MECHANICAL MOTION OF SOLAR TRACKER

Submitted in partial fulfillment of the requirements
for Major Project
of

Bachelor of Technology

in

Mechanical Engineering

By

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CERTIFICATE

This is to certify that this Major Project Report entitled "**MECHANICAL MOTION OF SOLAR TRACKER**" is a bonafide record of work submitted by

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ABSTRACT

The aim of this Mechanical Motion Solar Tracker for Solar panel project is made to tracking the Sun at day time for utilizing its solar energy properly for solar panel. The Sun trackers are all-weather, reliable and affordable tracking and positioning instruments. This project orients the Solar Panel toward the sun, so that it can utilize with higher accuracy. Our Sun Tracker system track the Sun by use of sensors and rotate the solar panel by means of stepper motor.

For flat-panel applications, trackers are used to minimize the angle of incidence between the incoming light and a solar panel. This increases the amount of energy produced from a fixed amount of installed power generating capacity. The optics in concentrated solar applications accepts the direct component of sunlight light and therefore must be oriented appropriately to collect energy. Tracking systems are found in all concentrator applications because such systems do not produce energy unless oriented closely toward the sun.

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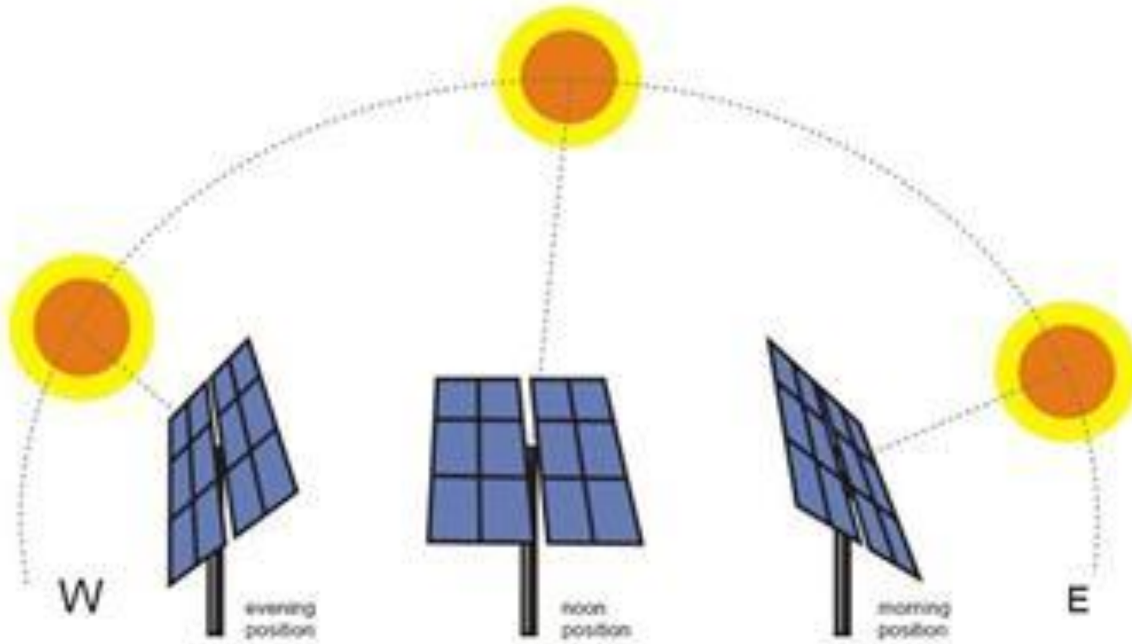
CHAPTER 1

INTRODUCTION:

OVERVIEW

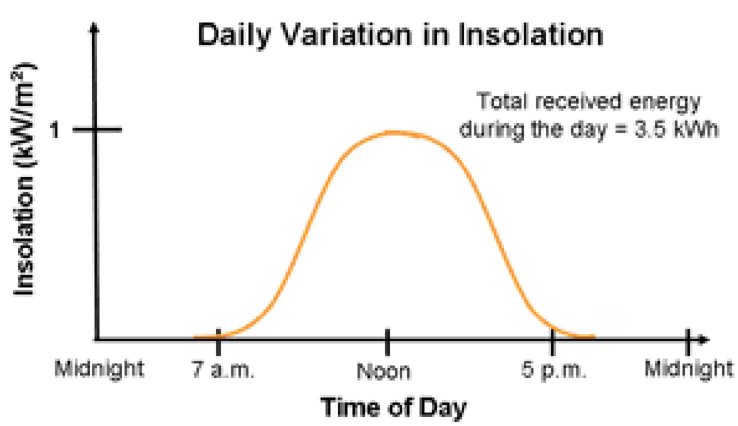
The use of power is increasing day by day and the demand for energy is increasing accordingly. The more use of non-renewable resources such as coal, oil.etc. as the main source of energy nowadays. As these resources are expected to end up from the world during the recent century which explores a serious problem in providing the humanity with an affordable and reliable source of energy due to the use of these resources as their daily need. This leads to an extinction of these resources and the alternative sources must be implemented to overcome this crises. So, the use of renewable sources such as Wind energy, solar energy.etc. came into exist which give optimize results when used in proper.The need of the hour is renewable energy resources with cheap running costs. Solar energy is considered as one of the main energy resources in warm countries.


W
evening position
noon position
morning position
E

VARIATION DURING THE DAY

In India we came under a long sunny day which are more than ten months and partly cloudy sky and in full cloudy sky in the rest of two months. Thus a rich in use of solar energy is attained. Many projects have been done on using photovoltaic cells in collecting solar radiation and converting it into electrical energy but most of these projects did not take into account the difference of the sun angle of incidence by installing the panels in a fixed orientation which influences very highly the solar energy collected by the panel.

As we know that the angle of inclination ranges between 0o after sun rise and 180o before sun set passing with 90o at noon. This makes the collected solar radiation to be 0% at sun rise and sun set and 100% at noon. This variation of solar radiations collection leads the photovoltaic panel to lose more than 40% of the collected energy.



SOLAR POWER IN INDIA

Solar power in India is a fast-growing industry. As of 6 April 2017, the country's solar grid had a cumulative capacity of 12.28 giga watts (GW) compared to 6.76 GW at the end of March 2016. In January 2015, the Indian government expanded its solar plans, targeting US$100 billion of investment and 100 GW of solar capacity, including 40 GW from rooftop solar, by 2022. Commenting on the key importance India attaches to solar power, “The world must turn to (the) sun to power our future. As the developing world lifts billions of people into prosperity, our hope for a sustainable planet rests on a bold, global initiative.”

India's initiative of 100 GW of solar energy by 2022 is an ambitious target given the world’s installed solar power capacity in 2014 was 181 GW.

India quadrupled its solar power generation capacity from 2,650 MW on 26 May 2014 to 12,288.83 MW on 10 March 2017. The country added 3.01 GW of solar power capacity in 2015-2016, and 5.525 GW in 2016-2017, the highest of any year.

In addition to the large-scale grid connected solar PV initiative, India is continuing to develop the use of off-grid solar power for localized energy needs.

India has a poor electrification rate in rural areas. In 2015, only 55% of all rural households had access to electricity, and 85% of rural households depended on solid fuel for cooking. Solar products have increasingly helped to meet rural needs, and by the end of 2015, a cumulative total of just under 1 million solar lanterns had been sold in the country, reducing the need for expensive kerosene. During 2015 alone, 118,700 solar home lighting systems were installed, and 46,655 solar street lighting installations were provided under a national program. The same year saw just over 1.4 million solar cookers distributed or sold in India.

DESCRIPTION

The navigation of sun is related to see that solar panel always points toward the sun and which results into maximum power output. The unique feature of this solar tracking system is that instead of taking the earth as its reference, it takes the sun as a guiding source. Its active sensors constantly monitor the sunlight and rotate the panel towards the direction where the intensity of sunlight is maximum.

So, there is a necessity to sense the sun’s radiation and rotate the panel according to it. So, the light dependent resistor’s (L.D.R.) are used do the job of sensing the change in the position of the Sun. These senses from the input from sensor and gives command to the motor to run in order to tackle the change in the position of the sun. By using this system the additional energy generated is around 30% to 35% with very less consumption by the system itself. The project describes the use of a mechanically designed solar tracker. Light dependent resistors are used as the sensors of the solar tracker. The tracking system maximizes solar cell output by positioning a solar panel at the point of maximum light intensity**.**

This paper describe the use of DC motor, to operate moving parts of the solar tracker. The system was designed as the normal line of solar cell always move parallel to the rays of the sun. The Aim of this project is to develop and implement a maximum power output than to the supply. This solar-tracking system is controlled with 12V, 6W DC motor. A single light sensor (LDR) is used to track the sun and to start the operation.

The project concentrates on the design and control the orientation system for the photovoltaic solar panels. The orientation system calculations are based on astronomical data and the system is assumed to be valid for any region with small modifications. The system is designed to control the Altitude angle in the vertical plane as well as the Azimuth angle in the horizontal plane of the photovoltaic panel workspace. And this system is expected to save more than 40% of the total energy of the panels by keeping the panel's face perpendicular to the sun.

