

MULTI AXIS AUTOMATIC SOLAR TRACKING SYSTEM USING MICROCONTROLLER

A Project Report Phase - II

Submitted in partial fulfillment of the requirements for the
award of Bachelor of Engineering degree in Electronics and Communication Engineering

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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of
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Who carried out the project entitled "MULTI AXIS AUTOMATIC SOLAR TRACKING
SYSTEM USING MICROCONTROLLER" under our supervision from November
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DECLARATION

We **J.SAI HARSHA VARDHAN & SAMPATH KUMAR KADA P** hereby declare that the Project Report entitled **MULTI AXIS AUTOMATIC SOLAR TRACKING SYSTEM USING MICROCONTROLLER** done by us under the guidance of Dr.F.V. JAYASUDHA is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

DATE: 19-04-2023

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ABSTRACT

The generation of power from the reduction of fossil fuels is the biggest challenge for the next half century. The idea of converting solar energy into electrical energy using photovoltaic panels holds its place in the front row compared to other renewable sources. But the continuous change relative angle of the sun with reference to the earth reduces the watts delivered by solar panel. This paper presents the implementation of a system that ensures a perpendicular profile of a solar panel with the sun in order to extract maximum energy falling on it. The unique feature of the proposed system is that instead of taking the earth as its reference, it takes guiding source. Solar trackers move the payload towards the sun throughout the day.

The light dependent resistors do the job of sensing the change in the position of the sun which is dealt by the respective change in the solar panels position by switching on and off the geared motor the control circuit does the job of fetching the input from the sensor and gives command to the motor to run in order to tackle the change in the position of the sun. In this paper different types of tracking system are reviewed and their pros and cons are discussed in detail.

The results presented in this review confirm that the azimuth and altitude multi-axis tracking system is more efficient compared to other tracking system. However, in cost and flexibility point of view single axis tracking system is more feasible than multi-axis tracking system.

An improvement in the hardware design of the existing solar energy collector system has been implemented in order to provide higher efficiency at lower cost.

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LIST OF ABBREVIATION

ABBREVIATION	DEFINITION
LDR	Light Dependent Resistor
LCD	Liquid Crystal Display
DC Motor	Direct Current Motor
PV System	Photo Voltaic System
LED	Light Emitting Diode

CHAPTER 1

INTRODUCTION

Energy is required for a large applications such as transportation, industrial applications, agricultural applications, household requirements and office requirements. It can have many forms like heat energy, electrical energy, chemical, energy nuclear energy, light energy and so on. The relationship between social development and use of energy is very clear; nations with more use of energy are in more advanced state of development. The supply of energy should be secure and sustainable as the use of energy has become an integral part of our life.

Sun is the most abundant source of energy and one day it could be the greatest luminous energy source. People commonly use fossil fuels like oil, natural gas and coal for the need of electricity. However, using fossil fuels as energy sources have negative impacts like acid rain pollution and global warming which harmfully effect many animals, plants and humans in the surroundings. Therefore solar energy is considered best among all the energy resources as it is a renewable resource and abundantly available. It gives an endless static supply through the time. As solar energy is free from pollution it is also known as a green source of energy.

Solar energy is obtained from sun in the form of light and heat. It is replenish able and freely obtainable source of energy on earth and can be converted into electricity using the photovoltaic cells. It is sometimes called PV cells or solar cells. Photovoltaic cells use sunlight and convert it directly to electricity leaving the environment free from pollution. The maximum efficiency of solar panel is 24.5%. Efficiency can be improved by enlarging the cell efficiency, maximization of power output and by using a tracking system.

Solar tracking system is a device that orients a solar panel according to the movement of sun for maximizing the intensity of sunlight. It automatically changes its position when the intensity of sunlight decreases. Solar tracker is designed in such a way that the angle between the sunlight and solar panel is maintained around 360 degree at all the times. Using solar trackers electricity

production can be increased by around 40% when compared with fixed modules. This tracking system can move a 180 degree of rotation. Therefore, solar tracker is much superior than a stationary module.

1.1 GENERAL BACKGROUND

Bustling civilization is the vein through which modern civilization is operated. Energy day by day is put to use at its best to fulfill the desires and ambition of the peoples at large. Each and every corner of our life is caged with various layers of impediment and in this response; energy is becoming an indispensable factor. Therefore, the source of energy needs to be endless/ perpetual in order to carry this colossal population ahead. Human beings being evolutionary in nature are perhaps the best ever creation of nature is always in the race of envisaging the probable and available comforts and benefits in every possible angle in this perilous world. The evidential matrix manifests that in a dichotomy of various opinions what options best expedite the scarcity of energy in an immensely heterogeneous society like ours. Our motto is to endeavor in forwarding such noble goal of energy conservation.

Taking a look at the present scenario it is evident that conventional sources of energy such as coal, natural gas, oil, etc. are at the edge of extinction. Being in mortal combat with time itself to fulfill every demand for energy the demand for these resources for energy has escalated to its zenith. The conventional use of energies due to the burning of fossil fuels like coal, oil and natural gas, the whole environment is getting polluted. The present project, therefore, is orchestrated with components like LDR module, DC Motor, Photovoltaic array etc. according to which while the functioning of, unlike other use of the conventional energies, would not emit any pollution and in turn act as a reservoir of energy taken from the Sun itself. As adumbrated no other energy is more abundant than solar energy as per as its availability and freeness are concerned, utilization of which, compounded with rest of the fact of its conversion into electrical energy. Historically if counted, in the year 1881 for the first time ever solar panel was invented. Later on, all through the hands of Russell Ohl in the year, 1941 concept of the solar cell was conceived and subsequently workability of a solar panel has also advanced in comparison with the

earlier span. Though it is improbable still it is not impossible as per as tracking of the mother energy is concerned in furtherance to which attempt has been taken through this project to confine every drop of energy from being left out. The DC Motor adjacent with the system with the help of LDR module by measuring the intensity of the sun rays fixed on the upper edge of the solar panel will help the solar panel to revolve around proportionately with the movement of the Sun itself in order to grab and store the maximum amount of energy as it can. In pursuance of such objectivity, this project comes forth into existence.

When heat is the source of every creation, Sun produces the biggest ever energy in this solar system to produce and transcend life from one organism to the other. In this response, the project called "Automatic Solar Tracking System" serves the purpose of utilizing the maximum amount of energy taken from the Sun and to convert such energy into some other production. The basic endeavor is crooned to scoop out from this project in making this system an economically convenient subject, accessibility of which is easy and functioning of which is optimum in the end. In the wake of technological advancement when the pace of time is at its best to pass by, this system is a time worthy production, produced to create the best of its kind. In a stretch, it could be signified that this project which is an extension of solar energy, is a renewable source of energy, never-ending phenomena. It's only 10 to 20 per cent of the solar cells that are being used commercially out of which the best potential of the cells gets reflected and therefore scope for better use of the solar cells exist.

In the world of pollution, this system is an eco-friendly alternative, hence a valuable asset. When the ocean of pollution is encumbering every corner of life, this system would be able to create ripples of hope in the midst of this bustling civilization. The survivability of this system lies upon its workability. In the trend of comparison with other mind-boggling systems, it could be a trailblazer.

CHAPTER 2

LITERATURE SURVEY

The following are the review paper on two different tracking systems based on their mode of rotation.

2.1 REVIEWS ON SINGLE AXIS SOLAR TRACKER:

Mayank Kumar Lokhande [2] presented an automatic solar tracking system. He designed a solar panel tracking system based on microcontroller and observed that single axis tracker increases efficiency by 30% compared to the fixed module.

Guiha Li, Runsheng Tang, Hao Zhong [3] investigated horizontal single-axis tracked solar panels. They obtained result as east-west axis tracking was poor to improve the energy while tracking the sun about south-north was best. The efficiency increased for east-west axis was less than 8% whereas for south-north axis increased by 10-24%.

Chaiko and Rizk [4] developed a tracking system using solar panels efficiently. They designed a simple single axis tracking system using stepper motor and light sensor. They observed that this system stretches the efficiency of power collection by keeping a solar panel perpendicular to the sun rays. And they also found that the power gain was increased by 30% over static PV system.

Imam Abadi, Adi Soeprijanto and Ali Musyafa [5] designed fuzzy logic based single axis solar tracker. They implement a fuzzy logic controller on ATMEGA 8353 microcontroller to improve the power energy of PV panel. They found that the PV panel has maximized and it exceeded up to 47% compared to the stationary system.

Ashwin R, Varun A.K et al. [6] presented a sensor based single axis solar tracker to achieve highest degree of energy through solar panel. It keeps tracking continuously for the maximum strength of light. This system spontaneously changes its direction when the sun moves from its position to get maximum light energy.

Therefore, the experimental result shows the robustness and productiveness of the proposed method.

Gamal M DOSOUKY, Abou-Hashema et al. [7] presented an enhanced orientation design for energy-productivity in PV panels. For maximum incident radiation, the panels are pitched with monthly-based angle.

They investigate the proposed strategy in two cities i.e. Japan (Fukuoka) and Egypt(Al-Kharijah). The results showed that the proposed design attained a growth of energy building in both the cities.

In 2013, Anusha, Chandra, and Reddy [8] designed solar tracking system based on real time clock. They compared a static photovoltaic (PV) panel and single axis tracker based on real time clock using ARM processor. The experiment demonstrated that the tracking system build up the efficiency about 40% and the energy achieve from the sun is enhanced from 9:00 am to 6:00 pm.

Tiberiu Tudorache and Liviu Kreindler [9] presented a tracking system devoted to the PV conversion panels. The proposed design certifies the perfection of converting solar energy into electricity by genuinely aligning the solar panel according to the actual posture of sun. The result concluded as output energy is maximized by the PV panel through desirably locating implemented only for adequate amount of light intensity.

