Maximum Power Tracking Photovoltaic Polycristalin and Monocrystalline Optimized with Algorithm Dual Axis Solar Tracking Using Four LDR Comparator Sensor

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Abstract. The output power from solar panels is a major problem because it is not constant which is influenced by the tilt position, solar irradiance, the type of solar cell and the technical nature of the module. Solar panels will work optimally and efficiently when the maximum number of light particles from the sun hit the cells perpendicularly or 90°. To find out the optimal peak and slope time of solar panels in producing power, this study uses a solar tracker which functions to measure voltage, current, power, slope, azimuth and light intensity received by the solar panels automatically and in real time. By comparing polycrystalline and monocrystalline solar panels, the peak time for solar panels to produce maximum power is at 11 a.m until 1 p.m.

Keywords: Solar Panel · Azimuth · Slope · Polycrystalline · Monocrystalline · Solar tracker

1 Introduction

Demand for energy sources is increasing, while fossil energy sources such as coal, oil and natural gas are depleting [1]. Fuel oil will produce CO2, methane, nitrous oxide and fluorinate, these chemicals are very dangerous for climate change around the world [2]. Today, there is a policy to reduce CO2 emissions from energy sources is very important for environmental scientists. Meanwhile, on the other hand, energy demand is predicted to increase very rapidly to double by 2030 [3, 4].

Indonesia is included in a tropical country which has a high potential for solar energy with an average daily radiation of 4 kWh/m2/day [5]. This potential can be utilized to reduce the cost of electricity payments and reduce the negative impact of fuel oil. Efforts to reduce the negative effects of fuel oil must be made by utilizing renewable energy [5]. For example, using photovoltaic (PV) cells or commonly called solar panels, a number of research articles show how to increase the efficiency of using renewable energy. The method most often used in the use of solar panels is to choose a suitable material so that it can provide an efficiency of up to 27.5% [6].

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The performance of solar panels is influenced by several factors such as solar radiation, temperature and installation slope [7]. The output power from solar panels is a major problem because it is not constant which is influenced by the tilt position, solar irradiance, the type of solar cell and the technical nature of the module. Generally, the laying of solar panels is placed in a certain position without changes [8]. The main disadvantage of solar panel energy is that the sunlight is not perpendicular to the surface of the panel [9].

Although behind the solar panels have been given the output values of the panels, but not all panels can produce the maximum value every day. The position and slope of the solar panels are also important so that they can absorb solar energy optimally every day [10]. Solar panels will work optimally and efficiently when the maximum number of light particles from the sun hit the cells perpendicularly or 90° [8].

2 Changing Solar Energy into Electricity

Solar panels consist of a collection of solar modules connected in series, parallel or in combination to obtain a certain value of voltage, current and power. The number of modules connected in series is determined by the required voltage value, while to determine the current value, parallel installation is carried out [11]. The conversion of solar energy into electricity has a basic mathematical equation. Method suggested by [12] to promote a simplified model of solar panels. According to the method, the maximum output power of a solar panel is determined by:

$$\mathrm{Pout} = \mathrm{CFF\ Nm}\ \eta\mathrm{conv}\frac{\mathrm{G_{In}}\left(10^6\mathrm{G}\right)}{\mathrm{T}}\ \left(\mathrm{kW/m^2}\right) \quad (1)$$

where Nm is the number of PV modules in the solar panel, CFF is the solar panel constant coefficient, Nc is the efficiency of the converter with maximum power controller, GIn is the current level of global insolation, W/m2, is the current temperature of the PV module.

The maximum output of the solar module depends on the temperature and radiation. This factor has a great influence on the output voltage and current of solar panels in particular. The intensity of solar radiation reaching the surface is weak in the morning and evening and peaks in the afternoon. This event occurs because the direction of the sun's rays on the earth's surface is not vertical [9, 13].

3 Installation Till

The conversion of solar thermal energy into electrical energy requires a solar panel module. To get the maximum voltage from a solar panel module requires proper placement. Solar panels will work optimally and efficiently when the surface is perpendicular to the sun [8]. Attempts to determine the optimal slope can use the equation The sun's declination or the angle between the equator and a line drawn from the center of the earth to the center of the sun can be determined by:

$$\delta = 23,5 sin\left(\frac{(360(284 + n)}{365}\right)(^\circ) \quad (2)$$

where n is the - day of the year [14].

