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DESIGN OF A PORTABLE SOLAR POWER GENERATOR WITH SINGLE AXIS TRACKING

A Project Report

submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY
in
MECHANICAL ENGINEERING

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CERTIFICATE

This is to certify that the project entitled **"DESIGN OF A PORTABLE SOLAR POWER GENERATOR WITH SINGLE AXIS TRACKING"** submitted by **Swadesh Samarpit Kuanr, Ashique Ranjan Behera, , Payal Sahu, Sumitesh Behera and Amlan Tripathy** bearing registration number **1902090087, 1902090100, 1902090102, 1902090019 and 1902090126** respectively in partial fulfilment of the requirements for the degree of **Bachelor of Technology**, during session 2022-23 in the department of Mechanical Engineering of **Veer Surendra Sai University of Technology, Burla**, is a bonafide work carried out by them under my supervision and guidance.

I believe that the thesis fulfils part of the requirements for the award of degree of Bachelor of Technology. Neither this dissertation nor any part of it has been submitted for any degree or academic award elsewhere.

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CERTIFICATE OF APPROVAL

This is to certify that we have examined the dissertation entitled "**DESIGN OF A PORTABLE SOLAR POWER GENERATOR WITH SINGLE AXIS TRACKING SYSTEM**", submitted by **Swadesh Samarpit Kuanr** (Regd. No. 1902090087), **Ashique Ranjan Behera**(Regd. No. 1902090100), **Payal Sahu**(Regd. No. 1902090102) **Sumitesh Behera**(Regd. No. 1902090019) and **Amlan Tripathy**(Regd. No. 1902090126) in partial fulfilment for the degree of Bachelor of Technology at the Department of Mechanical Engineering of Veer Surendra Sai University of Technology, Burla, Odisha.

We hereby accord our approval of it as a dissertation work carried out and presented in a manner required for its acceptance for the partial fulfillment for the award of degree of Bachelor of Technology in Mechanical Engineering for which it has been submitted. The approval does not endorse or accept every statement made, opinion expressed or conclusions drawn as recorded in this thesis. It only signifies the acceptance of the thesis for the purpose it has been submitted.

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Internal Examiner   **External Examiner**

DECLARATION

This is to declare that the project entitled **"DESIGN OF A PORTABLE SOLAR POWER GENERATOR WITH SINGLE AXIS TRACKING"** submitted by us in partial fulfillment of the requirement for the award of the degree, Bachelor of Technology, in Mechanical Engineering, Veer Surendra Sai University of Technology, Burla, Odisha, comprises only our original work and due acknowledgement has been made in the text to all other materials used. It has not been previously presented in this institution or any other institution to the best of our knowledge.

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ABSTRACT

Renewable energy refers to energy sources that are clean and inexhaustible. Principally, they differ from fossil fuels in their abundance, diversity, and potential for use in any part of the planet, but apart from that, they produce neither greenhouse gases which cause climate change nor polluting emissions. Some of these sources include solar energy, wind energy, and tidal energy. However, of all the energy sources solar energy is a renewable energy source that is abundantly available. Since India is a tropical country, there is sufficient sunlight available year-round which makes it a favorable location to harness solar energy.

Solar energy as we know can be harnessed by using either photovoltaic cells to convert light energy to electrical energy or by thermal collectors to convert light energy to heat energy. Further, the photovoltaic cells are made more efficient by using tracking systems such that the solar panel always faces the sun.

However, normally available tracking systems depend upon a lot of electronic components and complex micro-controllers which make the whole system quite expensive.

Our aim in this project is to design an economical and portable solar power generator utilizing an inexpensive tracking system which unlike conventional tracking systems does not utilize any sensors, micro-controllers, or voltage regulators. It utilizes cheaply available small solar panels to sense the sunlight and with the help of DC motors changes the direction of the whole system to always face the sun normally. It is capable of performing dual axis tracking and this project has been manufactured inexpensively to produce solar generators which can be used for domestic purposes.

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1.INTRODUCTION

Modern civilization is heavily dependent on energy. Every day energy is utilized massively to perform activities which sustain our lifestyle and society. 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 endeavour 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 fulfil every demand for energy, the demand for these resources for energy has escalated to its zenith. The conventional use of energies and due to the burning of fossil fuels like coal, oil and natural gas, the whole environment is getting polluted.

Thus, an approach towards non-conventional energy sources is very essential in order to meet our energy demands. In this project we have tried to harness the energy from sunlight into electricity with the help of a portable solar generator that is also capable of dual axis tracking.

Tracking systems have shown to increase the efficiency of energy generation by almost 40% compared to fix solar panels. However, this comes at an extra cost of components required for tracking system, along with maintenance and upkeep.

We have attempted to design a tracking system for our solar generator which not only requires lesser electronic components and solves the hassle of complex circuitry but also is cost effective and easy to install and operate.

Normally solar tracking systems use LDR sensors along with a Micro-controller, power modules and DC motors to track the maximum intensity of sun. LDR sensors sense the intensity data and data is sent to the micro-controller which accordingly guides the DC motors to tilt the panels in a given direction. Simplifying the above process, we have designed a tracking system which eliminates the need of micro-controllers, LDR sensors, Voltage regulators etc.

Our design simply uses small 0.6 V solar panels as sunlight sensors and generate electric current which then operate DC motors to face the panel towards maximum sun intensity. We have researched upon different types of solar panel and compared their efficiencies in order to find the optimum solution to design our solar power station.

This project 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 endeavour 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 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.

2. LITERATURE REVIEW

2.1: 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 themotion 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.