Asmarashid Ponniran et al. [11] developed an automatic solar tracking system which tracks the intensity of light by keeping the solar panel perpendicular to the sun in order to maximized power energy. Besides, they also used DC geared motor with low speed for omitting parameter of motor speed so that the panel focus only in following the sun's intensity. Therefore, the result showed successful that maximum output power was tracked regardless motor speed.

Active tracking systems- use electrical energy as their source. A number of categories exist such as; Electro-optical based tracker, Auxiliary bifacial solar cell and chronological (time and date based) tracker.

At some instances, a combination of these different systems may be realised and the resulting system will be referred to as Hybrid. Of all active trackers, electro-optical based-trackers are generally more popular.

Mousazadeh et al (2009) reports (2) the use of differential illumination of coupled electro-sensors to generate a differential signal to a controller which then sends a signal to drive the solar system.

For improved photosensitivity, the sensor can be mounted on a pyramidal structure (in the figure 2b outlines the photo-diode mounted on pyramid) or use of collimator tube might be vital to prevent diffuse irradiation from reaching the sensors therefore ensuring precise measurement of the position of the sun.

Fig.1c is a system made up of four mini- solar module positioned on the North- south and east-west that detect the light intensity, this system also uses the Programmable Logic Controller (PLC) to manipulate the two positioning mechanisms through two DC motors . 582 Emmanuel Karabo Mpodi et al. / Procedia Manufacturing 35 (2019) 580-588 Mpodi, e.k., et al/ Procedia Manufacturing 00 (2016) 000-000 3 to prevent diffuse irradiation from reaching the sensors therefore ensuring precise measurement of the position of the sun.

Fig.1d is a system made up of four mini- solar module positioned on the North- south and east-west that detect the light intensity, this system also uses the Programmable Logic Controller (PLC) to manipulate the two positioning mechanisms through two DC Auxiliary Bifacial Solar cell trackers. In this type of trackers an auxiliary PV cell is used to sense the position of sun and also provide the tracking energy, as it is connected to a permanent magnet DC motor.

Both these are fixed to a driving axle of the tracker (8). Chronological tracker – Uses the geographical and astronomical data to calculate the relative path of the sun for a specified period of time (day and month), with the aid of mathematical formulae and algorithms. In two cities i.e. Japan (Fukuoka) and Egypt (Al-Kharijah). The results showed that the proposed design attained a growth of energy building in both the cities.

2.2 REVIEWS ON DUAL AXIS SOLAR TRACKER:

V sundara Siva Kumar and S Suryanarayana proposed a dual axis tracking system to implement and develop a simple and efficient control scheme with only single tracking motor. Their main motive is to improve the power gain by accurate tracking of the sun. In this paper they successfully designed, built and examined a dual axis sun tracking system and received best result. They concluded saying that this tracking technology is very simple in design, precise in tracking and inexpensive.

Dhanalakshmi.V, Lakshmi Prasanna H.N presented a smart dual axis solar tracker. They used arduino uno for the development of their proposed model. After the experiment, they observed that maximum voltage was tracked about 25% to 30% and the generating power increased by 30% compared to static system.

M.Kacira overlooked the cause of a dual axis solar tracking with development of power energy compared to a fixed PV panel in Sanliurfa, Turkey. They found that everyday power gain is 29.3% in solar radiation and 34.6% in power generation for a particular day in the month of July.

In 2017, Chaitali Medhane, Tejas Gaidhani implemented a microcontroller based dual axis model working on a solar panel. Through this model, they observed that the solar panel extracts maximum power if the solar panel is aligned with the intensity of light receiving from the sun. It improves the power output and also precaution necessary for the system from rain and wind.

Midriem Mirdanies, Roni Permana Saputra proposed dual axis system with a combined method of an Astronomical algorithm and camera based feedback processing for localizing and tracking light intensity to increase the efficiency in achieving power energy. They also designed a compound algorithm method to merge approximation data of the sun acquired from astronomical based and visual based feedback. After simulation, it resulted that the azimuth and elevation sum squared errors from the proposed algorithm are 0.3688 and 0.3874 degree, and the astronomical algorithm are 1.0997 and 1.2877 degree.

S.B. Elagib, N.H. Osman describes the development of solar tracking systembased on solar maps using microcontroller, which can forecast the real detectable position of the sun by latitude's location for maximizing the efficiency of

energy level. Their main motive of this design was to work with minimal operator interaction in the isolated areas where there is lack network coverage.

Jing-Min Wang and Chia-Liang Lu presented a simple execution of sun tracker with one dual-axis AC motor to predict the sun's position and used a stand-alone PV inverter to energize the whole system. They worked on May 2012 in New Taipei City, Taiwan and the day was slightly cloudy. A static panel was placed along the south at a tilt angle of 23.5 degrees with maximal standard solar radiation when the latitude of Taiwan is 23.5 degree along north. The experiments resulted that their system raising the energy level up to 26.31% for a slightly cloudy day.

M.M. Abu Khader observed an experiment under Jordanian climate on the cause of utilizing two-axis sun tracking systems. They found that the power outcome improved by 30-45% compared to static system for a particular days.

Song presented a dual axis tracking system based on hybrid scheme. This system was based on two stage tracking process using a photosensitive sensor and a coarse adjustment with coordinate calculation algorithm. They used optical fibers. for tracking of concentrated sunlight. Therefore, they observed that system followed the sun's focal area with a position accuracy of less than 0.3mm and the tracking angle accuracy is 0.1 degrees.

In 2010, Mohammed designed an automatic two axes sun tracking system using solar cooker. This system removed standing in the sun for a period of time to get continual tracking and facing the intensive solar cooker. In the year 2008, they performed the test continuously for three days from 8:30 to 16:30 hours and the result obtained that for maximum registered ambient temperature i.e. 36 degree Celsius, a water temperature inside the cooker's tube reached 90 degree Celsius in normal sunny days.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1 The Earth: Rotation and Revolution:

The position of the sun changes continuously throughout the day. It is due to the motion of earth that we experience sun at different angles in the sky. Earth exhibit two types of motion. One is the motion of earth along its own axis, and the other is the earth revolving around the sun. the motion of the earth along its own axis, known as rotation, results in the phenomenon of days and nights. One rotation of the earth takes 23 hours and 56 minutes. On its own axis, the motion of the earth is west to east.

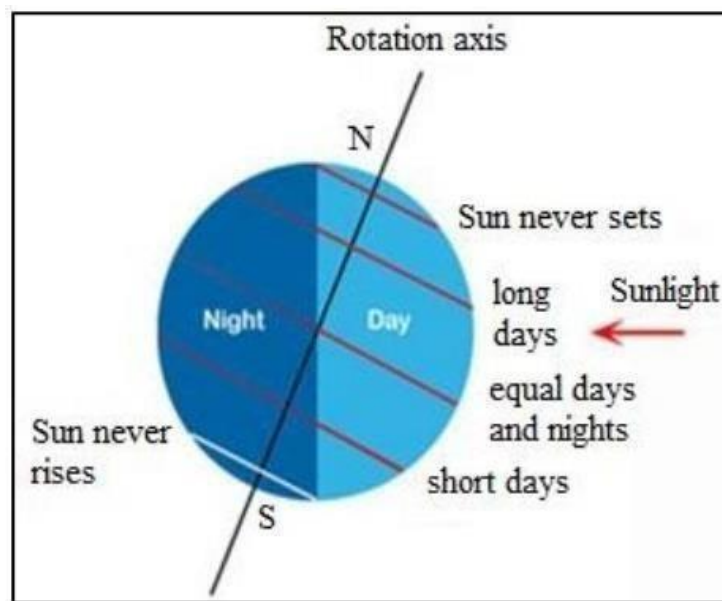


Fig.3.1 : Earth Rotation

Revolution that is the motion of the earth around the sun is responsible for the different seasons in the year. The earth takes 365 days to revolve around the sun. Earth revolves around the sun in an elliptical orbit and the plane covered by the earth during the revolution is known as an ellipsis. The axis of rotation and ellipsis makes an angle of 66.5 degrees between themselves. This is the explanation behind the summer/winter solaces and spring autumn equinoxes. Due to these motions of the earth, the amount of sunlight received throughout the year varies. Sunlight is the

Sunlight is the electromagnetic radiation from the sun expropriated by the earth. The total power given off by the sun into space is much more than that intercepted by the earth.

Earth rotates on its axis from west to east, and the Sun and the Moon appear to move from east to west across the sky. The spinning of the Earth around its axis is called 'rotation'. The axis has an angle of $23\frac{1}{2}^{\circ}$ and is perpendicular to the plane of Earth's orbit. This means the Earth is tilted on its axis, and because of this tilt, the northern and southern hemispheres lean in a direction away from the Sun. The rotation of the Earth divides it into a lit-up half and a dark half, which gives rise to day and night. The direction of the Earth's rotation depends on the direction of viewing. When viewed looking down from the North Pole, Earth spins counterclockwise. On the contrary, when viewed looking down from the south pole, the earth spins in the clockwise direction.

3.2 Importance Of Rotation :

Some of the importance of the rotation of the Earth are listed below:

- The Earth's rotation creates the diurnal cycle of lightness and darkness, temperature and humidity changes.
- The Earth's rotation causes tides in the oceans and seas. Revolution of the earth-The movement of the Earth around the Sun in a fixed path is called a revolution. The Earth revolves from west to east, i.e., in the anticlockwise direction. The one revolution of the Earth around the Sun takes around one year or precisely 365.242 days. The revolution speed of the earth is 30 km/s^{-1} .

