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Fabrication and Analysis of Solar Tracking Device without External Power Consumption

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Abstract - A photovoltaic conversion panel is planned to be employed in a solar tracker system controlled by a microcontroller. Our aim is to design a single axis solar tracker is self-power tracker system. The sun is tracked by the tracker and its position is changed in such a way that it maximizes the power output. The solar panel is rotate by two geared DC motors so that sun's light is able to remain aligned with the solar panel. The power supply by the solar tracking system model is separate fixed solar panel arrangement. The experiment device's operation is based on a DC motor that is intelligently controlled by a dedicated drive till it moves a tiny photovoltaic panel, and the existence of two simple but effective light sensors that receive signals from a microcontroller. The solar tracker device's performance and attributes are investigated experimentally.

***Key Words*:** Solar Panel, Microcontroller, Relay, Limit switch, LDR.

1.INTRODUCTION

Many homes throughout the world have employed electric solar systems as a backup power source in the last ten years. This is because solar energy is a limitless energy source that is expected to become more essential in the long run for supplying power and heat to users. Solar energy has the potential to become the primary source of energy in the future. A solar tracker is an automated solar panel that tracks the Sun to maximise power output. The position of the sun in the sky varies with equipment as well as any permanent point. The heliostat, a moveable mirror that reflects the moving sun to a fixed place, is one well-known type of solar tracker, although there are many others Active trackers use motors and gear trains to drive the tracker in response to the solar direction, which is commanded by a controller. Solar cells, solar day-lighting systems, and solar thermal arrays are only some of the applications for the solar tracker. The solar tracker is ideal for devices such as solar cells that require more sunshine for increased efficiency. Many of the solar panels were mounted on a permanent structure, such as a roof. This strategy is not the greatest because the sun is a moving object. One alternative is to actively track the sun by moving the solar panel to follow the Sun using a sun tracking system. When the Sun is always shining on the panel, the maximum amount of energy may be absorbed because the panel is at its most efficient. The primary goal of this research is to maximise the efficiency of the solar cells. Despite the fact that there are numerous solar panels, the best sunlight is identified. It's fully automated, and it keeps the panel in front of the sun till it's visible. Its active sensors constantly monitor the amount of sunlight and spin the panel towards the direction with the most intensity. Residents who employ solar power as an alternate energy source will reap the rewards

2. Sun Tracking

Electric motors, light sensors, a gearbox, and electronic control are all required for the sun tracking mechanism to precisely focus on the sun at all times. However, because these components add to the system's cost, sun tracking is not used in many circumstances, particularly in modest residential applications.

2.1 Types of Solar tracking

- Single axis solar tracking
  - Horizontal axis solar tracking
  - Vertical axis solar tracking
- Dual axis solar tracking
  - Azimuth tracking

Single axis solar tracking

The PV surface on these tracking systems can be rotated/tilted along axes to obtain an appropriate angle that will assist them get the most sunlight. Single-axis tracking refers to the movement or adjustment of the PV surface by rotating around one axis.

Vertical axis solar tracking

To track the sun's more "up-and-down" movement in the sky, these systems can be installed in a north/south or east/west direction. These are most common among high areas, as well as in locations with much more extreme latitudes.

Horizontal axis solar tracking

HSAT rotates from east to west on a fixed axis parallel to the ground throughout the day, and it is generally regarded as the most cost-effective tracker design in many PV applications. When compared to other tracking geometries, the HSAT structure is positioned on several supports along the rotating axis, takes less material for fabrication, has the most preferred horizontal arrangement.

Dual axis solar tracking

In addition to tracking the sun's east-west movement, the dual-axis solar tracking system keeps track of its angular height. The dual-axis collects solar energy more effectively than just a single axis by rotating its axis along vertical and horizontal axes.

Azimuth tracking

The east-west movement of the collector surface is accomplished. So because movement of the surface and the variation in azimuth angle are identical, it is also known as azimuth tracking.

3. Types of solar panel

- **Fixed solar panel**
- **Rotating solar panel**

Fixed solar panel

Fixed solar panels, also known as fixed solar photovoltaics or fixed PV panels, are panels that are set on a roof, ground mount, or tracker system to capture the sun's rays and generate power. This power is converted into useful energy by inverters.

Rotating solar panel

The Rotating Solar Panel system detects from one horizon to the next to determine the current position of the sun and, as a result, the best location for converting solar energy into electricity. To charge the battery, the position with the maximum energy capacity is selected.