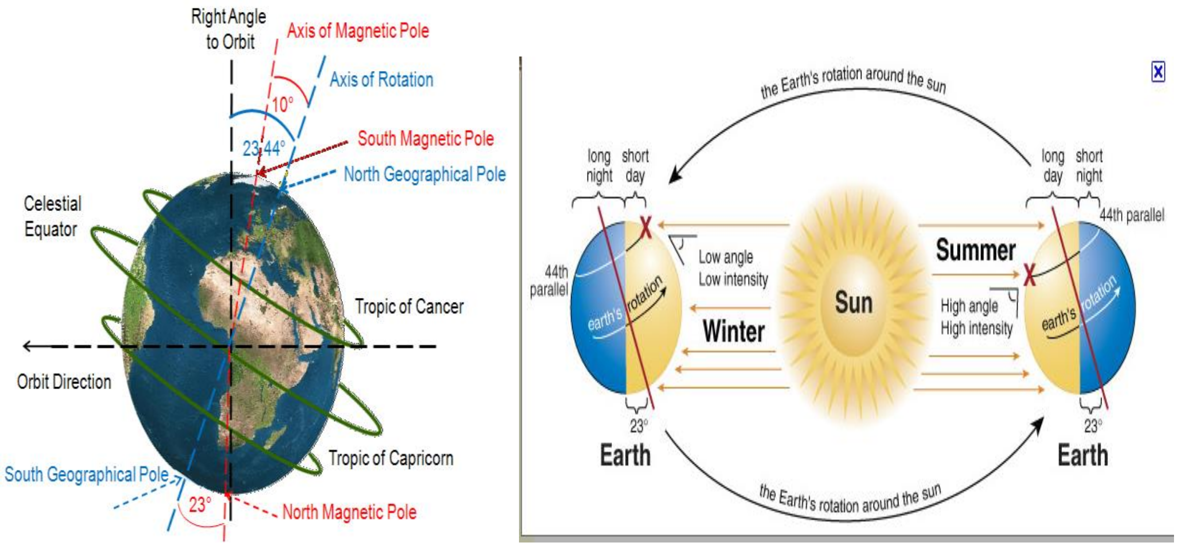


FIG 2.1: Earth's Rotation and Revolution.

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, 6 hours, 9 minutes 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 solstices and spring autumn equinoxes. Due to these motions of the earth, the amount of sunlight received throughout the year varies.

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. Within a given period of time, the emission of solar radiation is somewhat constant and the intensity the radiation hitting a unit area of the earth's crust is constant, known as solar constant. The value of this solar constant can be expressed as –

$$\mathbf{G} = \sigma T^4 (4\pi R)^2/(4\pi D)^2 = 1367\ W/m^2 \quad \text{-----------(2.1)}$$

In the above expression, σ is termed as Stefan Boltzmann Constant with a value of 5.67×10^{-8} W/m^2. K^4, R is known as the radius of the sun, $696*10^6$ m and D is $150*10^9$ m, the average distance between the Sun and the earth.

The absorption of solar radiation on the surface of the earth also varies with different parameters. Latitude and longitude are one of the prescribed parameters. Latitude the horizontal imaginary line, parallel to the equator, is the angle

suspended by the arc linearly join a person's position and the equator, at the centre of the earth. On the contrary longitudes are the vertical imaginary lines, where longitude is the angle suspended by the arc joining the north-pole and south-pole as well as passing through the given location, linearly with the Greenwich meridian, at the centre of the earth. The latitude and longitude express north-south and east-west directions respectively on the earth.

The sunlight is observed at different angles depending on the place on the earth and the angles of the sun. The sun's angle can be classified into the following -

- Elevation Angle
- Zenith angle
- Azimuthal angle

The **elevation angle** is the angle made by the sun with the horizon. The elevation angle is 0 degree at sunrise and 90 degrees around noontime, at the equator. The elevation angle is different at a different time of the day and different for different latitudes. The depicted formula can be used to determine the elevation angle.

$$\alpha = 90 + \varphi - \delta \quad \text{-----------------------(2.2)}$$

When the equation above gives a number greater than 90° then subtract the result from 180°. It means the sun at solar noon is coming from the south as is typical the northern hemisphere.

φ is the latitude of the location of interest (+ve for the northern hemisphere and −ve for the southern hemisphere). δ is the declination angle, which depends on the day of the year.

Zenith angle is akin with elevation angle. The only difference being it is measured along the vertical. Therefore, it's the angle between the sun and the vertical i.e., Zenith Angle = 90° – elevation angle.

$$\zeta = 90° - \alpha \text{ -------------------------------(2.3)}$$

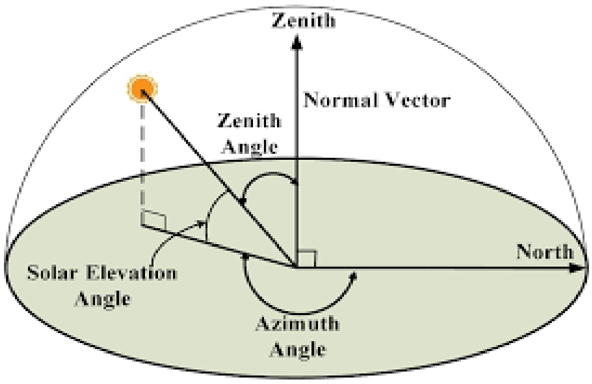


FIG 2.2: Azimuthal, zenith and elevation angle.

Azimuthal Angle, this is the compass direction from which the sunlight is coming. At solar noon, the sun is directly south in the northern hemisphere and directly north in the southern hemisphere. The azimuth angle varies throughout the day. At the equinoxes, the sun rises directly east and sets directly west regardless of the latitude. Therefore, the azimuth angles are 90 degrees at sunrise and 270 degrees at sunset.

2.2. Different types of solar panels

The paucity of available resources has forced contemporary society to look for measures to consummate the demands of the latter. With the nurturing civilization, the depletion of conventional fuels, due to human practices has been an alarm to sustainable development issues. The scarcity of energy and its source guided us towards the optimistic approach of using the alternative resources bestowed to humankind–Solar, tidal etc.