3.3 Importance of the revolution-

- Revolution causes seasons.
- Revolution creates perihelion and aphelion. Perihelion occurs when the Earth is closest to the Sun. Aphelion occurs when the Earth is far from the Sun.
- Revolution has a direct influence on the varied length of day and night time.

The duration of days and nights are the same at the equator. This is known as the equinox. The duration of days and nights vary in the Northern and Southern hemispheres. This is known as solstices.

3.4 WHAT IS SINGLE AXIS SOLAR TRACKER:

The single axis solar tracker project is a very good example of a mini project if you are looking for an electronics mini project. It is one of the most popular projects recently.



Fig 3.2 : Solar Panel

- Single axis solar tracker is just a system that follows the sunlight. by using this system you can make more power collected through the sunlight by the solar system.
- This system has a solar panel on it; all the systems track the light in two directions. For example, if the sun rises in the morning the system moves toward the same direction and for the evening also.
- Now the sunset is in the opposite direction so the system will also move with the sun so the system can get the maximum power by the sun tracking.
- In solar panels make more power to more intensity. That means the solar power converted to electricity is directly proportional to the intensity of light.
- In solar tracker we use LDR sensor for detecting the light.

Single axis trackers have one degree of freedom that acts as an axis of rotation. The axis of rotation of single axis trackers is typically aligned along a true North meridian. It is possible to align them in any cardinal direction with advanced tracking algorithms.

There are several common implementations of single axis trackers. These include horizontal single axis trackers (HSAT), horizontal single axis tracker with tilted modules (HTSAT), vertical single axis trackers (VSAT), tilted single axis trackers (TSAT) and polar aligned single axis trackers (PSAT). That is why they have one degree of freedom that acts as an axis of rotation. The axis of rotation of single-axis trackers is usually aligned along a true north meridian. That said, it is possible to align them in any cardinal direction with advanced tracking algorithms.

The orientation of the module with respect to the tracker axis is important when modeling performance. single-axis rotation tracking, and the work principles are similar. According to the results of the calculation of the rotation angle of the sun, the collectors rotate around the axis of rotation to track the sun. At high noon, the angle between the incident direction of the sun and the normal direction of the collector's aperture is the smallest; collectors can then obtain the maximum heat flux. In the morning or afternoon the sunlight is oblique. Single-axis tracking has the advantage of simple structure; the disadvantage is that the incident light cannot always be perpendicular to the collector's aperture, so the collection of solar energy is not enough to maintain the maximum

3.5 WORKING OF SINGLE AXIS SOLAR TRACKER:

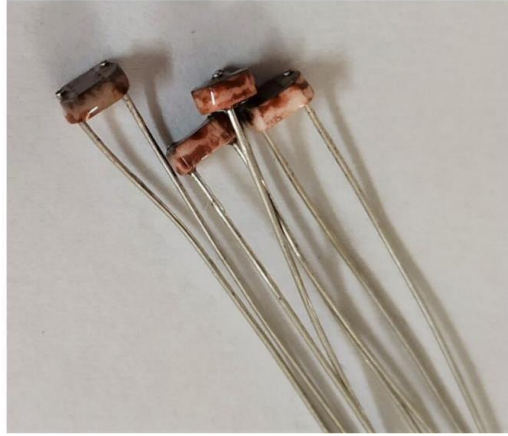


Fig.3.3 : LDR

Single axis solar tracker system content servo motors which help it to move in two directions on one axis. For example, it is for the x-axis then it will move in the +x axis and -x axis. And the rotating degree is dependent upon us usually we use 60 degrees in each direction.

Now, understands the working of this project.

There is a sensor called LDR (light-dependent resistor). Which decreases the resistance in the circuit when the light incident on it. There are two LDR sensors in the circuit on both sides.

- So, which LDR sensor shows the less resistance the motor will start to move in that direction.
- LDR sensor gives output to the Arduino every time. And Arduino process the data that comes from the LDR and Sends instructions to the Servo motors. I hope the above working on the project is sufficient to understand the single axis solar tracker project.

These three methods are all single-axis rotation tracking, and the work principles are similar. According to the results of the calculation of the rotation angle of the sun, the collectors rotate around the axis of rotation to track the sun.

At high noon, the angle between the incident direction of the sun and the normal direction of the collector's aperture is the smallest; collectors can then obtain the maximum heat flux. In the morning or afternoon the sunlight is oblique.

Single-axis tracking has the advantage of simple structure; the disadvantage is that the incident light cannot always be perpendicular to the collector's aperture, so the collection of solar energy is not enough to maintain the maximum.

Collectors that usually use single-axis tracking are CPCs, parabolic trough collectors (PTCs), and linear Fresnel collectors.

CHAPTER 4

CODING

Coding for Multi axis solar tracking system:

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(8,9,10,11,12,13);
#include<Servo.h>
Servo Myservo;
int pos;
int i;
int j;
int k;
void setup()
{
  lcd.begin(16,2);
  lcd.setCursor(0,0);
  lcd.print("Solar Tracking");
  lcd.setCursor(0,1);
  lcd.print("Based onLDR");
  delay(2500);
  lcd.clear();
  Myservo.attach(7);
  Myservo.write(0);
}

void loop()
{
```

```
int ldr1=analogRead(A2);

lcd.setCursor(0,0);

lcd.print("L1:");

lcd.print(ldr1);

int ldr2=analogRead(A3);

lcd.setCursor(8,0);

lcd.print("L2:");

lcd.print(ldr2);


if(ldr1>400 && ldr2>400)

{

if(k==1)

{

MyServo.write(170);

delay(100);

MyServo.write(160);

delay(100);

MyServo.write(140);

delay(100);

MyServo.write(130);

delay(100);

MyServo.write(110);

delay(100);

MyServo.write(90);
```

```
delay(100);  
Myservo.write(70);  
delay(100);  
Myservo.write(60);  
delay(100);  
Myservo.write(40);  
delay(100);  
Myservo.write(20);  
delay(100);  
  
}
```

```
if(k==2)  
{  
  Myservo.write(45);  
  delay(100);  
  Myservo.write(70);  
  delay(100);  
  Myservo.write(60);  
  delay(100);  
  Myservo.write(40);  
  delay(100);  
  Myservo.write(20);
```

```
delay(100);  
}  
k=0;  
Myservo.write(0);  
lcd.setCursor(0,1);  
lcd.print("Morning Mode");
```

```
i=0;  
j=0;  
}  
if(ldr1<100 && ldr2>200)  
{  
  if(i<1)  
  {  
    Myservo.write(10);  
    delay(100);  
    Myservo.write(20);  
    delay(100);  
    Myservo.write(30);  
    delay(100);  
    Myservo.write(40);  
    delay(100);  
    Myservo.write(50);  
    delay(100);  
    Myservo.write(60);  
    delay(100);
```

```

//Myservo.write(70);
delay(100);
//Myservo.write(80);
delay(100);
}
i=2;
k=2;
Myservo.write(60);
lcd.setCursor(0,1);
lcd.print("Afternoon Mode");
}
if(ldr2<60)

{
if(j<1)
{
Myservo.write(100);
delay(100);
Myservo.write(110);
delay(100);
Myservo.write(120);
delay(100);
//Myservo.write(130);
delay(100);
//Myservo.write(140);
delay(100);

```

```
//Myservo.write(150);  
  
delay(100);  
//Myservo.write(160);  
delay(100);  
// Myservo.write(170);  
delay(100);  
}  
j=2;  
k=1;  
Myservo.write(120);  
lcd.setCursor(0,1);  
lcd.print("Evening Mode");  
  
}  
  
delay(1000);  
lcd.clear();  
  