4 How Solar Tracker Works

The working principle of a solar tracker is to follow where the sun's light moves. The solar tracker consists of a light sensor or Light Dependent Resistor (LDR) to track the movement of the sun. When the LDR is exposed to light the resistance will decrease, while if it is covered in shadows or dark the resistance will increase. There are 4 LDR sensors placed on four sides of the solar panel. When the left segment of the resistance is greater then the servo motor will move the solar panel counter clockwise. Then, if the lower segment gets a greater resistance then the servo motor will move the solar panel up.

After the 4th resistance of the LDR sensors has been balanced, the voltage and current generated by the solar panel will be processed through the INA219 module. The BH1750 module also processes the captured light. Servo analog data is converted to digital in the form of degrees. Then all the data obtained is recorded or noted by the SD Card module which acts as a data logger.

In Fig. 1 it is explained that when the light is read by the LDR sensor, the servo motor will move the solar panel following the sunlight. The output voltage and current from the solar panel will be measured by the INA219 sensor and the intensity of sunlight will be measured by the BH1750 sensor which then all data measured by the sensor will be noted by the data logger.

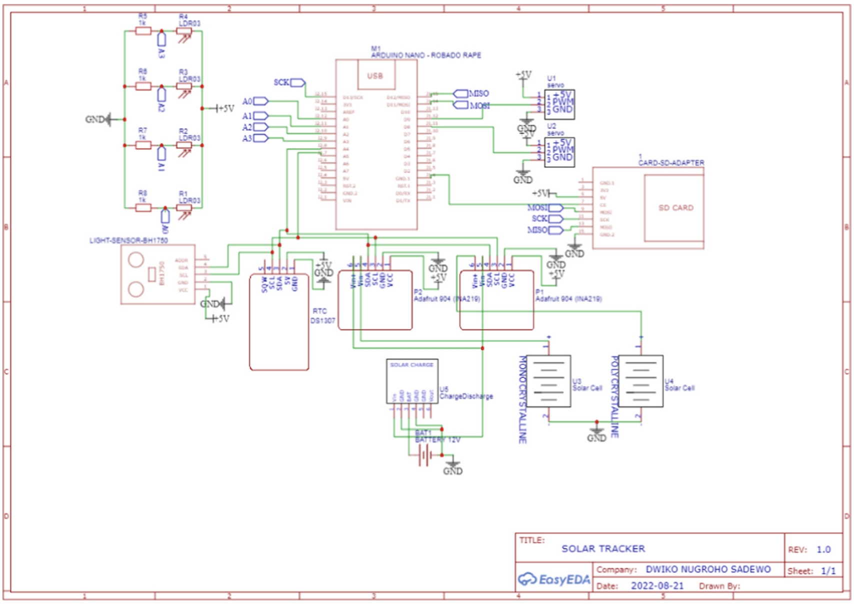

Fig. 1. Solar Tracker Wiring

5 Solar Tracker Seat Design

Making the solar tracker mount design using the AutoCAD 2020 application. This application can display parts of the solar tracker mount with a three-dimensional view. Because the base material of this stand is made of 2 mm acrylic, it is necessary to design a two-dimensional design for each piece before assembling it. After doing the two-dimensional design the acrylic will be cut according to the design. Then each part is glued together using special acrylic glue so that it can stand up as shown in Fig. 4.

6 Measurement Methods and Parameters

To determine the maximum power generated by solar panels, this study uses direct measurement methods to obtain real time data. With this method the author can determine the maximum power generated by the solar panels mounted on the solar tracker. Data collection starts at 7 a.m - 4 p.m with the help of a compass to direct the panel to the 0° azimuth angle, which is towards the north.

After being redirected to 0¬° Azimuth angle, with the help of the Arduino Nano microcontroller, the Solar tracker will detect where the sun is moving with a program that has been set so that the sunlight is perpendicular to the surface of the solar panel.