The Sun has been looked upon as an imperative source of energy. Solar energy is an eco-friendly resource as compared to its counterparts. The advancement of technology has out-turn foster techniques to utilize this energy into its own good use. Be it as thermal energy, electricity, fuel production and many more. Photovoltaic or concentrated solar power (CSP) systems are operated to transfigure the solar power expropriated by the earth into electricity. Solar tracking device utilizes this expropriated solar power through the channel of photovoltaic arrays, an oriented scaffolding of photovoltaic/solar cells.

Solar cells, also known as photovoltaic cells are used to convert light energy into electricity. Photovoltaic cells work on the principle of the photovoltaic effect, which is similar to the photoelectric effect. Differences being that the electrons in photovoltaic are not emitted instead contained in the material around the surface, creating a voltage difference. Solar cells are forged with crystalline silicon. It is the most commonly used material in a solar cell. The use of silicon inthe solar cell has been very efficient and low cost. Two forms of crystalline silicon can be used tomake solar cells. Other than silicon, solar cells can be fabricated with cadmium telluride (CdTe), Copper indium gallium (di)selenide (CIGS) etc. the fabrication of solar cells with materials othersilicon is slightly expensive, thus making silicon the best material to be used in solar tracking systems.

One of the finest and extensively used material, monocrystalline silicon has an efficiency of about15-20%. While under high temperature the performance of the cell material drops by 10-15% of the initial.

Polycrystalline silicon is another form, cheaper than the latter but has the same band gap as that ofmonocrystalline silicon. Though it has the same band gap energy, it lags in efficiency, hence this material is used in low-cost products.

Amorphous silicon cells can work under extremely high temperatures, but the efficiency of thesecells is comparatively lower than the other silicon forms.

The technologies which use CdTe, CIGS, Amorphous Thin-Film Silicon (a-Si, TF-Si) in the fabrication of solar cells are known as thin film photovoltaic modules. These thin-film solar cells are relatively cost-effective than the solar cells of crystalline silicon.

Table 2.1: Types of Solar cell based upon the material

Cell Technology	Crystalline Silicon	Thin Film Silicon
Types	• Mono-crystalline silicon (c-Si) • Poly-crystalline silicon(pc-Si/ mc-Si)	• Amorphous Silicon (a-Si) • Cadmium telluride (CdTe) • Copper indium gallium (di)selenide (CIG/CIGS)
Temperature resistivity	Lower	Higher
Module Efficiency	13-19%	4-12%

There are several other factors on which the efficiency of a solar cell depends.

- Cell temperature
- Energy Conversion Efficiency

2.3: Different types of Solar Tracking systems

Solar panels are a cumulative orientation of photovoltaic cells. The PV cells are arranged in a solar panel or a PV array such that is serves the purpose of exciting the electron of the material consisting inside the solar cells using photons. The average amount of sunlight received by solar panels particular depends on the position of the sun.

Being a repository of energies, Sun witnessed to be the eminent and ever continuing source of emitting radiation from it. A part of this source of natural energy is received by the solar panel. Certain ways have been developed to utilize this energy source as an alternative to other non- renewable sources. Considering its multitudinous flourishing ways in which it can be applied to bring about the change in conserving other resources, the manipulation of the energy source is encouraged.

Solar panels are hence used to utilize solar power in electrical means. They are aligned different arenas to collect maximum solar power. Though, solar panels can be used to absorb or collect solar power, there work is bounded to certain hours of the day and the sunlight pouring directly on them, i.e., the angle between the sunrays and the panel is orthogonal. While at other hours of the day, the angle of the sunrays is different, hence the amount of the solar power captured is very less.

To overcome such pitfalls, and encapsulate the maximum available of solar energy the solar tracking systems were introduced. A solar tracking system is designed with the intention of keeping the angle between the sunrays and the solar array 90°.

The solar tracking system have three different modules-

- The mechanism
- Driving motors
- The tracking controller.

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.

Single axis tracking can be considered as one of the handy systems or prime solution in terms of small-scale photovoltaic power plants. Single axis tracking can be done using three different arrangements, which are based on the different axes of tracking-

- Inclined shaft installation
- South-North axis horizontal installation
- East-West axis horizontal installation.

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.

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

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

The rotational axis in the dual axis tracker is 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 being-

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

The efficiency of these tracker is much more than any single axis tracker. It conventionally follows the movement of the un and hence captivates maximum solar energy.

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.

Solar **tracking controller** can also categories solar trackers into two different module-

- Open loop control- The approach followed requires microprocessor. This method has an inbuild 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 photosensor to compare the light intensity. These sensors are fixtures at the side of panel and helps in detection of the position of the sun.

2.4: The efficiency of solar panel

Efficiency can be described as the ratio of the input energy through the solar cell to the energy of the sun. The efficiency of the solar panel is monitored by the light intensity, material of the solar cell, temperature etc.

For the calculation of the energy, we calculate the maximum power, which is defined as the product of open-circuit voltage (VOC), short-circuit current (ISC) and fill factor (FF).

$$P_{max} = V_{OC} I_{SC} FF \quad \text{--------------------------------}(2.4)$$

The efficiency (η) is then calculated as:

$$\eta = V_{OC} I_{SC} FF / P_{in} \quad \text{----------------------------}(2.5)$$

Where, P_{in} is the total input power.

2.5: Comparison between different types of trackers

Table 2.2: Types of Solar tracker

Types	Specification
Active Solar Tracker	• It uses motors and gear trains or direct drive actuators, to follow the movement of the sun. • Directed by a controller. • Deactivates during darkness based on the design of the system. • It uses a light sensor to locate the angle at which maximum sunlight can be absorbed. • The MCU directs the solar panel to change the angle.
Passive Solar Tracker	• It uses a liquid, easily compressible and boiled. • It is driven by the solar heat. • The fluid moves when heated, like a teeter-totter and hence the solar panel moves.
Chronological Solar Tracker	• Works with the rotation of the earth. • Have no sensors. • Depends on the geographical location. • Uses a controller to calculate the moment and position of the earth with respect to the sun at a given time and location.
Single Axis Tracker	• Tracks in a single cardinal direction. • It has a single row tracking configuration. • More reliable. • It has a longer lifespan. The common categories in which single axis trackers can be classified holds: • Horizontal single axis trackers (HSAT). • Horizontal single axis tracker with tilted modules (HTSAT). • Vertical single axis tracker (VSAT). • Tilted single axis tracker (TSAT). • Polar aligned single axis tracker (PSAT).

