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DESIGN AND DEVELOPMENT OF PROTOTYPE MODEL OF DUAL AXIS SOLAR TRACKING SYSTEM

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ABSTRACT

Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. As such, it is vital that those in engineering fields understand the technologies associated with this area. project will include the design and development of prototype model of dual axis solar tracking system. Solar tracking allows more energy to be produced because the solar array is able to remain aligned to the sun. solar tracking PV panel produced more energy than the fixed one with about 49% efficiency. Two degrees of freedom orientation is feasible. The controller has been used to control the charge and discharge of DC battery to retain their long life. As well as dual axis tracking is possible due to two tracker are available in horizontal/vertical direction with LDR as senser. Which control the position of DC motor to track the panel in real orientation. The controller is designed to rotate the panel from -90o to +90o. The presented dual axis solar panel tracking system keeps the solar photovoltaic panel perpendicular to the sun throughout the year and thereby improving the efficiency of the solar system. There are 2 axes of rotation for this system which rotates according to Hour Angle and Declination.

KEYWORDS: Azimuth, Collector, Declination, Elevation, Hour Angle, LDR, Sensor, Tracker

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.

The tracker is uses a commercially bought sun sensor to follow the sun across the sky throughout the day. For building the tracker some additional physical analysis, structural analysis for load-bearing components of tracker is done. Tracker is compared with fixed solar panel to see what kinds of power output improvements the tracker was able to generate. Solar tracker can generate a noticeable improvement in power output over an extended period of time when compared to a fixed solar panel.

MATERIALS AND METHODOLOGY

How do Photovoltaic Work?

Photovoltaic is 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 is 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.

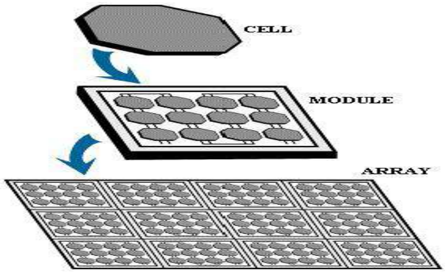

Figure 1: Photovoltaic Panel or Array

In general, the larger area of a module or array, 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.

Equipment Used in Solar Tracker System

Solar Panel

A solar panel is a packaged, connected assembly of photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Multi crystalline panel is rated by its DC output power under standard test conditions.

Figure 2: Solar Panel

Battery

In electricity, a battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. There are two types of batteries: primary batteries (disposable batteries), which are designed to be used once and discarded, and secondary batteries (rechargeable batteries), which are designed to be recharged and used multiple times. The battery is used to store the dc voltage obtained from solar radiation through solar panel. Here we are using a lead-acid battery.

Specification

Voltage and Ampere-hour capacity:12V, 7Ah

Constant voltage charge = 15-35 at 20°C

Voltage regulation:-

Cycle use = 14.4-15.0 V at 20°C

Stand by use = 13.5-13.8 V at 20°C

Figure 3: Lead Acid Battery

Light Dependent Resistor (LDR)

Figure 4: LDR

The LDR is a sensor whose resistance decreases when light impinges on it. This kind of sensor is commonly used in light sensors circuit. LDR is made of a high resistance semiconductor. It can also be referred to a photoconductor. If light falling on the device is of the high enough freq. Photons absorbs by the semiconductor give bond electrons enough energy to jump into the conduction band. The resulting free electron conducts electricity thereby lowering the resistance.

DC Motor

Figure 5

DC motors are cheaper to buy, and simple to drive but they need fed back sensor to allow Figure 5:DC motor control of the speed. It is necessary to detect the rotation of the wheels, usually by means of sensors better controlled by pulling the motor supply that uses less battery power than the resistor methods. The Advantages of dc motor are torque and their speed is easier to control. The drawback of DC motors is that they consumed huge amount of power.

Specification: Voltage = 12 V DC

Revolution = 10 rpm

Working of Solar Charge Controller

A solar charge controller is needed in virtually all solar power systems that utilize batteries. The job of the solar charge controller is to regulate the power going from the solar panels to the batteries. Overcharging batteries will at the least significantly reduce battery life and at worst damage the batteries to the point that they are unusable. The most basic charge controller simply monitors the battery voltage and opens the circuit, stopping the charging, when the battery voltage rises to a certain level. Older charge controllers used a mechanical relay to open or close the circuit, stopping or starting power going to the batteries.

