International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

December 2016 | Issue 29 | Volume 8 | Number 4 | Pages 34-38

DESIGN DUAL AXIS SUN POWER TRACKING SYSTEM USING ARDUINO

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Abstract- The demand for electricity generation increased so much in the present time, so photovoltaic (PV) solar energy is one of the processes that gain power electricity from renewable resource and it is ecofriendly and clean. To get the highest efficiency for solar panel a solar tracking system that has dual axis is designed and used to track the sun's position during daylight. Arduino Mega is used to control the rotation of solar tracking system that has dual axis and save the data inside it. Four LDRs used to detect the position of the sun in the sky so that the tracking system follows to make vertical sunlight on the surface of the photovoltaic panel. Experiments is carried out to verify the theoretical results.

Keywords: PV, Dual Axis, Solar Tracker, Arduino Mega.

I. INTRODUCTION

Fossil fuels provides nearly 79% of the energy consumption. The World Energy Forum states that the fuels of fossil origin – petroleum, coal, and gas – would last no longer than a century [1]. Since the electricity price is constantly increased overtime and to solve this problem the renewable energy resources are used with small installable capacities for demands, and it is a suitable way to reduce environmental pollution, the using of fossil for energy and cost of transports [2].

The solar energy is an alternative energy to satisfy the increasing in electricity command due to its availability in everywhere, plentiful, and steady, despite the sporadic of sunlight, solar energy is broadly obtainable and totally free of cost. Therefore the renewable energy sources have been an important research issue for researchers and investors. The solar energy, as being an important renewable energy sources, is environment friendly, releases no gas harmful to the atmosphere, causes no pollution, available for investment and an ergonomic energy source [3]. It appears that solar power looks a useful source of energy for Earth, in terms of making investment and using it. Many nations, aware of this fact, have invested billions of dollars on the solar power systems [4].

The energy conversion of photovoltaic panel is a one-step conversion process that convert the solar energy to electrical energy [5].The photovoltaic panels have a little efficiency which need to be improved and it can be adjust by two ways either by improving of photovoltaic panel structure design or improvement of materials, by better use of the same photovoltaic panel with the intention that the solar radiation to remain perpendicular on photovoltaic panel.

The study was performed at Van-Turkey located on the eastern of Turkey (latitude 38.566 and longitude 43.282). Van province is located to the east of Turkey and it is surrounded by mountains, the heights of which vary between 2400 meters to 3000 meters. The positive effect of the altitude to the solar energy potential is seen in the annual global radiation value of the province which is obtained as 1635.81 kWh/m^2 per year [6]. The effect of the atmosphere thickness and low humidity as well as clean air quality is complementary to each other from solar potential point of view. On the other hand depending on the temperature profile of Van it can be said that the city has cold climate with average temperature of 9.85 °C yearly. The temperature reaches -13.6 °C most while the highest temperature is 31.7 °C.

A PV solar tracker is used as an adjustable for a day lighting reflector. The equipment that are used for solar power can work very well when they are pointed at sun. Therefore, a solar tracker system can produce energy more successfully than any fixed solar system. The tracker allows the panel to pursue the lines of the sun and gives more power when it soaks up more sunlight. Concentrators, especially in applications that use the solar cells, need a high correctness degree to make certain that the focused sunlight is pointed exactly to the power device.

This paper highlights the expansion of a reproduced model of dual axis solar tracker by using Arduino (mega 2560) microcontroller to control the rotation of DC motor is also given depending on the voltage differences from the sensor LDR based on intensity of sunlight.

II. SYSTEM DESCRIPTION AND METHOD

Two 20Wp polycrystalline PV panels have been used for fixed and dual axis tracker experiments. The fixed PV system is installed at the Yuzuncu Yil University (Van, Turkey) campus area inclined at 27° facing due south. The prototype of the dual axis tracker study consists of two parts, the first one is hardware and other one is software. One part of the hardware is a fixed toward south latitude

angle 27° which is suitable for latitude of Van city as show in Figure 1 and the other part of hardware is rotatable and have two axes of rotation the panel around the vertical axis to follow the azimuth angle by one DC motor and around the horizontal axis to follow the altitude angle by second DC Motor as shows in Figure 2.

Figure 1. Fixed PV system

Figure 2. PV system with tracker

Arduino microcontroller which is given in Figure 3 is used to control and rotating the system to follow the suns position in the sky depending on photo cells. Arduino is an open source electronics platform which includes hardware and software. The Arduino Software (IDE) and programming language are used for processing the Arduino Mega 2560.