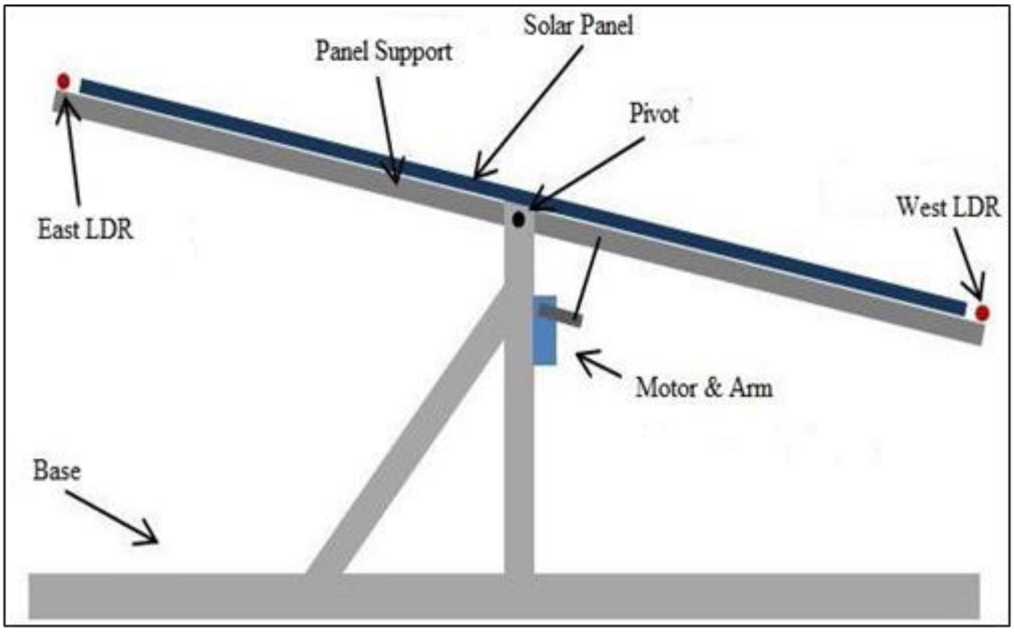


Figure 2.3: Single Axis Tracker

Dual Axis Tracker	• It moves along two cardinal directions (Horizontal & Vertical). • The axes are traditionally orthogonal. • Its efficiency is much more than any single Axis Tracker. • It conventionally follows the movement of the sun and hence captivates maximum solar radiations.

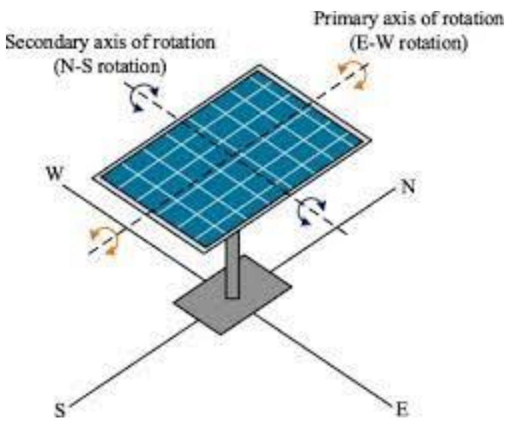


Figure 2.4: Double Axis Tracker

Fixed Collectors

Figure 2.5: Fixed Collectors

The fixed collectors are secured at a place where the net solar energy obtained is relatively higher than most of the predefined places and the inclination is kept in accordance with the defined context. The motive is to install it in places which are subjected to receive the maximum amount of sunlight and collect solar energy over a long period of time hence the demand for tracking devices can be overcome. This creates a substantial diminution in the expenses and the preservation of the collectors. The knowledge of the movement of the sun throughout a season and different hours of the year is essential to enable maximum captivation of solar energy. Therefore, Sun charts are used for fixed type collectors to determine the position of installation.

2.6: Advantages of Solar tracking system:

- Trackers generate additional electricity than their stationary counterparts courtesy of augmented direct exposure to solar rays. This increase is can vary from 15 to 25% pending on the geographic location of the following system.
- Solar trackers generate more electricity in roughly the same quantity of area required for fixed-tilt systems, creating them ideal for optimizing land usage.
- Solar trackers come in a variety of configurations, including single-axis and dual-axis trackers, each of which can be tailored to a specific jobsite. The

size of the solar installation, the weather in the area, the degree of latitude, and the electrical requirements are all factors that might influence the type of solar tracker that is best suited for a certain solar installation.

- Advancements in technology and reliability in electronics and mechanics have drastically reduced long-term maintenance concerns for tracking systems.
- Dual-axis trackers provide the optimal solution for areas that may hinder solar productivity. Some of these areas could be a complicated structure of the ground, complicated relief, stone protrusions, descent towards the North, and others.
- The payback period on investment is lower in the case of dual-axis trackers. Also, there will be a significant increase in profits during their lifespan.

2.7: Disadvantages of Solar tracking system:

- Due to the more complex technology and moving parts required for their functioning, solar trackers are slightly more expensive than their stationary counterparts. This is dependent on the project's size and location.
- Because of the improvements in reliability, solar trackers require more maintenance than standard fixed racks, albeit the quality of the tracker can influence how much and how often this maintenance is required.
- Fixed racking is a simpler arrangement than trackers. This usually necessitates additional site preparation, such as additional trenching for wiring and some grading.
- Fixed collector systems can be adjusted conveniently and easily compared to tracking systems.

