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Measurement of 3 Solar Panel Output Involving Controller and Reflector

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Abstract

Solar cell as one of renewable energy source had been treated differently in this research. In order to optimize its output and efficiency, three panels output was measured simultaneously by vary its movement and sun light exposure. The variations of measurement are one static panel without any treatment; one static panel with two mirrors as reflector; and one dynamic panel with reflector. The dynamic panel movement controlled by microcontroller. Result had revealed that the treatment succesfully improve the output of solar cell.

***Keywords**: solar cell, mirror, reflector, microcontroller, optimum efficiency*

1. Introduction

One of the renewable energy source is solar cell which produce DC current by converting sun's energy. In Indonesia, where the sun irradiates the country every day over the year, several research had been done related to solar cell. All of them has one goal : how to improve solar cell output by increasing the material efficiency or designing an effective measurement technique.

For example, a research which combine solar panel with mirrors as sun light reflector had been proven increase solar panel output by 56 - 77 % compare to panel without reflector [1]. Some techniques also had been applied to optimize panel output by building tracking panel [2-5]. It tracked the sun direction to keep panel at perpendicular position to the sun-rays by moving the panel utilize stepper motor controlled by microcontroller [6, 7] or even by PLC [8]. The result had brought the efficiency value up to 65%.

In this research, integration between reflector and controller on solar cell had been conducted to gain optimum efficiency of a panel's output. To validate the datas collected from the experiment, we measured simultaneously 3 solar cell's output by vary the treatment of each panel. Hypothetically, the panel with complete treatment-reflector integrated with controller, will has the most efficient output than others.

2. Research Method

Three panel of solar cell had been utilized and its output was measured simultaneously by different technique of treatment. Figure 1(a), 1(b) and 1(c) show the difference. The first panel output was measured without any treatment where it mounted staticly (Figure 1(a)). The second one was measured by subjoin 2 mirrors to a static panel's side (Figure 1(b)). They are mounted on the north and south side of the static panel. These mirrors function as reflector to increase the sun light exposure to panel surface.

Reflector method had been conducted by J. Rizk et al in 2011 [9]. They compare the number of reflectors used on the side of solar panel. The experiment's result stated that 2 reflectors has sufficient and efficient output not different much from 4 reflectors output. For that reason, only 2 reflectors was used in this research. Those 2 mirrors was mounted and arranged with 60^0 tilt from horizontal line. The degree was chosen based on result from Amalia and Satwiko's research [1].

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The third panel was treated by adding microcontroller integrated with 2 reflectors in order to increase the sun light exposure more than second panel (Figure 1(c)). Microcontroller had been used to control stepper motors for panel movement [2-7]. The movement was adjusted to follow and track the position of the sun. In this research, the sun tracker integrated with reflector systems to improve sun light's intensities on panel surface better than 2 others.

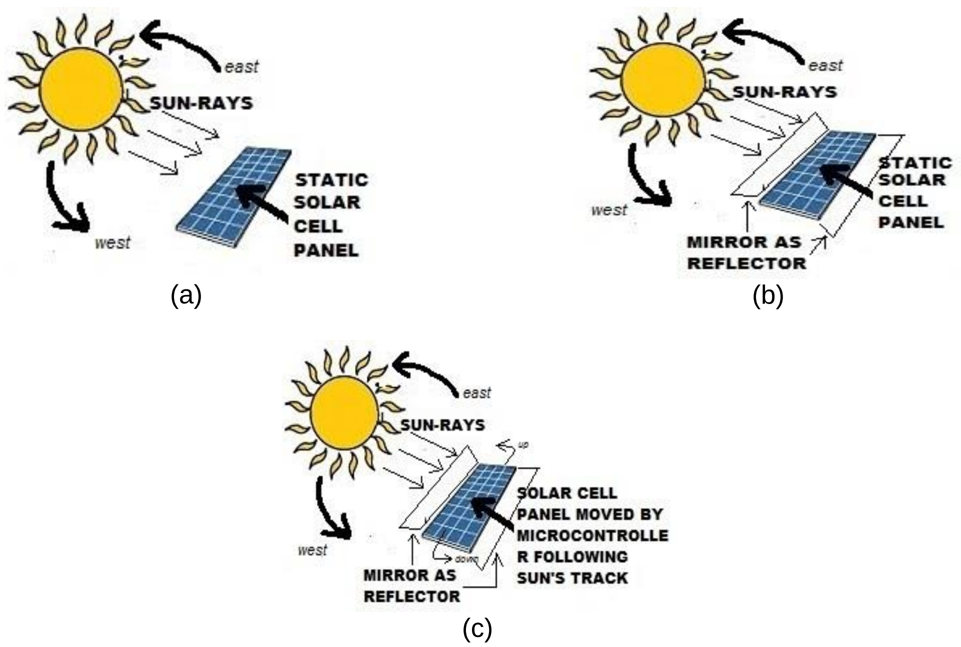

Figure 1. Different treatment in measuring 3 solar panel's output: (a) static panel, (b) static panel with reflector, (c) dynamic panel with reflector controlled by microcontroller