The paper discusses the technology options, their current status and opportunities and challenges in developing solar thermal power plants in the context of India. The National Solar Mission is a major initiative of the Government of India and State Governments to promote ecologically sustainable growth while addressing India's energy security challenge. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change.

AIM OF THE PROJECT

The aim of this project is to solve the problem of energy crisis which is considerably serious issue in today's period. It is becoming essential to increase use of renewable sources of energy namely solar energy as compared to conventional sources for energy generation. A technology namely solar tracking system is introduced to improve efficiency of solar cells by tracking sun's energy. It helps to keep the solar photovoltaic panel perpendicular to the sun throughout the year in order to make it more efficient. The axis of solar photovoltaic panel takes astronomical data as reference and the tracking system has the capability to always point the solar array toward the sun and can be installed in various regions with minor modifications. The vertical and horizontal motion of the panel is obtained by taking altitude angle and azimuth angle as reference. The solar tracking system ensures the point to point motion of the DC motors while tracking the sun. It uses stepper motor to move solar panel according to position of sun. Photo resistors are also used to detect light intensity.

CHAPTER 2

SOLAR TRACKING

INTRODUCTION:

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

NEED FOR SOLAR TRACKER

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

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

A tracker rotating in the east-west direction is known as a single-axis tracker.

Direct power lost (%) due to misalignment (angle *i*)

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

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

COMPONENTS IN THIS TRACKING SYSTEM:

The components play a key role in the function of the solar tracking with the use of regulation control in tracking to the Sun’s direction. They are as follows:-

Circuit Components:

- Power diodes, capacitors.
- Indication L.E.D’s, L.D.R., heat sink regulators.

Other Components:

- Solar panel assembly structure containing L.D.R., stepper motor, current supply cable.

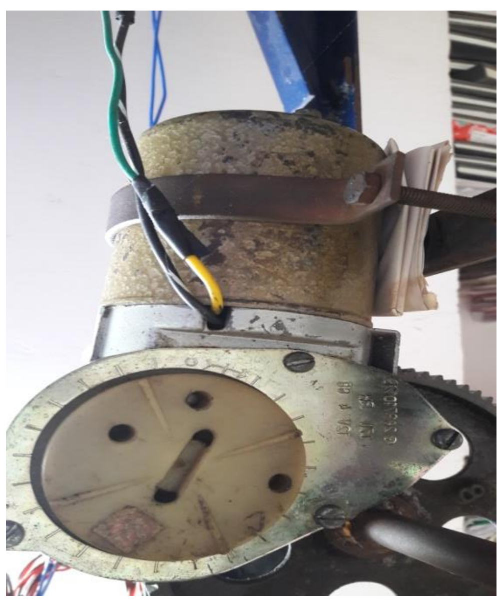
MOTOR SELECTION:

The concept is based on the selection of motor as it is the basis for the tracking system. There are many types of motor can be selected in MMSTS design. Currently, several types of motors being used in the area of MMSTS around the world are: Step-motor, Servo-motor, AC asynchronous motor, permanent magnetic DC servo motor, permanent magnetic brushless synchronous motor, etc.

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

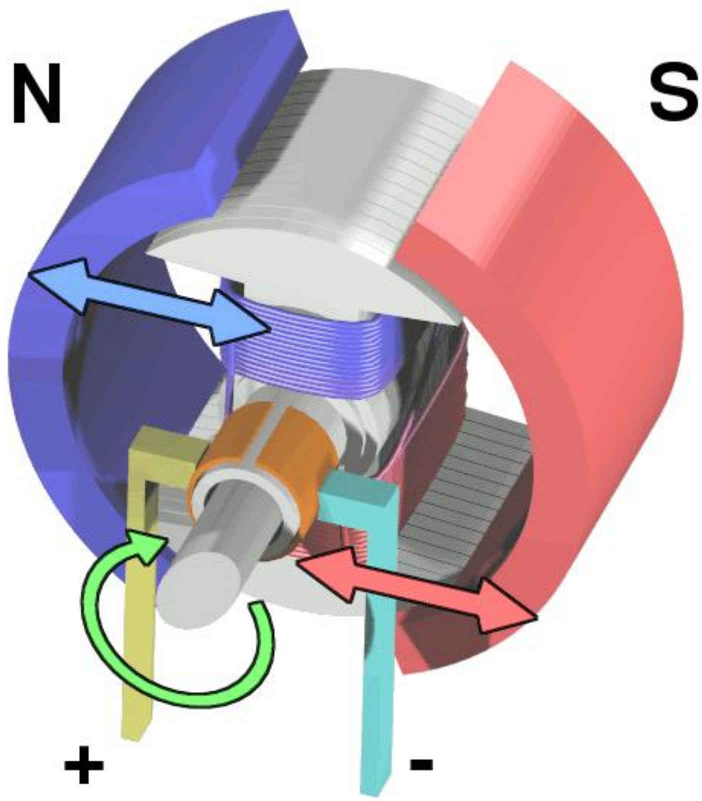
DC motors were the first type widely used, since they could be powered from existing direct current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

There are two types of DC servo-motor: motor with brush and motor without brush. Motor with brush is low in cost, simple in structure, and high in start torque. Also it has wide range of speed adjustment, is easy to control. Though it needs maintenance from time to time, it is very convenient to repair (replace the brush). However it produces electro-magnetic interfere. Motor without brush is small in size, light in weight, high in output, fast in response, small in inertia, smooth in spinning, stable in output torque, low motor maintenance fee, high in efficiency, low in electro-magnetic radiation, long life, and can be applied in different working environments.



Working of a brushed electric motor with a two pole rotor (armature) and permanent magnet stator. "N" and "S" designate polarities on the inside axis faces of the magnets; the outside faces have opposite polarities. The + and- signs show where the DC current is applied to the commutator which supplies current to the armature coils.

A simple DC motor has a stationary set of magnets in the stator and an armature with one or more windings of insulated wire wrapped around a soft iron core that concentrates the magnetic field. The windings usually have multiple turns around the core, and in large motors there can be several parallel current paths. The ends of the wire winding are connected to a commutator. The commutator allows each armature coil to be energized in turn and connects the rotating coils with the external power supply through brushes. (Brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes.)



Typical brushless DC motors use one or more permanent magnets in the rotor and electromagnets on the motor housing for the stator. A motor controller converts DC to AC. This design is mechanically simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. The motor controller can sense the rotor's position via Hall effect sensors or similar devices and can precisely control the timing, phase, etc., of the current in the rotor coils to optimize torque, conserve power, regulate speed, and even apply some braking. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost, and more complicated motor speed controllers. Some such brushless motors are sometimes referred to as "synchronous motors" although they have no external power supply to be synchronized with, as would be the case with normal AC synchronous motors.

AC servo-motor is also a type of motor without brush. There are two types of AC servo-motor: synchronous AC motor and asynchronous AC motor. Currently, synchronous AC motor is generally used in movement control. It can cover a wide power range, which could be up to a very high power level. Nowadays, with the fast development of semiconductor technology, the shift frequency of power assembly, and the processing speed of micro-computer have been increased significantly. Fourthly, the comparison between AC servo-motor and step motor is done.AC servo-motor runs smoothly during low speed period; while step-motor is apt to have low-frequency vibration.

In terms of the frequency-torque Characteristics, the output torque of step-motor decreases with the increasing of rotation speed. Furthermore the decrease is steep in high-speed range. AC servo-motor has a comparably stable output torque, when the rotation speed is within the rated rotation speed. It gives the constant output power when the rotation speed is beyond the rated value.

Step-motor doesn’t have the overload capability; while AC servo-motor posses a satisfactory overload capability. The Panasonic AC servo-system is an example: The maximum output torque is three times big of the rated output torque, which can be used to overcome the inertia load during the start period. As the step-motor doesn’t have the overload capability, a much bigger size of step-motor is needed. Obviously the step-motor will be over-sized during normal operation.

Controller’s type of Step-motor is open-loop type. It is easy to have the error of “step loss” or blockage when the start frequency is high or the load is heavy. Also it is easy to have the error of overshoot when it is stopped. So, to make sure the precision of control be achieved, designer needs to pay more attention to the speed-increase or speed-decrease periods. AC servo-motor system is a closed-loop system. It is possible for the driver-component to sample the signal from the motor encoder to complete a “position cycle” and “speed cycle” internally. As such, AC servo-motor system generally will not have the errors of “step loss” or “overshooting”, and is more reliable in terms of controlling performance.

Step-motor needs 200 to 400 mil-seconds to accelerate from still to a typical working speed of several hundred rpm. AC servo-motor is better in terms of acceleration performance. For example, Panasonic MSMA 400W needs only a few mil-seconds to accelerate from still to its rated speed of 3000RPM. So it is clear that step-motor’s performance is not so good. However it’s cheaper. Started from late 70s and early 80s, with the development of micro-process technology, high-power, high-performance semiconductor technology, and manufacturing technology of permanent magnetic material, the performance price ratio of AC servo-system has been improved significantly. Price of AC servo-system also is gradually deceasing in recent years. AC servo motor is becoming the dominant product.