3.System Design

3.1: Design Constraints and Design Methodology

3.1.1: Geometrical Constraints:

The second we decided to design the single axis solar tracker system for the project there are some constraints that should be taken under consideration. First of all the major problem was to create solar tracker system of suitable size that will be easy to handle. The main point which was creating hurdle was that the size of the dual axis solar tracker should not affect the performance and efficiency of panel. For that, lots of studies were performed to get wellbalanced final product.

3.1.2: Sustainability:

As an entire system design should be capable of preserve it self physically and functionally and it is simple not fragile system apart from the solar panels as they require special care. To make up the expense of the device the system needs to work for quite a while. The unique characteristic of this system is that instead of taking the earth as its reference, it takes the sun as a guiding source. The sunlight is monitored by the active sensors and rotates the panel towards the direction where the intensity of sunlight is maximums**.**

3.1.3: Environmental Concern:

There will be abundant availability of solar energy in the nature because the sun emits energy at an extremely large rate. The world's energy demand could be fulfilled if all the solar energy is converted in to useable forms. Solar energy can be converted to more usable energy forms through solar tracking solar panel. There is unprecedented interest in renewable energy, particularly solar energy.

3.1.4: Social Impact:

On one hand we can see that the world's energy resources depletion will be one of the major problems and on other hand we know that global warming is major concern of the world. But solar energy which we can gain from solar panel, we can gain maximum energy which is clean and green and improving its efficiency by using sun trackers is a great option in near future.

3.1.5: Economic:

The major constraint of the project was the financial concerns related with the creation of the system. Solar energy can reduce the electricity bills of households since solar energy can be used to supplement other resources of energy. One might install a solar tracking system with a solar panel considering the advantages like the efficiency increases by 20-60% that is equivalent to more money. The space requirement is reduced for solar park and they sustain the same output the profit time of the investment is reduced. Long-term maintenance concerns for tracking systems are drastically reduced by advancement in technology and reliability in electronics and mechanism.

3.1.6: Safety:

Our design has also been planned to sustain safety at all times during its functional lifespan. The solar tracking solar panel system is securely mounted to prevent it from becoming a failing hazard.

3.1.7: Ethics:

Solar tracking solar panel designs and models are already in use in markets and in our daily life but we intend to present this solar tracking solar panel system with some modifications in it. The aim of this project is to ensure the sunlight rays are falling perpendicularly on the solar panel to give the maximum solar energy. An automated system is required to get a constant output, which should be capable to constantly rotate the solar panel. The solar tracking system was made as a prototype to solve the problem.

4. OBJECTIVE

- The aim of this project is to design a solar power generator which can be used for domestic purposes.
- The designed product should be portable, easy to operate and cost-effective.
- The designed product should be capable of performing dual axis tracking.
- This project is aimed towards developing a tracking mechanism which is innovative, electronically simple and economical so as to it can be afforded by common person.
- The designed project shall be compared to fixed type solar collectors and efficiency improvement should be measured.
- The project should be designed as to work in real world conditions and deliver satisfactory performance.

4. METHODOLOGY

The solar generator is produced by integrating a primary solar panel required for power generation along with LDR (light dependent resistor) which are used as sensors. The tracking system utilizes electric current as signals from solar panels to power the DC motors whose objective is to align the panel ina direction so as to provide maximum intensity of sunlight falling on the panel. Culminating towards making the said project caviar in its utilization several components have been unleashed, some of which are mentioned so

1. Solar Panel.
2. DC Motors.
3. Solar charge controller.
4. Battery.
5. Frame of the system
6. LDR Sensor
7. Micro controller

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 solar panel by receiving input signal from the LDR sesnser in accordance with the length of it, revolves in aid with the DC 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 endeavour.

4.1: Hardware components

Solar panel - Towards building of this prototype we have used a monocrystalline solar panel since it provides with the highest efficiency.

Nominal power (P_{max}) – 30 W

Voltage at Max power – 18.1 V

Current at Max power – 1.66 A

DC motor - DC motor is required towards development of this project for the rotation of solar panel which is 18 degree from the horizontal Low rpm high torque geared motor is used to rotate the frame towards direction of sun.

RPM – 100

Voltage – 24 V

Solar Charge controller - We have used a solar charge controller which will be directly connected to the Solar panel which will be utilized in charging batteries and providing AC supply.

Maximum Current- 6 A

Input Voltage – 17-25 V

Battery voltage – 12 V

Battery- One battery is used in this setup of 12 V and capacity of 7 Ah to create backup for emergency use.

Frame- A three legged frame of stainless steel is used to hold the solar panel and all other components required for the project.

LDR Sensor- LDRs are tiny-sensing devices also known as photoresistors. An LDR is a resistor whose resistance changes as the amount of light falling on it changes. The resister of the LDR decreases with an increases in light intensity.

Microcontroller- A microcontroller is embedded inside of a system to control a singular function in a device. In our project microcontroller is used as light sensing and controlling device.

4.2 Design of Solar Generator

4.3: Working Principle of Tracking system

The tracking system is inspired by the Parker probe made by NASA which is used to collect data on the sun.

In the Parker probe a large heat shield is used to cover the electronics. The probe is designed in such a way that the heat shield always faces the sun and electronics are protected behind the shield. This is achieved by utilizing solar wind electron sensors installed in the back of the probe. These extensions extend till the edge of the heat shield.

If the probe gets misaligned the sunlight falls upon the sensors which were in shade up until now and then the sensors send signals for the probe to rotate in an opposite direction such that the shield faces the sun directly.

