

# MATLAB based Performance Analysis: DC Motor used in Solar Tracking System

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**Abstract**—This paper presents the performance study of single axis tracking system compared static PV system. To increase the efficiency of PV System. We designed a simple and cost effective 170 watt sun tracking system for the experiment. The whole experimental setup has been implemented in Simulink platform for the analysis of improved efficiency. The objective of this paper to optimize the solar energy receivers. In this paper, a Simulink model of the static PV system and Tracking PV system has been presented. In the fabrication of real The sun tracker system we used a 24 Volt c motor and a simple LDR based control circuit for the tracking purpose. The block diagram with detailed description and performance of the tracking system are presented.

**Index Terms**- DC-motor model, Simulink based Static PV System, Solar tracking system, Photovoltaic.

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## I. INTRODUCTION

THE Sun is an abundant source of solar energy. The total amount of energy received from the sun on the Earth planet – around  $10^{17}$  Watt. The value of the solar constant is  $1000 \text{ W/m}^2$  at sea level on a clear day. While In cloudy sky, there could be a small component of direct radiation and a substantial component of diffuse radiation [1-4].

In order to optimize the efficiency of PV system, Solar tracker is invented because generated power of any PV system is directly dependent on irradiance value and the static PV system disables to move toward the sunlight when the sun moves from east to west. In a past days much research was done in this field. The existing sun tracking techniques is classified in two types (a) passive tracking system (b) active tracking system. In passive tracking system, mechanical techniques are used to track the sun position while in active tracking system electrical and mechanical concept is used. The passive tracking system is cheaper than an active tracking system. Hession and Bonwick [5] designed a photo-transistor based sun tracker system.

Ayala, J. Kenneth [6] presented, Microprocessors based tracker system. For experimental setup a simple, low cost tracker system was designed. to track the position of the sun a 24 volt DC motor was used and the motor is connected to a PV cells via simple tracking control circuit. we avoid the use of battery for the tracking purpose. this paper also presented a SIMULINK model of Tracking PV system as well as Static PV system.

According to Kupta and Mirakhur [7] a single axis tracker increases annual output by approximately 30%, and a dual axis tracker an additional 6%. The Simulation results shows, the accuracy of designed tracking system is much greater than the previous presented tracking system.

## II. WHY SUN TRACKER REQUIRED.

Solar energy is radiated uniformly in all the direction the spectrum of this radiation lies in the visible and infrared part of the EM (Electromagnetic) wave. The luminosity of the Sun is about  $3.86 \times 10^{26}$  watts. The distance of the sun from the earth is 150 million kilometer and the earth radius is 63000 kilometer approximately. The solar power we received at the earth surface is approximately 1370 watts per square meter is called solar constant. It is varies by +/- 3% because of the Earth's slightly elliptical orbit around the Sun as

The Earth rotate in elliptical orbit around the sun and also around in own axis known as polar axis, mathematically declination angle ( $\partial_z$ ) can be expressed as [10].

$n_d$  = day of the year.

$$\partial_z = 23.45^\circ \cdot \sin \left[ \frac{360 \cdot (n_d - 180)}{365} \right]$$

If  $\theta_z$  is the zenith angle then:  $\theta_z = \varphi - \partial$ .

Where  $\varphi$  = latitude angle.

$\partial_z$  = declination angle.

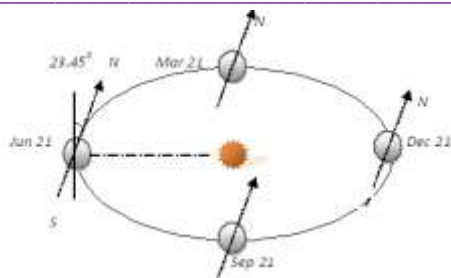


Figure 1. position of earth with respect to sun.

Solar Event	Date
Vernal equinox	Mar-21
Summer solstice	June-21
Autumnal equinox	Sep-23
Winter solstice	Dec-21

The azimuth angle is zero at solar noon and increases toward the east. The angle about the vertical axis is called the azimuthal angle and is 0 at due south and becomes positive as you start to point east. The angle about the horizontal axis is called the altitude and is 0 level to the horizon and becomes positive as you point towards the sky.