}
```

CHAPTER 5

METHODOLOGY

5.1 IMPLEMENTATION:

The project called “Automatic Solar Tracking System” is produced through installation of the various nitty-gritty such as solar panel which provides 12 volts as output, an NodeMcu as MCU, a motor driver – with IC L293D, two LDR sensor module, a 10 r.p.m. simple DC motor, a current sensor and a 9 V battery.

Construction of the said project is being built out of the wooden base installed at the ground of it, affixed with the iron rods on both the sides in a cross-shaped manner connected with a hollow cylindrical rod from both the sides and the DC motor is clinging at one edge of the hollow rod. Three-fold sections into which the circuit of the solar tracking system is divided.

The input stage has two LDR module that is so arranged to form a voltage divider circuit, the microcontroller is programmed through the software named Arduinoide being decked up in the system and lastly the driving circuit that has the DC motor helps in rotating the solar panel.

The motor driver is embraced with three terminals- two for motor input/ output respectively and the third one for power input. The terminal for motor input is connected to 2 of the 14digital input/output pins of Arduino UNO and subsequently, the motor output terminal is connected to the DC motor.

The two LDR sensor modules are annexed to the scaffolding with NodeMcu analogue inputs. The light dependent resistors are then affixed along the length, on either side of the solar panel.

The results of this step are documents and/or pictures that describe in detail the events and actions that occur over time in the prototype solar tracker operation; the details may include labels of possible sensors and actuators needed.

The instrumentation and control of the new solar tracker. The solar tracking system follows the trajectory of the sun using a three-point motion for azimuthal tracking with a clockwise open-loop control system that operates from 6:00 to 18:00

each day and a linear actuator is used for tracking the declination over the year.

This section establishes the minimum number of tracking points that can be managed each day according to the EFO range established in the previous step, as well as the verified azimuth and elevation angle ranges based on the solar trajectory at the installation site throughout the year.

According to the flow diagram shown. Assuming that the sun advances at 15° per hour, according to the EFO chart, the azimuth tracking can have a range of $\pm 30^\circ$ of the defacement. In hourly solar tracking from 6:00 to 18:00, the tracking can be divided into three fixed positions with evenly spaced angular points and time locations.

Regarding the adjustment of the solar tiles, a follow-up via daily adjustments based on the declination is proposed; this method considers that the declination value is 16° , that it can be maintained within 25° (per the solar chart for a latitude of 27.5° north), and that the mechanism has a low cost.

This step consists primarily of the selection of the mechanism, in accordance with the capacities required for the solar tracker prototype, using comparison matrices that facilitate the selection of devices according to the evaluation criteria. Here, “H” is assigned to high values, “M” to medium values, and “L” to low values. In addition, calculations including arithmetic, finite element analysis (FEA), and computer-aided design (CAD) tool computations are performed on the structures and mechanisms required to develop the prototype. The first component of the design for the solar tracker is the PV system support structure, which corresponds to a 1 kW PV system composed of four panels with dimensions of 0.95×1.05 m and a power of 250 W.

This supporting structure is designed using CAD software and FEA. FEA to determine which structure exhibits better resistance against wind action is performed using a wind speed of 33.3 m/s, which was chosen based on the maximum wind speed records at the installation location. According to the FEA, the most appropriate structure uses structural steel (PTR-14, PTR-20) and $\frac{1}{2}$ ” tubing.

The control technique (e.g., Grafcet, Petri Nets, Neural Networks, or Diffuse Logic) is selected based on the process to be performed, while considering the detailed description of the solar tracker prototype operation and the control device.

The latter could be a field programmable gate array (FPGA), programmable logic controller (PLC), microcontroller, or industrial personal computer (PC), based on the previously selected technique. Finally, a program is developed for the algorithm and control technique previously established in Steps 4 and 5.

According to the data previously obtained to fulfil the design requirements of minimizing the amount of movement and utilizing $\pm 30^\circ$ windows for maximum efficiency, a general time tracking system with an open-loop control with both automatic and manual control is proposed. One feasible option for the development of the control system is a system based on a microcontroller combined with an H bridge due to its low cost and high availability; however, FPGA boards are equally feasible.

The selected control system is used to perform basic arithmetic operations and to facilitate the incorporation of a manual alignment system for the installation of the solar tracker.

The Grafcet technique is selected, as it facilitates programming sequences of transitions defined by a change of states and its simplicity allows the expansion of the program code for a solar tracker. In addition, the developer has a large amount of knowledge in applying this technique.

Illustrates the Grafcet technique used to develop the program of an algorithm that follows the trajectory of the sun along three points separated by 60° along the azimuth axis using the low-cost microcontroller selected in the previous step that has limited digital I/O and the capacity to perform basic arithmetic operations and manage the date and time.

The tracking begins at point P1, located 30° above the azimuth axis, and the tracker remains at this point until 10:00. One minute later, the tracker moves to point P2, which is located 90° above the azimuth axis from the previous point, due to the activation of actuator A1. the tracker remains at this point until 14:00? At 14:01, the

tracker moves to point P3, which is located 60° from the previous point, due to the activation of actuator A1, and it remains at this point until 18:00. Finally, one minute after 18:00, the tracker returns to point P1 by activating the actuator A1 to turn 120° in the opposite direction.

Therefore, the present work proposes a new methodology for the development of a solar tracking system that exploits. The advantage offered by knowing the degree of latitude of the installation site to allow the incorporation of low-accuracy, low-cost control mechanisms that keep the PV modules in adequate ranges of efficiency as a function of orientation.

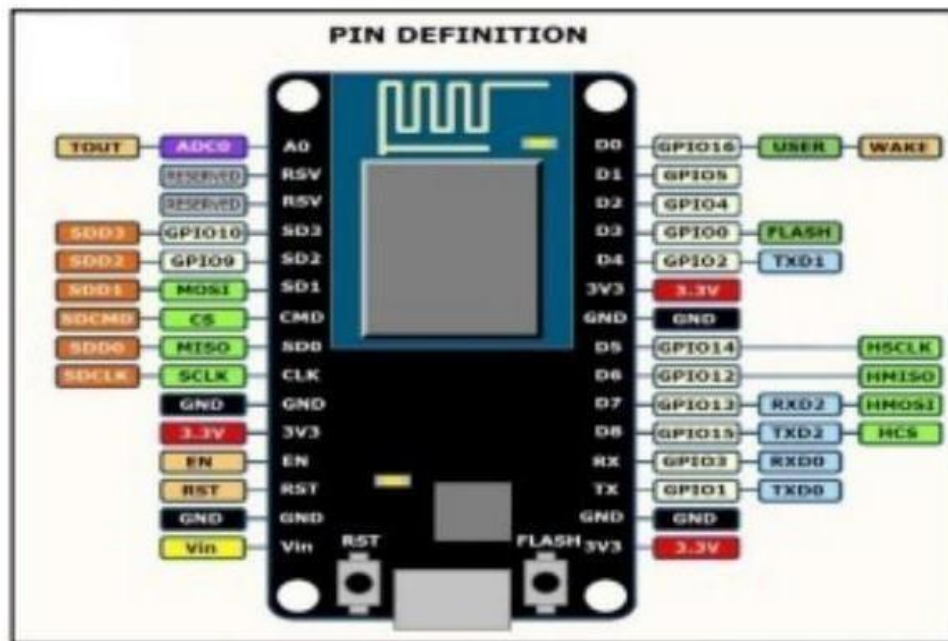


Fig.5.1 : Pin Diagram of NodeMCU

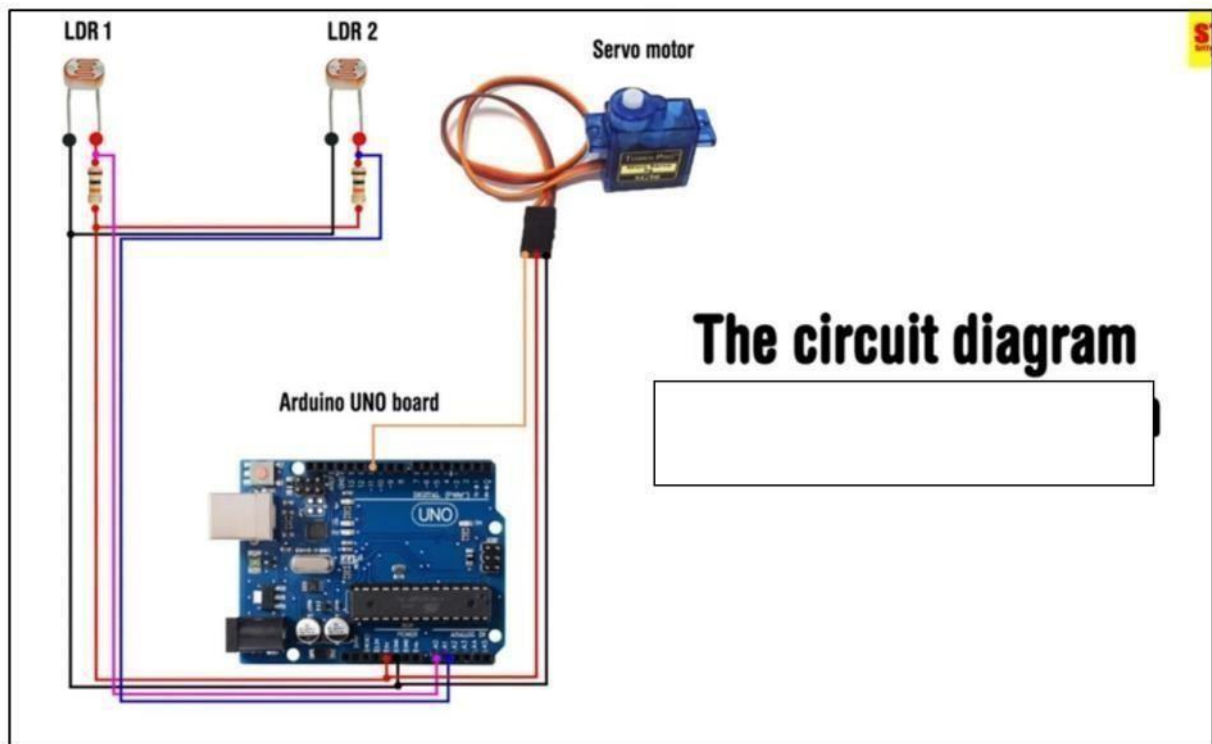


Fig.5.2 : Block Diagram of Automatic Solar Tracking System

Before being consolidated into one system, three independent stages are engineered independently. This approach, similar to stepwise refinement in modular programming, has been employed as it ensures an accurate and logical approach which is straight forward and easy to understand. This also ensures that if there are any errors, they are independently considered and corrected.

5.2 THEORY OF USING TWO LDR:

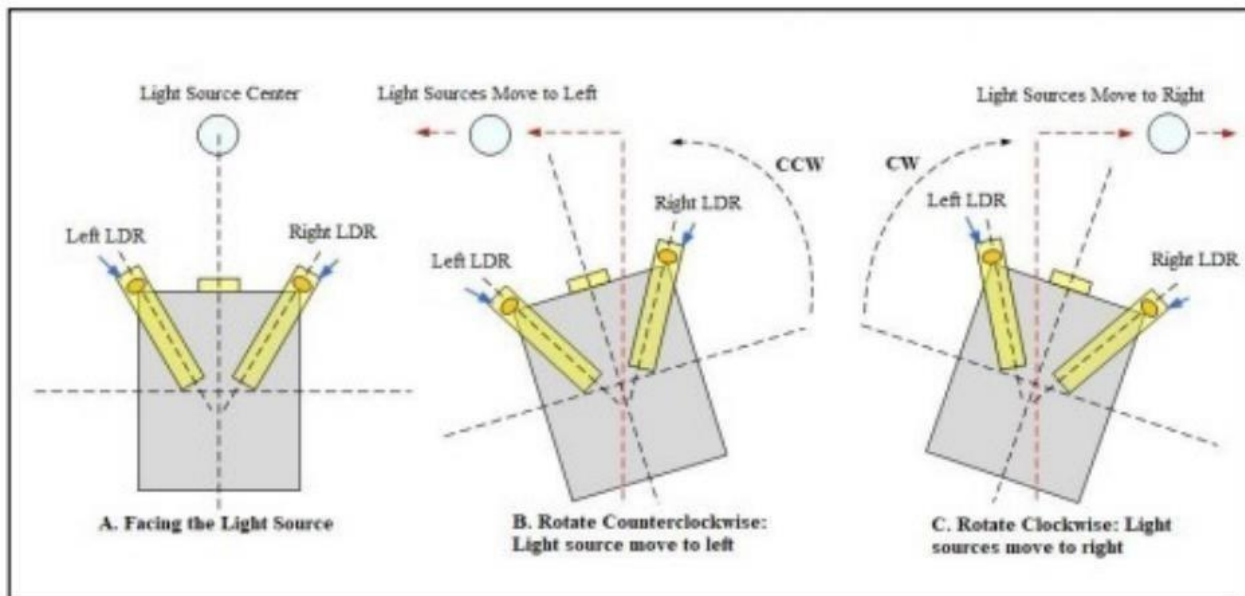


Fig 5.3 : Concept of Using Two LDR

The figure depicts the notion for the installment of the light dependent resistors (LDR). A secure state is attained when the light intensities of the two LDR become the same. The principal source of light energy, the Sun, moves from east to west. This movement of the Sun causes the variation in the level of light intensities falling on the two LDRs. The designed algorithm compares the variation in the light intensities inside the microcontroller and the motor then is operated to rotate the solar panel, so it moves aligned with the trail of the light source.

5.3 RESEARCH DESIGN:

Contemplating the idea of building the said project, the idea that has been conceived primarily is to make the best use of solar energy. The next path that unravels is firstly the method to be adopted in storing the solar energy at its maximum level which further ends up with hatching of the project called "AUTOMATIC SOLAR TRACKING SYSTEM". Culminating towards making the said project caviar in it is, therefore, necessary to change the position of the photovoltaic panels to follow the sun and capture the maximum incident beam. This work describes our methodology for the simulation and the design of a solar tracker system using the

advantages that the orientation and efficiency of the PV panel offer due to the latitude and the number of hours of sunshine in the testing area.

This proposed methodology is experimentally validated through the implementation of a single-axis solar tracker at a specific location (36.261° latitude), which allowed the incorporation of a high-availability tracking mechanism, low precision, and low cost. Based on the results, the feasibility of this type of solar tracker for latitudes close to 36° was demonstrated, as this tracking system costs less than traditional commercial systems.

Furthermore, this system increased the collection efficiency compared to a fixed device. Our results provide an excellent platform for engineering technology researchers and students to study the design theory of a sun-tracking solar system. In this case, the design, optimization, and realization of systems based on this technology are current issues since they can lead to better exploitation of solar energy if they are correctly done. One of the paths taken is increasing the solar radiation captured since maximum efficiency is achieved when the incident light is perpendicular to the cells of the photovoltaic panels: this is the concept of “solar tracking”.

Therefore, the energy efficiency of these systems depends on the climate conditions of solar radiation, ambient temperature, and wind speed, the matching of the system with the load, and the appropriate placement of the solar panels. Most solar panels are used in a stationary position and therefore do not consistently output the maximum amount of power they can produce.