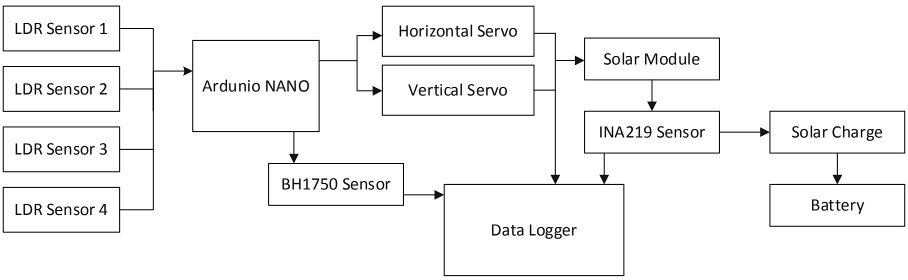

Fig. 2. How Solar Tracker Works

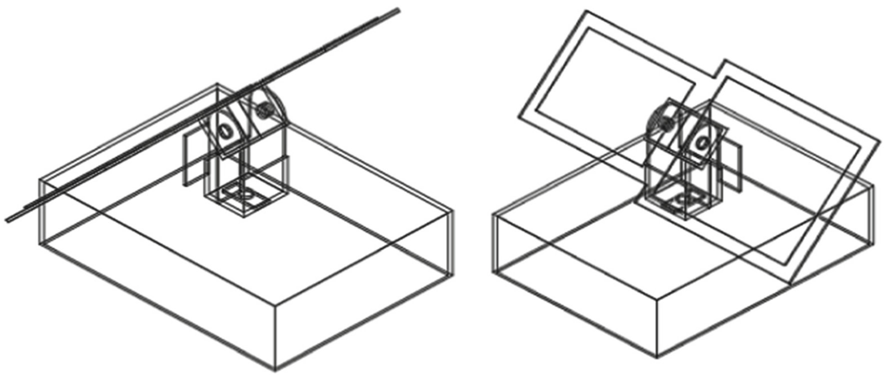

Fig. 3. Solar Tracker Design

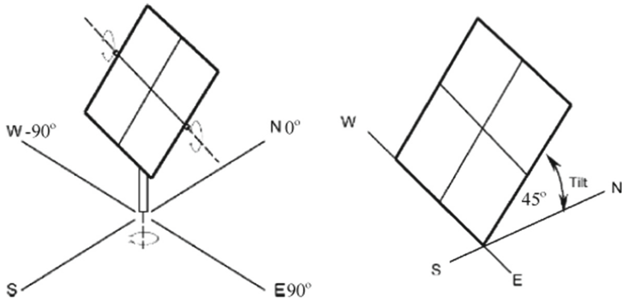

Fig. 4. Aiming the Panel Angle Azimuth 0°

Furthermore, the measurement parameters of voltage, current, installation slope, azimuth angle and light intensity are recorded by the Data Logger. All measurement data will be automatically recorded in real time and saved in.txt data format. The data will be updated every 10 min. After measuring the data that has been obtained will be compared based on the data that has been taken.

7 Results and Discussion

In the solar tracker there are two types of solar panel materials, polycrystalline and monocrystalline. This device is programmed through the Arduino Nano microcontroller which has 13 digital pins and 7 analog pins so that it can process 2 current and voltage sensors, 4 light sensors, 1 light intensity sensor, 2 servo motors, 1 real time clock module (RTC) and 1 SD card module.

In the Table 1 can be seen the results of measurements for 5 days. The optimal inclination angle for both types was obtained for polycrystalline 0.89 W on the fifth day at 11:47:39 with a slope of −16.07° and azimuth angle of −12.51° and recorded with a light intensity of 5461 Lx while for monocrystalline materials the peak power was 1.30 W. on the fourth day at 13:25:54 with a slope of −15.3° and an azimuth angle of −12.51° with a light intensity of 5461 Lx.

Based on the results obtained from the measurements on the first day, the graph of the slope comparison with the current is shown in Fig. 3, the current produced by both types of solar panels is unstable because the weather on that day is cloudy so that the incoming solar radiation on the solar panels is also unstable. Unlike the measurements on the second and third days, the weather on that day was scorching hot.

On the second to the last day of measurement, the voltage produced by the two types of solar module materials in Fig. 2 is more stable, but the current produced by polycrystalline is not more stable than monocrystalline. The same is true for polycrystalline currents so that the power produced is not stable with a peak voltage of 11.82 V and for monocrystalline it produces 12.87 V.

