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COMPARATIVE ANALYSIS OF DUAL AND SINGLE AXIS SOLAR TRACKER

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Abstract-*Solar energy is becoming a very important means of renewable energy resource. The primary forms of solar energy are heat and light. Sunlight and heat are transformed and absorbed by the environment in a multitude of ways. The aim of this paper is to present two solar energy collection technologies. To present these two solar distributed generation systems, a dual and a single axis solar tracker are designed, fabricated and tested. Their power outputs and efficiencies are compared to each other. The trackers track the sun and change their positions for maximize the power outputs. The power output and efficiency are respectively 1.3832 W and 69.85% for dual axis solar tracker and 0.88589 W and 44.74% for single axis solar tracker.*

Keywords: Single axis solar tracker, Dual axis solar tracker, Power output, Efficiency

1. INTRODUCTION

Energy acts as a major factor for the progression of a nation. In global society, huge energy is consumed, extracted, converted and distributed daily. The necessity for energy is increasing with the rising scarcity of conventional energy. The sources of conventional energy are limited and emission of greenhouse gases results in global warming. There is a rising demand for energy from renewable energy sources like wind, tidal waves, hydrothermal, biomass and solar to provide the production of sustainable power and a pollution free world in future. Uses of non-conventional energy sources and dependency on solar energy are increasing day by day.

The modern concept of using solar power is originally came from the usage of looking glasses to generate fire by concentrating the sunlight to the body to be burned [1]. The reflective characteristics of bronze shields were used by Archimedes for focusing sunrays and setting fire to wooden ships from the Roman Empire. The usefulness of the sun was recognized by the people around the world for the purposes of heating houses or setting fire to rival ships [2].

Photovoltaic (PV) cells are used to generate electricity by capturing the sunrays. DC electricity can be generated by it without environmental impact and emission. PV cells use solar photovoltaic arrays to convert sunlight into electricity. PV system consists of solar collector, micro controller, battery, PV array, DC converter. This is always affected by the change of temperature, relative humidity, the intensity of sun radiation and shadow. These factors reduce the maximum production of power produced by solar cells [3].

Solar tracker is replacing PV cells to extract maximum solar energy. Solar trackers are the technology to increase the solar panel efficiency by placing the panels perpendicular with the sun. Solar trackers are driven by actuators or motors and keep the surface of solar panel perpendicular to the sun path and also LDR sensors are uses [4]. Solar tracker was first introduced by Steve Hines solar to enhance the efficiency of any solar system. [5]. It traces the sun position efficiently and keeps the solar PV module at such an angle for producing large amount of power.

Researchers have found that the maximum power absorption happen when the solar panel is aligned with the sun. Solar trackers can be single and dual axis depending on design requirement. The huge amount of solar radiation is used to generate electricity for the applications such as lightening, water pumping, and telecommunication [6].

Sanzidur Rahman et al. [7] designed a dual axis solar tracker to track the sun actively and could be varied its position to increase the output power. Use of two geared stepper motors besides other basic components made the model to be able to keep the panel perpendicular to the sunrays. The tracker was capable of 52.78% power gains in comparison with a fixed mount panel.

A comparative discussion between single and dual axis solar tracker with fixed mount solar panel revealed that the efficiencies of single and dual axis tracker were higher to the fixed solar panel. Although the design complexity of the hardware was higher in the dual tracker than other two but it was able to track in cloudy days also. The efficiency of single axis tracker from the experiment was 25% more than the fixed solar panel [8].

Experimental results showed that the overall efficiency of the dual axis tracker was improved by 43.65% neglecting the DC motor power consumption when solar panel is positioned perpendicularly to the sunlight [9].

By using a thermal camera, the distribution of temperature had been analyzed on a flat and sphere shaped plate absorber exposing to sunlight without cover. A good interrelationship between taken value of absorbing surfaces temperatures and incident sun light values could be found with a sun tracking and a fixed pyranometer. The overall daily average temperature on the flat plate absorber was higher than the spherical one showing that the average hourly incident radiation on a tracking surface is 820 W/m^2, with about 29% higher than on the fixed plate collector with 584 W/m^2 [10].

Ankit Gupta et al. modeled and compared maximum power point tracking (MPPT) methods using three types of signal generation system like conventional, artificial intelligence and hybrid methods in MATLAB/Simulink environment. The observed results showed that the best dynamic response could be achieved by ANFIS method comparing to other MPPT methods [11].

Hussain S. Akbar et al. [12] showed that the dual axis tracker design and implementation that traced the sun by using an AVR microcontroller in both azimuth and altitude axes. The proposed system contained AT mega 328 controller, DC motors, light sensors and relays. The power output of the PV panel was decreased by the temperature effect of the solar panel covering with colored cellophanes.

