Comparison of Solar Tracking and Solar Fix Mode on the Efficiency Electric Energy Generation Based on Microcontroller

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Abstract: A Solar tracker is a device that is powered by solar panels motors, aiming to adjust the position of the panel with the movement of the sun so that energy can be absorbed optimally. This study will compare the use of solar panels and solar trackers fix the model, so on getting the efficiency of each system. The test site is on the campus of the Institute of Technology of Sumatra. Prototype solar tracker is controlled using a microcontroller Arduino, ethernet shield as a liaison Arduino with local networks that can be connected to the web, the stepper motor is used as a driver, is equipped with a voltage sensor, current sensor, the sensor LDR (Light Dependent Resistor) for parameter tracking the sun, solar charge controller as control the charging and battery as energy storage. Parameter solar energy tracker and fix displayed realtime models consist of the reading of voltage, current, and power in the form of a graph on a web monitoring. Calculation of energy that can be generated a model of solar tracker is the difference between the energy stored in the battery is reduced by the energy to activate the motor driver, so we get solar tracker models to use efficiency as compared to fixed models.

1. Introduction
Currently, energy sources produced throughout the world mostly fossil fuel cannot be updated and its existence dwindling, the effort to seek other alternative sources is still being developed. There are a number of alternative energy sources other than fossil fuels, but most of the same characteristics of fossil energy that cannot be updated.

Solar panels to be one source of the current potential for sustainable power resources, especially in Indonesia. This is because the sun is one source of energy that has a very large amount and time utilization of the relatively longer. Thus, the construction of power plants with solar energy sources into one type of plant is very promising, considering the human need greater electrical energy.

The solar cell is a component that converts solar energy into electrical energy with the principle of PN junction. Photons are tiny particles that hit the semiconductor silicon solar photovoltaic cells that generate energy to separate the electron from the atom. When the negatively charged electrons are separated from the atomic he will move freely around the conduction band of the semiconductor material. Atoms that there is a vacuum in the structure called the "hole" with a positive charge [1].

Semiconductor region which is negatively charged free electrons act as an electron donor and an N-type semiconductor (n-type), while the positively charged hole acts as an electron acceptor (acceptor) is a P-type semiconductor (P-type). PN junction region will cause energy to push electrons and holes
move in the opposite order. Electrons moving away from the negative region while the hole is moving away from the positive region so that when given the burden of PN junction area of electronic devices will generate electric current [2,3].

The solar cell is a component that converts solar energy into electrical energy with the principle of PN junction. Photons are tiny particles that hit the semiconductor silicon solar photovoltaic cells that generate energy to separate the electron from the atom. When the negatively charged electrons are separated from the Sun tracking control system is a technological development in the field of solar panels to conserve energy by utilizing solar energy. Tracking control system is made to be applied more on a solar panel device as a means of collecting solar energy so that solar panels can move dynamically [3].

Solar tracker is a solar panel frame control circuits that can detect the direction of the sun that is always perpendicular position by regulating the movement of the motor. The goal is that solar panels can absorb sunlight optimally to produce optimum power as well. In this study, using mikrokontroller Arduino UNO as a control center and LDR sensor system as a method of comparison direction of the sun so that the solar panels can set position perpendicular to the sun coming to produce the optimum power. Use of the method of comparison LDR sensor on the arduino aims to move the solar panels to always be positioned perpendicular to the direction of the sun[4].

Data from the controller in the form of a PWM signal (Pulse Width Modulation) is sent to the stepper motor driver. The pulse of the driver then give commands to the stepper motor so that the motor moves and moves the solar panels with the appropriate step by step movement direction of the sun to obtain optimum sunlight. Framework made prepared with mechanical system that moves one axis (single axis) to the x axis [5,6].

2. Method

2.1. Openness Design

Here is a block diagram of control system design single axis solar tracker system.

![Block diagram system](image)

**Figure 1.** Block diagram system

In Figure 1, when the solar panel receives sunlight as the main source. Wherein the output voltage and current generating to produce power. The power is controlled by SCC (Solar Charge Controller) to control charging to the battery as an energy source to the load. Arduino will command the motor rotates based on the reading of the value of sunshine compared to the LDR sensor.

![Block diagram of the movement of solar panels](image)

**Figure 2.** Block diagram of the movement of solar panels
This study uses the comparison value as a reference LDR sensor stepper motor movement. Data from the controller in the form of a PWM signal (Pulse Width Modulation) is sent to the stepper motor driver. The pulse of the driver then gives commands to the stepper motor so that the motor moves and moves the solar panels with the appropriate step by step movement direction of the sun to obtain optimum sunlight. Framework made prepared with a mechanical system that moves one axis (single axis) to the x-axis using a stepper motor, look at Figure 2.

2.2. Design solar tracker

The solar tracker design creation framework uses the comparison method LDR sensor values as a motor rotation control. The position of the solar panels is exposed to the east or west in the direction of movement of the sunrise and sunset [7]. Figure 3 is the design of the solar tracking system is made.

The mechanical construction of the solar tracker framework consists of solid iron pipes that are designed as possible to optimize the movement of solar panels. The tool has a main stem height of 113.5 cm, a cross-sectional area of solar panels 111 cm x 67 cm, the foot-kai buffer that crosses 83 cm. The solar panel frame is made shown in Figure 4.

