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DESIGNING BEAM CAPTURE SETTINGS FOR SOLAR POWER PLANTS

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ABSTRACT

Solar Power Plant (PLTS) absorbs solar energy and is adjusted to the change in circulation from 06.00 in the morning to 17.00 in the afternoon. This requires adjustment to the installation of a solar power plant so that energy capture can be optimal; this adjustment uses a sunlight capture tool called Suntracker. The main tools are in the form of movers, timers and work steps that can be dragged. Based on the testing results and discussion of the overall design of solar trackers, namely. The highest current measurement results in stationary solar cells (static) occur at 11.00 WIB, which is 0.23 A. The highest current measurement results on solar trackers also occur at 10.00 WIB, 0.25 A. The highest voltage measurement in stationary solar cells occurs at 10.00 WIB, which is 14.2 volts. Moreover, the highest voltage measurement results on the solar tracker occurred at 10.00 WIB, which is 20.3 volts.

Introduction

Solar Power Plant consists of several components, which include a series of solar modules equipped with a buffer structure, batteries, control systems, inverters to meet loads that have reciprocating runs, wiring, and generator diesel as an option if the system requires a backup system, as shown in the following figure below:

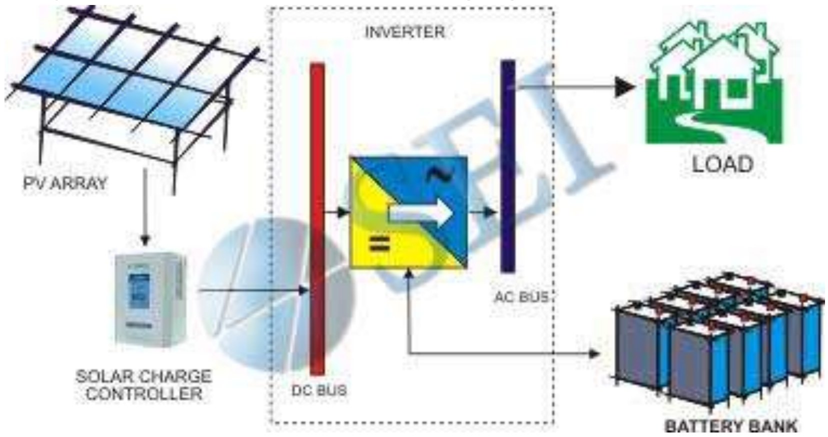

Figure 1 Solar system and components

Image caption:
1. PV Array or network of modules
2. Solar Charge Controller
3. Energy storage bank battery
4. Inverter to convert DC to AC
5. Load.

Modul Sel Surya (module photovoltaics)

Solar or photovoltaic cells can convert solar radiation energy directly into electrical energy. The cell is a diode type composed of P –N junctions. Photovoltaic solar cells are made from semiconductor materials that are processed in such a way that can produce direct current (DC) electricity (Mukarromah, 2016). In use, solar cells are connected, parallel or in series, depending on their use, to produce power with the desired combination of voltage and current.

Battery

A battery is a device that stores power generated by solar panels that are not immediately used by the load (Pasaribu & Reza, 2021). The stored power can be used during low solar radiation or at night. Battery components are sometimes called accumulators. Batteries store electricity in the form of chemical power. The most commonly used batteries in solar applications are maintenance-free lead-acid batteries, also called recombinant or VRLA batteries (Idris, 2019).

Batteries fulfil two essential purposes in photovoltaic systems: to provide electrical power when the solar panels' arrays do not provide power and to store the excess power generated by the panels whenever it exceeds the load (Putra, 2019). Such batteries undergo a cyclical process of storing and discharging, depending on the presence or absence of sunlight. During the time of the sun, the panel array produced electrical power. Unused power is immediately used to charge the battery (Ariprihata, Erfandy, Susilo, & Sujito, 2023). During the time of the absence of the sun, the demand for electrical power is provided by the battery, which therefore will discharge it.

This store and discharge cycle occurs whenever the power generated by the panel does not equal the power required to support the load. The battery will store power if there is enough sun and the load is light. The battery will discharge power at night whenever a certain amount is needed (HUTAPEA, 2023). The battery will also discharge power when the irradiation is insufficient to cover the load requirements (due to natural variations in climatic conditions, clouds, dust, etc.).