Data acquisition was conducted by measuring 3 panels' output simultaneously (Figure 3). The DC current produced by 3 panels was measured using Multimeter while at the same time the sun light's intensities was obtained by using Luxmeter. The DC current data of each panel will be compared and analyzed one to another. These datas were also utilized for efficiency calculation based on formula 1.

$$\text{Efficiency of each panel} = \frac{\text{Power output of each panel}}{\text{Sun light's intensities x Panel's area}} \qquad (1)$$

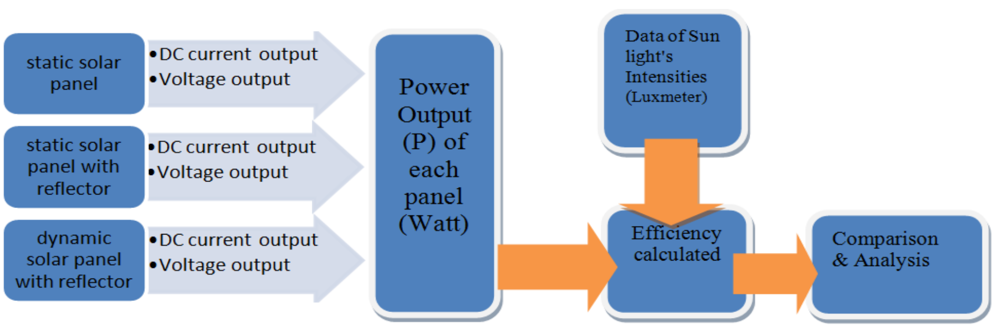

Figure 2. Block Diagram of Data Acquisition and Analysis

3. Results and Analysis

The measurement of solar cell's output had been done to 3 panels with different treatment. They are a static panel integrated reflector (Figure 3(a)), a dynamic panel (controlled by microcontroller) integrated reflector (Figure 3(b)) and a static panel output without any treatment- reflector or microcontroller- as a base line of measurement (Figure 3(c)).

(a) (b) (c)

Figure 3. Solar panels with various treatment: (a) static panel with reflector, (b) dynamic panel integrated reflector, (c) static panel only

The dynamic panel had been succesfully moved following the sun's track in single axis during the day. The movement had been controlled by ATMEGA16 utilising LDR (Light Dependent Resistor) as its sensor input. These sensor was quite sensitive to the sun light after modifying the microcontroller circuit as shown in Figure 4.

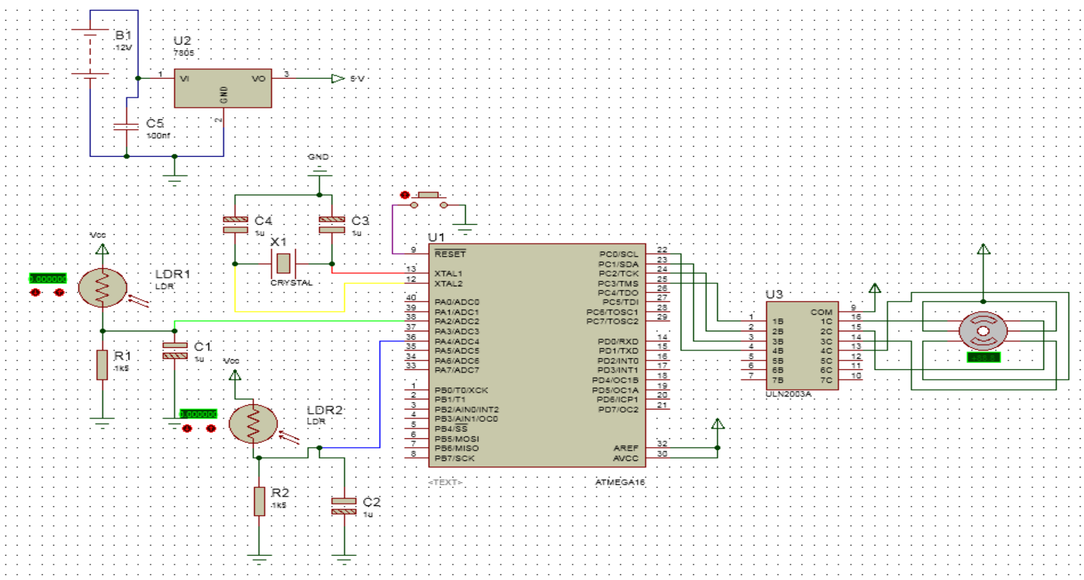

Figure 4. Microcontroller Circuit Design

The measurement of these solar panels output had been conducted on November 27th 2015 in Sriwijaya University campus. The data (V and I) had been recorded manually from 7 a.m to 5 p.m every 10 minutes. Meanwhile, the sun's light intensities data had been obtain using Luxmeter simultaneously with the measurement of panel's output. From those data, solar panel efficiency was calculated and analysed to see the effect of each treatment (Figure 3(a), 3(b), 3(c)).

