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Design and Fabrication of Dual Axis Solar Tracking System For Performance Enhancement

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Abstract— The upward trend in energy demand across globe, renewable energy sources have emerged as one of the most viable options. The increasing pollution of the environment as well as the rising costs of fossil fuels have brought a significant amount of attention to renewable energy sources. Solar power is a significant contributor to the overall supply of renewable energy. Because of the ever-increasing need for solar power in a variety of contexts, including but not limited to the generation of electricity, the provision of heating, the illumination of public spaces, solar charging stations, and use in industry, etc. Therefore, solar energy is the best and most efficient option for a variety of uses. According to studies and data, the efficiency of solar panels is approximately 16% to 18%. As a result, research and development are currently being conducted to enhance of solar panel performance by increasing gross power it produces. The present work is focussed to implement dual-axis solar tracker arrangement to improve the overall efficiency of system. The fabrication of entire set up along with experimental work and testing has been conducted at MIT ADT University. The work on the project primarily centered on the design of the hardware, the manufactured part, and the assembly. The comparative study for single and dual axis solar tracker reveals superior performance of dual axis solar tracker arrangement. As a result of the testing that was carried out, we have come to this conclusion. This method produces a broad field of view while also reducing the amount of error effectiveness.

Keywords—*Real time clock, Arduino, stepper Motor, DC Motor.*

I. Introduction

The various thermal power stations in India consumed approximately 470 million tonnes of coal in 2017, which resulted in a significant amount of pollution. The solar tracking system plays a significant part, as its primary function is to collect highest of energy possible from the sun. In those days, the method for generating electricity was not nearly as efficient as it is today. This is due to the fact that there are many different kinds of power generation systems available today of various other non-renewable and renewable energy source power generation methods. A novel approach to the integration of solar detection sensors into photovoltaic dual- axis sun tracker systems is presented here. The prototype hasbeen constructed and put through its paces, which has resultedin a broad field of solar [1]. The structure of system is that ofa PILOT-PANEL, with every panel having a light to frequency converter (LTF) installed in it. The output frequency of LTF is proportional to irradiation, which also means that it is proportional to the power. This is an advantage of the LTF.

The PILOT will proceed to follow the rising sun constantly. A microcontroller is responsible for reading the frequencies of both LTFs and comparing them whenever the PILOT is moved to another location. If the disparity is smaller compared to the offsets, the Panels will remain in its present location while the PILOT will continue to follow its course. [2]. Using the dual-axis solar monitor, that is capable of rotating in both the horizontal and altitude directions, the goal of this study will be to mimic and then build the algorithm for control that will prove to be the most appropriate and effective. The simulation provides tracker with various angles needed to position the solar panel together with path of sun's rays in such a way that its surface receives maximum possible solar irradiation [3].

This system has been shown highly effective and advantageous over single-axis and fixed arrangements [4], even though the decision to make use of trackers is primarily determined by the physical characteristics of the land. In general, however, this is the case. The idea that was ultimately chosen was developed and improved in order to improve performance of solar panel. This has been accomplished by angling the panel in such a way that it was always perpendicular to the solar radiation.

As we fabricated the entire system and after placing the solar panel, we take readings in a day from 8 am to 6 pm by comparing with single axis solar panel. According to readings taken the efficiency is calculated and the dual axis solar tracking system is more efficient .

A. *Arrangement of Base for Dual Axis solar Tracker .*

- Specifications:-
- Solar Panel (Havells 100 W Polycrystalline Panel)
- MS Rectangular Coil Tube 3x1 inch(For Frame).
- MS Square Plate - 300mm x 300mm x 5mm.

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- Two MS Square Plates - 200mm x 200mm x 4mm.
- Square Pipe - 100mm x 100mm x 3mm
- 4 Nut Bolts - 12mm
- Ball Bearings

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- Arrangement of Spur gear for smooth rotation :-

As the solar panel is placed on frame and below the frame, we had made one arrangement of spur gear for smooth rotation of solar panel in north – south direction and due to the arrangement of spur gear the load acting or weight acting will manage by gears and it reduced the speed of rotation.

B. Governing Equation for the Analysis :-

The mechanical arrangement to follow the sun, it first needs to know where the sun is located. During the daytime, there are two different ways to track the sun. There is also a passive mode, which contrasts with the active mode. Linearity is the foundation of the passive mode's system. It is entirely dependent on the output of the sensors. This sensor determines where the sun is in relation to the atmosphere and then transmits that information to the controlling device. The disadvantage of using a tracking system based on linearity is that it is susceptible to being affected both physically and environmentally. The amount of solar radiation and the angle of solar incidence will shift throughout the year due to variations in climate. When the altitude and azimuth angle of the concentrators are in sun position, they are able to yield the highest amount of solar energy possible.The tracking device is essential in order to correctlyposition the concentrator in relation to the sun. Calculating the angles of azimuth and altitude is essentialif one is to make use of the solar radiation that is available.