The solar tracking system that has dual axis is used to fallow the sun position. The Arduino is used to control the rotation of the solar tracking system that has dual axis rotation. Four LDRs are used to detect the sun position in sky so that the tracking system follows it to make the solar radiation perpendicular on photovoltaic panel surface.

A microcontroller can be defined as a small computer which has a single integrated circuit consist of a core that all computers have for process, memory, and the input-output peripherals that can be controlled and the properties that microcontroller have make it important for process [6].

Figure 3. Arduino Mega 2560 [7]

The tracking system also needs a strong mechanical structure to handle the Photovoltaic panels. The mechanical structure we will make in to two parts; upper and lower parts. Both parts connected by four bolts and nuts. The mechanical structure is shown in Figure 4.

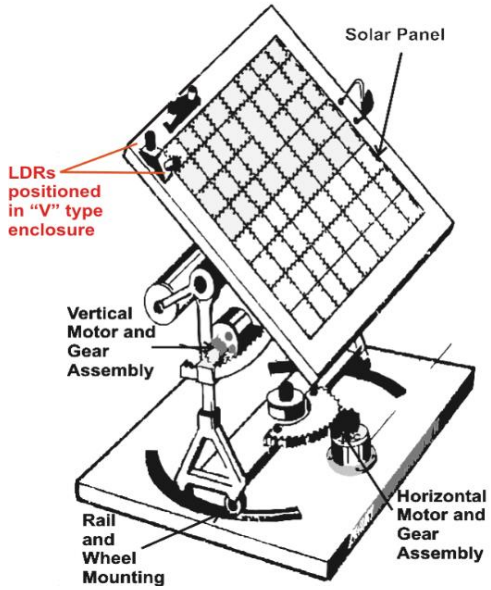

Figure 4. The mechanical structure of the tracker

The function of upper part is to rotating the photovoltaic panel to follow altitude angle of the sun which we need by using a DC actuator. To make the rotation smoothly two ball bearings were used. The lower part used to rotate the photovoltaic panel toward east and west to follow the sun's azimuth angle at which we need using a DC motor. One ball bearing was used to smooth the rotation of the structure. The lower part is strong and rugged enough to carry and rotate the whole mechanical parts.

III. EXPERIMENTAL RESULTS

Based on the design configuration the completely operational experimental model of a dual axis solar tracking system using Arduino has been executed. Two solar photovoltaic panels with the same specification were used to collect data. One was fixed toward the south and the other followed the sun from sunrise to sunset. The specifications of the two solar photovoltaic panels which were used are shown in Table 1.

Table 1. The specifications of the solar photovoltaic panels

Description	Value	Unit
Max Power (P_m)	20	W
Open-Circuit Voltage (V_{oc})	21.08	V
Short-Circuit Current (I_{sc})	1.37	A
Max Power Voltage (V_m)	17.5	V
Max Power Current (I_m)	1.14	A

The tests took place at Van which latitude 38.566 and longitude 43.282 on a cloudy weather in September 21, 2016, which was a sunny day until time 1:30 pm afternoon, but then the weather changed to rain.

Before beginning tests we have to find the maximum power point of the PV panel. This can be done by using a variable resistor as a load resistor (R_L), connecting to PV panel outputs then measuring both voltage and current across using voltmeter and ammeter. The circuit diagram is shown in Figure 5.

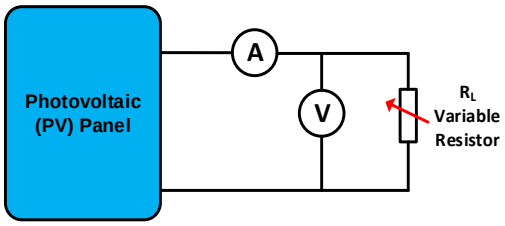

Figure 5. Circuit diagram for *V-I* curve of the PV panel

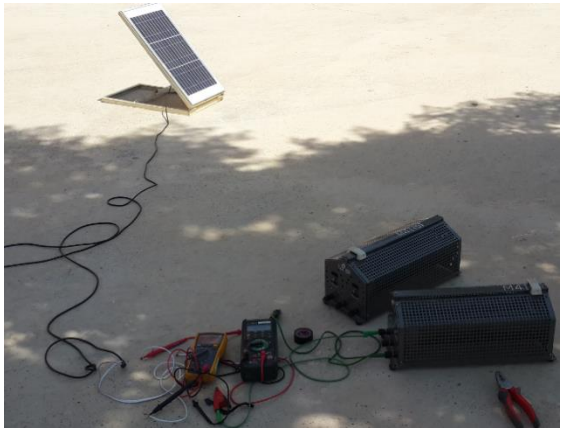

Figure 6. Experimental circuit for *V-I* curve of the PV panel

To obtain maximum power point results collected on August 12, 2016 which the load resistor (R_L) value changed from its maximum value (110 ohms) to 0 and both voltage across and current through it were recorded with minimum steps of voltage as shown in Table 2 and Figure 6.