4. Solar cell

Depending on whether the source of light is sunlight or artificial light, solar cells are classified as photovoltaic. They can be employed as a photodetector (for example, infrared detectors), detecting light or other electromagnetic radiation near the visual range, or measuring light intensity in addition to creating energy

4.1 Types of solar cell

- **Crystalline Silicon cell**
  - Mono-crystalline silicon cell
  - Poly-crystalline silicon cell
- **Thin-Film Silicon Cell**
  - Cadmium Telluride
  - Amorphous Silicon
  - Copper Indium Diselenide
  - Gallium Arsenide

Crystalline silicon cell

Crystalline silicon (c-Si) refers to the crystalline forms of silicon, either polycrystalline silicon (Poly-Si) or monocrystalline silicon (Mono-Si) (Mono-Si, a continuous crystal). The most prevalent semiconducting material used to make solar cells in photovoltaic devices is crystalline silicon. These cells are placed into solar panels as part of a pv system to generate solar electricity from sunlight.

Thin-Film Silicon cell

A thin-film solar cell is a type of multilayer solar cell made by depositing one or more thin layers of photovoltaic material onto a substrate like glass, plastic, or metal. Thin-film solar cells built of cadmium telluride (CdTe), copper indium gallium diselenide (CIGS), and amorphous thin-film silicon are all commercially available.

Cell Type	Crystalline Silicon cell	Thin-Film silicon cell
Types	Mono-crystalline silicon cell, Poly-crystalline silicon cell	Cadmium Telluride, Amorphous silicon, Copper indium, Gallium diselenide
Temperature	Lower	Higher
Module Efficiency	20%	7 up to 18%

Table 4.1 Solar cell based on material

5. Environmental effect of solar power

Air Pollution

Chemical reactants employed in storage or organic fluids used for heat transport can induce that. The release of CO, SO2, SO3, hydrocarbon vapor's and other toxic gases should be accounted, through their magnitude is not high. There is a risk of fire from overheated organic working fluids. Because of the high energy flux densities, human tissues would be burned if exposed.

Land use

Solar plants demand a vast amount of land, and the gathering field produces shadowing that isn't generally seen across such a large region. This could disrupt the environment in the area.

Noise and thermal effect

Solar power plants have negligible thermal impact. These methods, in fact, remove local thermal pollution caused by fossil fuel combustion. If power produced is exported abroad, it will result in a drop in the local environmental heat budget or balance. Solar systems do not contribute any more noise to what is already present in industrial or utility locations.

6. Solar Photovoltaic

The photovoltaic effect, or the conversion of light into electricity, can directly turn solar energy into electrical energy. Solar cells are photovoltaic energy conversion devices that employ the photovoltaic effect to convert sunlight to electricity.

One of the most widely used nonconventional energy sources is photovoltaic energy conversion. The photovoltaic cell has already demonstrated its ability to capture solar energy in a way that produces clean, adaptable, and sustainable electricity. This simple device has no moving parts, requires little maintenance, emits no pollution, and lasts as long as a typical fossil fuel.

By isolating electrons from their parent atoms and speeding them across a one-way electrostatic barrier established by the interaction between two different types of semiconductor material, photovoltaic cells capture solar energy and turn it to electrical signal immediately.

6.1 Photovoltaic effects on semi-conductor

Materials that are neither conductors nor insulators are known as semiconductors. In nature, the photovoltaic effect can be seen in a number of materials, however semiconductors have demonstrated to be the most effective.

When photons from the sun are absorbed by a semiconductor, they produce higher-energy electrons than the electrons that provide boarding in the base material. Once these higher-energy electrons have been produced, an electric field must be applied to cause them to flow out of the semiconductor and perform beneficial work. A junction of materials with varied electrical characteristics provides the electric field in most solar cells.

Let us briefly review the function and qualities of semiconductors in order to gain a better understanding of them. Semiconductors are divided into two categories.

- Extrinsic semiconductor
- Intrinsic semiconductor.

6.1.1 Extrinsic semiconductor

Extrinsic semiconductors are those that are completely free of impurities, while extrinsic semiconductors are those that have impurities introduced to them. P type and N type semiconductors are the two types of extrinsic semiconductors.

P-Type semiconductor

This p type semiconductor is created when a small amount of pentavalent impurities (such as gallium, iridium, aluminium, or boron) is added to an intrinsic semiconductor.

When an electric potential is given externally to a p type semiconductor, the holes are driven towards the negative electrode. As a result, current is generated.

A p-type semiconductor is a semiconductor which has been loaded with an acceptor; "p" indicates for positive. An acceptor contributes extra holes, which are regarded positively charged. It's worth noting that the substance remains electrically neutral throughout.