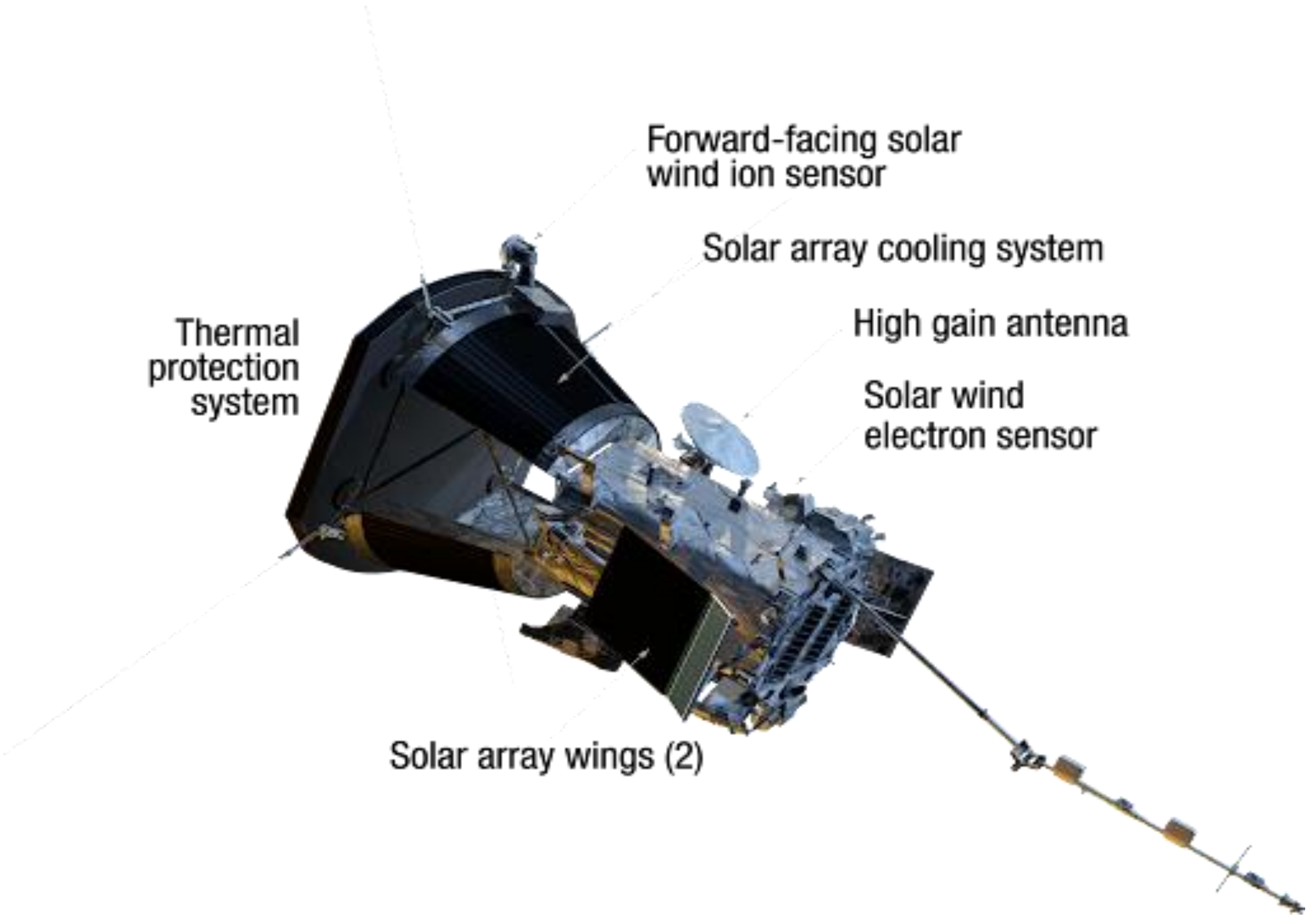
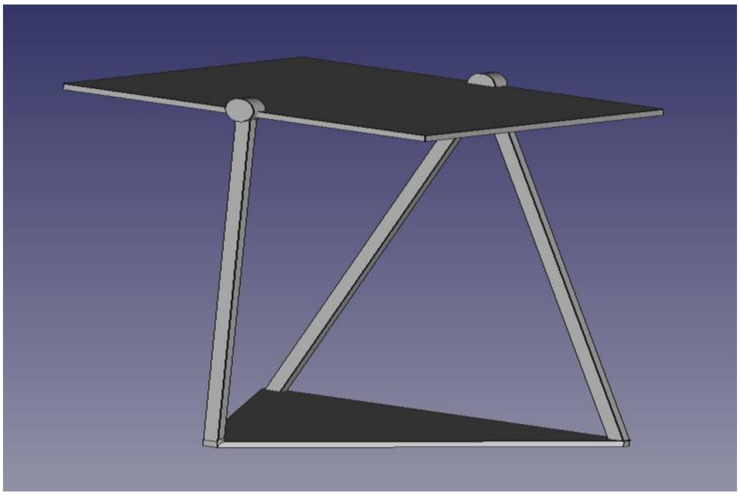


Fig 4.2: Parker Solar Probe.

As can be seen in the image of Parker Probe, the solar wind sensors extend till edge of the shield and thus can be used to guide the probe always face the sun. Otherwise, the electronics will be damaged upon direct exposure to sun.



In our designed project when the sun is perpendicular to the primary panel , the sensors attached on both sides receive same amount of light intensity which gives signal to micro-controller resulting in a balanced state and no power signal is given to the motor.

Fig 4.4: Sunlight falling at an angle to the panel

In the above configuration where the panel is at an angle to the sun, then sunlight falls directly upon one sensor that generates pulse in the micro-controller to power the motor to rotate it such that the radiation incident on the both the sensor becomes equal.