This paper is presenting both of the single axis and dual axis solar tracker model to track the sunlight providing the efficient way to enhance the power output and efficiency.

2. METHODOLOGY

A total workflow diagram for the experiment is shown by fig. 1 for a dual axis solar tracker and by fig. 2 for single axis tracker. The basic difference with single axis tracker is in placing servomotor under the base in case of dual axis tracker.

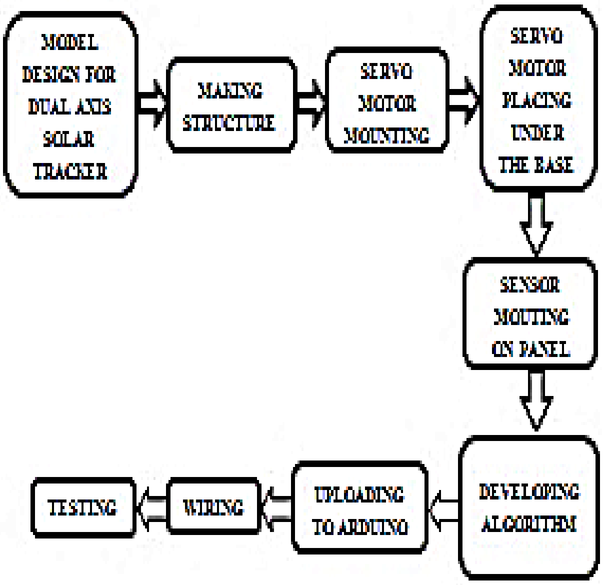


Fig. 1: Flow diagram for dual axis solar tracker

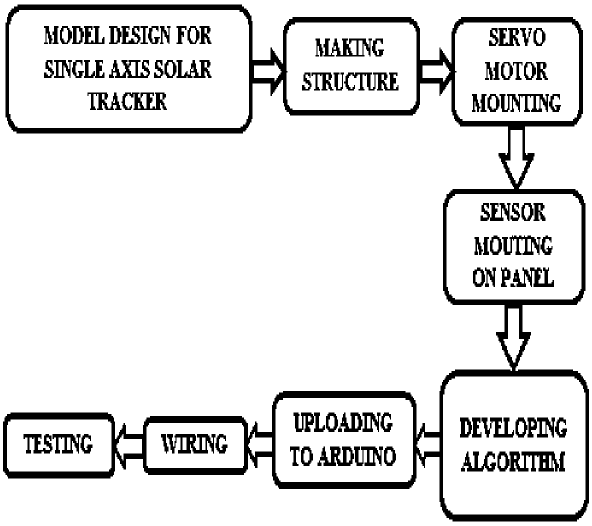
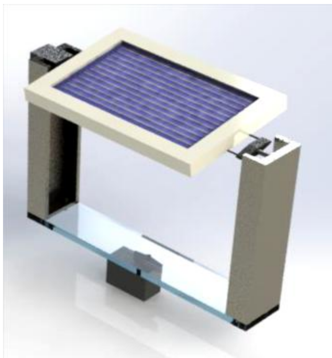


Fig. 2: Flow diagram for single axis solar tracker

3. DESIGN OF THE MODEL

Isometric views for both of the single and dual axis trackers model are shown in fig. 3.

(a)



(b)

Fig. 3: Isometric view of model for (a) single axis solar tracker, (b) dual axis solar tracker