The data obtained from the *V-I* experiment of the panel are used to draw the maximum power and *V-I* curve of the panel as shown in Figure 7.

Table 2. Experimental results of the PV panel

Resistor (Ω)	Power (W)	Current (A)	Voltage (V)
0.00	0.00	1.36	0.00
0.09	0.15	1.36	0.11
0.46	0.73	1.35	0.54
0.93	1.46	1.35	1.08
1.39	2.19	1.35	1.62
1.85	2.92	1.35	2.16
2.31	3.65	1.35	2.70
2.78	4.37	1.35	3.24
3.24	5.10	1.35	3.78
3.70	5.83	1.35	4.32
4.17	6.56	1.35	4.86
4.63	7.29	1.35	5.40
5.09	8.02	1.35	5.94
5.56	8.75	1.35	6.48
6.07	9.39	1.34	7.02
6.54	10.11	1.34	7.56
7.01	10.83	1.34	8.10
7.48	11.56	1.34	8.64
7.94	12.28	1.34	9.18
8.41	13.00	1.34	9.72
8.88	13.72	1.34	10.26
9.35	14.45	1.34	10.80
9.81	15.17	1.34	11.34
10.28	15.89	1.34	11.88
10.75	16.61	1.34	12.42
11.21	17.33	1.34	12.96
11.79	17.89	1.33	13.50
12.38	18.43	1.31	14.04
12.61	18.71	1.31	14.26
12.93	18.81	1.30	14.47
13.22	18.91	1.29	14.69
13.58	19.00	1.28	14.90
14.00	18.90	1.25	15.12
14.95	18.99	1.21	15.66
16.30	18.63	1.15	16.20
17.82	18.20	1.09	16.74
19.75	17.50	1.01	17.28
22.60	16.26	0.91	17.82
26.56	14.69	0.80	18.36
32.41	12.76	0.68	18.90
42.86	10.21	0.53	19.44
59.68	7.74	0.39	19.98
103.83	4.69	0.23	20.52
145.30	3.42	0.17	20.71

After obtaining *V-I* curve and power results of the PV panel, the results of the fixed PV system and dual axis tracker PV system were collected on September 21, 2016, from sunrise at 6:30 am to at 3:00 pm. Where the weather good condition are as follows: temperature between 9 ºC and 21 ºC, until time 1:30 pm, but then the weather changed to rain. If we look at the results, we see good results have gained.

The results measured and recorded automatically on memory every 10 minutes for voltage and current for both fixed photovoltaic panel and the panel with tracking. The block diagram of the hardware configuration is given in Figure 8.