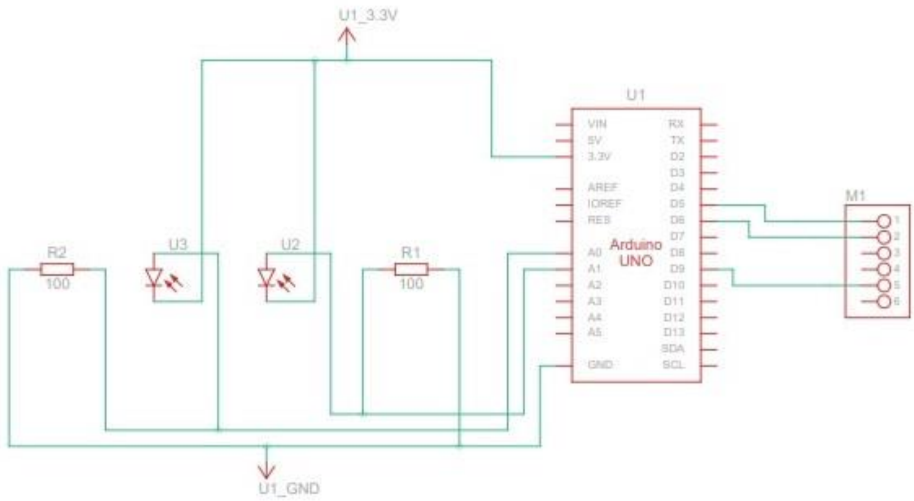
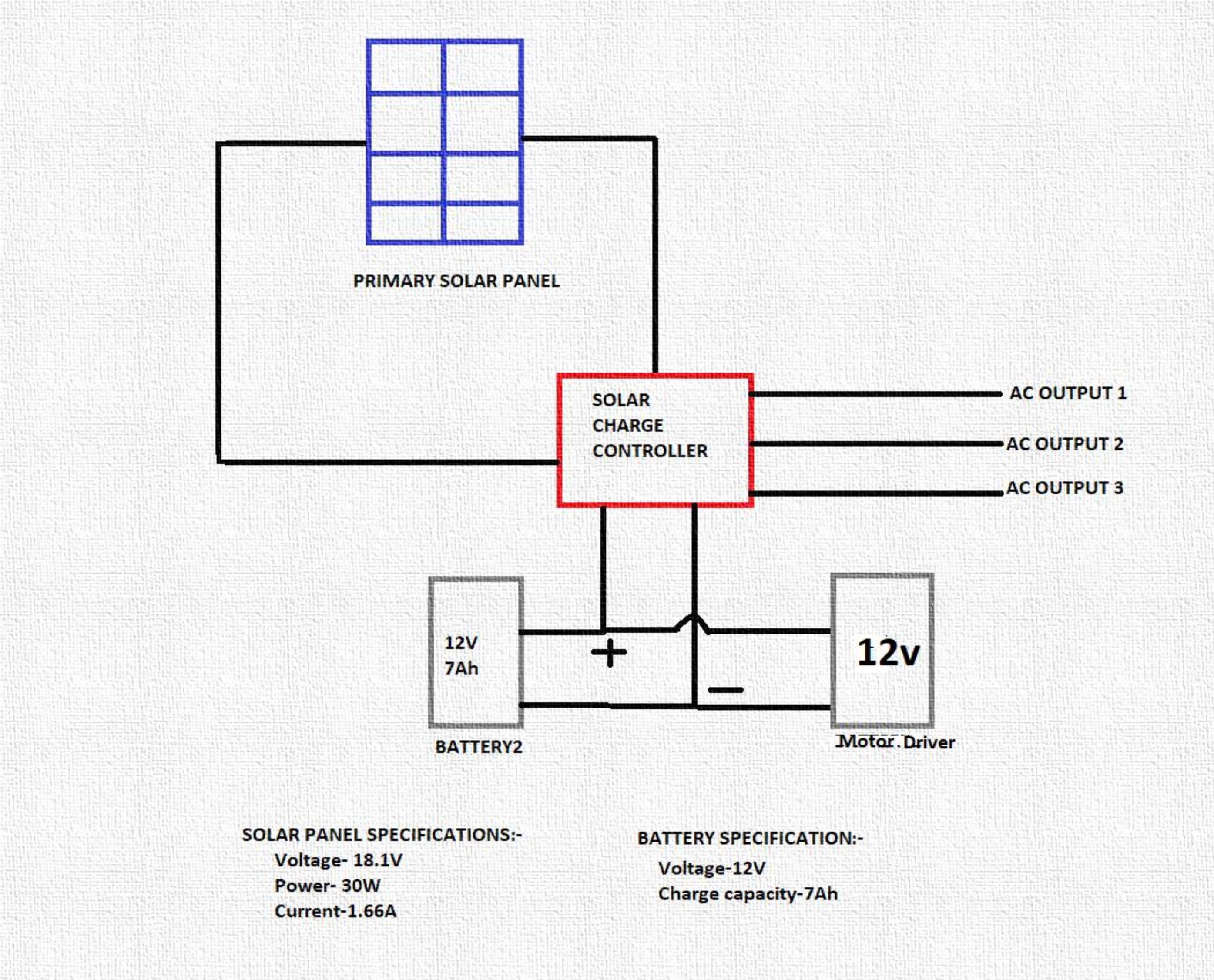


Fig 4.5: The circuit diagram for sensor and tracking operation.

In the above circuit diagram sensors LDR 1(U1) and LDR 2(U2) are connected to the micro-controller at analog input pins A0 & A1. The Signal received by the microcontroller is processed in the microprocessor that compare the light intensity falling on both the sensors. The microcontroller then gives signal to the motor-driver through output pins D5 to power the motor for rotating the panel and compensate the light intensity falling upon the LDR sensor equally.

The tracking mechanism helps to improve the efficiency of our solar generator by always tracking and setting the panel to receive maximum intensity of sunlight thus generating more energy compared to fixed collectors.



The power generated by solar panel is sent to solar charge controller which provides DC current to charge the batteries and AC current to operate low powered appliances such as LED bulbs and small table fans. This power generator can also be used readily in remote locations where power supply is not stable and can be handy in applications where portable power source is essential.

5. OBSERVATION AND RESULTS

The fixed panel arrangement and the panel with the tracking system were both tested simultaneously. We collected data with both the panels working together under identical conditions on the same day for the same duration. Fixed tracking system was installed in the direction 165 degree south and an inclination angle of 45 degree.

