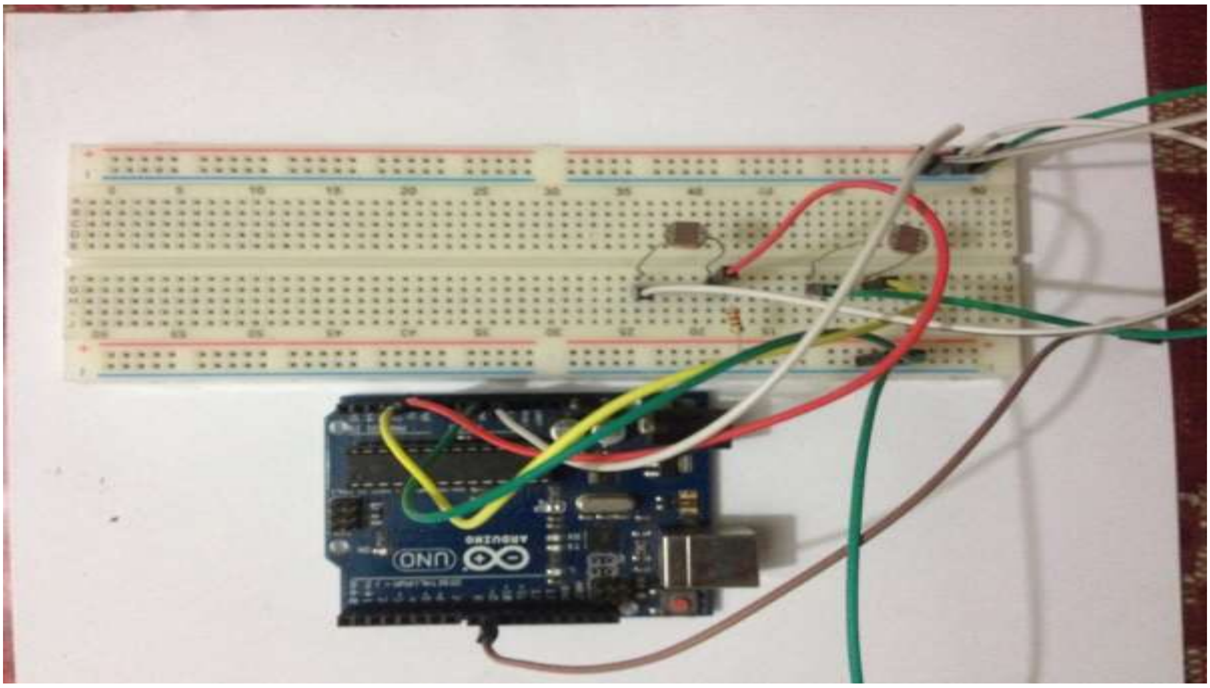


Fig 4.9: Arduino’sAnalog Pin connection to Breadboard

FULL SYSTEM WITH SOURCE CONNECTION

The full system of the single axis solar tracker are shown at figure 4.9.When all the wire connection are completed after turn on the power this device can track the sun or any sort of light way.

