Solar Tracker on Solar Home System to Optimize Sunlight Absorption

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Abstract. This study presents solar tracker in resolving optimization of solar panel to capture the sunlight on solar home system. The concept of this solar tracker development utilizing a parabolic actuator drive as a mechanical driver of solar panels. The mechanical solar panels adjusted to the needs of solar panel motion in order to obtain optimal sunlight. The mechanical motion of the solar tracker covering east to west to optimize sunrise to sunset and from north to south or vice versa as an optimization of the annual sun shifts. The study phase begins by designing the solar tracker, controller system design, development, testing, and analysis. Measurement data obtained by testing the results of development according by the performance of the system. After testing phase, the mounting of solar panel can follow the sunlight from all angles overall from sunrise to sunset and sun shift too. The result of the angle change of solar tracker for five days in average generate 507 watts per day while those not using solar tracker produces 403 watts per day and the use of the actuator for five days in average is 12.54 watts. The data usage of the solar tracker can optimize the capture of sunlight while the power consumption of the motor is quite small. The use of solar tracker can increase the optimal use of solar panels as a source of renewable energy.

1. Introduction

Indonesia is a country with abundant sunlight. The geographical position of Indonesia is located on the equator. As on rainy season happened Indonesia still gets sunlight. With abundant sunlight raises the prospect of using sunlight as an alternative source of energy to replace fuel that becoming fewer and fewer [1]. On the other hand the use of sunlight as the electrical energy also help people gain the power source independently and not rely on the State Electricity Company (PLN). Every year the electrical load borne by PLN continues to increase, that often causing a crisis on electricity supply. All regions in Indonesia is a region which is located around the equator, meaning that every day of the year certainly there is sunlight shining on Indonesian territory in daylight. So, the solar-powered electric energy generation is quite possible to be implemented in all regions of Indonesia, even in remote areas such as rural and mountainous areas.

To take the advantage of sunlight into electricity source, require the tools that capture sunlight automatically then converted into electricity source [2]. This automation uses a DC motor as an actuator [3] and [4]. Solar panels are devices that convert sunlight into electricity. The solar panels have several advantages: easy maintenance, long-lived, and the most important is environmentally friendly.
The solar panel is equipped with battery as the storage of solar-generated electricity. The electricity stored in the battery is direct current source (DC). Meanwhile, in the everyday life of household appliances using alternating current source (AC). The process of changing the direction of the power source into an alternating electric source takes a device that is DC to AC inverter [5]. This is to change the DC electrical energy from the battery into AC electrical energy that is ready for residential lighting [6]. The specifications of the output power that generated by this power generation system is oriented to the consumption of common residential home [7].

To get the maximum results of the solar panels to charge the battery the position of the solar panels should be perpendicular to the sun. Because the position of the sun changes every time, so the position of the solar panels must also change in order get maximum battery charge. To change the position of the solar panels in order to remain perpendicular to the sun manually is extremely inefficient, therefore we need a system that controls the solar panels in order to remain perpendicular to the sun automatically using a microcontroller data processing [8].

To solve this problem, the idea comes by developing a solar home system installed with solar tracker to optimize the capture of sunlight. So the users of solar panels no longer have to adjust the position of the solar panels manually.

2. Method

This study developed with several stages consist of analyzing the needs of the system, designing the system design, development and the testing phase. Measurement data obtained by testing the results of development according by the performance of the system. The data retrieval technique used in this study is descriptively compare between data variables with the other data variables. This study has been conducted at the laboratory of the control system of the Department of Electrical Engineering Faculty of Engineering, University of Yogyakarta. The Data have been observed at the 4th floor at the same LPTK Building faculty on March till April 2017.

3. Result and Discussion

The data retrieval of solar tracker system performance on the solar home systems equipped with multiple tools that are used are as follows: (1) Multimeter, (2) Ammeter, (3) Digital Camera, (4) Stopwatch, and (5) Protractor.

The purpose of testing and data retrieval is to know the truth and the performance of solar home system installation is fit with the desired target or not. The target is every hour solar cells change the angle position to obtain optimal sunlight. Then, writing every angles movement and processing the data with variable comparison. Variables that compared are the angle changes of the solar cells hourly and the voltage produced by the solar cells that placed constantly in certain angle. Then calculate each variable so the results can be compared. The observation and data retrieval are expected to note the work of the overall system and get an analysis of the solar cells in optimal performance.

In this study, the results conducted in parts, to confirm the performance of this system is able to work fit with the target or not. The next test is the process of getting the angle and the output voltage that produced every hour. The test is conducted step by step as follows : testing the controller power supply circuit, photodiode sensor, smartphone module, LCD viewer, and the block relay.
The power supply system of the SHS, the usage of power supply on SHS for the 5 volts power supply met for the circuit that uses 5 volts power supply which are (1) series microcontroller arduino, (2) relay module 5 volts and, (3) hybrid module, This is proved by the LM 7805 output voltage which is 5 volts.

On electronics circuits of power supply, the 12 volts and 5 volts relays were already connect to current and voltage flowing in manual or automatic mode. The number of 12 volts and 5 volts relays are respectively four and eight relays. The performance of the solar tracker to optimize the absorption of sunlight can be seen based on the work of relay system to change the direction of motor in auto or manual mode. Relay will work automatically when the photodiode sensor detected sunlight. In the auto system, when the upper part of sensor detected sunlight, the relay one will work to turn the motor actuator ON so the solar panels will rise slowly and vice versa, if the bottom part of the sensor detect sunlight, the relay two will work to turn the motor actuator ON so the solar panels will drop slowly. For the right sensor, if it detect sunlight the relay three will work to turn the motor actuator ON so the solar panels will move to right slowly and vice versa for the relay four.