Test time – 6 am to 6 pm
Average day temperature - 43° C

Table 5.1: Power generated by Fixed Tracking system vs Dual Axis tracking

The observed data is listed in the below table-

Time	Fixed Tracking (Watts)	Single Axis Tracking (Watts)
06:00	0.00	3.46
07:00	2.27	8.78
08:00	6.44	15.43
09:00	9.70	24.47
10:00	17.72	28.64
11:00	22.50	31.07
12:00	29.93	31.40
13:00	29.45	32.20
14:00	27.82	31.97
15:00	22.59	32.61
15:45	12.70	33.29
16:40	10.81	27.98(cloudy)

17:00	4.84	29.51(partially cloudy)

The data above can be visualized by using the graphs generated from the above data.

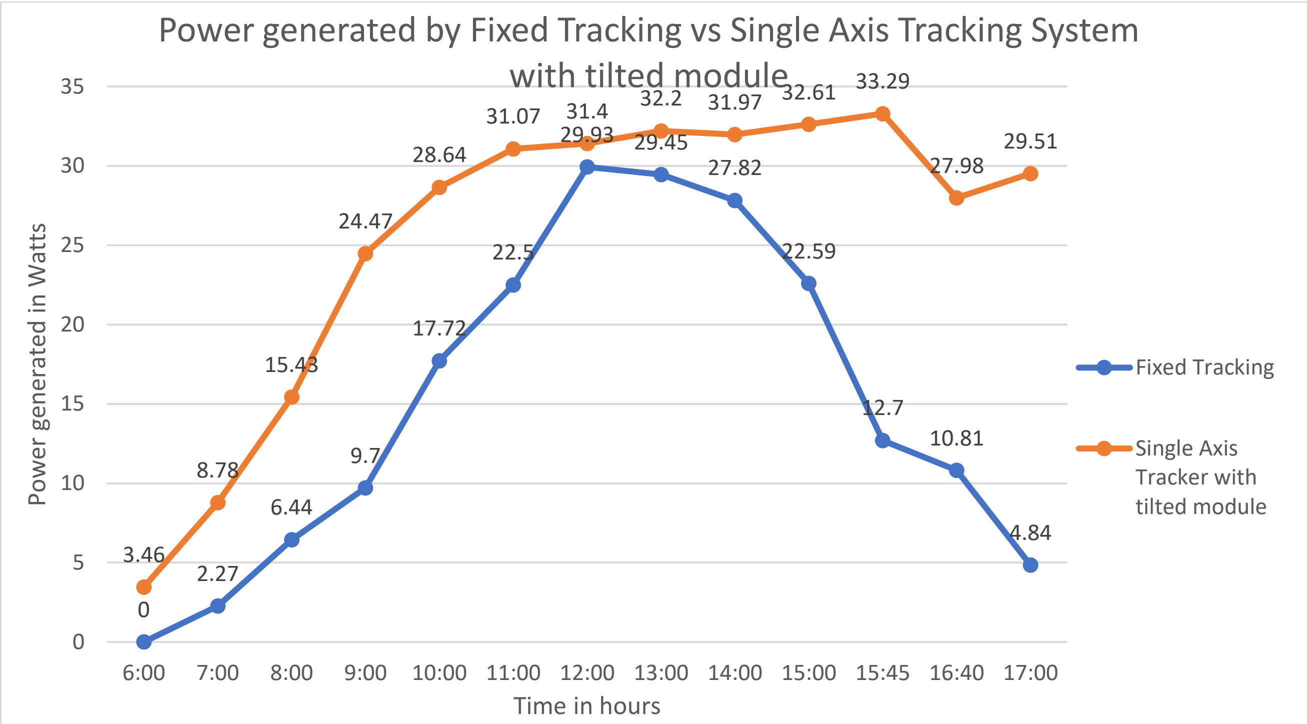


Figure 5.1: Power generated by Fixed vs Single Axis Tracking System with tilted module

The two graphs show power generated by Fixed vs Single Axis tracking system with tilted module. As can be seen from the graphs the dual axis tracking system gives more consistent and higher power output throughout the day. Compared to this the fixed tracking system fluctuates highly with the time and generally gives optimum output during noon time.

Power generated by Single Axis Tracking mechanism Area under the Orange graph = 288.43W hr

Power generated by Fixed tracking system: Area under the blue graph = 196.77 W hr

Excess power generated by tracking system = 91.66 W

Improvement in power generation due to single axis tilted module tracking system: = (91.66/196.77) ×100 = 46.58%

Via the above experiment we concluded that the tracking system generates 46.58% energy under identical conditions.
This increase in power is achieved without the significant increase in cost which would have been if conventional tracking method with micro-controllers would have been used.

6. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

We learnt about why solar energy is such a valuable energy source and a power source to look forward to. Solar energy needs to be harnessed as effectively as possible since it is non-polluting, renewable and abundantly available in every part of earth. Further due to no geographic constraints, this source cannot be politically manipulated like oil. It is a sustainable method to ensure our energy demands.

Tracking mechanisms are a method to improve the harnessing of solar energy but due to lot of extra components this remains an expensive method which cannot be afforded by everyone. Via this project we have envisioned a solution which can track sun’s movement effectively, is affordable and simple in design. Our aim in this project was to develop a secondary power source for every household which can be used for power generation but should also be cost-effective so that it can be afforded by everyone. Our project represents our idea of an economical solar tracking mechanism which fulfils our objectives.

6.2 Future scope

Solar energy is the most reliable source of energy looking into the future. A huge amount of solar energy is wasted due to panels not being highly efficient. However, research is being done for manufacturing highly efficient panels with efficiency ranging around 40% such as Perovskite cells. Also, research is being done for manufacturing of thin film solar panels which are flexible as well as efficient in the range of 20-25%.

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