The conclusion is that all the motors, step-motor, AC asynchronous motor, DC motor with/without brush, AC servo-motor, can be applied in MMSTS. Asynchronous AC motor is the cheapest. But it is big in size, and low in technical specification. The step-motor has a simple controlling mode and is also low in price. AC servo-motor has the best performance and wide power range. Its price is also the highest. As for the performance and price for permanent magnetic DC brushless motor, they are both rated between step-motor and AC servo-motor. Its performance is close to servomotor. For the situations that the output torque is not very high (less than 2 NM), permanent magnetic DC brushless motor is a good option.

PHOTODIODE:

A photodiode is a semiconductor device that converts light into current. The current is generated when photons are absorbed in the photodiode. A small amount of current is also produced when no light is present. Photodiodes may contain optical filters, built-in lenses, and may have large or small surface areas. Photodiodes usually have a slower response time as their surface area increases. The common, traditional solar cell used to generate electric solar power is a large area photodiode.

Photodiodes are similar to regular semiconductor diodes except that they may be either exposed (to detect vacuum UV or X-rays) or packaged with a window or optical fiber connection to allow light to reach the sensitive part of the device. Many diodes designed for use specifically as a photodiode use a PIN junction rather than a p–n junction, to increase the speed of response. A photodiode is designed to operate in reverse bias.

SOLAR PANEL:

Solar panel(8x9 cells)

Solar Panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating.

A photovoltaic (PV) module is a packaged, connect assembly of typically 6×10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 watts.

The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few commercially available solar modules that exceed 22% efficiency and reportedly also exceeding 24%. A single solar module can produce only a limited amount of power; most installations contain multiple modules.

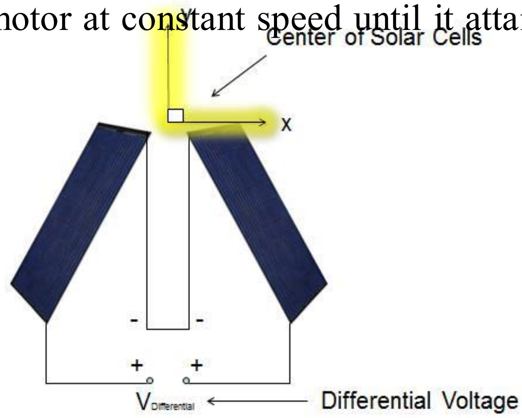
A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism.

CHAPTER 3

WORKING MMSST:

Principle:

The basic principle involved in the design of this system are L.D.R., motor specifications and their operation depends upon the intensity of light that incidents on the solar panel. These L.D.R. gives a signal to the P.C.B. board and sends the information to run the motor at constant speed until it attains the incidence of sun’s radiation.



Sun Tracking System (STS)

Sunlight has two components, the "direct beam" that carries about 90% of the solar energy, and the "diffuse sunlight" that carries the remainder - the diffuse portion is the blue sky on a clear day and increases proportionately on cloudy days. As the majority of the energy is in the direct beam, maximizing collection requires the Sun to be visible to the panels as long as possible.

The energy contributed by the direct beam drops off with the cosine of the angle between the incoming light and the panel. In addition, the reflectance (averaged across all polarizations) is approximately constant for angles of incidence up to around 50°, beyond which reflectance degrades rapidly.

i	Lost = 1 - cos(*i*)	*i*	Hours	Lost
0°	0%	15°	1	3.4%
1°	0.015%	30°	2	13.4%
3°	0.14%	45°	3	30%
8°	1%	60°	4	>50%[8]
23.4°[9]	8.3%	75°	5	>75%[8]

Direct power lost (%) due to misalignment (angle *i*)

For example, trackers that have accuracies of ± 5° can deliver greater than 99.6% of the energy delivered by the direct beam plus 100% of the diffuse light. As a result, high accuracy tracking is not typically used in non- concentrating PV applications.

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

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

Generally speaking, the losses due to seasonal angle changes is complicated by changes in the length of the day, increasing collection in the summer in northern or southern latitudes. This biases collection toward the summer, so if the panels are tilted closer to the average summer angles, the total yearly losses are reduced compared to a system tilted at the spring/fall solstice angle (which is the same as the site's latitude).

Types of solar collector:

Different types of solar collector and their location (latitude) require different types of tracking mechanism. Solar collectors may be:

- non-concentrating flat-panels, usually photovoltaic or hot-water,
- concentrating systems, of a variety of types.

Solar collector mounting systems may be fixed (manually aligned) or tracking. Tracking systems may be configured as:

- Fixed collector / moving mirror - i.e. Heliostat
- Moving collector

Fixed collector / moving mirror

Main article: Heliostat

Many collectors cannot be moved, for example high-temperature collectors where the energy is recovered as hot liquid or gas (e.g. steam). Other examples include direct heating and lighting of buildings and fixed in-built solar cookers, such as Scheffler reflectors. In such cases it is necessary to employ a moving mirror so that, regardless of where the Sun is positioned in the sky, the Sun's rays are redirected onto the collector.

Due to the complicated motion of the Sun across the sky, and the level of precision required to correctly aim the Sun's rays onto the target, a heliostat mirror generally employs a dual axis tracking system, with at least one axis mechanized. In different applications, mirrors may be flat or concave.

Moving collector

Trackers can be grouped into classes by the number and orientation of the tracker's axes. Compared to a fixed mount, a single axis tracker increases annual output by approximately 30%, and a dual axis tracker an additional 6%.

Photovoltaic trackers can be classified into two types: standard photovoltaic (PV) trackers and concentrated photovoltaic (CPV) trackers. Each of these tracker types can be further categorized by the number and orientation of their axes, their actuation architecture and drive type, their intended applications, their vertical supports and foundation

Non-concentrating photovoltaic (PV) trackers:

Photovoltaic panels accept both direct and diffuse light from the sky. The panels on standard photovoltaic trackers always gather the available direct light. The tracking functionality in standard photovoltaic trackers is used to minimize the angle of incidence between incoming light and the photovoltaic panel. This increases the amount of energy gathered from the direct component of the incoming sunlight.

The physics behind standard photovoltaic (PV) trackers works with all standard photovoltaic module technologies. These include all types of crystalline silicon panels (either mono-Si, or multi-Si) and all types of thin film panels (amorphous silicon, CdTe, CIGS, microcrystalline).

Concentrator photovoltaic (CPV) trackers:

The optics in CPV modules accept the direct component of the incoming light and therefore must be oriented appropriately to maximize the energy collected. In low concentration applications a portion of the diffuse light from the sky can also be captured. The tracking functionality in CPV modules is used to orient the optics such that the incoming light is focused to a photovoltaic collector.

CPV modules that concentrate in one dimension must be tracked normal to the Sun in one axis. CPV modules that concentrate in two dimensions must be tracked normal to the Sun in two axes.

Single axis trackers:

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). The orientation of the module with respect to the tracker axis is important when modeling performance.

Horizontal:

Horizontal single axis tracker (HSAT):

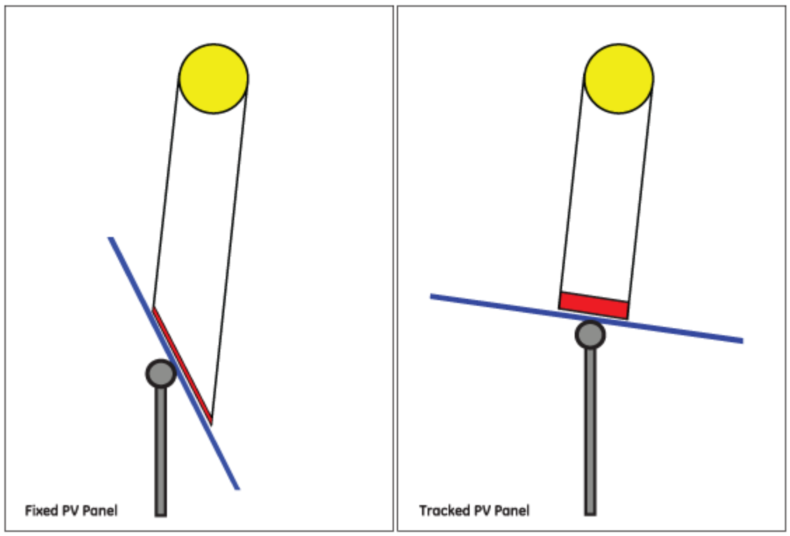
4MW horizontal single axis tracker

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. 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.

Vertical:

Vertical single axis tracker (VSAT):

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 utilization. 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.