Sel Surya (Solar Cell)

Photovoltaic comes from two words, photo and volt, which means light-electric. Cells that convert sunlight radiation into electricity are called photovoltaic cells, also known as solar cells (Sampeallo, Galla, & Mbakurawang, 2018). A photovoltaic module is a unified circuit consisting of several photovoltaic cells connected in series, parallel, or a combination of series and parallel. To get a large enough power requires a lot of solar cells. Usually, solar cells have been arranged so that they are in the form of panels and are called photovoltaic (PV) panels.

Research Methods

The type of research used is quantitative research with content analysis. Electronic design is the initial stage carried out. This is intended to obtain a circuit that suits your needs, where it is expected that the device made can follow the movement of the sun (tracker) from morning to evening. Electronic design includes the process of selecting electronic components and assembling these components into tools with good specifications. Once the designed tool shows the desired results, the solar cell module can be tested. Testing solar cell modules with circuits that have been made aims to show the circuit's performance in maximising the use of photovoltaic devices to capture and change solar radiation from morning to evening so that testing needs to be carried out for two days starting at 06.00 to 17.00. Some of the indicators tested to demonstrate the modulator's performance include testing current and voltage over time by comparing absorption by PV cells when the module is stationary and by using a tracker, both on the first day and on the second day.

Results and Discussion

Motor Servo

A servo motor is a motor with a closed feedback system where the motor's position will be informed back to the control circuit in the servo motor. The motor consists of a motor, a series of gears, a potentiometer and a control circuit. The potentiometer serves to determine the angular limit of the servo rotation. Meanwhile, the angle of the axis of the servo motor is set based on the width of the pulse sent through the signal leg of the motor cable. As shown in the picture with a pulse of 1.5 mS in a period as broad as two mS, the angle of the motor axis will be in the middle position. The wider the OFF pulse, the greater the axis movement clockwise and the smaller the OFF pulse, the greater the axis movement in the counterclockwise direction.

Servo motors usually only move to a certain angle and are not continuous like DC or stepper motors. However, servo motors can be modified to move continuously for specific purposes. In robots, this motor is often used for legs, arms or other parts with limited movement and requires large enough torque.

A servo motor is a motor that can work in two directions (CW and CCW), where the direction and angle of movement of the rotor can be controlled only by providing PWM signal duty cycle settings on the control pins. The Servo Motor is shown in Figure 2

Figure 2 Servo Motor

A Servo motor is a DC motor with electronic controls and internal gear to control movement and angular angle. The Servo Motor Mechanical System is shown in Figure 3.

Figure 3 Servo Motor Mechanical System

A servo motor is a slow-rotating motor, usually indicated by its slow rotation rate, but has a strong torque due to its internal gear.

More deeply, it can be described that a servo motor has:

1. 3 cable paths: Power, Ground, and Control
2. Control signal controlling position
3. The operation of the servo motor is controlled by a pulse ± 20 ms wide, where the pulse width between 0.5 ms and 2 ms represents the end of the maximum angular range.
4. The construction includes internal gear, potentiometer, and feedback control.

Types of servo motors

a. Motor Servo Standard 180°

This type of servo motor can only move in two directions (CW and CCW) with deflection of each angle reaching 90° so that the total angle deflection from right – centre – left is 180°.

b. Motor Servo Continuous

This type of servo motor can move in two directions (CW and CCW) without the limitation of rotational angle deflection (can rotate continuously).

Principles of Work of the Servo Motor

The working principle of the motor is based on laying a conductor in a magnetic field. Discussion of the principle of magnetic field flow will help us understand the working principle of a motor. A rotating magnetic field will be generated if a conductor is wound with a current wire. The contribution of each rotation will change the intensity of the magnetic field present in the field covered by the coil. It is in this way that a strong magnetic field is formed. The power to drive the flux is called the magnetomotive Force (MMF).

Flux magnets determine how much flux there is in the area around the coil or permanent magnate. A permanent magnet generates the magnetic field in a DC servo motor, so power is unnecessary to create a magnetic field. The magnetic field flux in the stator is unaffected by the armature current. Therefore, the ratio curve between speed and torque is linear.