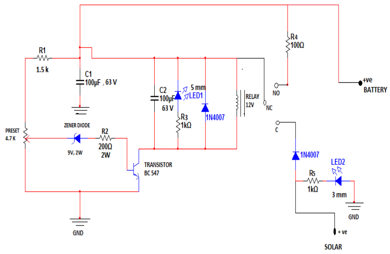

Figure 6: Solar Charge Controller Circuit

In Solar charge controller circuit switching transistor is used to sense the overvoltage of Battery. When battery charged fully, the zener diode which is connected to the base of the Transistor goes in breakdown mode, which triggered base of the transistor result in switching ON the relay circuit, which cut down the direct charging path of the battery from solar panel, so that the battery can be protected from the over current and heating. A low resistance is connected between the contact of relay allow very low current to pass through battery charging this reduce discharging rate of battery in ideal mode.

Table 1: Components Used In Solar Charge Controller

Component Used	Model
1. Big preset (1 nos)	4.7 K
2. Resistor (1 nos, green)	1KΩ
3. Resistor (vertical)	220Ω, 2 W
4. Resistor (grey)	1.5 KΩ
5. Zener diode(red)	9 V,2 W
6. Relay (black)	12 V ,10 A
7. Diode (black-big)	6 A
8. Diode (small)	IN 4007
9. Red LED(1 nos)	3mm, 5mm
10. Capacitor (1 nos)	100µF, 63V
11. Transistor(1 nos)	BC 547

Working of Relay Circuit

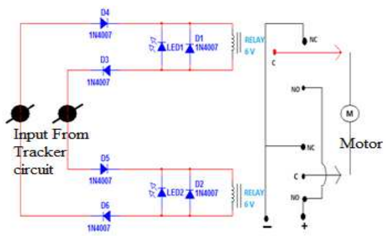

Figure 7: Circuit Diagram of Relay

The relay is activated by the output current and normally-open contact closes. In this case, the tracking motor rotates clockwise in the azimuth direction and thus the PV panel moves eastward to face the Sun. More specifically, the Sun tracker attempts to adjust the PV panel such that all the voltages produced by LDRs are nearly equal and balance. As a result, the PV panel is almost perpendicular to the sunlight and has a high energy generation.

Basic Working Principle of Solar Tracker

Basic power operating of solar tracking device is feed from battery bank which charge through solar panel. This is dc power which is regulated to 12v for having a stable performance. Even during battery low or full condition this power is feed to comparator within a put off LDR through biasing circuit. The output of two differentiator is amplifying by two power transistor. For running the dc motor on both directions four diodes are put in the circuit, also for maintaining the steady state voltage in the circuit. This motor is coupled with tracker device for keeping the face of solar panel at 90 degree to the sun rays. Comparator input through LDR are installed in two phase of triangle slope. The peak of the slope is pointed towards the sun.

Working of Solar Tracker

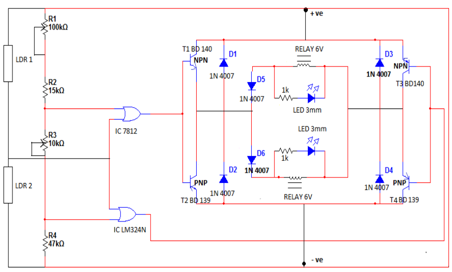

Figure 8: Circuit Diagram of Solar Tracker

When sunlight falls on both the LDR the comparator compares the potential output which is amplified through power transistor and deliver to DC motor. The equal source of light on LDR produces the zero volts on comparator output which doesn't allow the motor to rotate But when light intensity is lower on anyone of the LDR then the output of comparator become high and supplies the operating voltage to DC motor to rotate until the voltage on motor becomes zeros. This how both LDR are maintaining forward and reverse voltage parameter on the motor. Power transistors are used to compensate the load of motor. While all four diode are used to damp the ripple and surges voltage which is develop by rotating motor due to back EMF.