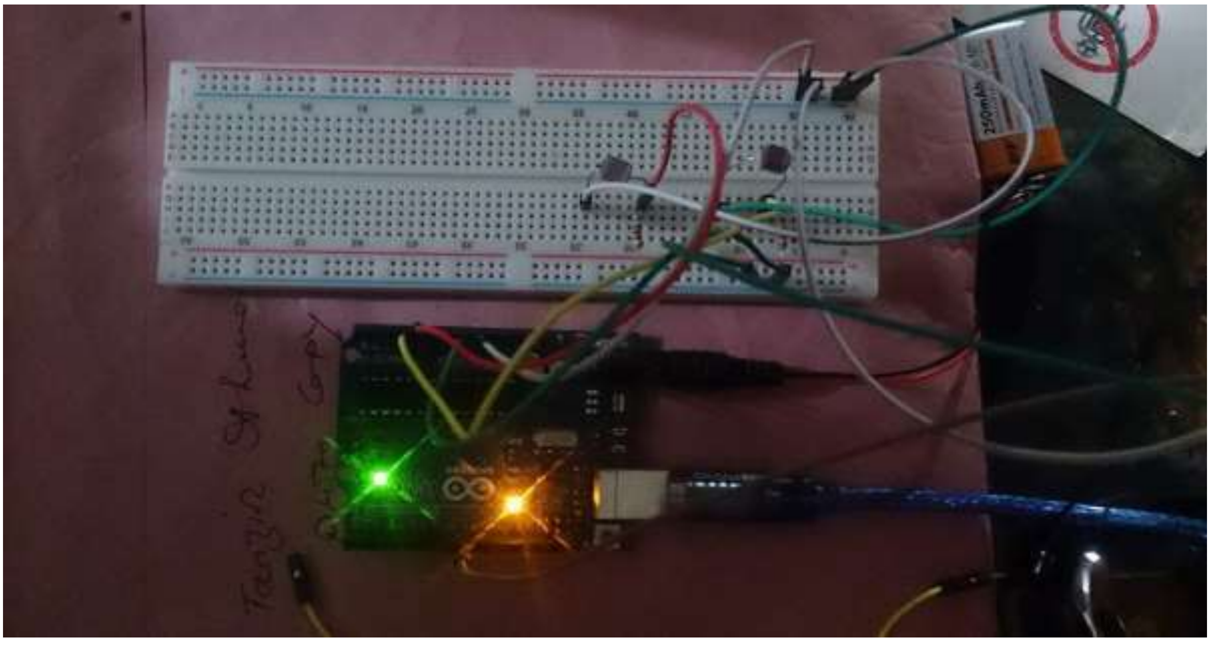