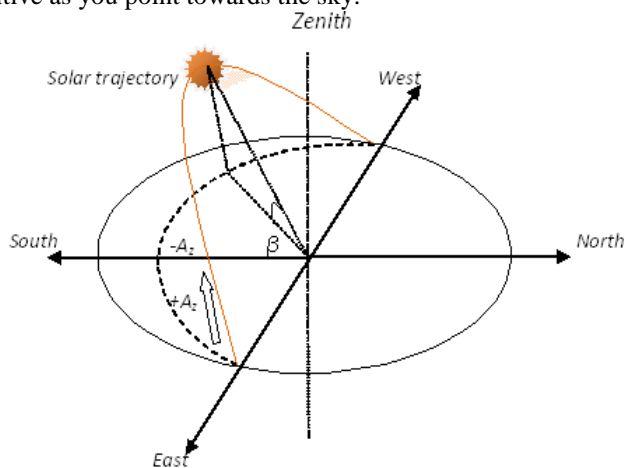


Figure 2 Solar Trajectory

III. SOLAR TRACKING PV SYSTEM.

The position of sun in the sky varies in both directions Azimuthally as well as elevated direction in the whole day and throughout the year. the block diagram of experimental setup has been presented in figure 1 and figure 2 shows the actual fabricated solar tracker PV system.

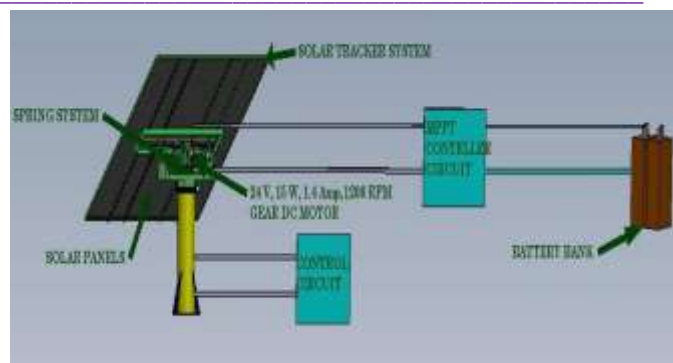


Figure 3 Block diagram of Solar PV System



Figure 4 Designed solar tracker PV system.

Figure 2 shows the designed dual axis solar tracker system. In this system two 24 volt DC motor was used to track the Sun position azimuthally (East-West) as well as elevated. for the performance analysis of tracking PV system and DC motor the system has been developed in Simulink platform.

IV. SPECIFICATION

DC-motor specification:

For the dual axis tracking, Two 24 Volt each DC motors was used in the designed solar tracker PV system because we avoid the use of battery for the tracking purpose. these motors was directly connected to 170 watt PV module. The DC voltage equation for the armature circuit is:

$$V = I \cdot R_a + K \cdot \omega$$

Where:  $R_a$  is the armature resistance. Increasing  $R_a$  The back emf is  $E=K \cdot \omega$  where:  $K$  is the constant, and  $\omega$  is the angular speed of rotor in rad/sec.

The specification of DC motor is: 2-POLE permanent magnet Lap wound dc motor. DGM-3440-24Volt, 15 watt, 1200 rpm, 1.5 Amp geared.

Configuration	Single Glass Laminated Type With 72 Cells (12 × 6) In Series
Overall Size	1595 (± 3) × 790 (± 2) × 50 (± 1) MM
Weight	15 Kg. (Typical)
Typical Electrical Characteristics of L24150 type module (170Wp)	

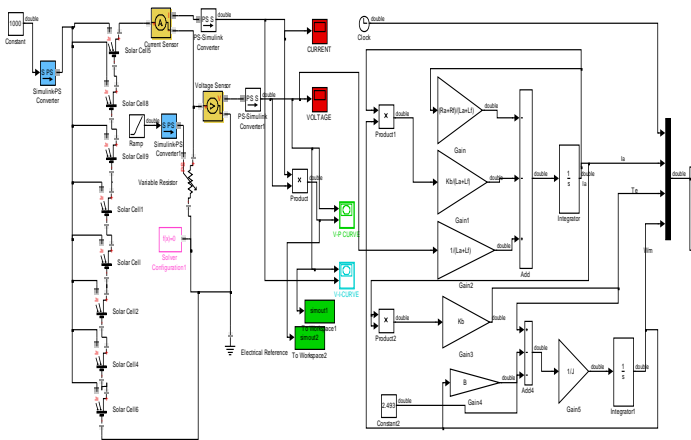
Open Circuit Voltage ( $V_{oc}$ )	42.0 V
Short Circuit Current ( $I_{sc}$ )	4.86 A
Operating Voltage	35 V
Max Power Output	170.0 W $\pm$ 3%