N-Type semiconductors

N type semiconductors are created by adding a small amount of pentavalent impurities (such as antimony, arsenic, bismuth, and phosphorus) to intrinsic semiconductors. Free electrons are driven towards the positive electrode when an external electrical field is applied. As a result, current is generated.

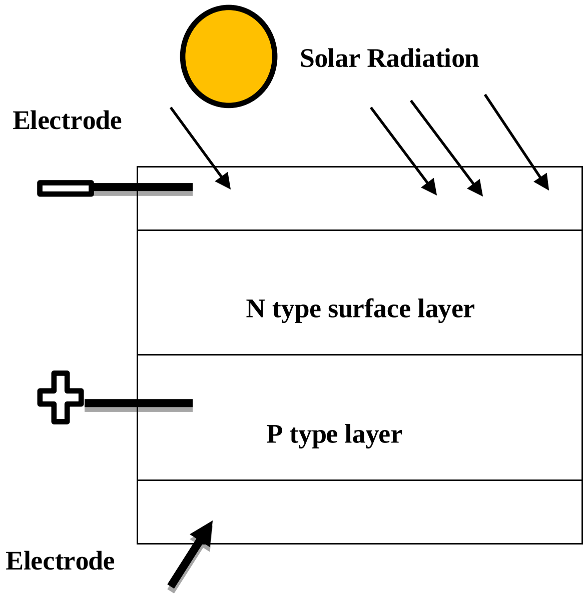
An n-type semiconductor is an extrinsic semiconductor that has been doped with electron donor atoms, as the majority of charge carriers in the crystal are negative electrons.

PN Silicon solar cell

A PN junction is created by diffusing p type materials to one half of a semiconductor and N type materials to the other half.

It is made up of both types of semiconductors. The N type layer is located in the direction of the sun. Light can pass through the N type layer since it is thin.

The energy of the sun causes free electrons to form in N type materials and holes to form in p type materials. The voltage in the crystal is increased as a result of this circumstance. Because the holes will go to the +ve region and the holes will go to the –ve region, respectively. One of the key technical aims in the fabrication of solar cells is the capacity to conduct electricity.



Photovoltaic

7. Components and their function

7.1 Solar Photovoltaic array

- Flat plate array
- Concentrating array

Solar Photovoltaic array

A solar photovoltaic array is made up of a certain number of solar cells that are connected in series or parallel to deliver the requisite current and voltage. Throughout the year, the array is angled to collect the maximum amount of solar radiation. Tracking arrays, modules, and fixed arrays are all possibilities. A tracking array is one that is constantly mechanically perpendicular to the sun array line, intercepting the maximum insolation at all times. These arrays must be physically moveable by a proper primary mover and are typically far more sophisticated than fixed arrays. A fixed array is typically aligned east-west and slanted up at an angle about equal to the site's latitude.

7.1.1 Flat plate array

Solar cells are adhered to some form of substrate structure, usually semi-rigid, with an appropriate adhesive to prevent the cells from cracking. This technology is derived from photovoltaic technology used in space, and numerous similar arrays have been developed in varying power capacities.

7.1.2 Concentrating array

Suitable optics, such as Fresnel lenses and parabolic mirrors, are used in an array with photovoltaic cells. In terms of hardware development, this technology is relatively new to photovoltaics, and fewer such arrays have been created.

7.2 Solar charger controller

Solar chargers with a voltage of up to 48 V and a capacity of hundreds of ampere hours can charge lead acid or Ni-Cd battery banks. In most solar charger systems, a smart charge controller is used. A collection of solar cells can be connected to a battery bank and installed in a stationary place to store energy for off-peak consumption. They can also be used in concert with mains chargers each day to save electricity.

7.3 Battery

An electric battery is a power source thought up with one or more electrolytic cell with external connections that can be used to power electrical equipment. The positive terminal of a battery is the cathode, and the terminal voltage is the anode when it is supplying power.

7.4 Arduino Microcontroller

Arduino Uno is an open automatically connected that makes it simple to use by using minimal hardware and software. Arduino boards can convert inputs like light from a sensor, a thumb on a button, or a Twitter comment into outputs like turning on a Bulb, starting a motor, or publishing anything online. You may inform the panel's microcontroller what to do by sending it a set of instructions. The Arduino programming language (based on Wiring) and the Arduino IDE (Integrated Development Environment) (based on Processing)

Fig 1

7.5 Relay

A relay is an electrically activated or deactivated switch. A set of input terminals for a single or multiple control signals, as well as a set of functioning contact terminals, make up the device. The switch can have any number of contacts in any contact form, including make contacts, break contacts, and combinations of the pair.

