

DESIGN AND FABRICATION OF SINGLE AXIS SOLAR TRACKING SYSTEM

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Abstract: While a majority of the world's current electricity supply is generated from fossil fuels such as coal, oil and natural gas, these traditional energy sources face a number of challenges including rising prices, security concerns over dependence on imports from a limited number of countries which have significant fossil fuel supplies, and growing environmental concerns over the climate change risks associated with power generation using fossil fuels. As a result of these and other challenges facing traditional energy sources, governments, businesses and consumers are increasingly supporting the development of alternative energy sources and new technologies for electricity generation. Renewable energy sources such as solar, biomass, geothermal, hydroelectric and wind power generation have emerged as potential alternatives which address some of these concerns. As opposed to fossil fuels, which draw on finite resources that may eventually become too expensive to retrieve, Solar energy is unlimited in availability.

Solar energy has emerged as one of the most rapidly growing renewable sources of electricity. Solar energy production does not require fossil fuels and therefore there is less dependency on the limited and expensive fossil fuel resources. Although there is variability in the amount and timing of sunlight over the day, season and year, a properly sized and configured system can be designed to be highly reliable while providing long-term, fixed price electricity supply. But there is the problem of changing angles of sunlight during a day which poses a problem for collection of solar energy.

Our project presents a solution by power generation and sensor based solar tracking system to utilize the maximum solar energy through solar panel by setting the equipment to get maximum sunlight automatically. This proposed system keeps tracking continuously for maximum intensity of light. When there is decrease in the intensity of light, this system automatically changes its direction to get maximum intensity of light. Hence this system attains the maximum amount of input light on the solar panel by tracking sunlight throughout the day thereby consequently increasing the amount of power generated.

I. INTRODUCTION

1.1 Solar Tracking Systems:

This paper presents a theoretical and practical study of importance tracking solar energy. Solar energy is the prime factor for the development of a nation. An enormous amount of energy is extracted, distributed, converted and consumed in the global society daily. 85% of energy production is dependent on fossil fuels. The resources of the fossil fuels are limited and their use results in global warming due to emission of greenhouse gases. To provide a sustainable power production and safe world to the future generation, there is a growing demand for energy from renewable sources like solar, wind, geothermal and ocean tidal wave. The sun is the prime source of energy, directly or indirectly, which is also the fuel for most renewable systems. Among all renewable systems, photovoltaic system is the one which has a great chance to replace the conventional energy resources. Solar panel directly converts solar radiation into electrical energy. Solar panel is mainly made from semiconductor materials. It is used as the major component of solar panels, which has a maximum efficiency of 24.5%. Unless high efficient solar panels are invented, the only way to enhance the performance of a solar panel is to increase the intensity of light falling on it. Solar trackers are the most appropriate and proven technology to increase

the efficiency of solar panels through keeping the panels aligned with the sun's position. Solar trackers get popularized around the world in recent days to harness solar energy in most efficient way. This is far more cost effective solution than purchasing additional solar panels and dual axis tracker.

The most abundant and convenient source of renewable energy is solar energy, which can be harnessed by photovoltaic cells. Photovoltaic cells are the basic of the solar system. The output power of a photovoltaic cell depends on the amount of light projected on the cell. Time of the day, season, panel position and orientation are also the factors behind the output power. Solar panel gives maximum power output at the time when sun is directly aligned with the panel.

1.2 Scope Of Present Work:

Solar tracking is mainly used for power generation and to utilize the maximum solar energy through solar panels by setting the equipment to get maximum sunlight automatically. The system has reduced size and cost, making it attractive for compact portable solar panels and solar battery chargers, such as for cell phones, laptops, and other portable electronics with rechargeable batteries. Electric energy is essential to maintain daily life activities and industrial activities. India uses mainly

fossil fuels to produce electricity. Generation of electricity from fossil fuels is the primary source of air pollution and greenhouse gas emissions. Alternatives to fossil fuels should be considered to avoid undesirable effects of greenhouse gases. Nowadays, the alternatives on the market that provide examples of successful implementation are the wind farms, the solar cells, nuclear energy, biomass, hydropower and geothermal energy. The objective of this paper is to evaluate one of the alternative technologies currently available in daily life to generate electricity from the solar cells.

Due to rising costs of conventional energy and their limited resources, photovoltaic energy becomes a promising energy with advantages such as the absence of any pollution and the availability with more or less large quantities anywhere in the world. Currently, there is a big interest in solar energy applications especially in regions with favorable climatic conditions. One of the most popular standalone applications of the PV energy utilization is water pumping system driven by an electric motor.

1.3 Problem Identification:

However, there are many problems associated with its use. The main problem is that it is a dilute source of energy. Even in the hottest regions on the earth, the solar radiations flux available rarely exceeds 1 KW/m, which is a low value for technological utilization. The problem associated with the use of solar energy is that its availability varies widely with time. The variation in availability occurs daily because of the day night cycle and also seasonally because of the earth's orbit around the sun. To rectify these above problems the solar panel should be such that it always receives maximum intensity of light. For existing solar panels, which are without any control systems typical level of efficiency varies from 10% to 14% - a level that should improve measurably if the present interest continues.