To obtain the maximum efficiency from photovoltaic panels, it was necessary to study the problem of PV orientation, which requires using a solar tracker connected to the photovoltaic system. A solar tracker will track the sun throughout the day and adjust the angle of the solar panel so that the sun is normal, typical to the solar panels at all times. There are two ways to maximize the useful energy rate: by optimizing the conversion and degree of absorption and increasing the incident radiation rate by employing mechanical steering systems. In this context, in our project, we decided to realize such a system, which is commonly

called a “solar tracker”. Utilization several components have been unleashed, some of which are mentioned so

1. Solar Panel,
2. Servo Motor,
3. Arduino,
4. LDR sensor module,
5. 12V Driver,
6. L293D Driver,
7. LED

All in consolidation of the said components the concerned project is orchestrated, ought to seek for imbibing the sun rays at its maximum level through the LDR sensor module etched on the edges of the solar panel in accordance with the length of it, revolves in aid with the stepper motor by maintaining the proportionality of the Sun’s movement. Therefore, the genesis lies upon the fact of making solar energy a profitable source in the production of various other aspects which are in rest with the acute need of the society. In addition to which it would be further worthier to state that when the world is being maligned and sick through the pollution ruckus this project could unveil to be a robust endeavor.

CHAPTER 6

COMPONENTS

6.1 SOLAR PANEL:

A solar cell panel, solar electric panel, or solar panel, also known as a photovoltaic (PV) module or PV panel, is an assembly of photovoltaic solar cells mounted in a (usually rectangular) frame. Solar panels capture sunlight as a source of radiant energy, which is converted into electric energy in the form of direct current (DC) electricity.



Fig 6.1 : Solar Panel

A neatly organized collection of solar panels is called a photovoltaic system or solar array. Arrays of a photovoltaic system can be used to generate solar electricity that supplies electrical equipment directly, or feeds power back into an alternate current (AC) grid via an inverter system.

6.1.1 THEORY AND CONSTRUCTION OF SOLAR PANEL:

Photovoltaic modules consist of a large number of solar cells and use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. Most modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can be either the top layer or the back layer. Cells must be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells are usually connected electrically in series, one to another to the desired voltage, and

then in parallel to increase current. The power (in watts) of the module is the mathematical product of the voltage (in volts) and the current (in amperes), and depends both on the amount of light and on the electrical load connected to the module. The manufacturing specifications on solar panels are obtained under standard conditions, which are usually not the true operating conditions the solar panels are exposed to on the installation site.

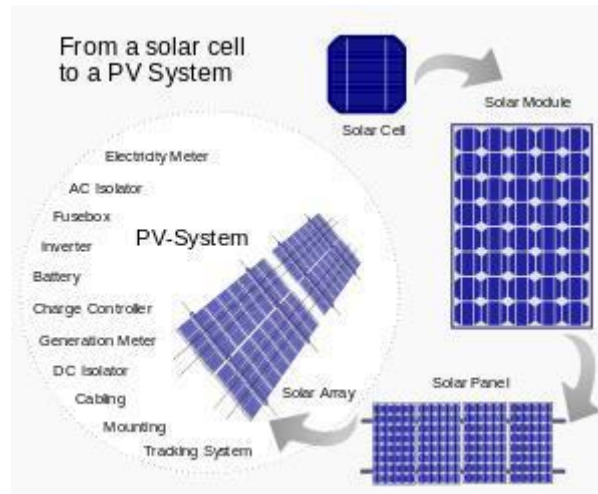


Fig 6.2 : Solar Cell to a PV System

A PV junction box is attached to the back of the solar panel and functions as its output interface. External connections for most photovoltaic modules use MC4 connectors to facilitate easy weatherproof connections to the rest of the system. A USB power interface can also be used. Solar panels also use metal frames consisting of racking components, brackets, reflector shapes, and troughs to better support the panel structure.

6.2 SERVO MOTOR:

A servomotor (or servo motor) is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity, and acceleration.^[1] It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Servomotors are not a specific class of motor, although the term *servomotor* is often used to refer to a motor suitable for use in a closed-loop control system. Servomotors are used in applications such as robotics, CNC machinery, and automated manufacturing.

6.2.1 MECHANISM:

A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analog or digital) representing the position commanded for the output shaft.

The motor is paired with some type of position encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero, and the motor stops.

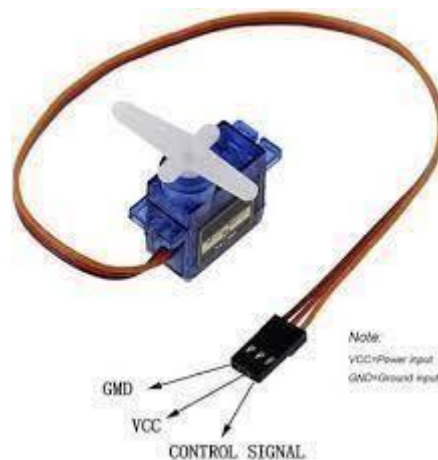


Fig 6.3 : Servo Motor

The very simplest servomotors use position-only sensing via a potentiometer and bang-bang control of their motor; the motor always rotates at full

speed (or is stopped). This type of servomotor is not widely used in industrial motion control, but it forms the basis of the simple and cheap servos used for radio-controlled models.

More sophisticated servomotors make use of an Absolute Encoder (a type of rotary encoder) to calculate the shafts position and infer the speed of the output shaft. A variable-speed drive is used to control the motor speed. Both of these enhancements, usually in combination with a PID control algorithm, allow the servomotor to be brought to its commanded position more quickly and more precisely, with less overshooting.

6.3 ARDUINO:

Arduino is an open-source hardware and software company, project, and user community that designs and manufactures single board microcontrollers and microcontroller kits for building digital devices. Its hardware products are licensed under a CC BY-SA license, while the software is licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially from the official website or through authorized distributors.



Fig.6.4 : Arduino

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs. The microcontrollers can be programmed using the C and C++ programming languages, using a standard API which is also known as the Arduino Programming Language, inspired by the Processing language and used with a modified version of the Processing IDE. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) and a command line tool developed in Go.

6.4 LDR SENSOR MODULE:

A photoresistor (also known as a photocell, or light-dependent resistor, LDR, or photo-conductive cell) is a passive component that decreases resistance with respect to receiving luminosity (light) on the component's sensitive surface. The resistance of a photoresistor decreases with increase in incident light intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light-sensitive detector circuits and light-activated and dark-activated switching circuits acting as a resistance semiconductor. In the dark, a photoresistor can have a resistance as high as several megaohms ($M\Omega$), while in the light, a photoresistor can have a resistance as low as a few hundred ohms. If incident light on a photoresistor exceeds a certain frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electrons (and their hole partners) conduct electricity, thereby lowering resistance. The resistance range and sensitivity of a photoresistor can substantially differ among dissimilar devices. Moreover, unique photoresistors may react substantially differently to photons within certain wavelength bands.

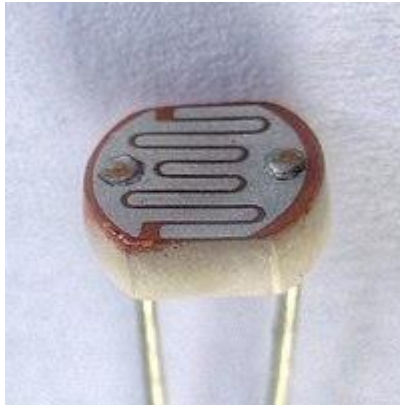


Fig 6.5 : LDR

6.5 12V DRIVER:

In electronics, a driver is a circuit or component used to control another circuit or component, such as a high-power transistor, liquid crystal display (LCD), stepper motors, SRAM memory, and numerous others. They are usually used to regulate current flowing through a circuit or to control other factors such as other components and some other devices in the circuit. The term is often used, for example, for a specialized integrated circuit that controls high-power switches in switched-mode power converters. An amplifier can also be considered a driver for loudspeakers, or a voltage regulator that keeps an attached component operating within a broad range of input voltages.

Typically the driver stage of a circuit requires different characteristics to other circuit stages. For example, in a transistor power amplifier circuit, typically the driver circuit requires current gain, often the ability to discharge the following transistor bases rapidly, and low output impedance to avoid or minimize distortion.

6.6 L293D DRIVER:

The L293D is quadruple high-current half-H drivers. It is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-

supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo- Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.



Fig 6.6 : L293D Driver

6.7 LED:

A light-emitting diode is a semiconductor device that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device. Appearing as practical electronic components in 1962, the earliest LEDs emitted low-intensity infrared (IR) light. Infrared LEDs are used in remote-control circuits, such as those used with a wide variety of consumer electronics. The first visible-light LEDs were of low intensity and limited to red. Early LEDs were often used as indicator lamps, replacing small incandescent bulbs, and in seven-segment displays. Later developments produced LEDs available in visible, ultraviolet (UV), and infrared wavelengths, with high, low, or intermediate light

output, for instance white LEDs suitable for room and outdoor area lighting. LEDs have also given rise to new types of displays and sensors, while their high switching rates are useful in advanced communications technology with applications as diverse as aviation lighting, fairy lights, automotive headlamps, advertising, general lighting, traffic signals, camera flashes, lighted wallpaper, horticultural grow lights, and medical devices.

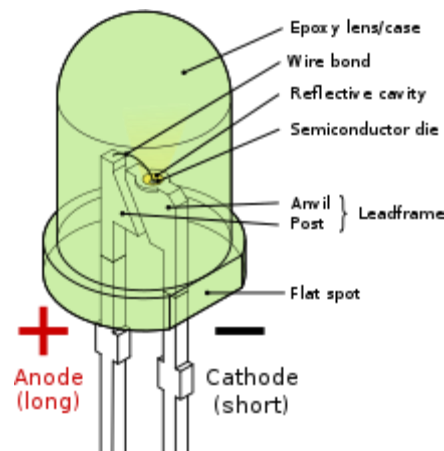


Fig 6.7 : LED

LEDs have many advantages over incandescent light sources, including lower power consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. In exchange for these generally favorable attributes, disadvantages of LEDs include electrical limitations to low voltage and generally to DC (not AC) power, inability to provide steady illumination from a pulsing DC or an AC electrical supply source, and lesser maximum operating temperature and storage temperature. In contrast to LEDs, incandescent lamps can be made to intrinsically run at virtually any supply voltage, can utilize either AC or DC current interchangeably, and will provide steady illumination when powered by AC or pulsing DC even at a frequency as low as 50 Hz. LEDs usually need electronic support components to function, while an incandescent bulb can and usually does operate directly from an unregulated DC or AC power source.