Table 2: Components Used in Solar Tracker

Component Used	Model No.
1. Diode (no.8)	IN 4007
2. IC (no.1)	LM 7812
3. Capacitor (no. 2)	100µF, 63V
4. Presetvariable	100 K & 10 K
5. Transistor (no.4)	BD 140 & BD 139
6. Resistor (n0.2)	47 K AND 15 K
7. IC (no.1)	LM 329

RESULTS AND DISCUSSION

Hourly Angle Variations of Solar Tracker

The controller takes two inputs as the references. The two inputs are:

- Altitude angle
- Azimuth angle

Elevation angle change according to seasonally and azimuth angle change daily. The fuzzy controller takes two inputs, processes the information and outputs a motor voltage setting. The controller would control the solar altitude and azimuth motors to adjust the direction of the solar panel accordingly.

Observation Table

Table 3: With Tracking System

No.	Time (hrs.)	Voltage (V)	Current (amp.)	Power(w)		Temp.(°C)	Ambient temp (°C)	Radiation (lux)	Wind peed (m/s)	Azimuth angle (°)	Altitude angle (°)
				Practical	Theoretical						
1	8:00	13.11	0.06	0.78	4.39	30.2	20.9	146.3	2.1	45	0
2	9:00	13.83	0.20	2.76	4.42	31.9	22.6	147.6	1.6	36	5
3	10:00	13.66	0.34	4.64	4.44	34.2	23.3	147.9	5.1	28	9
4	11:00	13.75	0.22	3.02	4.41	39.8	26.8	147.0	2.4	19	13
5	12:00	14.55	0.21	3.05	4.39	44.7	30.5	146.3	2.2	15	17
6	13:00	15.18	0.22	3.33	4.96	45.0	33.2	165.7	3.5	10	20
7	14:00	15.30	0.23	3.51	5.40	44.7	33.4	182.5	4.3	20	20
8	15:00	15.41	0.18	2.77	5.80	39.6	33.6	195.4	4.5	27	20
9	16:00	14.92	0.11	1.64	5.30	38.3	33.2	178.9	4.9	30	20
10	17:00	14.76	0.08	1.18	5.10	35.1	31.7	172.3	5.1	34	20
11	18:00	14.51	0.03	0.43	4.92	30.6	28.4	163.6	5.3	39	20

Table 4: Without Tracking System

No.	Time (hrs.)	Voltage(V)	Current (amp.)	Power(w)		Temp.(°C)	Ambient temp(°C)	Radiation(lux)	Wind peed (m/s)	Azimuth angle (°)	Altitude angle (°)
				Prac-tical	Theo-retical						
1	8:00	13.06	0.04	0.52	4.60	22.9	21.4	153.7	3.8	0	20
2	9:00	13.40	0.07	0.93	5.06	23.2	22.3	168.7	2.7	0	20
3	10:00	13.65	0.15	2.04	5.12	24.8	23.9	170.6	3.2	0	20
4	11:00	13.62	0.28	3.81	5.24	27.1	25.6	174.8	4.7	0	20
5	12:00	13.92	0.34	4.73	5.36	31.3	29.7	178.6	2.4	0	20
6	13:00	14.09	0.37	5.21	5.47	36.9	34.2	182.3	1.3	0	20
7	14:00	15.06	0.32	4.81	5.92	41.4	39.2	197.6	1.7	0	20
8	15:00	15.13	0.20	3.02	5.42	42.9	42.1	180.8	2.9	0	20
9	16:00	14.81	0.19	2.81	5.22	40.3	39.6	173.9	2.5	0	20
10	17:00	14.63	0.07	1.02	4.81	35.8	34.4	160.5	3.1	0	20
11	18:00	14.47	0.02	0.28	4.53	29.4	28.7	151.2	3.7	0	20

Radiation Measurement for Graph

Solar Power Curve

Radiation (W/m^2) = <u>Lux reading</u>

Multiple factor

Example**:** Maximum radiation (lux) readingin without tracker is 197.6 and multiple factor is 0.4 for Anand.

So, radiation (W/m^2) = 197.6/0.4 = 494 W/m^2

1000 W/m^2 solar radiation = 100 % power efficiency

494 W/m^2 solar radiation = 494 x 100/ 1000

= 49 % power efficiency

Theoretical solar power

100 % power efficiency = 12 W power

49 % power efficiency = 49 x 12/ 100

= 5.8 W power

Practical solar power:

W = V X I

= 15.6 x 0.32

= 4.8 W

So, 20 % less practical power than theoretical power. So, the power – time relationship curve at 30° C temperature and 2 m/s wind speed is generated.