The steps we followed in this project were:

- Literature Review.
- Selection of Materials.
- Problem Identification.
- Design
- Fabrication
- Conclusion
- Simulation

II. SELECTION OF COMPONENTS

In this chapter the selection of materials are discussed below, some of the components used in this project are

- Solar Panel.
- DC Geared Motor.
- Relay.
- Transistor.

- LDR Sensor.
- Battery.

2.1 Block Diagram:

Given below is the block diagram of our solar tracking system:

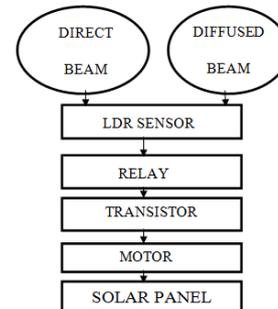


Fig 2.1 Block Diagram

2.2 Solar Panel:

The solar array or panel is defined as a group of several modules electrically connected in series-parallel combinations to generate the required current and voltage. Solar Panel Absorbs Energy from sunlight and converts into electrical energy by using photo voltaic cell. The photovoltaic cell converts Sun light Energy directly into electricity. The principle is, ' An electrical potential is developed when two dissimilar materials and their common junction is illuminated with radiation of photon'.

Factors influencing the solar panel are:

- The sun intensity.
- Sun angle.
- Load matching for max-power.
- Operating temperature.

Panel Configuration:

Solar Panels are Available in Cell, Module & Array Structures.

- Mono crystalline Silicon solar cells
- Encapsulated: PC film lamination
- Max Power Voltage(Vmp) 4.0V±8%
- Max Power Current(Imp) 100.0mA±8%
- Max Power(Ppm) 0.4W±8%



Figure 2.2 Basic structure

2.3 Dc Motor:

A Driver Motor mainly consists of a DC motor and Gear System and controlled by Motor Driver Circuit. Motors allow the use of economical low-horsepower motors to provide great motive force at low speed. This greatly reduces the complexity and cost of designing and constructing power tools, machines for Low Speed.

Motor Specifications:

- Voltage : 9V DC

- Speed :10 RPM
- Rotation output-clockwise and anticlockwise

Features:

- High Value Torque
- Low Shaft Speed
- Low Power Consumption



Figure 2.3 Motor

2.4 Relay:

A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Double Pole Double Throw. Such a relay has six terminals, including the coil.

Relay Specifications:

- Type : DPDT
- Sensitivity: 250 mW
- Capacity: 16A
- Coil resistance: 62.5 Ω
- Voltage: 5 VDC
- Current: 80.0 mA



Figure 2.4 DPDT type Relay

2.5 Transistor:

A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal. Today, some transistors are packaged individually, but many more are found embedded in integrated circuits.

Transistor Specifications:

- PNP Bipolar junction transistor
- Max voltage : 15V

- Max power :25mA



Figure 2.5 Transistor

2.6 Battery:

A Battery is two or more electromechanical cells which store chemical energy and make it Available in an electrical form. The lead-acid rechargeable batteries have a much harder life. They can withstand Vibrations, shock, heat, cold, and have long Life .lead-acid batteries provide the greatest energy density & longest life cycle and a large environmental advantage. Specifications:

- 9 V DC
- 1.2 AH/ 20HR



Fig 2.6 Rechargeable battery

2.7 Ldr Sensor:

A photo resistor or light dependent resistor (LDR) or photocell is a resistor whose resistance decreases with increasing incident light intensity; in other words, it exhibits photoconductivity.

A photo resistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electrons conduct electricity, thereby lowering resistance.



Fig 2.7 LDR Sensor

2.8 Diode:

A diode is an electronic component that has two terminals with asymmetric conductance. It has low resistance to current in one direction (ideally zero resistance), 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.



Figure 2.8 Diode

Specifications:

- Maximum repetitive reverse voltage (V_{RRM})= 100 V
- Average rectified forward current (I_O)= 200 mA ()
- Maximum direct forward current (I_F)= 300 mA .

III. CONSTRUCTION:

It consists of 7 sensors to track the solar rays the positive terminal is connected to positive terminal of the relay. Relay is having 3 points in which the first and second point is having a magnetic iron coil The output of the relay is taken and given to the positive terminal of the transistor. The transistor is used to reduce the input voltage given .For example the voltage is given is 9 volt then the voltage is reduced to 5volts.The output of the transformer is given to the reduction motor input. The reduction motor has gear arrangement which reduces the speed has required. The motor has a flywheel which has a arm of 10 cm. The arm is connected to the pulley .The pulley has another arm which connected to the solar panel

IV. WORKING & CALCULATION:

4.1working:

The LDR sensor senses the light and sends the command to the positive terminal of the relay. The Relay having a coil wounded with an iron core .When the command from the sensor comes to the relay the coil gets magnetized and transmit the current from one point to the another. The one end of the coil is connected to the negative terminal of the battery. The transmitted current sends to the positive terminal of the transistor. The Transistor has three terminals.