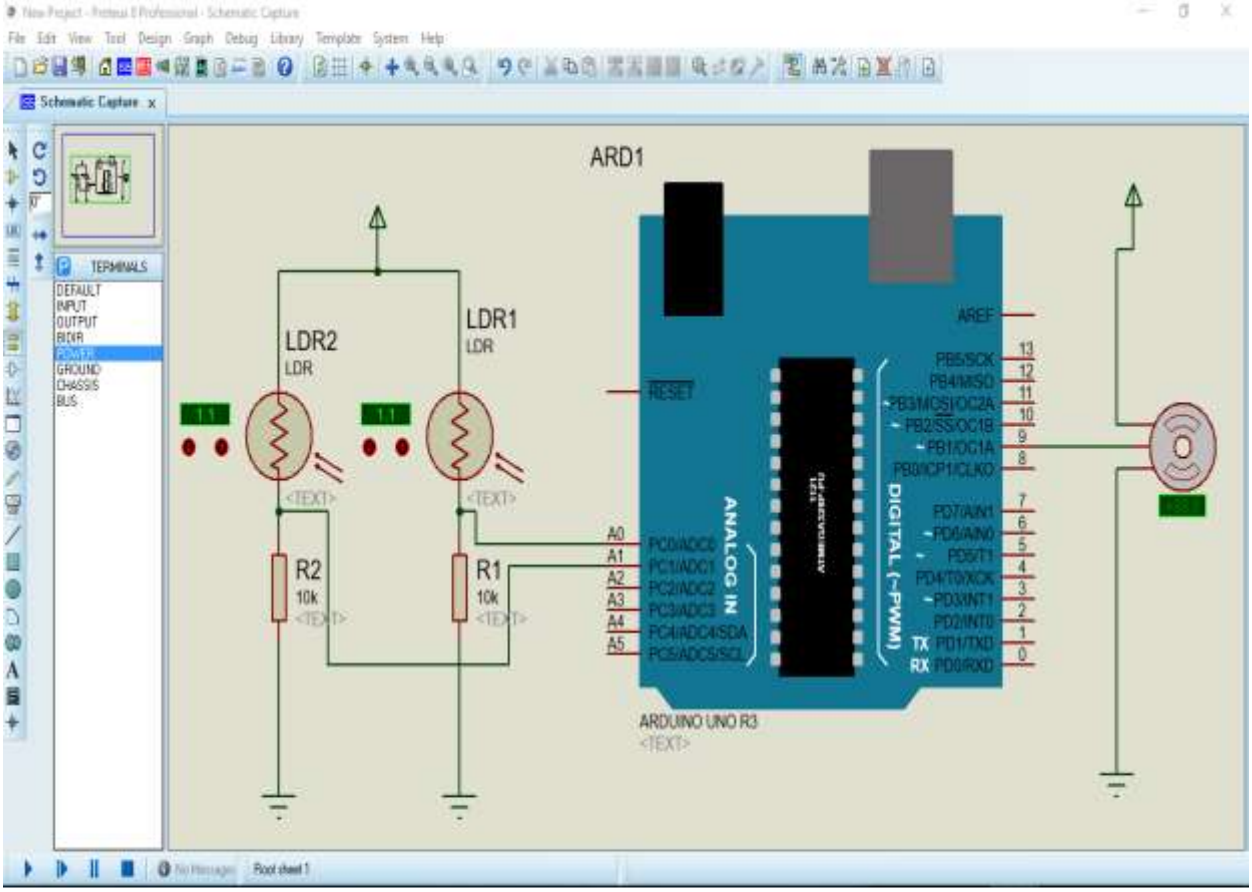