In principle, if a conveyor passes through, the electric current will generate a magnetic field around it. Then, whenever this conveyor is placed in magnetic induction B, it will acquire the FB style. The magnitude of the force posed is comparable to the electric current It and the length of the conveyor L, which cuts the magnetic induction B or commonly expressed by the equation, Magnetic induction,

Fb = B . I . L

Information:

Fb = Gaya (N)

B = Magnetic induction

I = Current (A)

L = Long (m)

When the motor rotates, the current in the motor coil produces a torque whose value is constant. In this servo DC motor, there are three primary coils, namely:

1. Armature
2. Magnet Permanent
3. Komutator

If a conductor (iron) is wound with a wire current, it will generate a rotating magnetic field; the contribution of each rotation will change the intensity of the magnetic field present in the field covered by the coil. In this way, the magnetic field is called Magnet Motive Force (MMF). Magnetic flux is used to determine how much flux there is in the area around the coil or permanent magnet. A permanent magnet generates the magnetic field in the servo motor, so there is no need for energy to create a magnetic field. The flux in the stator field is not affected by the motor's current. Therefore, the curve of the ratio between speed and torque is linear.

The mechanics use ball bearings at the bearing outputs to make the movement smoother, and vibrations and shocks can be reduced as little as possible. Inside a servo motor is a DC motor as an actuator drive, several capacitors and an electronic circuit potential odometer as a servo position feedback regulator.

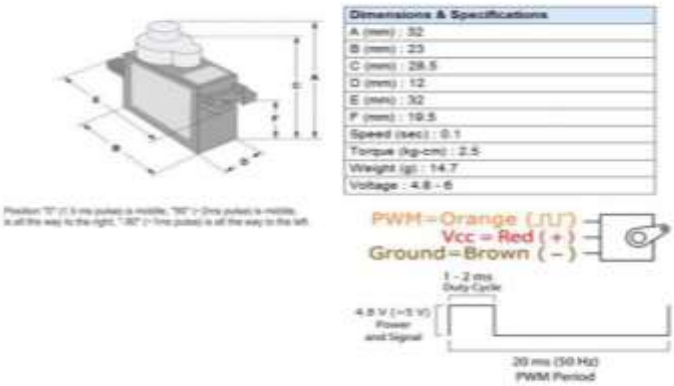

Figure 4 Side view

Electronic Planning

Electronic design steps are arranged to obtain the proper circuit considering the components' characteristics. With this design, the work stage from component selection to component assembly is carried out continuously to create equipment with good specifications.

Parts of the tool

1. The microcontroller, on the microcontroller part, is used to process data received from the LDR sensor.
2. Servo motor, used as a horizontal and vertical drive on solar panels according to the presence of the solar focal point
3. Solar cells and LDR panels: LDR sensors are adjacent to solar panels. The LDR sensor detects the presence of sunlight, and then the data obtained is forwarded to the microcontroller.
4. The accumulator serves as a store of electrical energy produced by solar cells.

Solar Cell Module Testing

This test is carried out directly under sunlight with sunny weather in the morning, afternoon and evening using a digital multimeter. The purpose of testing solar cell modules is to determine whether this tool works (Damanik, Pasaribu, Lubis, & Siregar, 2021). This test was conducted for two days, from 06.00 to 17.00.

The tests carried out start by measuring the output voltage of the solar cell, current with load, and then testing the power generated from the solar cell. Below are the results of testing on the Solar Cell Module (Sintaro, Surahman, & Pranata, 2021).

Table 1
Current and voltage testing against the time of the solar cell stationary on the first day

No.	Time (UTC)	Arus (Ampere)	Tension (Volt)	Intensity Light (lux)	Information
1.	06.00	0,15	13,3	437	bright
2.	07.00	0,17	13,5	462	bright
3..	08.00	0,19	13,8	516	bright
4.	09.00	0,20	13,9	696	bright
5.	10.00	0,21	14,1	841	bright
6.	11.00	0,23	14,2	965	bright
7.	12.00	0,20	14,1	576	overcast
8.	13.00	0,17	13,4	564	overcast
9.	14.00	0,16	13,3	754	bright
10.	15.00	0,17	14,2	653	bright
11	16.00	0,16	13,6	648	bright
12.	17.00	0,16	13,4	521	bright