Single axis solar tracker

Dual axis trackers:

Dual axis trackers have two degrees of freedom that act as axes of rotation. These axes are typically normal to one another. The axis that is fixed with respect to the ground can be considered a primary axis. The axis that is referenced to the primary axis can be considered a secondary axis. There are several common implementations of dual axis trackers. They are classified by the orientation of their primary axes with respect to the ground. Two common implementations are tip-tilt dual axis trackers (TTDAT) and azimuth-altitude dual axis trackers (AADAT). The orientation of the module with respect to the tracker axis is important when modeling performance. Dual axis trackers typically have modules oriented parallel to the secondary axis of rotation. Dual axis trackers allow for optimum solar energy levels due to their ability to follow the Sun vertically and horizontally. No matter where the Sun is in the sky, dual axis trackers are able to angle themselves to be in direct contact with the Sun.

Tip–tilt:

Dual axis tracker mounted on a pole.

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.

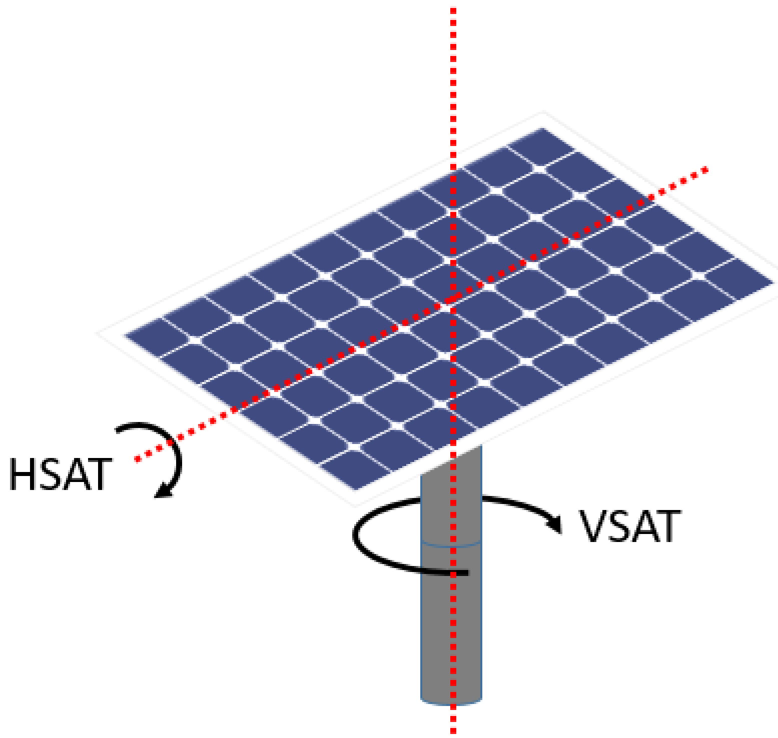
Other such TTDAT trackers have a horizontal primary axis and a dependent orthogonal axis. The vertical azimuthal axis is fixed. This allows for great flexibility of the payload connection to the ground mounted equipment because there is no twisting of the cabling around the pole.

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 in order 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.[24]

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.

Azimuth-altitude:

An azimuth–altitude 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 de



Dual axis solar tracker

CONTROL SYSTEMS IN SOLAR TRACKING SYSTEM:

There are mainly two types of control approach:

- Automatic Control
- Manual Control

Automatic/Self Control

The name itself gives a brief description that it is operated by having a program of instructions that are commonly fed into the system with use of software in computer.

With the help of an efficient algorithm (written in C) only one Master Microcontroller1 is being used to manage the automatic operation of this solar tracking is done. This controller has following functions:

• Senses all of six sensors.

• Drives stepper motor.

• Drives LCD.

• Controls the warning indicators e.g. buzzer, LED's etc.

• Communicates (by parallel port) with the slave microcontroller. The central driving components of automatic control are only six sensors. Their operation has been explained on the previous page.

Manual Control

The word says a view that the man interference is possible in some of the cases. As they may not be in control in the automatic machine structure. As no human made system is so perfect so an unpredictable fault may occur in the any system. That is why a manual control option was also introduced as their will be a frequent inspection of the device. While designing this part of control two objectives were kept in mind:

• The manual control should work efficiently.

• It should be as user friendly as possible. Following two approaches have been used to accomplish the manual control.

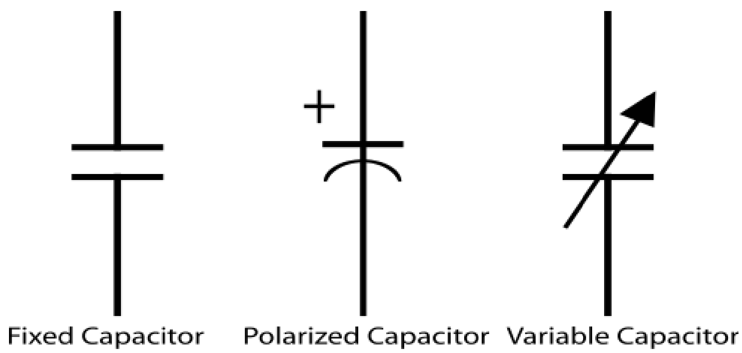
COMPONENTS IN BRIEF:

Capacitor:

The capacitance of a capacitor is proportional to the surface area of the plates (conductors) and inversely related to the gap between them. In practice, the dielectric between the plates passes a small amount of leakage current. It has an electric field strength limit, known as the breakdown voltage. The conductors and leads introduce an undesired inductance and resistance. Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In resonant circuits they tune radios to particular frequencies. In electric power transmission systems, they stabilize voltage and power flow. The property of energy storage in capacitors was exploited as dynamic memory in early digital computers.

A capacitor is a passive two-terminal electrical component that stores electrical energy in an electric field. The effect of a capacitor is known as capacitance. While capacitance exists between any two electrical conductors of a circuit in sufficiently close proximity, a capacitor is specifically designed to provide and enhance this effect for a variety of practical applications by consideration of size, shape, and positioning of closely spaced conductors, and the intervening dielectric material. A capacitor was therefore historically first known as an electric condenser.

An ideal capacitor is sufficiently characterized by a constant capacitance *C*, defined as the ratio of a positive or negative charge *Q* on each conductor to the voltage *V* between them.



The physical form and construction of practical capacitors vary widely and many capacitor types are in common use. Most capacitors contain at least two electrical conductors often in the form of metallic plates or surfaces separated by a dielectric medium. A conductor may be a foil, thin film, sintered bead of metal, or an electrolyte. The nonconducting dielectric acts to increase the capacitor's charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, paper, mica, and oxide layers. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy.

When two conductors experience a potential difference, for example, when a capacitor is attached across a battery, an electric field develops across the dielectric, causing a net positive charge to collect on one plate and net negative charge to collect on the other plate. No current actually flows through the dielectric, instead, the effect is a displacement of charges through the source circuit. If the condition is maintained sufficiently long, this displacement current through the battery ceases. However, if a time-varying voltage is applied across the leads of the capacitor, the source experiences an ongoing current due to the charging and discharging cycles of the capacitor.

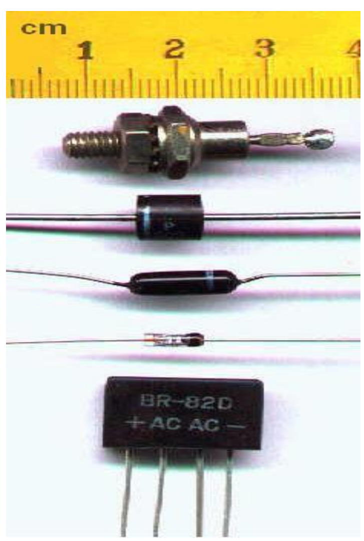
Resistor:

A resistor is a passive two terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors as discrete components can be composed of various compounds and forms. Resistors are also implemented within integrated circuits. The electrical function of a resistor is specified by its resistance: common commercial resistors are manufactured over a range of more than nine orders of magnitude. The nominal value of the resistance falls within the manufacturing tolerance, indicated on the component.

Diode:

In electronics, a diode is a two terminal electronic component that conducts primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance to the current in one direction, and high (ideally infinite) resistance in the other. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals.A vacuum tube diode has two electrodes, a plate (anode) and a heated cathode. Semiconductor diodes were the first semiconductor electronic devices. The discovery of crystals' rectifying abilities was made by German physicist Ferdinand Braun in 1874. The first semiconductor diodes, called cat's whisker diodes, developed around 1906, were made of mineral crystals such as galena.
Today, most diodes are made of silicon, but other semiconductors such as selenium and germanium are sometimes used.



The most common function of a diode is to allow an electric current to pass in one direction (called the diode's *forward* direction), while blocking current in the opposite direction (the *reverse* direction). Thus, the diode can be viewed as an electronic version of a check valve. This unidirectional behavior is called rectification, and is used to convert alternating current (AC) to direct current (DC), including extraction of modulation from radio signals in radio receivers—these diodes are forms of rectifiers.

However, diodes can have more complicated behavior than this simple on– off action, because of their nonlinear current voltage characteristics. Semiconductor diodes begin conducting electricity only if a certain threshold voltage or cutin voltage is present in the forward direction (a state in which the diode is said to be *forward biased*).

The voltage drop across a forward biased diode varies only a little with the current, and is a function of temperature; this effect can be used as a temperature sensor or as a voltage reference.