4. CIRCUIT DESIGN

Circuit designs for both of the design are shown in fig.4 and fig.5

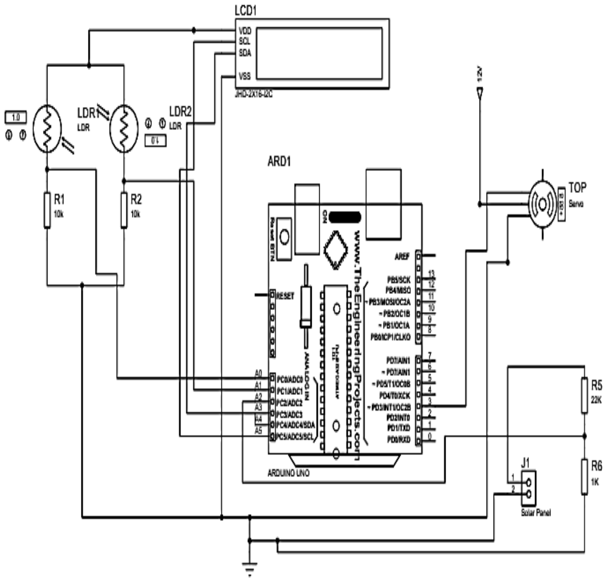


Fig. 4: Circuit design for single axis solar tracker

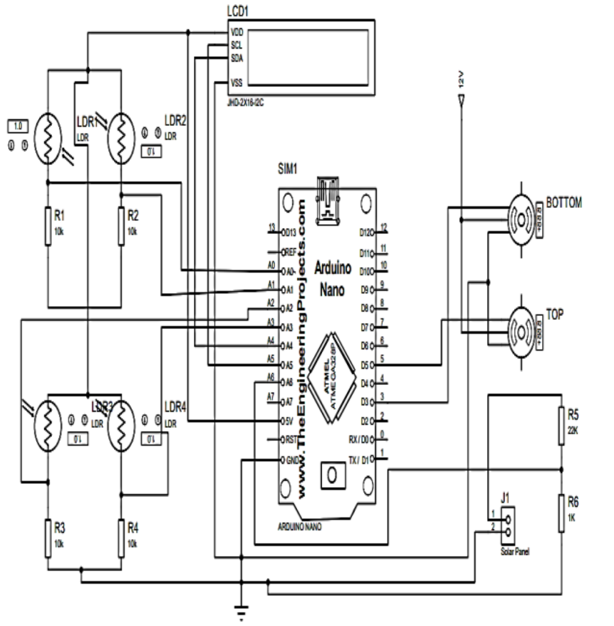


Fig. 5: Circuit design for dual axis solar tracker

2. EXPERIMENTAL SETUP

One servo motor is used for the rotation of the solar panel and the other servo motor is used to rotate the base. This base can be moved 360 degree. An extra servo motor is used in the base in dual axis tracker. Four LDR are used for developing dual axis tracker while in single axis tracker two LDR are used to detect the sun position. When light intensity increases, LDR resistance decreases. Two sensor senses the position of the sun in vertical axis and the other two sensors in the horizontal axis in case of dual axis tracker. The information from LDR is then passed to the light comparison unit. Microcontroller is the control unit of this tracking system. The output of light comparison unit from the microcontroller input determines the motors' movement in horizontal and vertical axes.

The structure of dual axis solar tracker consists of two servo motors, a PV panel with stands and a body to hold the panel in place. The structure of single axis solar tracker consists of one servo motor, a PV panel with stands and a body to hold the panel in place.

Arduino UNO is used for single axis tracker. The Arduino setup for single tracker shown in Fig. 6 is a simple setup. It gets inputs from two LDRs.

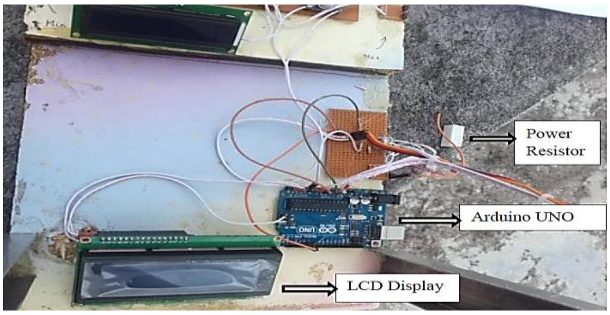


Fig. 6: Arduino setup for single axis solar tracker

Arduino setup for dual axis tracker shown in Fig. 7 is comparatively complex than single axis tracker. In this tracker, Arduino Nano is used which gets inputs from four LDRs.

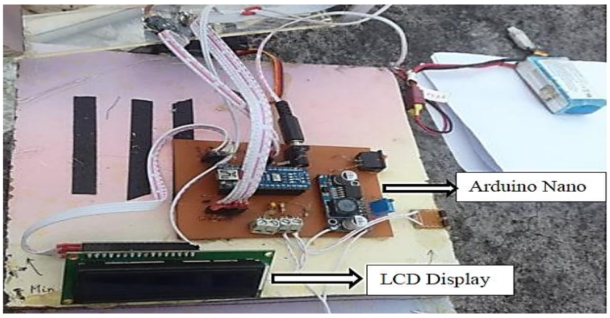


Fig. 7: Arduino setup for dual axis solar tracker

The complete mechanical structures of the designs of dual and single axis solar tracker are shown in Fig. 8. Solar panel, LDRs, Arduino UNO, Arduino Nano, servo motors, motor driver, power resistor, LCD display are used to fabricate this model.