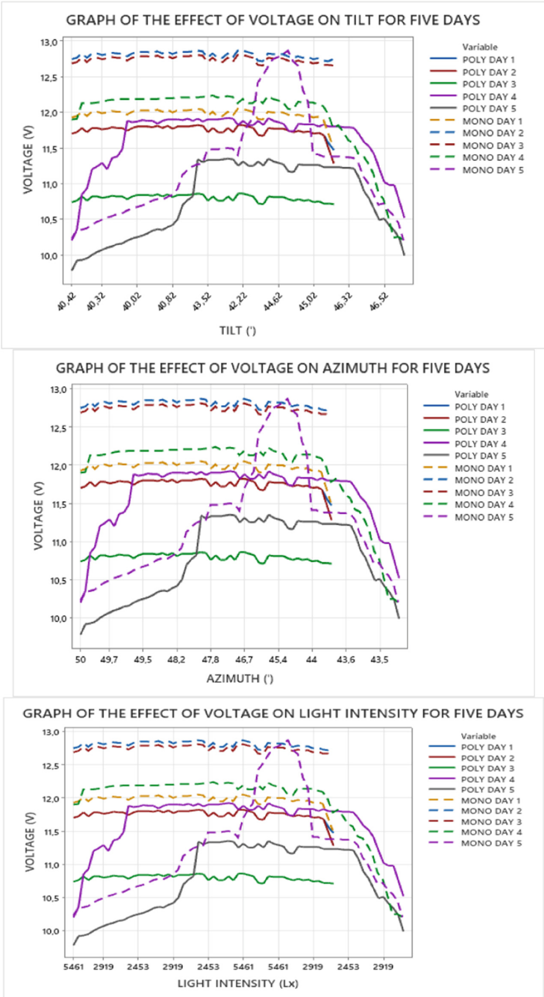

Fig. 5. Graph of the Effect of Voltage on Slope, Azimuth and Light Intensity for Five Days on Polycrystalline and Monocrystalline Types

Table 1. Peak Time and Power

DAY	DATE	Slope (')		AZIMUTH(')		PEAK POWER (Watts)		LIGHT INTENSITY (Lx)		PEAK TIME	
		POLY	MONO	POLY	MONO	POLY	MONO	POLY	MONO	POLY	MONO
1	05/07/2022	24.88	24.88	27.29	27.29	0.85	0.87	5461	5461	12:59:49	12:59:49
2	06/07/2022	−24.17	−24.17	−18.06	−18.06	0.77	0.84	5461	5461	13:23:54	13:23:54
3	07/07/2022	−63.97	−63.97	−20.09	−20.09	0.78	0.83	5461	5461	13:55:58	13:55:58
4	14/07/2022	−15.3	−10.05	−10.05	−10.05	0.80	1.30	5461	5461	13:25:54	13:25:54
5	14/07/2022	−16.07	−16.07	−12.51	−12.51	0.89	1.05	5461	5461	11:47:39	11:47:39

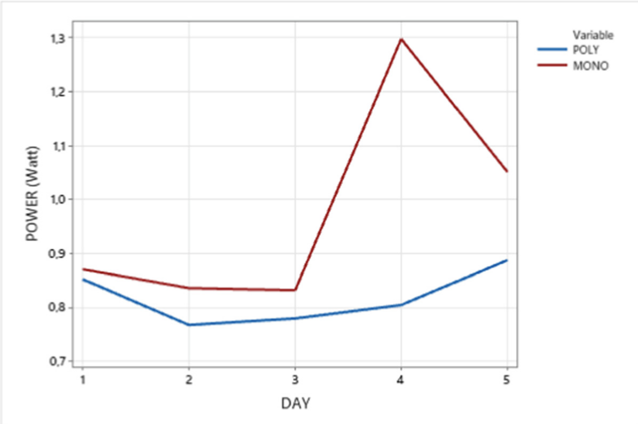

Fig. 6. Polycrystalline and Monocrystalline Peak Time and Power Comparison Graph

8 Conclusion

In this study, the results of the measurement of voltage, current and power were obtained based on the slope, azimuth angle and light intensity. From the results that have been collected, it can be concluded as follows:

1. Based on the power comparison graph from the power data generated by solar panels, it is known that the peak time when solar cells absorb sunlight and convert it into electrical energy is from 11 a.m to 1 p.m for three days.
2. The optimal inclination angle for both types was obtained for polycrystalline 0.89 W on the fifth day at 11:47:39 with a slope of −16.07° and azimuth angle of −12.51° and recorded with a light intensity of 5461 Lx while for monocrystalline materials the peak power was 1.30 W. on the fourth day at 13:25:54 with a slope of −15.3° and an azimuth angle of −12.51° with a light intensity of 5461 Lx.
3. Based on observations for five days, Monocrystalline solar modules emit more stable voltage, current and power and have a higher value than Polycrystalline solar panels.

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