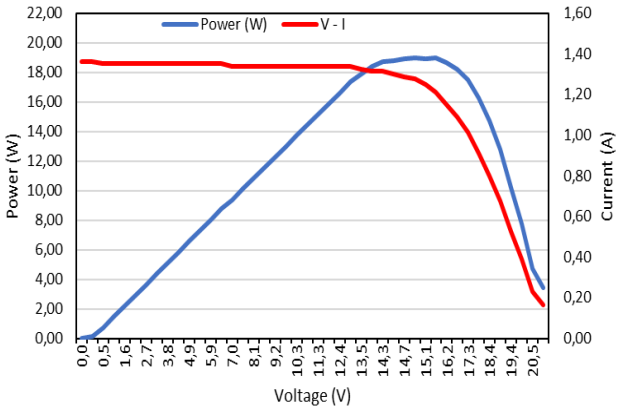

Figure 7. Measured *V-I* characteristics PV panel showing maximum power point

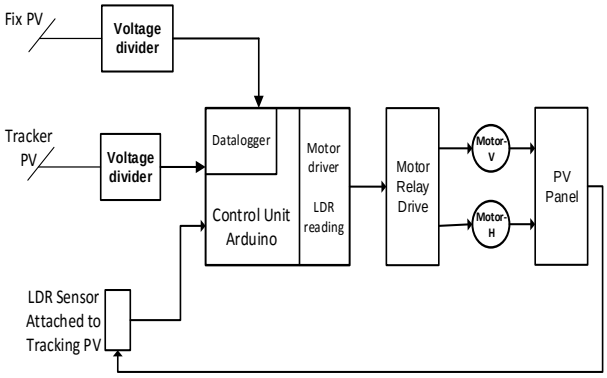

Figure 8. The block diagram of the hardware configuration model

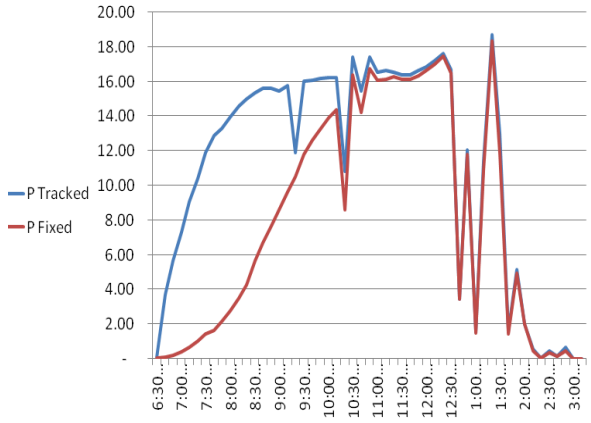

Figure 9. Output power for both fixed and tracked PV Panels

The experimental setup was established according to the hardware configuration model. The data given in Table 3 and Figure 9 are obtained via experimental studies for both fixed PV and tracker systems. The results from Table 3 and Figure 9 show that the tracker system produces more energy compared to fixed PV system.

Table 3. Output power for both fixed and tracked PV Panels

Time	*P* (W) Tracker System	*P* (W) Fixed System	Time	*P* (W) Tracker System	*P* (W) Fixed System
06:30	0.10	0.03	11:00	16.54	16.04
06:40	3.73	0.09	11:10	16.62	16.10
06:50	5.64	0.21	11:20	16.54	16.24
07:00	7.32	0.40	11:30	16.39	16.10
07:10	9.05	0.67	11:40	16.39	16.10
07:20	10.38	1.03	11:50	16.62	16.33
07:30	11.92	1.44	12:00	16.83	16.62
07:40	12.86	1.64	12:10	17.19	16.98
07:50	13.31	2.16	12:20	17.65	17.43
08:00	13.98	2.80	12:30	16.68	16.47
08:10	14.58	3.49	12:40	3.43	3.43
08:20	14.98	4.27	12:50	12.04	11.79
08:30	15.34	5.64	13:00	1.56	1.51
08:40	15.61	6.71	13:10	11.44	10.84
08:50	15.61	7.66	13:20	18.70	18.33
09:00	15.46	8.62	13:30	12.99	11.86
09:10	15.75	9.65	13:40	1.62	1.47
09:20	11.92	10.50	13:50	5.15	4.95
09:30	16.04	11.79	14:00	2.02	2.00
09:40	16.10	12.60	14:10	0.58	0.46
09:50	16.18	13.25	14:20	0.06	0.06
10:00	16.24	13.90	14:30	0.45	0.34
10:10	16.24	14.37	14:40	0.14	0.14
10:20	10.84	8.62	14:50	0.66	0.47
10:30	17.43	16.39	15:00	0.01	0.01
10:40	15.46	14.23	15:10	0.00	0.00
10:50	17.43	16.75			

IV. CONCLUSION

A dual axis solar tracking system has been designed to get the highest efficiency for solar panel by using Arduino Mega. Four LDRs are used to detect the position of the sun's position during daylight. In addition a fixed PV system has been also designed to compare its results with that of the tracker system. The observed data from the tracker PV system and fixed PV system have been compared and given via graphics. The results show that the tracker system produces more energy compared to fixed PV system. It will be better to compare the results of these systems in large period work.

ACKNOWLEDGMENT

The authors would like to acknowledge Scientific Research Fund of the Yuzuncu Yil University (YYU-BAP) for the financial support of this research with project number of 2015-MIM-B038.

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BIOGRAPHIES

Naci Genc received his B.Sc., M.Sc., and Ph.D. degrees from Gazi University (Ankara, Turkey), Yuzuncu Yil University (Van, Turkey) and Gazi University in 1999, 2002, and 2010, respectively. Currently, he is an Associate Professor in the Electrical and Electronics Engineering Department of Yuzuncu Yil University. His research interests include energy conversion systems, power electronics and electrical machines.

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