Fig 4.10(a): Total System interconnection

Fig 4.10(b): Total System interconnection

4.6 ARCHITECTURE OF THE OVERALL SYSTEM



CHAPTER 5

PERFORMANCE ANALYSIS

The project has been tested several times in laboratory and it was found working perfectly. The dumy solar panel moves in the direction of light sensed by LDR The result of the project is given below:

5.1 HORIZONTAL CHANGE FOR DAILY TRACKING

The direction of solar panel changes horizontally when light is detected in the LDRs. First when no light is detected the solar panel is positioned at zero degree. But with the increasing of light it moves to 90 degree sand up to 180 degrees respectively. For daily tracking of sun path horizontal change is used and the tracking mechanism is the comparison of the resistance change value of all LDRs.

Initial condition when light is not used :

Fig5.1: Tracker position when no light is used

When light is applied on the Right LDR and tracker change it's position towards at Right with an angle 90°

Fig5.2: Light applied on Right LDR

When light is applied on the Left LDR and tracker change it's position towards at Left with an angle 90°

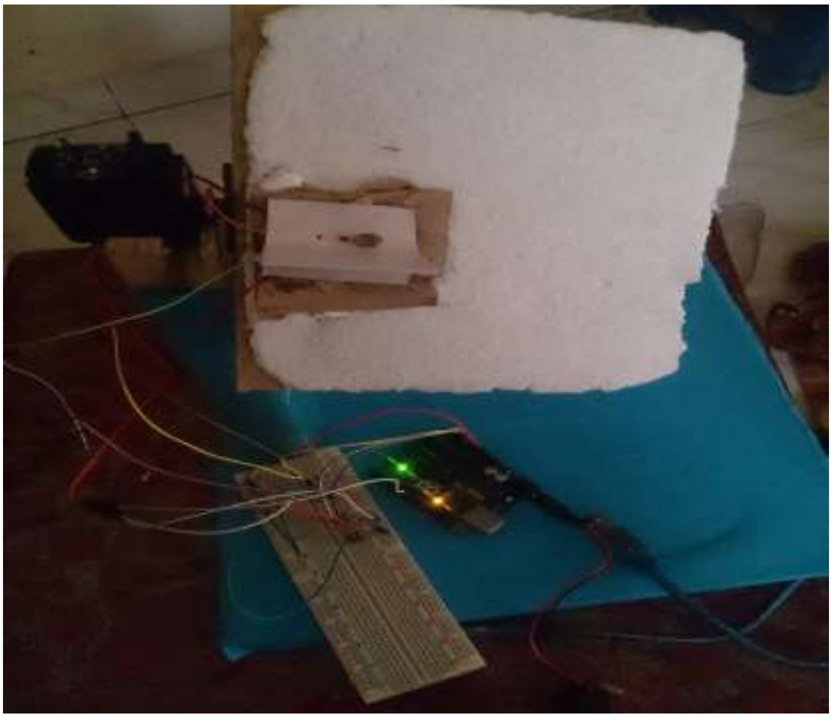


Fig5.3: Light applied on Left LDR

The change of angle with respect to light intensity is given below:

For Horizontal movement of the panel:

Light Intensity	Angle of Rotation (in degrees)
No light	0
Light with slight intensity	90
Light with heavy intensity	180

In horizontal movement the values of light intensity of all the four LDRs are compared and measured to control rotation.

Different values of voltage for different intensity of light:

Light Intensity	For LDR1
No light	0.2
Light with slight intensity	1.10
Light with heavy intensity	3.06

Light Intensity	For LDR2
No light	0.1
Light with slight intensity	1.12
Light with heavy intensity	3.04

CHAPTER 6

CONCLUSION AND FUTURE EXPANSION

6.1 CONCLUSION

The completion of this project has led to several conclusions to be made about this solar tracking system as well as solar tracking systems in general. From the concept of solar tracking system, this is well suited to utilize more energy than a fixed solar panel. We have tried to make a simple and low cost tracking system. Modification of the same system can be used for big application. Such as we have used rectangular frame for simplicity, but using Flat plate with soldering an U shape frame we can use the same system for street light. However, the system was not easy to made. We faced several problems and failed in different times. We used full rotation servos first, later exchanged with half rotation servos to meet actual purpose.

6.2 FUTURE EXPANSION

The project work can be more improved with a few adjustments in the design and development. The capacity of tracking and life time can be increased using more powerful motors though it will be a little bit expensive. But using microcontrollers in the place of Arduino board can make it cheaper though it will be complex.In future this project can be improved by making a dual axis solar tracker which will track the sun both daily basis and season basis.

REFERENCES

[1] Bailis, Robert. “Wood in Household Energy Use”. Encyclopedia of Energy. 2004. Pages 516,& 518.

[2] Ackermann, T., Andersson, G., Söder, L. “Distributed generation: a definition”. Electric Power Systems Research. April 2000. Page 195

[3]Renewable energy projects, IDCOL solar energy program, (2012, March). URL: http://www.idcol.org/prjshsm2004.php,

[4] Design and Implementation of a Laboratory-Scale Single Axis Solar Tracking System, Allan Chan Roong SOON, Shin-Horng CHONG, Chin Kim GAN, International Conference on Innovation in Science and Technology

[5] Design and Development of Tilted Single Axis and Azimuth-Altitude Dual Axis Solar Tracking System, Shashwati Ray, Abhishek Kumar Tripathi, IEEE Conference at Delhi Technological University.

[6] A Review of Principle and Sun-Tracking Methods for Maximizing Solar Systems Output, HosseinMousazadeha, AlirezaKeyhania, ArzhangJavadib, HosseinMoblia, Karen Abriniac, Ahmad Sharifib, Renewable and Sustainable Energy Review, journal homepage: www.elsevier.com/locate/rser

[7] solar.physics.montana.edu/ypop/Spotlight/SunInfo/Structure, Accessed: 4 July

[8] http://www.astronomynotes.com/starsun/s2, Accessed: 9 July

[10]http://www.thesuntoday.org/the-sun/solar-structure/, Accessed: 9 July

[11]http://www.pveducation.org/sites/default/files/PVCDROM/Properties-of-Sunlight/Animations/Sun_Calculator, Accessed: 10 July