The angle at which the sun is positioned is depicted in Figure 1.

δ	Declination angle
Ψ	Azimuth angle
α	Altitude angle
φ	Zenith angle
P	Ground Plane
H	Horizontal Line

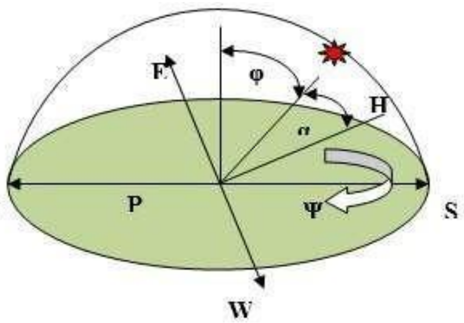

Figure 1 Direction of sun.

The angle known as the declination is shown by the symbol. Despite this, the axis of rotation of the earth is tilted at a 23.5-degree angle, and the range of the declination angle is

$$-23.5^o \leq \delta \leq +23.5^o$$

$23.45\sin[360/365\ \ d\ 24^0$ (1)

where 'd' is the day of the year. The following Eq. (2) provides the azimuth calculation,

cos(Ψ)= (sin(□) +sin(L) –sin(□) / (cos(□) cos(L)) (2)

where 'L' is the latitude. The vertical angle 'α' is denoted as altitude angle.
The altitude angle is calculated by:

sin(□) [cos(L)cos(□)cos(H)][sin(L)*sin(D)] (3)

where 'H' denotes inclination of the hourly. As determined by the next equations (4) and (5), the solar altitude in the northern region and the southern hemisphere, respectively.

□= 900 - (-□) (4)

□= 900 + (-□) (5)

The solar hour angle will increase by 15 degrees for each hour that passes. At twelve o'clock, the hour angle will be equal to zero degrees. The formula that is listed below can be used to determine it.

cos(Hs) = - tan(L)* tan(□) (6)

The sun rise angle (Hs) ranges from -180 degrees to 0 degrees, and the sun set angle (Hs ranges from 0 degrees to 180 degrees).The angle formed by the sun and the line that extends vertically from the ground plane to the zenith is known as the solar zenith angle. Equations (7) and (8), which can be found below, can be used to determine the zenith angle at the summer and winter solstices, respectively.

□= L - 23.5 (7)

□= L + 23.5 (8)

The equation that describes the position of the sun indicates that the tracker system is capable of following the sun. The location of sun can be entered into the microcontroller so that it will move in the same direction as that of sun. The linearity system will not have any influence on the tracking system in any way.

C. Description and Apparatus :-

□ Arduino UNO controller

- ATMEGA328P-PU is an 8-bit Microcontroller
- RISC Architecture
- Operating Voltage :- 1.8 to 5.5V
- Input Voltage:-7 to 12V
- Digital I/O pins:- 14
- Flash Memory:- 32k bytes.
- SRAM:- 2KB
- EEPROM:- 1KB
- Clock Speed:- 16MHz

□ Motor 1

Type= DC Planetary Geared Motor
Torque = 40 KG CM
RPM = 10 Shaft Diameter:- 10 mm
Weight = 400 g
Supplier- HITECH ELECTRONICS

□ Motor 2: -

Type = Stepper Motor
Torque=30.61 KG CM
Shaft Diameter = 6.35mm
Step angle :- 1.8 degree

□ Driver Module

Type :- TB6600 Stepper Motor driver controller

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Input current :- 0 -5 A
Micro step :- 1, 2/A, 2/B, 4, 8, 16, 32.
Power :- 160W
Temperature :- 10 - 45 Degre

- Solar Panel

Rated power (Pmax) Wp = 100 W
Max power voltage (Vmp),V = 19.12 V
Max power current (Imp),A = 5.23 A
Open circuit voltage (Voc), V = 22.68 V
Short circuit current (Isc), A = 5.60 A
Module efficiency (%) = 14.90 %
Number of cells = 4 * 9
Module dimensions (mm) = 1005 * 668
Module thickness (mm) = 35
Approximate weight (kg) = 9.7
Ambient temperature °C = -40 to +85
Hail impact velocity, m/sec = 23
Frame = Silver Anodized Aluminum Alloy
Solar Module Price = Rs.5376/-