The first terminal acts as the input .The input given is 9 volts and it is converts the it to 5 volts by the transistor. This output of 5 volts is taken from the third terminal and given to the positive terminal of the motor. The motor has a reduction gear arrangement such that the speed is reduced to required speed.The negative terminal of the motor and the second terminal of the transistor is connected to the neutral which is connected to the battery. The second terminal of the Relay is connected to the positive terminal of the battery. Thus the solar panel is moved horizontally and the charge is stored in the battery

4.2 Calculations:

In an ideal situation where atmospheric influence is negligible, the theoretical calculation of the energy surplus is carried out below. Assuming, the maximum radiation intensity, $I=1100w/m^2$ is falling on the area perpendicular oriented to the direction of radiation and the day length, $t=12$ hours (43, 200 seconds) as referred from recent literature. For fixed solar

collector, the projection of the sun bean on the PV cell is given by,

$$S = S_o \cos \theta$$

Where, S_o is the collector area ($S_o = 0.15m^2$)

θ is the angle changing in the interval ($\pi/2$ to $-\pi/2$).

$$\omega = 727 \times 10^{-7} \text{rads/sec}$$

The angular velocity of the sun moving across the sky, The differential of the falling energy is given by, $dE = IS_o dt$

$$E = \int_{-\pi/2}^{\pi/2} IS_o \cos \omega t dt$$

$$= IS_o \left[\frac{\sin \omega t}{\omega} \right]_{-\pi/2}^{\pi/2}$$

$$E = 2IS_o = 2 \times 1100 \times 0.15 = 4.54 \times 10^6 \text{ watt.sec}$$

$$727 \times 10^{-7}$$

For tracking collector,

$$E = IS_o t, \text{ since } \theta = 0^0$$

$$E = 1100 \times 0.15 \times 43,200$$

$$E = 7.13 \times 10^6 \text{ Watt.S}$$

For tracking collector,

$$E = IS_o t, \text{ (since } \theta = 0^0)$$

$$E = 1100 \times 0.15 \times 43,200$$

$E = 7.13 \times 10^6 \text{ Watt.S}$ Therefore, comparison between the results shows that about 57% energy surplus increase is achieved with the tracking system.

V. OBSERVATIONS

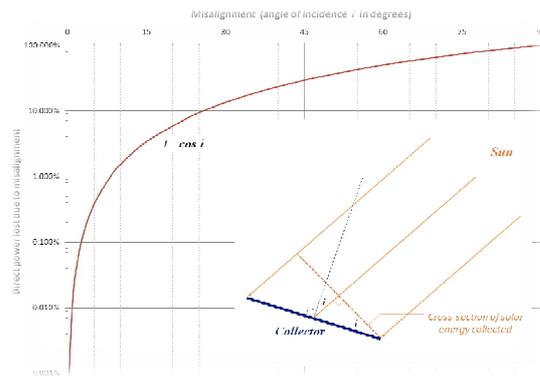
We placed the stimulation model in the sunlight for 6 hours that is from 9am to 3pm. We chose this time as it was the time so that the intensity of sun light is high and got the results as tabulated below referred from recent literature.

Solar Output of PV Panel in Fixed Mode			
Time of the day	Voltage (V)	Current (A)	Power (W)
9.00	13.87	0.88	12.21
10.00	15.29	0.97	14.83
11.00	15.09	0.95	14.34
12.00	16.17	1.07	16.33
13.00	18.09	1.17	21.15
14.00	16.25	1.06	17.23
15.00	15.88	0.99	15.72
TOTAL	110.64	7.09	111.81

Table 5.1 Shows the power collected by a stationary solar panel

Solar Output of PV Panel in Tracking Mode			
Time of the day	Voltage(V)	Current(A)	Power(W)
9.00	16.04	0.95	15.24
10.00	16.48	1.02	16.81
11.00	16.40	0.98	16.07
12.00	16.75	1.09	18.26
13.00	18.09	1.17	21.16
14.00	17.30	1.13	19.55
15.00	16.83	1.11	18.68
TOTAL	117.89	7.45	125.77

Table 5.2 Shows the Power absorbed by the single axis rotating solar panel



Graph 5.4 Shows Percentage of power lost by stationary solar tracker with respect to the angle[2].

CONCLUSIONS AND FUTURE PROSPECTS:

The sun-tracker and charge controller systems have been successfully implemented as explained. This method is easily applicable and needs less initial investment and produce more power than the solar tracking system with a microcontroller which increases the investment, needs regular maintenance and expert to handle it. The simulation results demonstrate the effectiveness and robustness of the proposed method than old method.

To design and fabricate the sensor based solar tracking system without microcontroller and show the experimental results with simulation model. Power system could be applied to systems such as Electricity production, water treatment, heating-cooling and ventilation, Architecture and urban planning, Transport and reconnaissance etc. This method in future can be used in large scale to get more power.

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