**Solar Panel specification:**

**Table 1: Specifications of Solar Photovoltaic Modules**

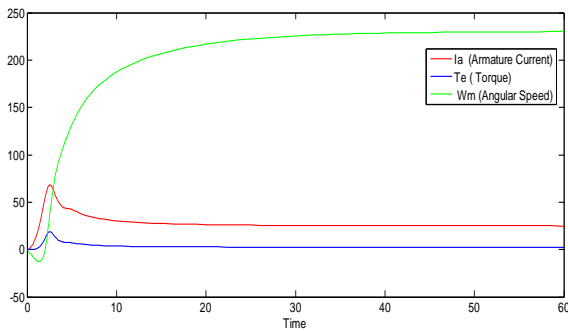
**V. SIMULINK MODEL**

**DC Motor:**



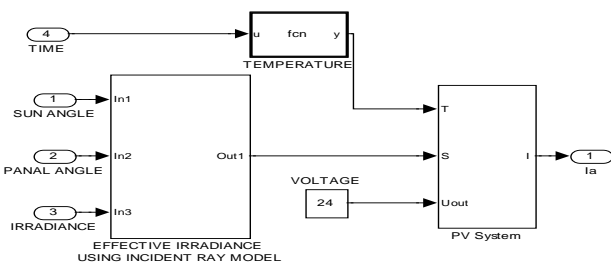
**Figure 5 DC motor directly connected to PV module.**

As shown in figure 3. The DC motor is directly connected to PV module the simulation results are presented in figure 4.



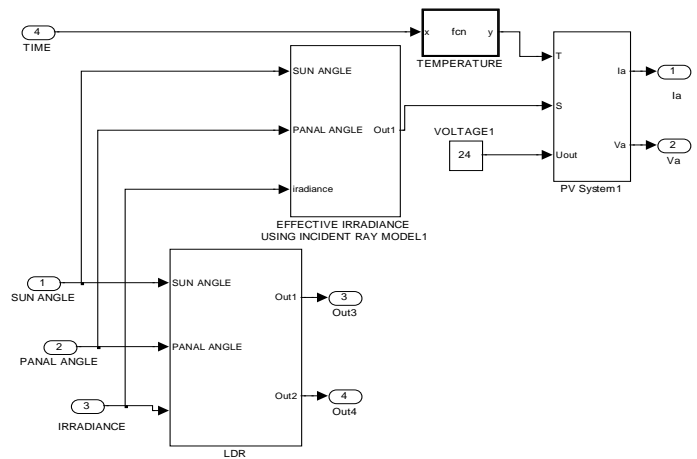
**Figure 6 Simulation result of DC motor connected to PV module**

**Static PV system:**



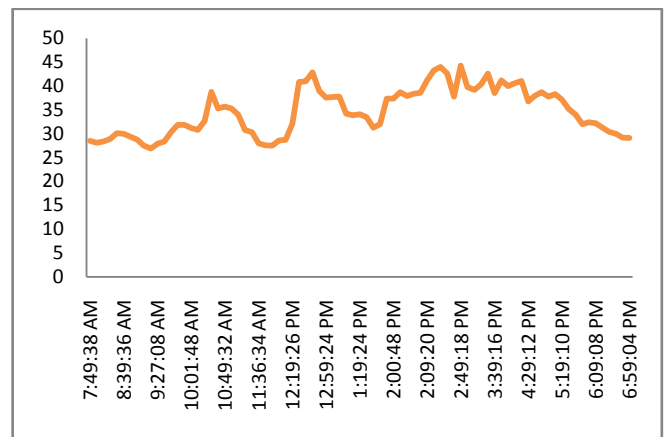
**Figure 7 Static PV System model in SIMULINK**