[12] http://www.ni.com/white-paper/7230/en/ Accessed: 11 July

[13] John A. Duffie,William A. Beckman Solar Engineering of Thermal Processes, 4th Edition - GearTeam,page: 471, 477

[14] SoterisKalogirou, Solar energy engineering: process and system, Page:479

[15] Solar Tracking, GerroPrinsloo, Robert Dobson 2014 Book Edition ISBN: 978-0-620-61576-1

[16] http://www.solar-tracking.com Accessed: 9 July

[17] Saravanan C., Dr .M.A. Panneerselvam, I. William Christopher, “A Novel Low Cost Automatic Solar Tracking System”, International Journal of Computer Applications (0975 – 8887) Volume 31– No.9, October 2011

[18] S. J. Hamilton, “Sun-tracking solar cell array system,” University of Queensland

Department of Computer Science and Electrical Engineering, Bachelors Thesis, 1999.

[19] Servomotor Database: http://www.servoda tabase.com, Accessed: 9 July

[20] Arduino: http://www.arduino.cc, Accessed: 9 July

APPENDIX A: Arduino UNO Code to Control Servos

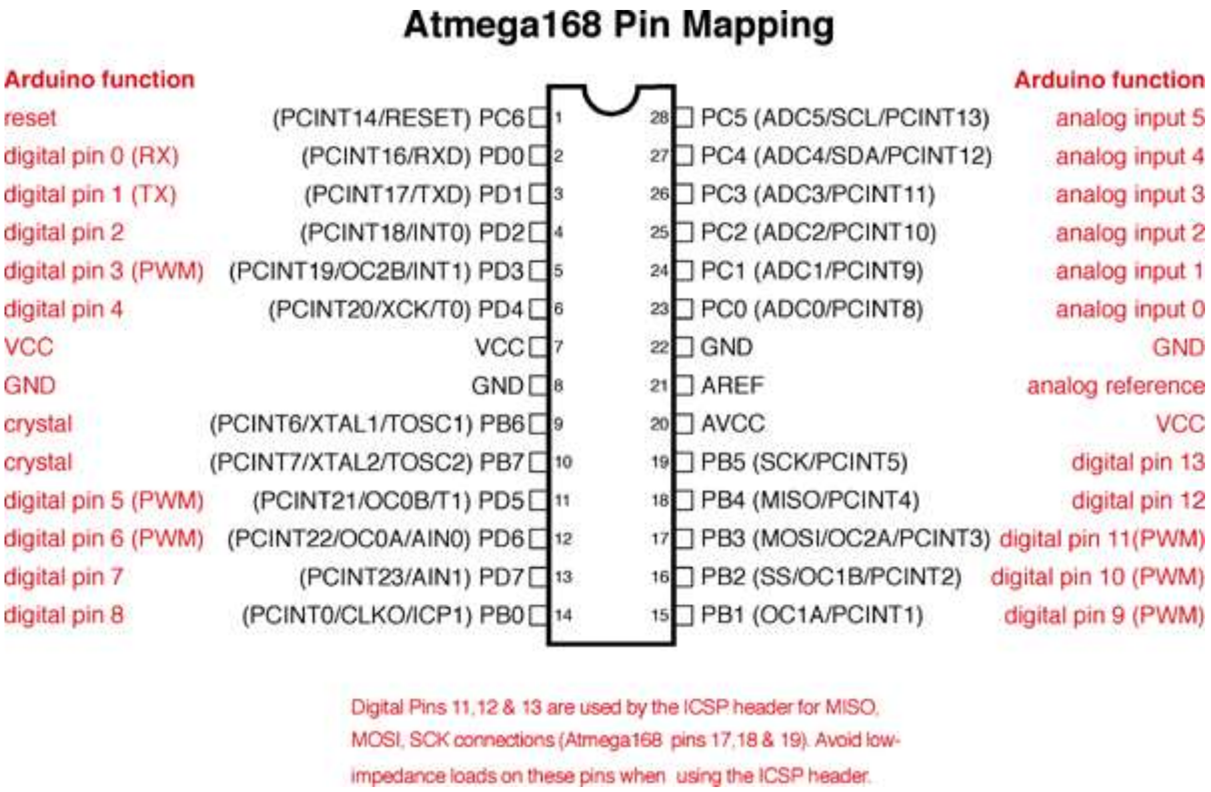
```
#include <Servo.h>

  Servo myservo;
  int pos = 90;   // initial position
  int sens1 = A0; // LRD 1 pin
  int sens2 = A1; //LDR 2 pin
  int tolerance = 200;

  void setup()
  {
   myservo.attach(9);  // attaches the servo on pin 9 to the servo object
   pinMode(sens1, INPUT);
   pinMode(sens2, INPUT);
   myservo.write(pos);
   delay(2000); // a 2 seconds delay while we position the solar panel
  }

  void loop()
  {
   int val1 = analogRead(sens1); // read the value of sensor 1
   int val2 = analogRead(sens2); // read the value of sensor 2

   if((abs(val1 - val2) <= tolerance) || (abs(val2 - val1) <= tolerance)) {
    //do nothing if the difference between values is within the tolerance limit
   } else {
    if(val1 > val2)
    {
     pos = --pos;
    }
    if(val1 < val2)
    {
     pos = ++pos;
    }
   }
```

```
  if(pos > 180) { pos = 180; } // reset to 180 if it goes higher
  if(pos < 0) { pos = 0; } // reset to 0 if it goes lower

  myservo.write(pos); // write the position to servo
  delay(50);
}
```

```
  myservo.write(pos);
  delay(2000); // a 2 seconds delay while we position the solar panel