![Figure 3. The design of single axis solar tracker system](image)

![Figure 4. Construction of mechanical solar tracker](image)

2.3. Stepper Motor Driver

The stepper motor driver used is the motor driver TB6600 given PWM signal from Arduino, shown in Figure 5. Its function is to transmit the power supply in the form of pulses to the stepper motor in order to rotate. The brief specification is shown in Table 1 and the schematic in Figure 5.

| Table 1. Specifications Stepper Motor Driver TB6600 |
|---------------------------------------------------|
| **input Current** | 0 ~ 5.0 A |
| **output Current** | 0-4A |
| **Power (MAX)** | 160 W |
| **temperature** | -10 ~ 42ºC |
| **weight** | 0.2 Kg |
| **Dimension** | 96 * 56 * 33 mm |

![Figure 5. The circuit schematic for stepper motors arduino](image)
2.4. Motor Stepper

Here are brief specs nema 23 stepper motor.
- Step angle: 1.8 °
- Voltage (V): 8.6
- Current (A): 2.0
- Resistance (Ohms): 4.3
- Inductance (mH): 16.2
- L0 Dimension (mm): 76
- L1 Dimension (mm): 21
- Holding Torque (kg.cm): 24.0
- Control Wires: 4
- Ambient Temperature: -20 °C ~ + 50 °C
- Temperature Rise: 80 °C Max.
- Radial Play: 0.02mm Max.
- End Play: 0.1-0.3mm

![Motor Stepper Image]

**Figure 6. The stepper motor nema 23**

2.5. Manufacture System

At this stage of the system making the programming, the process is carried out at the Arduino tool and set the stepper motor to rotate in accordance with the ratio of sunlight by the sensor LDR. So we get the solar panel angle position perpendicular to the direction of the sun. Here is a flow diagram of the solar tracking system is made.

![Flow Diagram Image]

**Figure 7. Flow diagram of the solar tracking system**

In Figure 7, explaining the process of tracking the sun begins when solar panels soak up the sun then the LDR sensor will read the sunshine is detected and sent to the Arduino of stress. Arduino will process the data and compare the value of each sensor LDR is then sent to the motor driver in the form of a PWM signal. Pulses from the motor driver will instruct the stepper motor to rotate.
3. Results and Discussion

3.1. Solar Tracking system Testing
Tests carried out at the Institute of Technology of Sumatra. The initial position of the solar panels forming the framework 45º angle to the west and the maximum spin forming an angle of 45º to the east so that the total turnover of the framework is 90º. The test is performed for 6 hours starting at 10:05 am to 16:05 pm. The solar panel testing using the LDR sensor value comparison method wherein the sampling period is done every 5 minutes in order to get an accurate measurement value.

![Figure 8. Graph measurement of current, voltage and power from solar panels static.](image1)

![Figure 9. Graph measurement of current, voltage and power from solar tracker](image2)

![Figure 10. Graph comparison measurement of solar power by tracker and static solar panel](image3)
Based on Figure 8, we get a measurement of current, voltage and power from solar panels static. Figure 9, shows the value of measurement of current, voltage and power from solar panel tracker, and in Figure 10, we show a comparison measurement of solar power by static and tracker solar panel. Voltage and power obtained average current value on static solar panel by 1.64 A and the value of the average voltage of 15.62 V and the value of the average power of 26.46 watts, while the solar tracker average current values obtained at 2.11 A and the value of the average voltage of 15.35 V and the value of the average power of 32.37 Watts. From the data obtained it can be seen that the use of a solar tracker produces a power output greater than power output static solar panel.

Efficiency Calculations

3.1.1. Efficiency Solar Pane Static.
Data collection was performed for 6 hours with a maximum output of solar panels based on the specification is 100 Wp

\[ \frac{P_{input}}{P_{output}} \times 100\% = \frac{26.46}{100} \times 100\% = 26.46\% \]

Based on the calculations above 26.46 is the average power to obtain the power output of solar panel efficiency of 26.46% of static solar panel capability based on the specification should 100 Wp.

3.1.2. Efficiency Solar Panel Tracker
Data collection was performed for 6 hours with a maximum output of solar panels based on the specification is 100 Wp.

\[ \frac{P_{input}}{P_{output}} \times 100\% = \frac{32.37}{100} \times 100\% = 32.37\% \]

Based on the calculations above 32.37 is the average power to obtain the power output of solar panel efficiency of 32.37% of static solar panel capability based on the specification should 100 Wp.

3.1.3. Calculation of Second System Efficiency Difference
\[ \Delta P_{total} = P_{tracker} - P_{statis} = 32.37\% - 26.46\% = 5.91\% \]

From the above calculation can be seen that the difference in power efficiency solar panel solar tracker with the static of 5.91%. The power output is increased when using a solar tracker.

4. Conclusions
From the test results and the above discussion is based on the graph the value of current, voltage and power generated by the system is fluctuating every time it takes so that it can be concluded that the use of solar tracking system is capable of producing 32.37% of the ability of solar panels produce power 100 Wp. While static solar panel system generates the power output by 26.46% of the capability of producing the solar panels of 100 Wp. Both systems have the power difference of 5.91 Watt solar tracker system which generates power that is better than the static solar panel system. Because Solar tracker made its kind single-axis then for further development it would be better if made dual axis so as to produce more optimal power.

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