**Tracking PV system:**

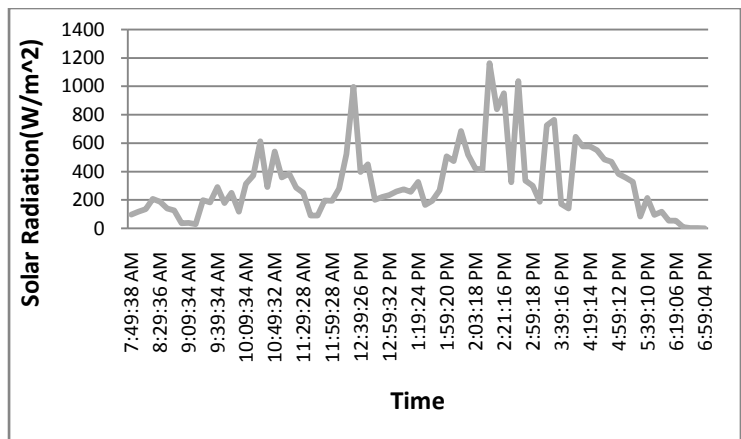


**Figure 8 Tracking PV System Model in SIMULINK**

For the Simulation Purpose Real time recorded data of temperature and irradiance value was used. because obtained data was discrete in nature therefore we fitted a spline curve for getting the data in a continuous form. Figure 7 and figure 8 shows the variation in temperature and Irradiance value with respect to time respectively.



**Figure 9 Actual Temperature recorded on date: 13-08-2014**



**Figure 10 Solar irradiance data Recorded on 13-08-2014**

VI. EXPERIMENTAL RESULTS

These data were taken in the month of August-13, 2014. Table.2 represents the recorded data of fixed PV system and Tracking PV System .

Table 2: Fixed system and Tracking System

TIME	Static PV System			Tracking PV System		
	Voltage (V)	Current (Amp)	Power (watt)	Voltage (V)	Current (Amp)	Power (watt)
7.00am	0.816	1	0.816	0.941	0.2	0.1882
7.30am	1.18	2	2.36	1.35	1	1.35
7.45am	1.168	2.5	2.92	2.04	1	2.04
8.00am	2.2	3	6.6	1.189	1	1.189
8.15am	3.485	4	13.94	1.01	2	2.02
8.30am	4.75	5.5	26.125	6.6	3	19.8
8.40am	7.35	6.5	47.775	14.5	10.5	152.25
8.55am	9.18	7	64.26	16.02	11	176.22
9.05am	10.41	7.52	78.2832	16.82	11.4	191.748
9.20am	12.51	8.4	105.084	17.87	11.7	209.079
9.36am	14.48	9.1	131.768	18.95	12	227.4
9.50am	16.21	9.6	155.616	19.8	12.4	245.52
10.05am	18.35	10.4	190.84	19.93	12.5	249.125
10.20am	19.28	10.6	204.368	20.12	12.5	251.5
10.40am	21.7	11.4	247.38	20.8	12.6	262.08
10.54am	22.45	11.6	260.42	21.02	12.6	264.852
11.10am	23.22	11.9	276.318	21.04	12.75	268.26
11.25am	23.45	12	281.4	20.85	12.9	268.965
11.45am	23.87	12	286.44	20.69	12.75	263.7975
12.00am	23.86	12	286.32	20.23	12.5	252.875
12.15am	23.91	12.1	289.311	19.53	12.5	244.125
12.40pm	23.04	12.1	278.784	20.34	12.45	253.233
1.00pm	23.91	12.1	289.311	20.35	12.4	252.216
1.10pm	23.9	12.1	289.19	20.45	12.5	255.625
1:25pm	23.81	12	285.72	20.71	12.5	258.875
1:44pm	22.9	12	274.8	20.37	12.6	256.662
1:55pm	22.83	11.9	271.677	20.03	12.6	252.378
2.10pm	21.51	11.7	251.667	19.87	12.5	248.375
2.25pm	20.7	11.5	238.05	17.85	12	214.2
2.35pm	21.22	11.4	241.908	19.04	12.1	230.384
2.50pm	18.7	10.9	203.83	17.26	11.8	203.668
3.00pm	17.9	10.5	187.95	17.06	11.5	196.19
3.05pm	15.65	10	156.5	14.66	11	161.26
3.21pm	14.98	9.6	143.808	14.16	10.9	154.344

3.44pm	10.22	7.5	76.65	10.07	9	90.63
4.00pm	9.7	7.5	72.75	10.38	9	93.42
4.22pm	6.9	6.5	44.85	7.93	8	63.44
4.35pm	5.64	6.1	34.404	6.62	7.5	49.65
4.40pm	5.05	6	30.3	5.26	7	36.82