CHAPTER 7

DISCUSSION

7.1 DIFFERENT TYPES OF SOLAR TRACKING SYSTEM:

The mechanism is accountable to furnish with accurate movements, in the sake of following the footsteps of the sun throughout the day. The prototype of the device is made durable enough to withstand unfavorable weather condition. This mechanism of the solar tracking systems classifies themselves into two segments single axis tracker, dual axis tracker.

7.2 SINGLE AXIS TRACKER:

Solar tracking systems can be classified by the mode of their motion. These tracking systems have the PV surface that can be rotated / tilted around axes to derive a proper angle that can help them get the maximum sunlight. When movement or adjustment of the PV surface happens by rotating around one axis, it is called single-axis tracking. When the movement of the PV surface happens around two axes simultaneously, it is called dual-axis tracking.

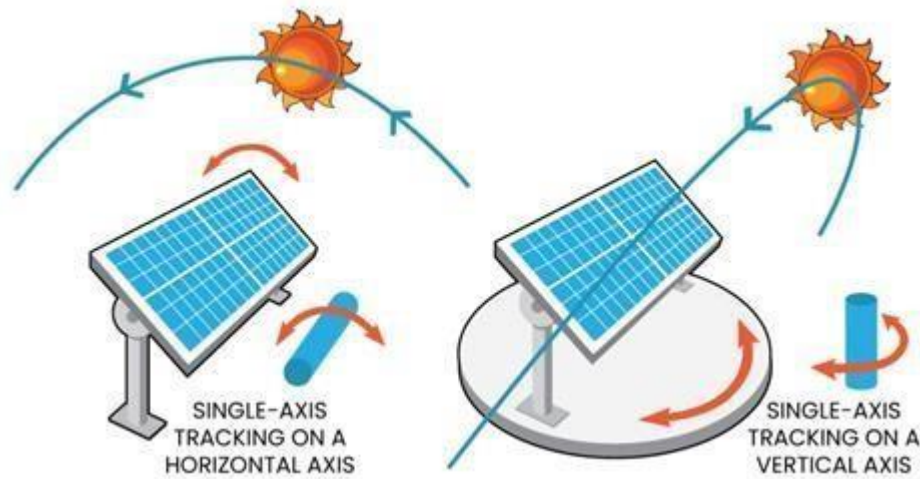


Fig 7.1 : Single Axis Tracker

Single axis tracker tracks in a single cardinal direction. The tracker has a

single row tracking configuration. The above maintained methods are the different arrangements in which single axis tracker can be implemented. The working mechanism of all the maintained methods is at par with each other. The angle of the sun with the surface of the collector is computed and examined, the collectors are thus charged to track down the movement of the sun to meet the expectations of captivating a greater percentage of solar radiance.

Single axis tracker merely means that it have single axis of rotation. It's axis of rotation is normally aligned along a true north meridian. They normally follow the sun's movement from east to west on a period of day. It enhances energy level by 25-35%.

There are numerable other imposition of single axis tracking tracker, including-

- Horizontal Single Axis Tracker (HSAT)
- Vertical Single Axis Tracker (VSAT)
- Tilted Single Axis Tracker (TSAT)
- Polar Aligned Single Axis Tracker (PSAT)

A solar tracker is a device that directs a payload toward the sun. Payloads are typically solar panels, parabolic troughs, fresnel reflectors, lenses, or the mirrors of the heliostat. Because solar trackers follow the sun, they constantly have to change their orientation throughout the day so as to maximize energy capture.

In photovoltaic systems, solar trackers help minimize the angle of incidence, which is the angle that a ray of light makes with a line perpendicular to the surface, between the incoming light and the panel. Minimizing the angle increases the amount of energy the installation produces.

Concentrated solar photo voltaics and concentrated solar thermal have optics that directly accept sunlight, so the solar trackers in these systems have to be angled correctly to collect energy. All concentrated solar systems have trackers because the systems can't produce energy unless directed properly toward the sun. Single axis trackers have one degree of freedom that acts as an axis of rotation. The axis of rotation of single axis trackers is typically aligned along a true North meridian. It is

possible to align them in any cardinal direction with advanced tracking algorithms.

The amount of solar energy available for collection from the direct beam is the amount of light intercepted by the panel. This is given by the area of the panel multiplied by the cosine of the angle of incidence of the direct beam (see illustration above). Or put another way, the energy intercepted is equivalent to the area of the shadow cast by the panel onto a surface perpendicular to the direct beam.

7.2.1 HORIZONTAL SINGLE AXIS TRACKER:

It is the most common type of single axis tracker design and is more suitable for small latitudes. Its axis of rotation lies horizontally concerning to the ground. They are very flexible and rotate from east to west on a fixed axis which is parallel to the ground. Suitable gapping can maximise the ratio of energy fabrication to cost, depending on topical area and shadow climate and a period of day value of the energy output. Horizontal tracker typically face the module situated aligned to the axis of rotation.

It brushes a cylinder like a module paths which is rotationally symmetric close to the axis of rotation. These trackers are classically utilized for huge allocated generation projects and feasibility scale projects. HSAT rotates from east to west throughout the day on fixed axis, which is parallel to the ground, and it is considered as the most cost effective tracker configuration in many PV applications. HSAT structure is placed on many supports along the rotating axis, requires less material for construction and its horizontal configuration is most preferred compared to other tracking geometries.

The axis of rotation for horizontal single axis tracker is horizontal with respect to the ground. The posts at either end of the axis of rotation of a horizontal single axis tracker can be shared between trackers to lower the installation cost. This type of solar tracker is most appropriate for low latitude regions. Field layouts with horizontal single axis trackers are very flexible. The simple geometry means that keeping all of the axes of rotation parallel to one another is all that is required for appropriately

positioning the trackers with respect to one another. Appropriate spacing can maximize the ratio of energy production to cost, this being dependent upon local terrain and shading conditions and the time-of-day value of the energy produced. Back tracking is one means of computing the disposition of panels.

7.2.2 VERTICAL SINGLE AXIS TRACKER:

These trackers have vertical axis of rotation with respect to the ground. They usually rotate from east to west throughout the day. Comparing to horizontal axis trackers these trackers are more operative at high latitudes. To keep away from needless energy losses and to enhance land utilization, a field layout must observe. Limitation in optimizing for dense packing is observed due to the nature of shading over a year. Vertical single axis trackers typically have face of the module oriented at an angle with respect to the axis of rotation. It brushes a cone like a module paths which is rotationally symmetric surrounding the axis of rotation.

The axis of rotation for vertical single axis trackers is vertical with respect to the ground. These trackers rotate from East to West over the course of the day. Such trackers are more effective at high latitudes than are horizontal axis trackers. Field layouts must consider shading to avoid unnecessary energy losses and to optimize land use. Also optimization for dense packing is limited due to the nature of the shading over the course of a year. Vertical single axis trackers typically have the face of the module oriented at an angle with respect to the axis of rotation. As a module tracks, it sweeps a cone that is rotationally symmetric around the axis of rotation.

Vertical single-axis solar trackers or VSATs rotate from east to west following the Sun throughout the day. These systems are often installed in high-altitude or mountainous locations. The profile of VSATs is not parallel to the ground, because of which it is easier for these trackers to maintain a consistent angle of solar incidence when the Sun is lower in the sky.

This is particularly beneficial in northern latitudes, for example, between 40° and 55°. However, unlike planar horizontal arrays, vertical field layouts need to accommodate the taller profile of the vertical tracker and spread units out to avoid

self-shading and energy losses.

7.2.3 TILTED SINGLE AXIS TRACKER:

They are usually known because of the trackers having its axes of rotation between horizontal and vertical. For reducing the wind profile and decreasing the elevated end height, tilt angles of this angle are often limited. They typically face the module oriented parallel to the axis of rotation. It brushes a cone like a module tracks which is rotationally symmetric surrounding the axis of rotation. This trackers offer optimal efficiency and solar tracking capabilities by tracking the sun throughout the day.

All trackers with axes of rotation between horizontal and vertical are considered tilted single axis trackers. Tracker tilt angles are often limited to reduce the wind profile and decrease the elevated end height. With backtracking, they can be packed without shading perpendicular to their axis of rotation at any density. However, the packing parallel to their axes of rotation is limited by the tilt angle and the latitude.

Tilted single axis trackers typically have the face of the module oriented parallel to the axis of rotation. As a module tracks, it sweeps a cylinder that is rotationally symmetric around the axis of rotation.

All the solar trackers which have axis of rotation between horizontal and vertical are named tilted single axis trackers. The tilt angles of the trackers are often limited so as to decrease the wind profile and reduce the elevated end's height from the ground. The field installations need to make consideration for the effect of shading so as to avoid unnecessary losses and also optimize area utilization. Using backtracking, they can be packed with no shading perpendicular to their own axis of rotation at any density. Yet, the parallel packing to the axis of rotation is limited by the latitude and the tilt angle. Tilted single axis trackers usually have the module's face oriented parallel to the rotation axis. As a module tracks the sunlight, it moves in a cylindrical motion that is symmetric around the axis of rotation.

7.2.4 POLAR ALIGNED SINGLE AXIS TRACKER:

These trackers are well known standard technique in ascending a telescope reinforce shape. The tilted single axis is aligned to the axis of rotation at polar star. Therefore, it is called a polar aligned single axis tracker.

7.3 DUAL AXIS TRACKER:

Dual axis trackers have two degrees of freedom. It tracks the movement of the sun from East to West through the day and from East to North or South through the season. The movement from East to West also known as Zenithal Angle and the other from East to North or South that happens through the year also called Azimuthal Angle. As this tracker move along the sun's direction vertically and horizontally, they help to achieve maximum solar energy. It improves the solar output by 40-45%. They are classified by the orientation of their primary axes with regard to ground. These trackers have two standard implementations.

The rotational axes in the dual axis tracker are orthogonal to each other. One of the axes is fixed in accordance with the ground level. This axis is known as the primary axis and the other axis is hence called the secondary axis. Dual axis trackers moved along two cardinal directions, horizontal and vertical. There are many applications of the dual axis tracker, the two most common beings-

- Tip-Tilt Dual Axis Tracker
- Azimuthal Altitude Dual Axis Tracker.

The altitude angle and azimuth angle of the sun are changing all the time. The dual- axis tracking device tracks the sun to collect more solar energy. According to the type of axis, the dual-axis tracking device can be divided into two types: polar-axis tracking and altitude-azimuth tracking.

Polar-axis tracking is also called spinning-elevation tracking. The principle of the polar- axis tracking device is one axis of the collector or concentrator pointing to the celestial north pole, which is parallel to the earth's rotation axis. The other axis is

perpendicular to the polar axis, called the declination axis.

When the device is working, the mirror or the collector rotates around the pole axis and the rotation speed is the same as that of the earth's rotational angle, but the rotation direction is opposite. In solar tracking systems, solar panels are mounted on a structure which moves to track the movement of the sun throughout the day. There are three methods of tracking viz active, passive and chronological tracking. These methods can then be implemented either in single-axis or dual-axis solar trackers.

In active tracking, the position of the sun in the sky during the day is continuously determined by sensors. The sensors will trigger the motor or actuator to move the mounting system so that the solar panels will always face the sun throughout the day.

A passive tracker moves in response to an imbalance in pressure between two points. The imbalance is a result of the solar heat creating gas pressure on a low boiling point compressed gas fluid which then moves the structure accordingly. However, this method of sun-tracking is not accurate.

A chronological tracker is a timer-based tracking system. The structure is moved at a fixed rate throughout the day. The motor or actuator is programmed to continuously rotate at an average rate of one revolution per day (15 degrees per hour). This method of sun-tracking is very accurate. However, the continuous rotation of the motor means more power consumption and tracking the sun on a very cloudy day is unnecessary. Electrical energy from solar panels is derived by converting energy from the sun rays into electrical current. The main challenge is to maximize the capture of the sun rays upon the solar panels, which in turn maximizes the output of electricity.

There are two possible ways to enhance output power from solar energy based systems. Either one can use an efficient material in the manufacturing of the photo voltaic cell or use a solar tracker to follow the sun. There are various ways of electricity generation like Hydro power plant, Nuclear power plant, Windmill plants and also Solar power plants. The former two are Non Renewable source of energy; hence we cannot depend only on such technology. Also Harnessing Energy from Hydro and

Nuclear is equally difficult. The latter two are Renewable source of Energy; nowadays we have lots of power plants established on Solar and Wind Technology.

7.3.1 TIP-TILT DUAL AXIS TRACKER:

A tip-tilt dual axis tracker has primary axis which is set horizontally with respect to the ground. Its secondary axis is normally referred to the primary axis. In this tracker, a panel array is ascended on top of a long pole. By spinning the array about the peak of a pole a movement from east to west takes place. To reduce the installation price, one end posts of the primary axis of rotation can be distributed among trackers.

They are very flexible and its axis of rotation which is parallel to one another is mandatory for suitably orienting the trackers with regard to one another. They can be packed without shading at any density with backtracking. Its axis of rotation is usually. All the solar trackers which have axis of rotation between horizontal and vertical are named tilted single axis trackers. The tilt angles of the trackers are often limited so as to decrease the wind profile and reduce the elevated end's height from the ground.

The field installations need to make consideration for the effect of shading so as to avoid unnecessary losses and also optimize area utilization. Using backtracking, they can be packed with no shading perpendicular to their own axis of rotation at any density. Yet, the parallel packing to the axis of rotation is limited by the latitude and the tilt angle. Tilted single axis trackers usually have the module's face oriented parallel to the rotation axis. As a module tracks the sunlight, it moves in a cylindrical motion that is symmetric around the axis of rotation. Tilted single axis trackers are becoming more and more important as the manufacturers and users of solar systems are looking for more ways to be efficient.

As for the cost of manufacturing of TSAT and improvement in reliability and performance of single-axis trackers, the systems are now being installed in a large percentage of utility scale projects. According to market research in 2017, the global sales volume of solar tracker systems hit a record 14.5. This represented a 32 percent year over year growth, with an equal or higher growth expected with the

increasing development of the large-scale solar deployments.

A tip-tilt dual axis tracker (TTDAT) is so-named because the panel array is mounted on the top of a pole. Normally the east-west movement is driven by rotating the array around the top of the pole. On top of the rotating bearing is a T- or H-shaped mechanism that provides vertical rotation of the panels and provides the main mounting points for the array. The posts at either end of the primary axis of rotation of a tip-tilt dual axis tracker can be shared between trackers to lower installation costs.

Other such TTDAT trackers have a horizontal primary axis and a dependent orthogonal axis. The vertical azimuthal axis is fixed. This allows for great flexibility of the payload connection to the ground mounted equipment because there is no twisting of the cabling around the pole.

Field layouts with tip-tilt dual axis trackers are very flexible. The simple geometry means that keeping the axes of rotation parallel to one another is all that is required for appropriately positioning the trackers with respect to one another. Normally the trackers would have to be positioned at fairly low density to avoid one tracker casting a shadow on others when the Sun is low in the sky. Tip-tilt trackers can make up for this by tilting closer to horizontal to minimize up-Sun shading and therefore maximize the total power being collected. The axes of rotation of many tip-tilt dual axis trackers are typically aligned either along a true north meridian or an east-west line of latitude. Given the unique capabilities of the Tip-Tilt configuration and the appropriate controller, totally automatic tracking is possible for use on portable platforms. The orientation of the tracker is of no importance and can be placed as needed. positioned either along a true North Meridian or an east-west line of latitude. Using advanced tracking algorithm, it is feasible to orient them in any fundamental direction.

7.3.2 AZIMUTHAL ALTITUDE DUAL AXIS TRACKER:

These trackers have its primary axis which is set vertically with reference to the ground. The elevation axis also known as secondary axis is ordinary just as the primary axis. Its function is quite same to tip-tilt system, but they vary in the array rotation for everyday tracking. They use a large ring mounted on the ground with the

array mounted on a series of rollers instead of rotating the array around the top of the pole. The main advantage of this tracker is that it allows supporting more large arrays.

However, compare to TTDAT, it may decrease the system density especially considering inter-tracker shading when the system is placed close together than the diameter of the ring. They are largely used in different research on tracking system based on their references.

On the basis of the driving mechanism solar trackers can again be of two kinds active solar trackers and passive solar trackers. The mechanism which makes use of electric motors such as DC motor can be termed as active driving mechanism. The passive ones are simply controlled by the movement of the earth that is the gravitational forces.

- **Open loop control-** The approach followed requires microprocessor. This method has an in-built prototype which is based upon the records of the movement of sun throughout the day. Hence, the microcontroller computes the time and determines the position of the sun at that particular hour. The control system is not affected by any geographical conditions.
- **Closed loop control/Feedback controllers-** This control system utilizes photo sensor to compare the light intensity. These sensors are fixtures at the side of panel and helps in detection of the position of the sun.

The prototype used in this research, is that of a horizontal single axis tracker. The tracking system utilizes photosensitive sensors to track down the movement or the path of the sun. This type of tracking technique is classified as active solar tracking. It is based on feedback control system or closed loop controlling. The intensities of light in our system are compared and the solar panel is charged to move. The primary axis is vertical and erected on the ground. The secondary axis is then normal to it and automatically horizontal. But the secondary is not fixed in space. The array is not supported at the top of the vertical structure used as support in the tip-tilt dual-axis tracker. In fact, a large horizontal ring is erected at a reasonable