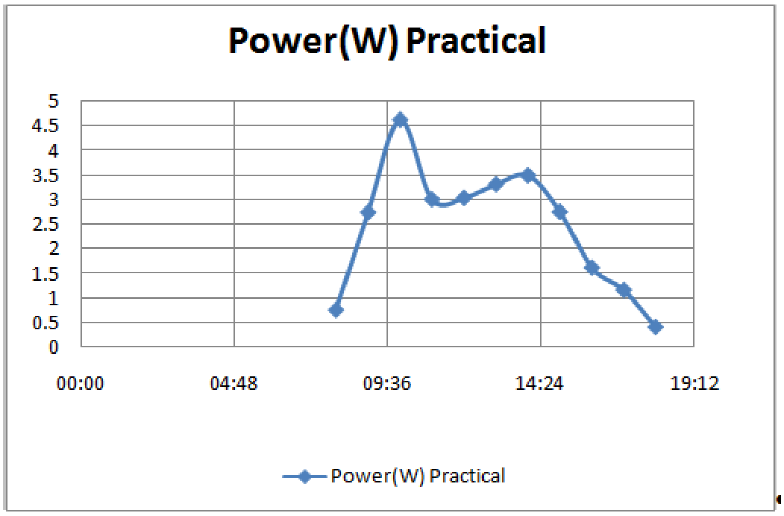

Figure 9: Power Curve without Tracking System

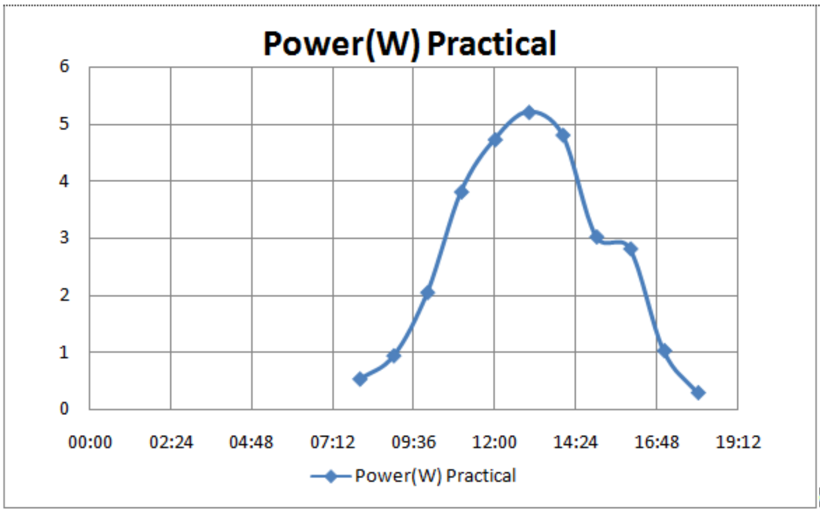

Figure: 10 Power Curve with Tracking System

Figure 11: Prototype Model of Solar Tracker

CONCLUSIONS

- Solar tracking PV panel produced more energy than the fixed one with about 49% efficiency.
- From experimental results it is observed that at duration of one hour time period of a day, current and voltage is increase with the increase of the time and temperature. The amount of current and voltage of with tracker is greater than without tracker.
- The voltage is 15.18V of with tracking system and 14.09V of without tracking system at peak time of 1 p. m. The current is 0.22A of with tracking system and 0.37A of without tracking system.
- The proposed prototype model of dual axis solar photovoltaic panel tracker is capable to track the sun throughout the year.
- Two degrees of freedom orientation is feasible. The controller has been used to control the charge and discharge of DC battery to retain their long life. As well as dual axis tracking is possible due to two tracker are available in horizontal/vertical direction with LDR as senser. Which control the position of DC motor to track the panel in real orientation.

- The controller is designed to rotate the panel from -90^o to +90^o. The presented dual axis solar panel tracking system keeps the solar photovoltaic panel perpendicular to the sun throughout the year and thereby improving the efficiency of the solar system. There are 2 axes of rotation for this system which rotates according to Hour Angle and Declination.

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