The purpose of testing the output voltage on the solar cell is to get the both data variables that will be compared. The output of solar cells that follow the angle of solar radiation is compared with the output of solar cell without following the irradiation angle of the sun. In addition, to determine whether the use of these solar cells already produce optimal power or not. The series of the testing phase was conducted in five days. The day of test is conducted by selecting the sunny weather conditions. If in the testing day the weather significantly, the test canceled and replaced to the next day. The first thing that need to be prepared before starting the process of data retrieval is to perform calibration of measuring instruments and tools of solar home systems to avoid mistakes or errors in the testing process.

Checking the cable connections and ensure each solar cell panels connected in parallel. Parallel connection between the solar cell panel is intended to get the same output voltage as the nameplate specifications of solar cells while get the higher electric current condition.

The sunlight on the solar cell panel module is absorbed and converted into the current output and voltage output. The solar cell panels placed at angle of 50° from the point of reference or aligned with the horizontal line facing up for the test that using one irradiation angle of sunlight.

For the use of solar tracker, the tool is placed to east (toward the rising sun) which starts from the reference angle of 0° (zero). The tests conducted in five (5) days because it is considered to have represented the effectiveness of the solar tracker. The data is the output voltage of the solar cells and the angular change in every hour. The test results are shown in Table 1 below:

| No. | Time | Position angle (°) | Current (mA) | Power (mW) |
|-----|------|--------------------|--------------|------------|
| 1   | 06:00| 0                  | 0            | 0          |
| 2   | 07:00| 4                  | 10           | 115        |
| 3   | 08:00| 12                 | 70           | 810        |

Table 1. The average power consumption test for the solar cell framework actuator during five days.
Based on the data can be concluded that average power consumption of the motor actuator for five days with the actuator voltage of 11.5 volts. There is difference in the results of the angle test on the average first day until the fifth day. This is influenced by the weather conditions which are never same everyday. Likewise, the intensity of the sunlight is different in every hour. The angle difference indicates that the solar tracker is searching for the angle with highest intensity of sunlight. So, the optimum angle in every hour can be determined. After conducting the testing phase, the data and comparison obtained with the conclusion the use of solar tracker is able to follow the high solar intensity and produces more optimal output power better than just placing the solar cells aligned with the horizontal line or the angle of 50° from the reference. In the use of actuator motor, the average power used for five working days equal to 12.54 mW which conclude the use of actuator motors more efficient because the power usage is relatively small. Table 2 shows the output voltage testing results of the solar panel during the five-day experiment. Significant results is obtained as the comparison between the installation of solar panels using placement of one angle irradiation with solar panels using solar tracker automatically.

**Table 2. The average voltage output test of the solar cell output during five days**

| No. | Hour   | Automation system with solar cell tracker | Placing a solar cell using one angle-irradiation |
|-----|--------|-------------------------------------------|-----------------------------------------------|
|     |        | Angle (°) Vout (volt)                      | Angle (°) Vout (volt)                          |
| 1   | 06:00  | 0 1                                        | 50° from the point of reference 0             |
| 2   | 07:00  | 4 4                                        | 2                                             |
| 3   | 08:00  | 12 12                                      | 6                                             |
| 4   | 09:00  | 20 17                                      | 10                                            |
| 5   | 10:00  | 28 18                                      | 14                                            |
| 6   | 11:00  | 35 22                                      | 17                                            |
| 7   | 12:00  | 44 21                                      | 20                                            |
| 8   | 13:00  | 59 20                                      | 19                                            |
| 9   | 14:00  | 78 20                                      | 18                                            |
| 10  | 15:00  | 101 19                                     | 16                                            |
| 11  | 16:00  | 115 9                                      | 8                                             |
| 12  | 17:00  | 118 5                                      | 4                                             |
| 13  | 18:00  | 120 0                                      | 0                                             |
The effect tracker usage on solar panel can be seen in Table 2 which is containing the average power output using solar tracker which is 507 watts per day and without using solar tracker obtained power output 403 watts per day with the average power usage for actuator in five days is 12.54 W.

Based on the test results of each parts on SHS and overall testing it can be described some answers related to some existing problems. After the testing phase, the solar cell panel holder can follow all angles of the entire solar radiation from sunrise to sunset. Thus, through the laboratory scale the SHS is expected to be applied as simple electric power generator that utilizes renewable energy sources and can cover areas that have not been connected with electricity by PLN through the application of Solar Home System.

4. Conclusion

A solar tracker with two axis which east - west and north - south has been established. With the two-axis model, the solar tracker is freely searching for solar radiation (the direction of the sunlight). With the main function of the tracker toward the direction of sunrises and sunsets up with the changes (shift of the sun from the north - south) every year. Performance of the solar tracker to optimize the absorption of sunlight can be seen based on the work of relay system in order to change the direction of motor in auto or manual mode. Relay works automatically when the photodiode sensor is detected sunlight. By using solar tracker the usage of power is more optimum than using manually in search of sunlight.

5. References

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