A semiconductor diode's current–voltage characteristic can be tailored by selecting the semiconductor materials and the doping impurities introduced into the materials during manufacture. These techniques are used to create special purpose diodes that perform many different functions. For example, diodes are used to regulate voltage (Zener diodes), to protect circuits from high voltage surges (avalanche diodes), to electronically tune radio and TV receivers (varactor diodes), to generate radiofrequency oscillations (tunnel diodes, Gunn diodes, IMPATT diodes), and to produce light (lightemitting diodes). Tunnel, Gunn and IMPATT diodes exhibit negative resistance, which is useful in microwave and switching circuits. Diodes, both vacuum and semiconductor, can be used as shotnoise generators.

Electric motor:

An electric motor is an electrical machine that converts electrical energy into mechanical energy. The reverse of this is the conversion of mechanical energy into electrical energy and is done by an electric generator. In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes to also produce electrical energy from mechanical energy. Found in applications as diverse as industrial fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives, electric motors can be powered by direct current (DC) sources, such as from batteries, motor vehicles or rectifiers, or by alternating current (AC) sources, such as from the power grid, inverters or generators. Small motors may be found in electric watches. General purpose motors with highly standardized dimensions and characteristics provide convenient mechanical power for industrial use. The largest of electric motors are used for ship propulsion, pipeline compression and pumped storage applications with ratings reaching 100 megawatts. Electric motors may be classified by electric power source type, internal construction, application, type of motion output, and so on. Electric motors are used to produce linear or rotary force (torque), and should be distinguished from devices such as magnetic solenoids and loudspeakers that convert electricity into motion but do not generate usable mechanical powers, which are respectively referred to as actuators and transducers.

Motor Construction:

Rotor:

In an electric motor the moving part is the rotor which turns the shaft to deliver the mechanical power. The rotor usually has conductors laid into it which carry currents that interact with the magnetic field of the stator to generate the forces that turn the shaft. However, some rotors carry permanent magnets, and the stator holds the conductors.

Stator:

The stator is the stationary part of the motor’s electromagnetic circuit and usually consists of either windings or permanent magnets. The stator core is made up of many thin metal sheets, called laminations. Laminations are used to reduce energy losses that would result if a solid core were used.

Air gap:

The distance between the rotor and stator is called the air gap. The air gap has important effects, and is generally as small as possible, as a large gap has a strong negative effect on the performance of an electric motor. It is the main source of the low power factor at which motors operate. The air gap increases the magnetizing current needed. For this reason air gap should be minimum. Very small gaps may pose mechanical problems in addition to noise and losses.

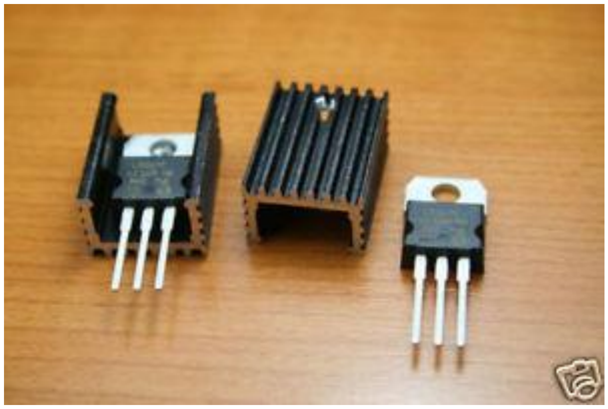
Windings:

Windings are wires that are laid in coils, usually wrapped around a laminated soft iron magnetic core so as to form magnetic poles when energized with current. Electric machines come in two basic magnet field pole configurations:

Salient pole machine and non salient pole machine.

In the salient pole machine the pole's magnetic field is produced by a winding wound around the pole below the pole face. In the non salient pole, or distributed field, or round rotor, machine, the winding is distributed in pole face slots. A shaded pole motor has a winding around part of the pole that delays the phase of the magnetic field for that pole.

Heat sink:



Heat Sink Regulator

A heat sink (also commonly spelled heat sink) is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant, where it is dissipated away from the device, thereby allowing regulation of the device's temperature at optimal levels. In computers, heat sinks are used to cool central processing units or graphics processors. Heat sinks are used with high power semiconductor devices such as power transistors and optoelectronics such as lasers and light emitting diodes (LEDs), where the heat dissipation ability of the component itself is insufficient to moderate its temperature.

A heat sink is designed to maximize its surface area in contact with the cooling medium surrounding it, such as the air. Air velocity, choice of material, protrusion design and surface treatment are factors that affect the performance of a heat sink.

Heat sink attachment methods and thermal interface materials also affect the die temperature of the integrated circuit. Thermal adhesive or thermal grease improve the heat sink's performance by filling air gaps between the heat sink and the heat spreader on the device. A heat sink is usually made out of copper and/or aluminium. Copper is used because it has many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity allows heat to pass through it quickly. Aluminum is used in applications where weight is a big concern.

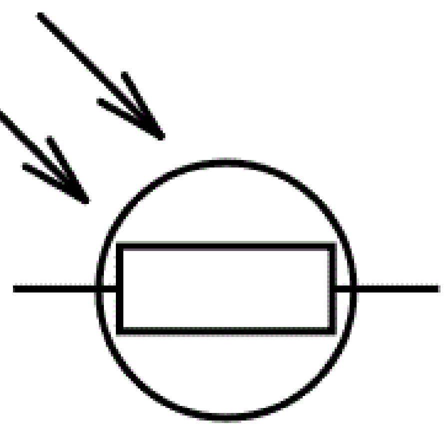
Heat transfer principle:

A heat sink transfers thermal energy from a higher temperature device to a lower temperature fluid medium. The fluid medium is frequently air, but can also be water, refrigerants or oil. If the fluid medium is water, the heat sink is frequently called a cold plate. In thermodynamics a heat sink is a heat reservoir that can absorb an arbitrary amount of heat without significantly changing temperature. Practical heat sinks for electronic devices must have a temperature higher than the surroundings to transfer heat by convection, radiation, and conduction. The power supplies of electronics are not 100% efficient, so extra heat is produced that may be detrimental to the function of the device. As such, a heat sink is included in the design to disperse heat to improve efficient energy use.

To understand the principle of a heat sink, consider Fourier's law of heat conduction. Fourier's law of heat conduction, simplified to a one dimensional form in the *x*-direction, shows that when there is a temperature gradient in a body, heat will be transferred from the higher temperature region to the lower temperature region. The rate at which heat is transferred by conduction, , is proportional to the product of the temperature gradient and the cross sectional area through which heat is transferred.

LDR:-

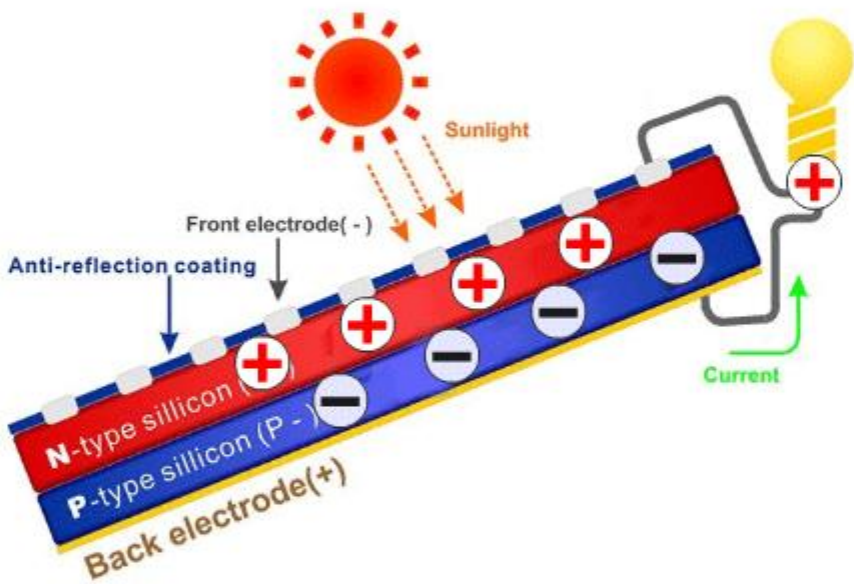
A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a LDR, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.



Working Principle of LDR:

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

Photo-Voltaic:-



The photovoltaic effect is the creation of voltage or electric current in a material upon exposure to light and is a physical and chemical property/phenomenon.

The photovoltaic effect is closely related to the photoelectric effect. In either case, light is absorbed, causing excitation of an electron or other charge carrier to a higher-energy state. The main distinction is that the term photoelectric effect is now usually used when the electron is ejected out of the material (usually into a vacuum) and photovoltaic effect used when the excited charge carrier is still contained within the material. In either case, an electric potential (or voltage) is produced by the separation of charges, and the light has to have a sufficient energy to overcome the potential barrier for excitation. The physical essence of the difference is usually that photoelectric emission separates the charges by ballistic conduction and photovoltaic emission separates them by diffusion, but one should note that some "hot carrier" photovoltaic device concepts blur even this line of distinction.