distance around the primary axis and the array is supported between the ring and the primary axis supported by a radial structure.

This structure is used to hold the array in place. The radial structure has its inner end able to move about the vertical primary axis (the azimuth axis) while the outer end rests on vertical support which can move over the ring. The movement of this structure about the vertical gives the array its horizontal (azimuth) movement which could go as far as 270 degrees on either side or more.

The elevation (or altitude) movement is provided by tilting the array towards or away from the vertical about a horizontal axis of rotation. This horizontal axis is always parallel to a tangent of the circular ring. In one design the array can make an elevation movement from a negative angle to a vertical position giving a net movement of over 90°. Such a scheme can support very large sizes of array structures. The main load is on the ground supported ring, and not on a single vertical pole. The tip-tilt tracker, because of its design cannot support large arrays.

- With this advantage, the alt-azimuth dual-axis tracker AADAT has some limitations also in comparison with the tip-tilt dual-axis tracker.
- First of all, the ring is large, the size depending primarily on the size and weight of the supported array. As a result, an adjacent tracker must be at least at a distance twice the radius of the ring on the ground. This will limit the special density of the trackers in a large system.
- Secondly, because of the wide azimuthal freedom of movement, cabling to the ground-fixed equipment can cause problems due to possible tangling. Extreme care must be taken in designing cabling routes.

The alt-azimuth dual-axis tracker cannot be considered for a mobile PV role. Inter-tracker shading at lower sun angles is a limitation that must be handled both in the tip-tilt and azimuth elevation trackers. Most often back-tracking can relieve the issue. An azimuth-altitude (or alt-azimuth) dual axis tracker (AADAT) has its primary axis (the azimuth axis) vertical to the ground. The secondary axis, often called elevation axis, is then typically normal to the primary axis.

They are similar to tip-tilt systems in operation, but they differ in the way the

array is rotated for daily tracking. Instead of rotating the array around the top of the pole, AADAT systems can use a large ring mounted on the ground with the array mounted on a series of rollers. The main advantage of this arrangement is the weight of the array is distributed over a portion of the ring, as opposed to the single loading point of the pole in the TTDAT. This allows AADAT to support much larger arrays.

Unlike the TTDAT, however, the AADAT system cannot be placed closer together than the diameter of the ring, which may reduce the system density, especially considering inter-tracker shading.

In comparing the various forms of renewable DG, five factors must be considered: location, ease of installation, reliability, capacity, and cost. Thermal power is a location dependent, high cost option whereas wind has a lower cost but is unreliable due to changing wind conditions and requires regular mechanical maintenance. Solar power has a relatively lower cost, easy to install and maintain, and for underprivileged countries near the equator, ideal for the location. However the problem with solar power is that it is directly dependent on light intensity. To produce the maximum amount of energy, a solar panel must be perpendicular to the light source. Because the sun moves both throughout the day as well as throughout the year, a solar panel must be able to follow the sun's movement to produce the maximum possible power. The solution is to use a tracking system that maintains the panel's orthogonal position with the light source.

There are many tracking system designs available including passive and active systems with one or two axes of freedom. The goal of our project was to design an active, dual axis, solar tracker that will have a minimum allowable error of 10° and also be economically feasible to market towards underprivileged countries.

We started by examining the prior work done in solar tracking methods to determine our course of action. From there we designed and tested several mechanical and electrical options and chose the ones with the most desirable characteristics. Finally, we built our final tracking system, tested and compared it to ensure that we met our original goal. As mentioned above in the introduction, the use of a tracking system greatly improves the power gain from solar radiation. This

background goes into further detail on the operation of solar cells and the reason tracking is needed. The different tracking technologies are also described and how they compare to one another. Azimuth angle is measured clockwise from the north vector between 0° and 360° . North, the reference plane, has azimuth 0° , east has azimuth 90° , south has azimuth 180° and west has azimuth 270° . Altitude angle is measured between 0° and 90° . Different formulas are presented for azimuth angle and altitude angle in current studies in the direction of maximum available intensity. Thus, the system works on the feedback of the weather condition.

CHAPTER 8

CONCLUSION

Today in the world of rampant productivity, energy is the fundamental source upon which the whole civilization is based upon. As it is said that energy can neither be created nor be destroyed and, in that response, it can be signified that it can somehow be stored. The attempt towards making such goal substantiated, this project has been endeavoured towards unravelling the path of such objectivity. It is quite natural that constant utilisation of energies somehow opens the door of scarcity as per as earthly sources are concerned. Sun, in the stand of which, the tallest source, spiked over for age's right from the origin of the whole universe, through which life has been conceived, is the basic and the mother source of all the energies. Considering the very fundamental from the viewpoint of storing such energy, the project has been unravelled. Energies other than from the Sun, are the process from which such are been produced through the burning of various materials, involving emission of a large amount of pollution, causing the environment and the atmosphere sick day by day. Fastness and smartness of the world's current behavioural visibility, where easy access of every sphere of life is in need of the acute comfortability, every day is a new challenge of hatching something new and unique which makes an energy to be the ultimatum source behind all the hard work exists. In that regards it would be worthier to reveal that commercialisation has boomed its wings to such an extent in the need of money and power that we are somehow present in the pool of acute ignorance of the world's resources scarcity, in consequence of which the whole world is wounded. Healing the world is the basis cultivation with which the hour clock is calling and this project presents the eye, therefore, to open the corridors of reducing the amount of pollution in storing of energy culled out from the Sun and also to make the pace of advancement revved around.

CHAPTER 9

FUTURE SCOPE

The very embodiment through which the futuristic conundrum be set aside, is the project called “Automatic Solar Tracking System”. A trailblazer by its spirit, this system works in its utmost efficiency, whether that is in terms of its pecuniary ability or in terms of its accessibility. In the smoke of the darkness where pollution engulfing every spheres of advancement as an outcome of producibility, this device in its very efficiency work towards only advancement and development by flushing out the pollution at large.

Solar trackers, be it single-axis or dual-axis, can help generate the optimum level of solar power. This is why it is important to decide which type of tracker is suitable considering various factors, including the terrain, climate, and the type of solar panels that are being used. If you are a solar installer, depending on the budgetary constraints of your client, the terrain and climate, and the lifespan of the system, you need to consider the key factors to make the right decision. Other business opportunities would include companies & individuals who would rent rooftop space from homeowners and install PV systems for commercial solar power generation.

There are going to be lot more companies out there producing PV panels, power controllers, Solar inverters, more efficient battery systems, switch gear for grid connection etc. All these industries will have multitude of career opportunities. Besides these there will be demand for metal workers, fabricators etc to support installing the panels and associated solar equipment, including automatic sun tracking systems. There are going to be various engineering/ operations/ management/ Finance related careers openings in the large grid connected solar power plants.

The career scope of solar energy in the future is expected to be very promising. With the increasing demand for renewable energy sources, there is a growing need for professionals with expertise in solar energy. The demand for solar

energy professionals is expected to increase significantly in the coming years as more and more organizations and individuals adopt solar energy as a primary source of energy. The growth of the solar energy industry is expected to create numerous job opportunities for professionals in various fields such as solar panel installation, maintenance, and repair, solar panel design and manufacturing, solar project management, and research and development . The field of solar energy In addition, the increasing demand for solar energy is expected to drive the development of new technologies and innovations in the field, providing opportunities for professionals with expertise in areas such as solar energy storage, solar power generation, and solar energy management.

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