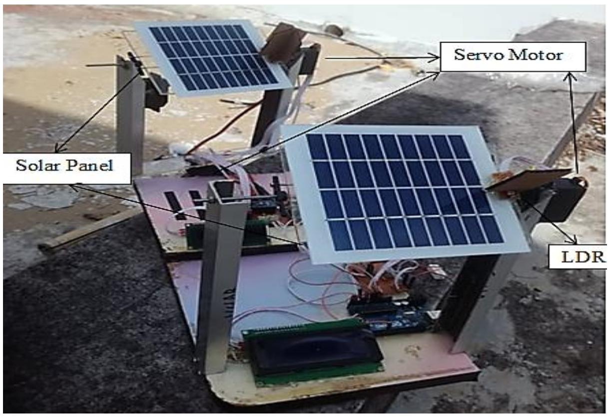


Fig. 8: The overall structure of dual and single axis solar tracker

5. PERFORMANCE TEST

The tracking mechanism is set in the east and west direction and north and south direction for dual axis tracker and in one axis for single axis solar tracker to face the sun. The panels are adjusted to a point where the solar panel is aligned with the sun. The outputs of the PV panels are recorded by multimeter for recording voltage and current. The PV panels are tracked automatically and data is recorded for both trackers in the same time. The test data are shown in table 1 collected for a time period of 6 hours with the interval of 30 mins.

Table 1: Performance Comparison of Solar Panels with Dual Axis and Single Axis Tracking

Time of the day	With Single Axis Tracking		With Dual Axis Tracking		Power(W)	
	Voltage(V)	Current(A)	Voltage(V)	Current(A)	Single Axis Tracking	Dual Axis Tracking
9.00	9.52	0.076	10.05	0.105	0.72352	1.05525
9.30	9.6	0.083	10.18	0.119	0.7968	1.21142
10.00	9.7	0.089	10.37	0.123	0.8633	1.27551
10.30	9.73	0.092	10.46	0.127	0.89516	1.32842
11.00	9.75	0.096	10.49	0.134	0.936	1.40566
11.30	9.81	0.120	10.54	0.180	1.1772	1.8972
12.00	9.87	0.125	10.59	0.186	1.23375	1.96974
12.30	9.79	0.109	10.50	0.162	1.06711	1.701
13.00	9.71	0.102	10.34	0.157	0.99042	1.62338
13.30	9.62	0.097	9.98	0.151	0.93314	1.50698
14.00	9.53	0.091	9.74	0.145	0.86723	1.4123
14.30	9.37	0.085	9.56	0.139	0.79645	1.32884
15.00	8.76	0.027	8.87	0.030	0.23652	0.2661

6. RESULT AND DISCUSSION

Average power obtained from solar panel is 0.88589 W for single axis solar tracker and is 1.3832 W for dual axis solar tracker. The efficiency is 69.85% for dual axis tracker and 44.74% for single axis tracker. It is observed that the dual axis tracking system provides more power output and presents an efficient system to collect solar energy which ensures more energy conversion than the single axis solar tracking system.

The power outputs for dual axis tracker are higher than the single axis tracker. Maximum power outputs for both of trackers are obtained at 12.00pm. Power is increasing from 9.00am to 12.00pm and is decreasing from 12.00pm to 3pm.The peak value of power is achieved at 12.00pm which is 1.96974 W for dual axis tracker and 1.23375 W for single axis tracker. Dual axis tracker produces more power as compared to the single axis tracker.

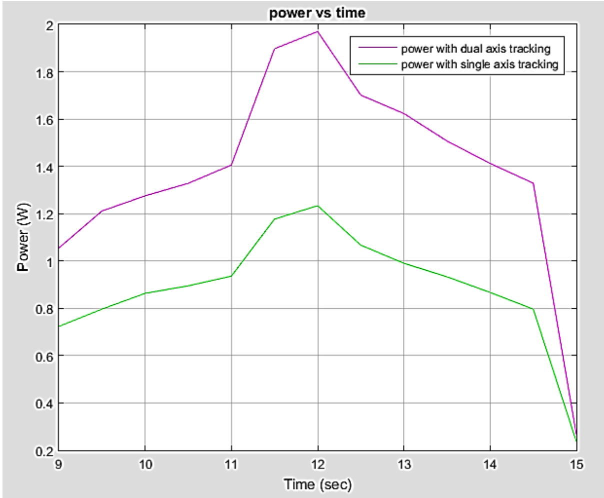


Fig. 9: Performance of dual and single axis tracker

The tracking mechanisms of dual axis and single axis solar tracker are capable of tracking the sun by consuming low power to run the servo motors. Dual axis solar tracker can track the sun according to its ray's incident on it. They can track sun in a region like ours more easily. But the structure and electrical circuit of dual axis solar tracker are little bit sensitive. That's why they could not withstand to strong wind. It is the main disadvantage of this type of tracking system.

7. CONCLUSION

Initial cost of setups is higher since they would require moving parts. They also require maintenance cost. For the use in home, tracking is not a good solution for the power supply but in large industrial power generation systems they are very useful. For a poor country like us where energy crisis will never ends, these tracking systems may be an important aspect to make some more power from the sun and reduce our countries power crisis.

Dual axis tracker is more efficient and gives more power than single axis tracker. Single axis tracker is cost effective. The complexity of hardware of dual axis tracker is more than single axis tracker.

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