Table 2
Current and voltage testing against the time of the solar cell stationary on the second day

No.	Time (UTC)	Arus (Ampere)	Tension (Volt)	Intensity Light (lux)	Information
1.	06.00	0,16	13,4	415	bright
2.	07.00	0,17	13,5	457	bright
3..	08.00	0,19	13,7	512	bright
4.	09.00	0,21	13,9	694	bright
5.	10.00	0,22	14,1	836	bright
6.	11.00	0,23	14,2	883	bright
7.	12.00	0,21	14,1	969	bright
8.	13.00	0,22	14,2	875	bright
9.	14.00	0,21	13,3	754	bright
10.	15.00	0,19	13,4	395	overcast
11	16.00	0,17	13,5	273	mendung
12.	17.00	0,16	13,3	243	Rain

From Table 1, a comparison between solar cells that use trackers and solar cells that are stationary on the first day, it can be seen that the comparison produced is more significant the current produced by solar cells that use trackers compared to solar cells that do not use trackers, namely using solar trackers 0.24 A while those that do not use trackers 0.23 A. The results of current testing on solar cells can be seen in Graph 1.

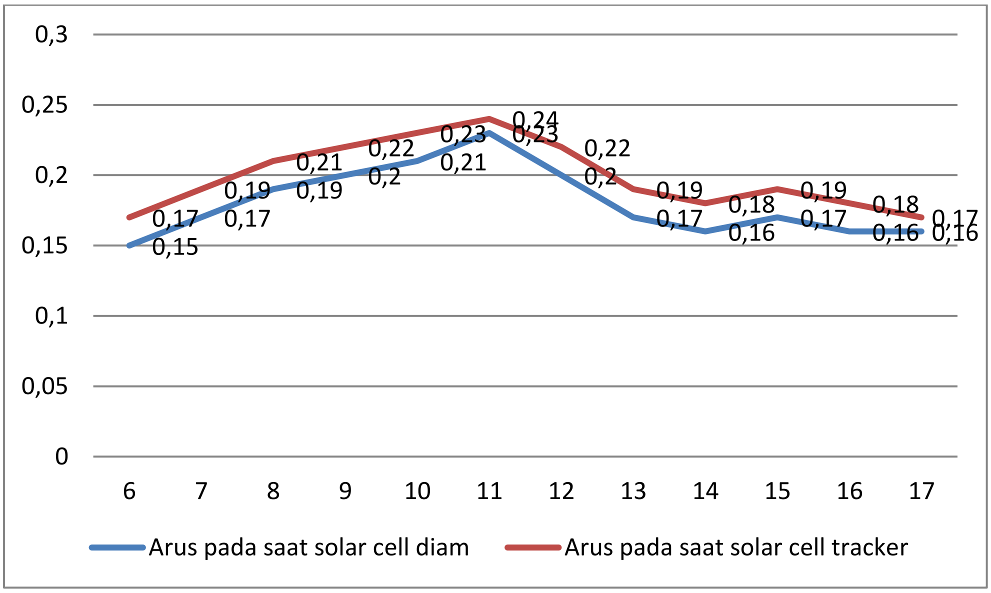

Chart 1
Comparison of current when using the tractor and at rest

Table 3
Current and Voltage Testing of the time generated by the first-day solar tracker

No.	Time (WIB)	Arus (A)	Voltage (V)	Information
1.	06.00	0.17	18.5	bright
2.	07.00	0.19	18.9	bright
3.	08.00	0.21	19.8	bright
4.	09.00	0.22	20.1	bright
5.	10.00	0.23	20.3	bright
6.	11.00	0.24	20.2	bright
7.	12.00	0.22	18.8	overcast
8.	13.00	0.19	18.9	overcast
9.	14.00	0.18	18.7	bright
10.	15.00	0.19	19.4	bright
11.	16.00	0.18	19.2	bright
12.	17.00	0.17	18.6	bright

Table 4
Current and Voltage Testing of the time generated by the second-day solar tracker