CONCEPTS ON SOLAR RADIATION:

Solar irradiance:

Solar irradiance is the power per unit area received from the Sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument. Irradiance may be measured in space or at the Earth's surface after atmospheric absorption and scattering. It is measured perpendicular to the incoming sunlight.

Total solar irradiance (TSI), is a measure of the solar power over all wavelengths per unit area incident on the Earth's upper atmosphere. The solar constant is a conventional measure of mean TSI at a distance of one astronomical Unit (AU). Irradiance is a function of distance from the Sun, the solar cycle, and cross cycle changes. Irradiance on Earth is also measured perpendicular to the incoming sunlight. Insolation is the power received on Earth per unit area on a horizontal surface. It depends on the height of the Sun above the horizon.

Before talking about the solar tracking systems, we will review some basic concepts concerning solar radiation and mention some important values to better understand the results of this work.

The sun, at an estimated temperature of 5800 K, emits high amounts of energy in the form of radiation, which reaches the planets of the solar system. Sunlight has two components, the direct beam and diffuse beam. Direct radiation (also called beam radiation) is the solar radiation of the sun that has not been scattered (causes shadow). Direct beam carries about 90% of the solar energy, and the "diffuse sunlight" that carries the remainder. The diffuse portion is the blue sky on a clear day and increases as a proportion on cloudy days.

The diffuse radiation is the sun radiation that has been scattered (complete radiation on cloudy days). Reflected radiation is the incident radiation (beam and diffuse) that has been reflected by the earth. The sum of beams, diffuse and reflected radiation is considered as the global radiation on a surface. As the majority of the energy is in the direct beam, maximizing collection requires the sun to be visible to the panels as long as possible.

Insolation

The solar irradiance integrated over time is called solar irradiation, solar exposure or insolation. However, insolation is often used interchangeably with irradiance in practice. Earth's atmosphere at any point in time is roughly 1366 watts per square meter. The Sun's rays are attenuated as they pass through the atmosphere, thus reducing the irradiance at the Earth's surface to approximately 1000 W m^{-2} for a surface perpendicular to the Sun's rays at sea level on a clear day. The insolation of the sun can also be expressed in Suns, where one Sun equals 1000 W/m^2

Units

The SI unit of irradiance is watt per square meter (W/m2). An alternate unit of measure is the Langley (1 thermochemical calorie per square centimeter or 41,840 J/m2) per unit time. The solar energy industry uses watt hour per square metre (Wh/m2) per unit time, the relation to the SI unit is thus 1 kW/m2 = 24 kWh/m2/day = 8760 kWh/m2/year. Irradiance can also be expressed in Suns, where one Sun equals 1000 W/m2 at the point of arrival.

Absorption and reflection

Part of the radiation reaching an object is absorbed and the remainder reflected. Usually the absorbed radiation is converted to thermal energy, increasing the object's temperature. Manmade or natural systems, however, can convert part of the absorbed radiation into another form such as electricity or chemical bonds, as in the case of

photovoltaic cells or plants. The proportion of reflected radiation is the object's reflectivity or albedo.

Projection effect

This 'projection effect' is the main reason why the Polar Regions are much colder than equatorial regions on Earth. On an annual average the poles receive less insolation than does the equator, because at the poles the Earth's surface are angled away from the Sun.

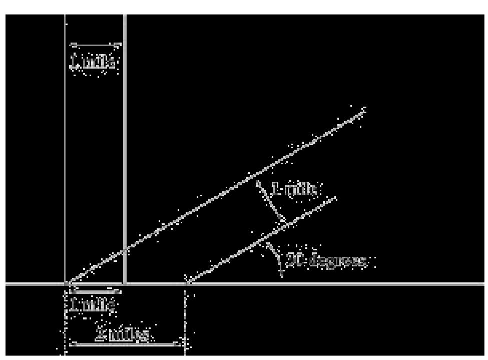


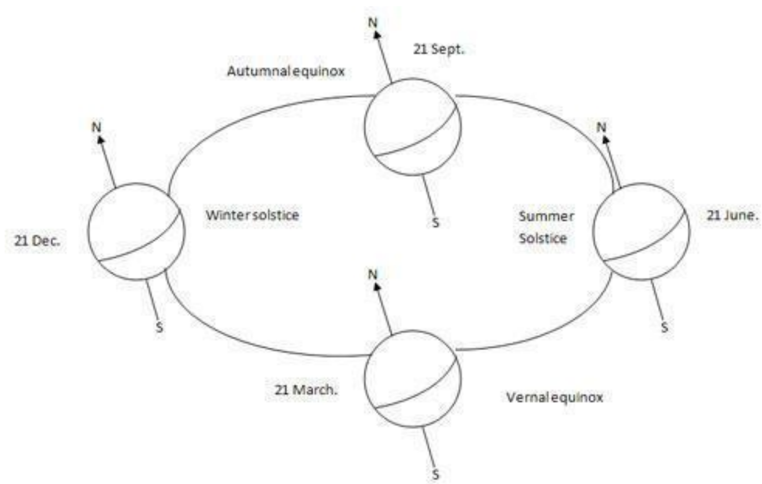
Figure One beam one mile wide shines on the ground at a 90° angle, and another at a 30° angle. The one at a shallower angle distributes the same amount of light energy over twice as much area.

Angular Effect:

The declination of the sun is the angle between the equator and a line drawn from the centre of the Earth to the centre of the sun. The declination is maximum (23.45^0) on the summer/winter (in India 21 June and 22 December) The declination angle, denoted by ä, varies seasonally due to the tilt of the Earth on its axis of rotation and the rotation of the Earth around the sun.

If the Earth were not tilted on its axis of rotation, the declination would always be 0°. However, the Earth is tilted by 23.45° and the declination angle varies plus or minus this amount. Only at the spring and fall equinoxes is the declination angle equal to 0°.

The Declination Angles



Hour Angle:

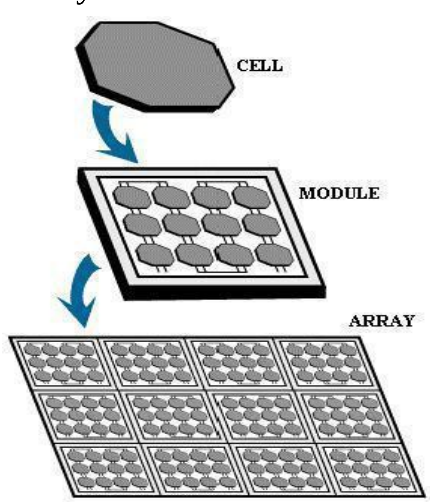
The Hour Angle is the angular distance that the earth has rotated in a day. It is equal to 15 degrees multiplied by the number of hours from local solar noon. This is based on the nominal time, 24 hours, required for the earth to rotate once i.e. 360 degrees.

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

WORKING OF PHOTOVOLTAICS

Photovoltaics are the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity.

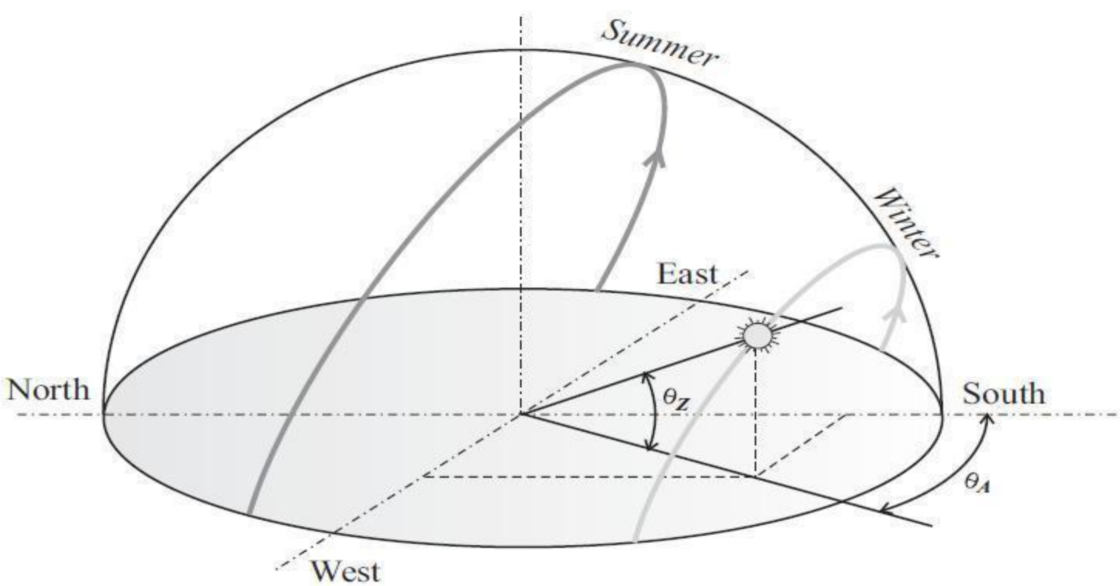
A solar cell (also called photovoltaic cell or photoelectric cell) is a solid state electrical device that converts the energy of light directly into electricity by the photovoltaic effect. Crystalline silicon PV cells are the most common photovoltaic cells in use today.