}

void loop()
{
  int val1 = analogRead(sens1); // read the value of sensor 1
  int val2 = analogRead(sens2); // read the value of sensor 2

  if((abs(val1 - val2) <= tolerance) || (abs(val2 - val1) <= tolerance)) {
    //do nothing if the difference between values is within the tolerance limit
  } else {
    if(val1 > val2)
    {
      pos = --pos;
    }
    if(val1 < val2)
    {
      pos = ++pos;
    }
  }

  if(pos > 180) { pos = 180; } // reset to 180 if it goes higher
  if(pos < 0) { pos = 0; } // reset to 0 if it goes lower

  myservo.write(pos); // write the position to servo
  delay(50);
}
```

```
Sketch uses 2,404 bytes (7%) of program storage space. Maximum is 32,256 bytes.
Global variables use 56 bytes (2%) of dynamic memory, leaving 1,992 bytes for local variables. Maximum is 2,048 bytes.
```

APPENDIX B: Arduino Microcontroller (Atmega 168) Pin Description


Atmega168 Pin Mapping

Digital Pins 11,12 & 13 are used by the ICSP header for MISO, MOSI, SCK connections (Atmega168 pins 17,18 & 19). Avoid low-impedance loads on these pins when using the ICSP header.

PIN DESCRIPTIONS

VCC: Digital supply voltage

GND: Ground

Port B: (PB7:0) XTAL1/XTAL2/TOSC1/TOSC2)

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit. Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier. If the

Internal Calibrated RC Oscillator is used as chip clock source, PB7.6 is used as TOSC2.1 input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

Port C (PC5:0)

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5:0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

PC6/RESET

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C. If the RSTDISBL Fuse is un programmed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running.

Port D (PD7:0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

AVCC

AVCC is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC6.4 use digital supply voltage, VCC.

AREF

AREF is the analog reference pin for the A/D Converter.

ADC7:6 (TQFP and QFN/MLF package only)

In the TQFP and QFN/MLF package, ADC7.6 serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.