- RTC (Real Time Clock)

Type :- DS1302
With Battery

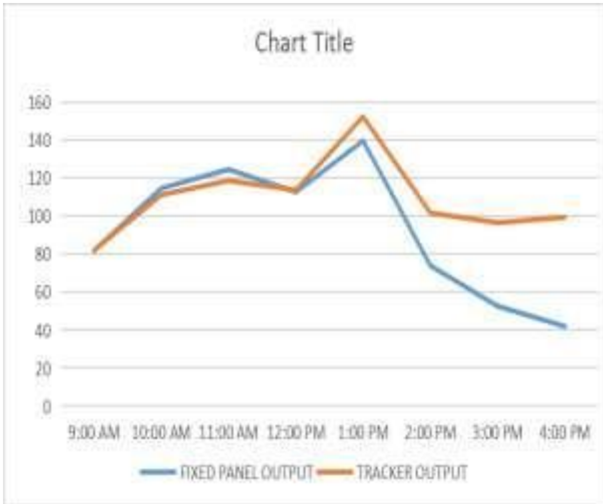
D. Result and Discussion

- Comparison between Existing and Proposed system

The comparison of solar panels to dual axis solar trackers from eight in the early hours till six in the late afternoon, it is observed that dual axis solar trackers are significantly effective over one-axis solar tracking devices. This conclusion is based on reading comparisons. The solar panel moves in the direction of RTC t and encounters a range of light intensities as it traverses the horizontal and vertical planes at varied angles and for varying amounts of time. This movement takes place as the panel moves in the direction of RTC t. The results of the important comparison that was carried out are presented in table no. 1 down here.

Figure 2:- Testing done in Morning

Figure 3 :- Testing Done at 4 pm evening



The x-axis of the graph that is being shown represents time, and the y-axis represents power in watts. The blue line represents a solar panel with a single axis, and the red line represents a solar tracker with two axes. When we look at the graph, we can see that the performance of the red line starts to shift slightly in the afternoon, and then a more significant shift takes place around noon. Therefore, the power output is maximized by using a solar panel with dual axes. In light of what has been discussed thus far, it should come as nosurprise that the Dual-axis Solar Tracker Systems come out on top in terms of both cost and benefits when pitted against the Fixed Solar System. Controlling stepper motors is just one of the many applications that can be made better with the assistance of an Arduino microcontroller. There are many others. For instance, the amount of time it takes for the position of a stepper motor to change in a step-by-step manner.

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- INITIALLY THE COMPARISON IS MADE BETWEEN STATIC AND SINGLE AXIS SETUP

The solar tracking system can generate mobile solar electricity anywhere in the world due to its mobility, efficiency, and ease of use. It's versatile.

TIME	**FIXED MODULE**			**DUAL-AXIS SOLAR TRACKER**			**Power**
	VOLTAGE (V)	CURRENT (I)	POWER (WATT)	VOLTAGE (V)	CURRENT (I)	POWER (WATT)	% Change
9 AM	21	3.90	81.9	21	3.90	81.9	0
10 AM	22.7	5.05	100.16	21.8	5.10	111.18	+0.11
11 AM	22.4	5.56	86.88	22.6	5.25	118.65	+0.35
12 PM	22.1	5.1	112.71	22.6	5.03	113.678	+0.85
1 PM	24.5	5.7	139.65	23.8	6.4	152.32	+8.3
2 PM	22.4	3.1	73.92	22.6	4.5	101.7	+37.58
3 PM	21.9	2.40	52.56	22.6	4.27	96.502	+83.6
4 PM	21.5	1.95	41.92	21.7	4.58	99.386	+137

E Overall system :

Figure 4 : - System

We use RTCs that track the sun at a rate of one degree every five minutes, and from eight in the morning until six in the evening, after which the RTCs stop functioning. Consequently, dual-axis solar tracking is more effective than fixed solar tracking.

CONCLUSION: -

Dual-axis solar trackers create more electricity than fixed-mount systems. This power-generating prototype is scalable.

The dual-axis solar tracking device will boost energy efficiency by tracking the sun's daily and seasonal movements. Efficiency gains will reduce solar panel size and electricity generation costs while maintaining output. An RTC-based dual-axis automatic sun tracking system will be designed, implemented, and tested in this project. The novel system was compared to a fixed solar tracking system. This RTC-based dual-axis solar tracking device produces more solar thermal output than a stationary solar concentrator. The real-time clock-based solar tracking system provides 75% better thermal gain than a fixed solar tracking system. system

G. Acknowledgement

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