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

ROTATTION DURING SEASONS:

The figure shows a typical behavior for the sun path in December (winter) and June (summer). The rotational angle of the orientation system in the vertical plane can be calculated from the following equation



Typical behavior for the sun path in December (winter) and June (summer)

$Sin\theta = Sin\Phi . Sin\delta + Cos\Phi . Cos\delta . Cos\omega$

Where

θz^{o} is the altitude angle of the system.

θz □90^{o}-Zenith angle of the sun

Φ is the latitude ($\Phi = 30^{o}$ for our example)

ω is the hour angle(15 ^{o}/hour), where $\omega = 0$ at local noon.

δ is the solar declination.

the δ is calculated from Cooper's equation.

$\delta = 23.45 . Sin[360/ 365(284 + N)]$

Here, N is the day of the year (1 to 365),

N=1 on the 1st of January

The rotational angle of the system in the horizontal plane ($\grave{e}_A$) is calculated from the equation:

where

$$Sin\theta_A = Cos\delta . Sin\omega / Cos\theta_Z$$

θ_A is the azimuth angle of the system.

KINEMATICS

Earth receives energy of 1000w/m^2 which means we can generate 1000 watts of energy from 1m^2 area. If we assume a 10% total efficiency of the photovoltaic panels, the predicted output power from the panel will be 100 Watt. Although, it is known that there are panels with higher efficiency but it is preferable to calculate for the least case. Earth complete its one rotation around its axis in 24 hours which means that it rotate by 360 degrees in 24 hour or one day. Therefore one hour cover $360^0/24=15^0$, which means one hour angle $=15^0$. The system can be designed to move discretely to cover the total daily track in desired steps to reduce the operating time. After sunset, the panel can be designed to return back pointing towards the east to collect the sun radiation next morning. This return process can be done in desired time interval. While the maximum needed power is required by the motors forms 1% of the output of the panel. So it is feasible to rotate the panel using electric motors fed by the output of the panel itself.

DYNAMICS

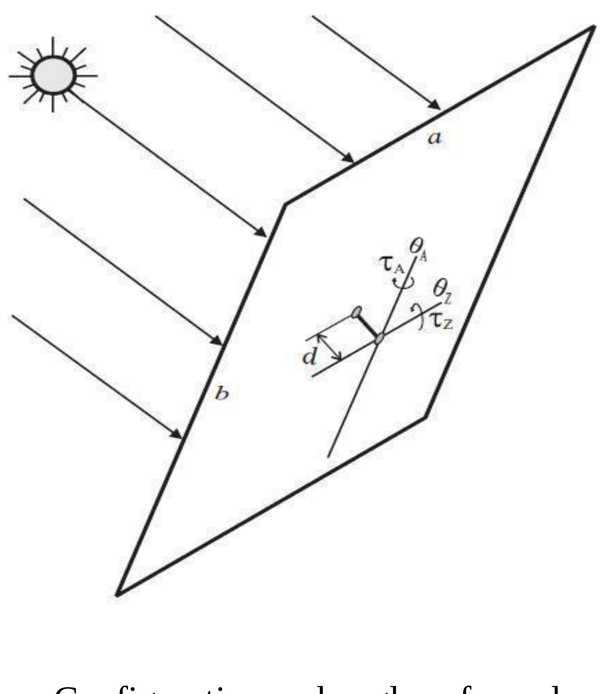
The solar array can be rotated in two directions, horizontal and vertical direction by taking azimuth and inclination angle as reference.

Two control techniques can be applied here:

Open-loop control technique that depends on calculating the voltage corresponding to the output angles and feeding them into the DC motors (to which our work is concerned).

Closed-loop technique which depends mainly on the signals sent by the two solar tracking sensors attached at the surface of the panel. The function of these sensors is to detect the position of the sun and feed the signal back to the electronic control circuit which in turn sends the signals to the motor to correct the real position of the panel perpendicular to the sun.

Each technique has its advantages and drawbacks, where the open-loop technique is safe and continuous but it needs to keep the motors operating all the time even when there is no sun in the cloudy days. The closed-loop technique saves power because it turns the motors on when the sun is shining only, while the system stops working in cloudy periods. The main disadvantage of the closed-loop technique is that it is expensive to be applied that it needs sensors, electronics and control kits. A timer can be used to return the whole system pointing towards the east after sunset to put the panel in a ready position facing the sun in the next morning. Consider the solar panel drawing shown in Fig. 3.4. In this drawing, *a* and *b* are the dimensions of the rectangular plate panel, *d* is the perpendicular distance from the center of gravity of the panel to the point of action of the rotating motor. èz and è$_A$ are the Altitude and Azimuth angles, respectively. □$_A$ and□$_B$ are the torques produced by the motors around the Altitude and the Azimuth directions respectively. These torqueses are responsible for the rotation of the two degrees of freedom of the system.



Configuration and angles of panel

θz^{o} is the altitude angle of the system.

$\theta z = 90^{o}$-Zenith angle of the sun

Φ is the latitude ($\Phi = 30^{o}$ for our example)

ω is the hour angle (15^{o}/hour), where $\omega = 0$ at local noon.

δ is the solar declination.

where δ is calculated from Cooper's equation.

CHAPTER 4

PROJECT WORK:

The project work is about to have the best use in tracking the solar panel in the direction of sun. This will be only attained in the best function and utilization of the components to have a better power output.

DESIGN COMPONENTS:

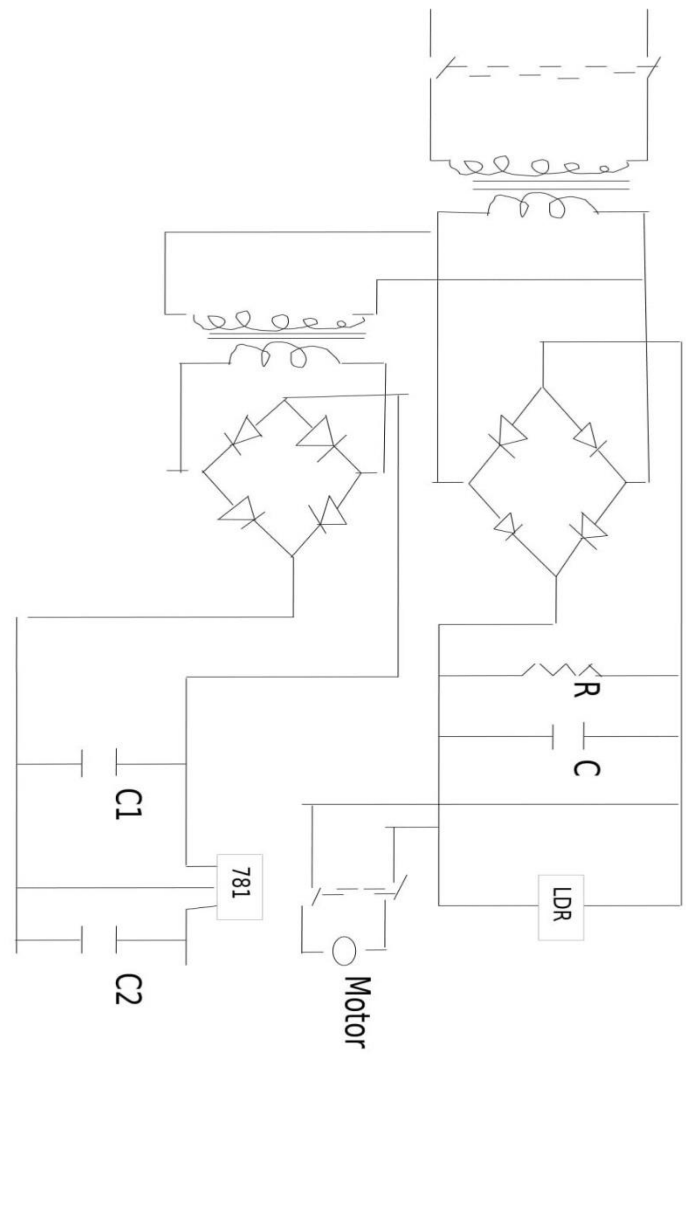
The components used in this project are as follows:

1. Solar Panel(8x9 cells)
2. D.C. Motor 17W,12V
3. Tower Stand (iron 3-4ft)
4. L.D.R.
5. Three way switch (10Amp-250V)
6. 2 External Spur Gears
7. 15V, 1.5 Amp transformer and 9V, 1 Amp transformer
8. 1N 4007 power diodes
9. 2200 micro faraday,22V Capacitor
10. 7812 Heat Sink Regulator
11. Resistor 86 ohms
12. Two P.C.B. Boards