EXPERIMENTAL RESULTS

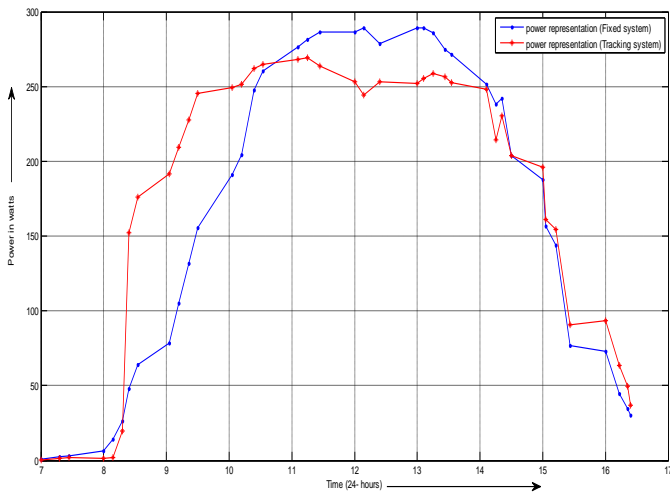


Figure 11. Graphical Representation of Power

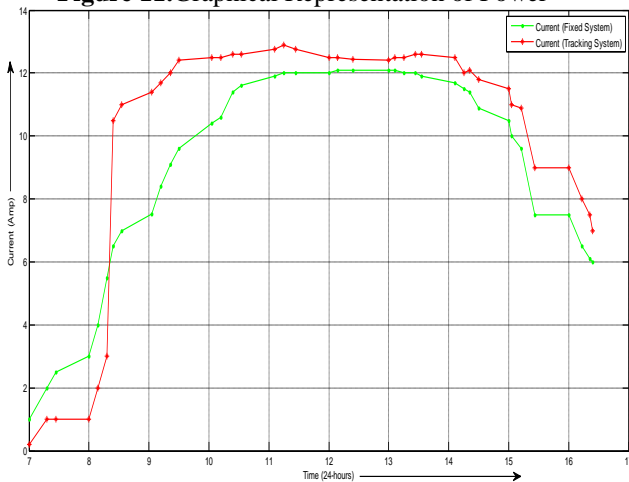
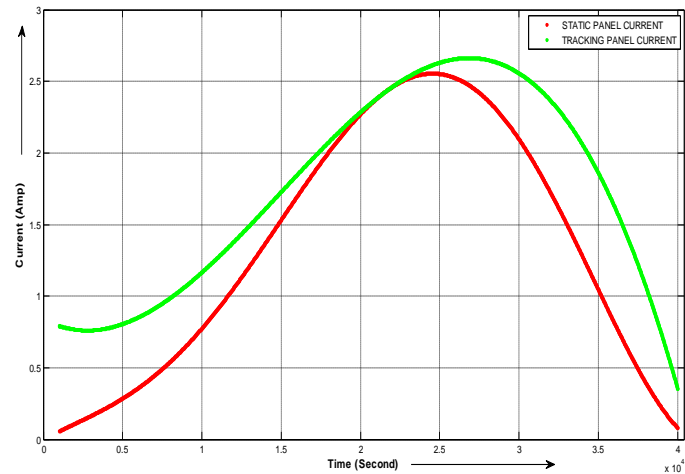


Figure 12 Graphical Representation of Current

SIMULATION RESULTS



A. Figure 13 Simulation Result of Tracking and Static Panel Current Vs Time

Figure 13 Shows the the current values of tracking system and static PV system with respect to time. The variation in efficiency is shown in figure 14.

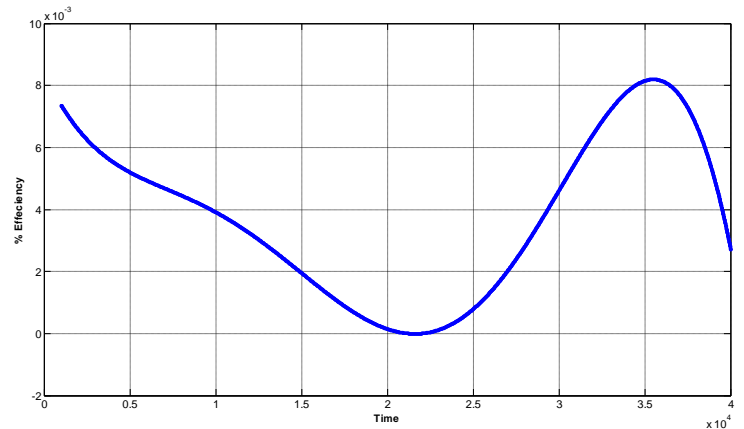


Figure 14 Simulation Result of Efficiency Vs time

VII. CONCLUSION

Simulation results show that the Improved efficiency of Solar PV system with tracker in azimuthal direction is 36 % compared to static PVsystem. While in the experiment, the Improved efficiency is 38 % compared to the static PV system.

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