Efficiency calculation of panel's output represented that static panel had maximum value at 16% during the PSH/ Peak Sun Hour (11 a.m to 2 p.m); static panel with reflector had maximum efficiency value at 23% during PSH; while dynamic panel integrated reflector had effiency values better than others as seen in Table 1.

Table 1 is the complete measurement result (1 day full) of dynamic panel integrated reflector treatment. It showed that 16% and 23% of efficiency values had already obtained since in the morning and keep maintained around 20% during all day. Its maximum values up to 27% during PSH as shown by data no. 32.

Table 1. Efficiency Calculation of Dynamic Panel Integrated Reflector

No	Time	Voltage (V)	Current (A)	Light's Intensity (Lux)	Watt/cm^2	η
1	08.10	12,3	0,35	85300	0,01248902	21%
2	08.20	10	0,19	50500	0,007393851	16%
3	08.30	11,3	0,21	54300	0,00795022	18%
4	08.40	11,2	0,17	36500	0,005344071	22%
5	08.50	11,7	0,19	59200	0,008667644	16%
6	09.00	11,5	0,16	34900	0,00510981	22%
7	09.10	12,6	0,34	100300	0,014685214	18%
8	09.20	13	0,37	117000	0,017130309	17%
9	09.30	11,9	0,33	121800	0,017833091	13%
10	09.40	13,1	0,39	128600	0,018828699	16%
11	09.50	12,5	0,41	125000	0,018301613	17%
12	10.00	12,4	0,42	135600	0,019853589	16%
13	10.10	13,4	0,45	149300	0,021859446	17%
14	10.20	12,4	0,5	148000	0,021669109	17%
15	10.30	11,8	0,18	56700	0,008301611	16%
16	10.40	11,7	0,15	58300	0,008535872	12%
17	10.50	12,8	0,44	121800	0,017833091	19%
18	11.00	11,7	0,25	68000	0,009956077	18%
19	11.10	11,4	0,16	57100	0,008360177	13%
20	11.20	13,5	0,5	141600	0,020732067	20%
21	11.30	12,9	0,67	159600	0,023367499	22%
22	11.40	12,8	0,47	107500	0,015739387	23%
23	11.50	12,1	0,36	78400	0,011478771	23%
24	12.00	12,4	0,45	99900	0,014626649	23%
25	12.10	13,8	0,75	183100	0,026808202	23%
26	12.20	11,9	0,21	53900	0,007891655	19%
27	12.30	11,7	0,06	19400	0,00284041	15%
28	12.40	11,7	0,07	27500	0,004026355	12%
29	12.50	11,6	0,09	36300	0,005314788	12%
30	13.00	11,8	0,25	67000	0,009809664	18%
31	13.10	11,9	0,28	61900	0,009062959	22%
32	13.20	13,9	0,84	181400	0,0265593	27%
33	13.30	11,7	0,21	56400	0,008257688	18%
34	13.40	11,8	0,09	30500	0,004465593	14%
35	13.50	11,7	0,08	30600	0,004480235	13%
36	14.00	11,3	0,09	28200	0,004128844	15%
37	14.10	11,5	0,09	26000	0,003806735	16%
38	14.20	11,9	0,08	27000	0,003953148	15%
39	14.30	11,5	0,17	42900	0,006281113	19%
40	14.40	11,8	0,11	33000	0,004831626	16%
41	14.50	11,9	0,1	32800	0,004802343	15%
42	15.00	10,9	0,19	35000	0,005124452	24%
43	15.10	11,5	0,25	56000	0,008199122	21%
44	15.20	11,6	0,23	43200	0,006325037	26%
45	15.30	11,4	0,15	39300	0,005754027	18%
46	15.40	10,2	0,09	31500	0,004612006	12%
47	15.50	10,1	0,08	21000	0,003074671	16%
48	16.00	10,2	0,05	15000	0,002196194	14%
49	16.10	10,3	0,02	16600	0,002430454	5%
50	16.20	10,2	0,05	15100	0,002210835	14%
51	16.30	10,1	0,02	10800	0,001581259	8%
52	16.40	11,1	0,03	12000	0,001756955	11%
53	16.50	10,9	0,02	8000	0,001171303	11%
54	17.00	10,1	0,02	5000	0,000732065	17%

This table also tell us about the weakness of LDR sensor which was less sensitive in tracking the sun. This weakness lead to decreasement of efficiency values at some points such as data no.19, 28 and 35. We believe it was caused by the panel's movement which not compatible with the change of sun's position. Yet overall, the table still stated that dynamic panel integrated reflector is the best way to keep solar panel on its optimum efficiency (16%) along the day.

4. Conclusion

This research had confirmed the hypothesis that solar panel integrated reflector and controller can mantain its optimum efficiency during all day. One thing that could be done in the future is to replace the light sensor at microcontroller input with the more sensitive one in order to avoid the slow change of panel movement in tracking the sun light.

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