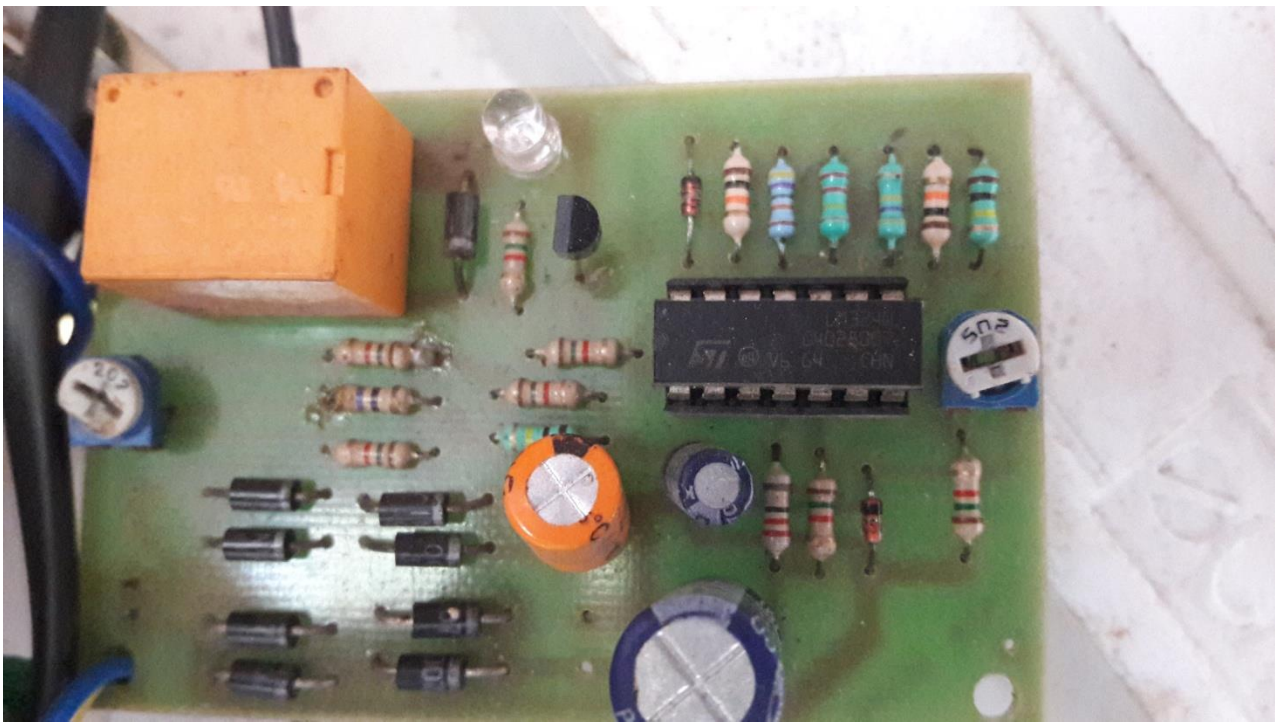
FIGURE:

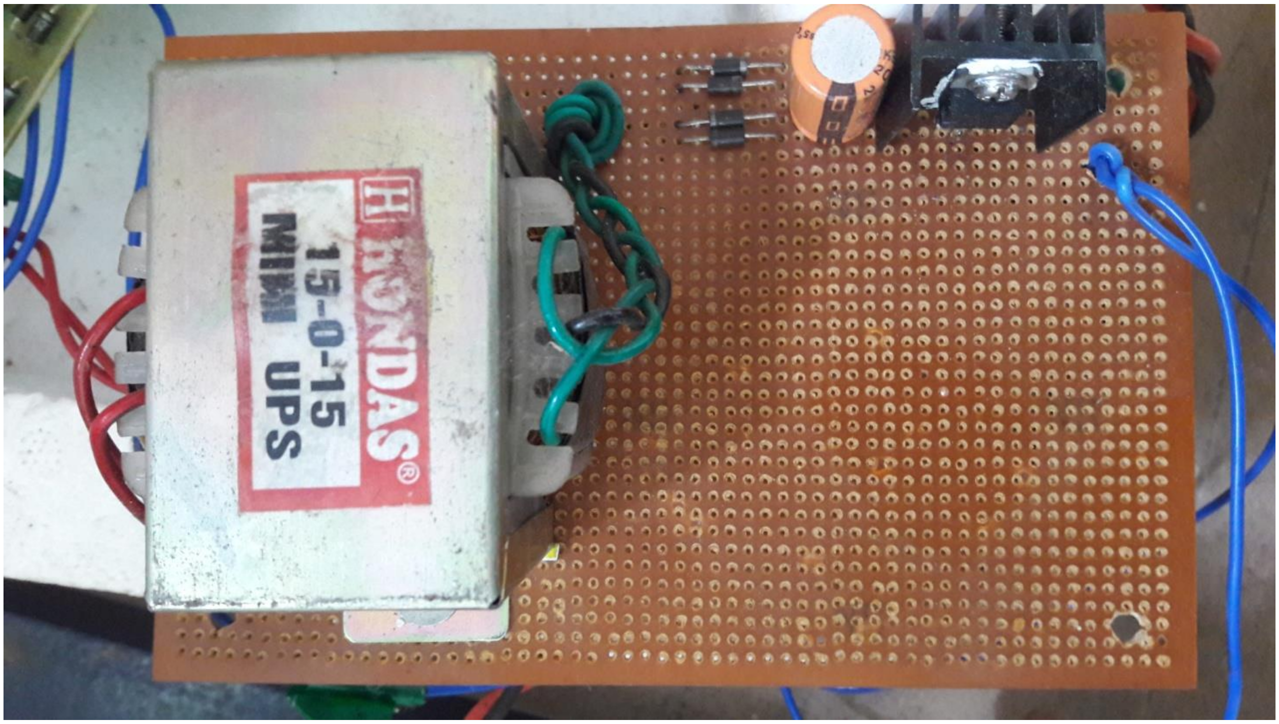
Circuits Diagrams:

Outline:



Diagrams:



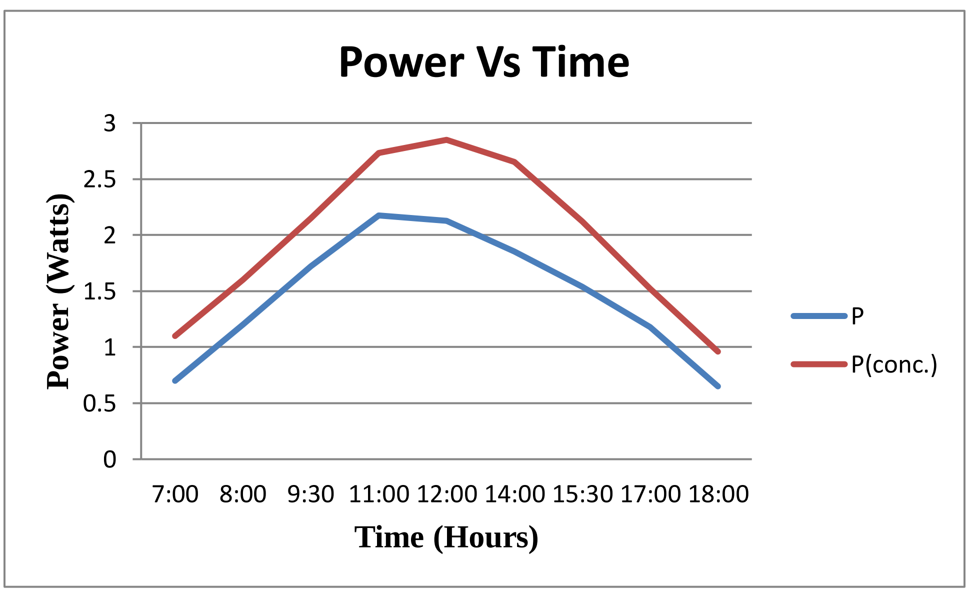


Experimental Values:

Variation of Maximum Power output with time with tracking and concentrator:

Sno.	Time	P	P(conc.)
1	07:00	0.7	1.1
2	08:00	1.2	1.6
3	09:30	1.72	2.15
4	11:00	2.175	2.73
5	12:00	2.125	2.85
6	14:00	1.854	2.65
7	15:30	1.537	2.12
8	17:00	1.18	1.52
9	18:00	0.65	0.96

Graph:



Power Vs Time
Power (Watts)
3
2.5
2
1.5
1
0.5
0
7:00
8:00
9:30
11:00
12:00
14:00
15:30
17:00
18:00
Time (Hours)
P
P(conc.)

CONCLUSION

This paper deals with the design and execution of a solar tracker system dedicated to the PV conversion panels. The proposed single axis solar tracker device ensures the optimization of the conversion of solar energy into electricity by properly orienting the PV panel in accordance with the real position of the sun. The operation of the experimental model of the device is based on a DC motor intelligently controlled by a dedicated drive unit that moves a mini PV panel according to the signals received from two simple but efficient light sensors. The performance and characteristics of the solar tracker are experimentally analyzed.

Thus the tracking is done to have a more efficient power as an output so, that the usage of power to run the motor will be less than that of the output power. So, the single axis solar tracking system is used where the mobility of the device on which this system was mounted was zero or less.

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