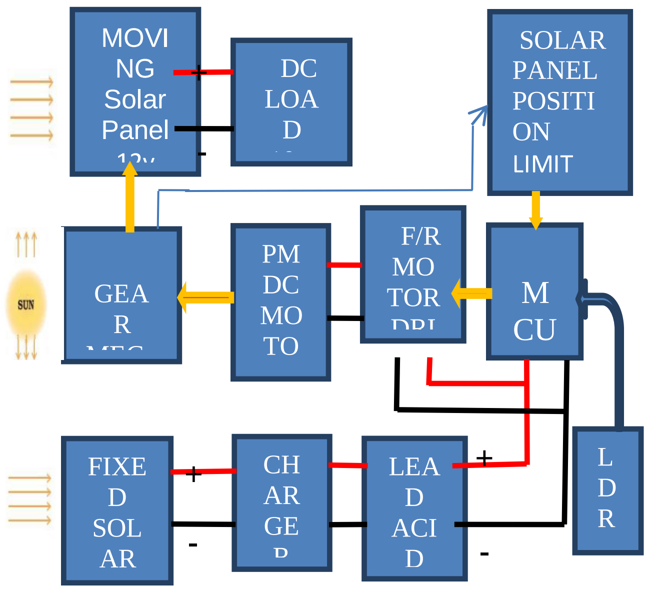
7.6 DC Motor

Any electrically operated motor that converts direct current (DC) electrical energy into mechanical energy is referred to as a DC motor. In today's world of engineering and technology, the DC motor has a wide range of applications. From an electric shaver to automotive parts, all little and medium-sized mobility is covered. Because of the wide range of applications, many functional types of motors are available on the market to meet individual needs.

7.7 LDR

As the title indicates, an LDR (Light Dependent Resistor) is a special sort of resistor that works on the photoconductivity principle, which means that resistance changes in response to the intensity of light. As the intensity of light increases, its resistance diminishes

8.Block Diagram



9. Working

The self-power solar tracking system consists of LDR sensor unit, ARDUINO controller and solar panel tracking mechanism. Moving solar panels change their orientation in relation to solar radiation. This orientation helps in getting full benefit of optimal angle between solar panels and solar radiations. This increases the efficiency and results in maximum production of energy. A solar panel with a 12-volt output, a motor driver with an IC driver, two LDR sensor modules, and a 10 RPM are all included. simple DC motor and a 12 V battery.

10. Experimental Result

The results for the project were gotten from LDRs for the solar tracking system and the panel that has a moving position. The results were kept track of for two days, then analyzed.

Time (Hrs)	Solar cell output (V)
06.00	08.26
07.00	08.98
08.00	09.53
09.00	09.90
10.00	10.39
11.00	10.78
12.00	11.09
13.00	10.87
14.00	10.65
15.00	10.55
16.00	10.04
17.00	09.20
18.00	08.30

Table 10.1 Solar output for sunny day 2nd June 2022

Time (Hrs)	Solar cell output (V)
06.00	08.36
07.00	08.99
08.00	09.60
09.00	09.98
10.00	10.55
11.00	10.88
12.00	11.22
13.00	10.80

14.00	10.60
15.00	10.52
16.00	10.02
17.00	09.08
18.00	08.15

Table 10.2 Solar output for clear sunny day 3rd June 2022

11. Conclusion

The objective of this project to design, fabricate and install a self-power solar panel mount with single -axis sun tracking capability has been achieved. The work was made possible through the cooperation and involvement of many different parties to guarantee that the project ran well, planning and communication skills were required. This system still has potential for development, and it is hoped that more research can be done to help it evolve further. The structure's design can be improved, for example, by adding coverings for the motors and improving the design of the sensor holder by making it waterproof. Apart from that, the current method of returning the frame to its previous position might be improved, eliminating the need to manually change the limit switches. A detailed analysis should be conducted to determine the percentage increase in electricity yield by adopting this system in order to determine whether the system is practical.

12. Our Fabrication

12. Abbreviations

CdTe - Cadmium telluride

CIGS - Copper indium disellide

DC - Direct current

I - Current

I/O - Input / output

LDR - Light depended resistor

MCU - Microcontroller unit

PV - Photovoltaic

R - Resistor

RPM - Rotation Per Minute

USB - Universal Serial Bus

V - Voltage

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