No.	Time (WIB)	Arus (A)	Voltage (V)	Information
1.	06.00	0.17	18.7	bright
2.	07.00	0.19	19.3	bright
3.	08.00	0.19	19.6	bright
4.	09.00	0.20	19.8	bright
5.	10.00	0.23	20.2	bright
6.	11.00	0.25	20	bright
7.	12.00	0.24	19.7	bright
8.	13.00	0.23	19.5	bright
9.	14.00	0.22	19.4	bright
10.	15.00	0.17	18.4	overcast
11.	16.00	0.15	17.5	mendung
12.	17.00	0.10	14.6	Rain

Table 3 shows the comparison between the voltage produced by solar cells that use trackers and solar cells that do not use trackers. The results obtained from testing between solar cells that use trackers and those that do not use trackers have a difference; namely, the voltage produced by solar cells that use trackers is greater than the voltage produced by solar cells that do not use trackers on the first day. The results of voltage testing on solar cells can be seen in graph 2.

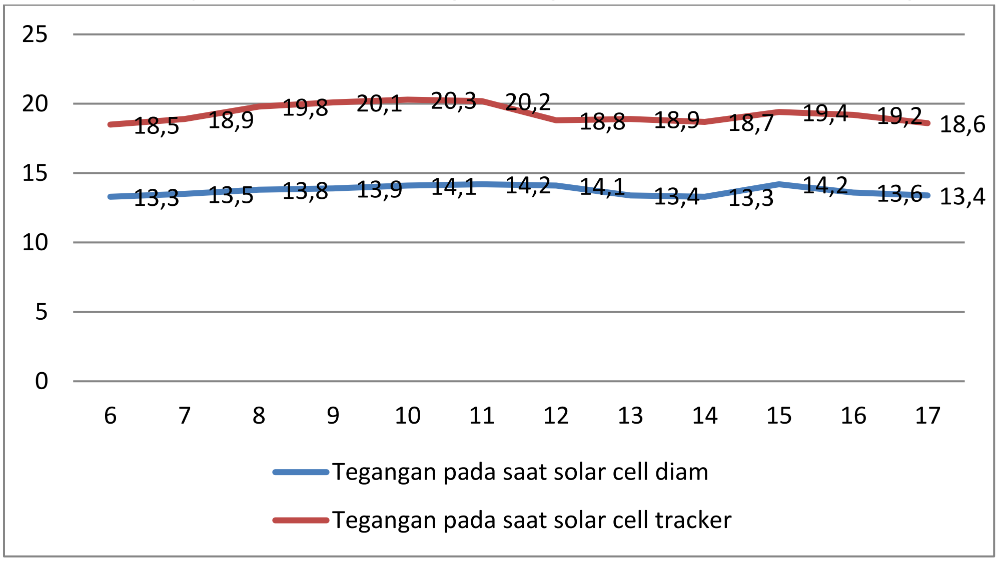

Chart 2
Voltage Comparison when using the tractor and at rest

From the results of taking current and voltage data from the solar cell, the power generated from the solar cell will be obtained using the following formula:

P = V x I ……………………………………………………………….. (4.1)

Information:

P = Solar cell power (Watt)

V = Solar cell voltage (Volt)

I = Solar cell current (Ampere)

From the two-day measurement data, solar cell power was obtained from 06.00 to 17.00. Data on power test results on solar cells can be seen in Table 5.

Table 5
The average measurement result in Solar cell power

No.	TIME	SOLAR CELL DIAM			SOLAR TRACKER		
		I'm (ampe)	V (Volt)	P (Watt)	I (ampere)	V (Volt)	P (Watt)
1	6	0.15	13.3	1.995	0.17	18.5	3.145
2	7	0.17	13.5	2.295	0.19	18.9	3.591
3	8	0.19	13.8	2.622	0.21	19.8	4.158
4	9	0.2	13.9	2.78	0.22	20.1	4.422
5	10	0.21	14.1	2.961	0.23	20.3	4.669

6	11	0.23	14.2	3.266	0.24	20.2	4.848
7	12	0.2	14.1	2.82	0.22	18.8	4.136
8	13	0.17	13.4	2.278	0.19	18.9	3.591
9	14	0.16	13.3	2.128	0.18	18.7	3.366
10	15	0.17	14.2	2.414	0.19	19.4	3.686
11	16	0.16	13.6	2.176	0.18	19.2	3.456
12	17	0.16	13.4	2.144	0.17	18.6	3.162
Average rating		0.180833 33	13.7333333	2.48991 67	0.19916667	19.283 333	3.8525

Table 5 shows that the power produced by solar cells that use trackers is more significant than solar cells that do not use trackers. The results of the calculation of power in solar cells can be seen in graph 5.

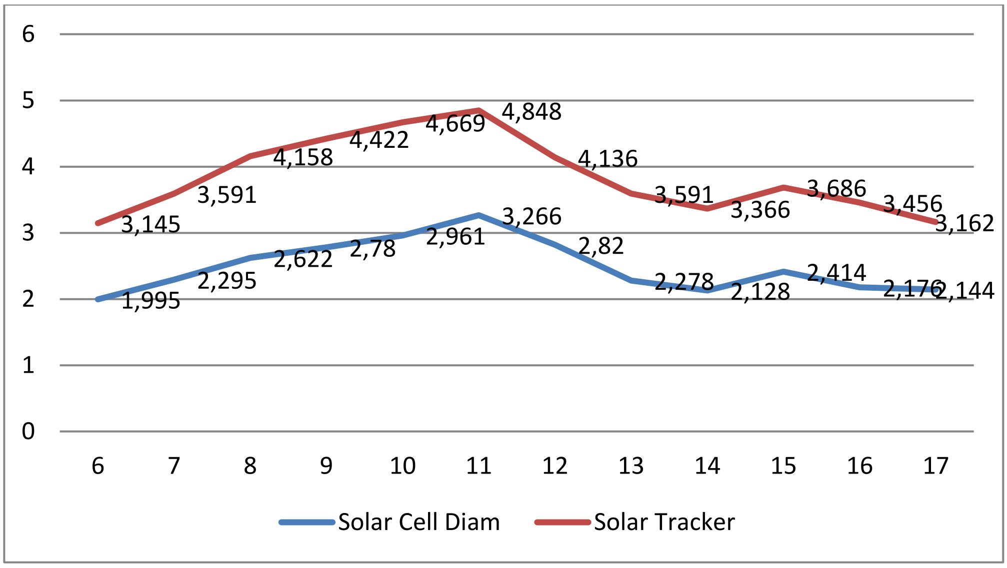

Chart 3

Network Overall Testing

In testing the solar cell module, the data collection was carried out by measuring the current and voltage from the solar cell using a digital multimeter. The power generated by the solar cell will be obtained from the current and voltage data. Data is taken within two days from 06.00 to 17.00.

Data collection of solar cell current and voltage is carried out two times, namely when using a tracker and when not using a tracker or solar cell at rest or straight (Utami, 2017). The results of the data obtained between solar cells that use trackers and those that do not use trackers are very different. The current and voltage taken when using a tracker are more significant than those in a solar cell that does not use a tracker. This proves that the efficiency produced by solar cells that use trackers is better than those that do not. So, using solar trackers in solar power plants (PLTS) is beneficial and more efficient in producing greater electrical power (Sirait, 2016).

All tools must be connected to see the whole set of tools working correctly. This tool works well but not as expected from the test results and the data generated. Because the microcontroller cannot be used due to problems and is used manually, the tracker is moved 15 minutes every hour; this solar tracker uses 2 DC servo motors, In the design of this solar tracker, the speed of motor movement needed is not so fast, because what will be tracker is a relatively slow movement of the sun that is 15 degrees per hour (Irfan, Pakaya, & Faruq, 2019). So, the response that will be given to the design of this solar tracker is prolonged to adjust to the sun's movement. However, if we want a fast tracker movement it can be done by adjusting the speed of the motor through a program that will be downloaded into the microcontroller.

Conclusion

Based on the test results and discussion of the overall solar tracker design, it can be concluded as follows. The highest current measurement result on a stationary solar cell (static) occurred at 11.00 WIB, which is 0.23 A. The highest current measurement result on the solar tracker also occurred at 10.00 WIB, which is 0.25 A. The highest voltage measurement in stationary solar cells occurs at 10.00 WIB, which is 14.2 volts. Moreover, the highest voltage measurement results on the solar tracker occurred at 10.00 WIB, which is 20.3 volts, the highest power measurement result in a stationary solar cell is 3,266 watts. Moreover, the highest power yield on the solar tracker is 4,848 watts.

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