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Solar Panel Tracking Control Monitoring System

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ABSTRACT

Solar energy is extraordinary and the largest energy on earth and no pollution. Solar cell technology is a technology that can absorb solar energy and convert in to electrical energy. In general, the installation of solar panels is only in one direction so that the absorption by the photovoltaic collector will not be optimal. Subsequence, the electricity produced is also less than optimal. To optimize the absorption of sunlight, the photovoltaic collector must be parallel to the sun. In this study, 4 LDR light sensors were used as detectors of the highest intensity of sunlight, the LDR output would enter the Arduino Mega microprocessor and control the DC motor to drive the solar panels. The monitoring process used a current/voltage sensor (INA219), temperature and humidity sensor (DHT 11), data from the sensor was processed by the ESP8266 Node MCU and then the data can be accessed via an Android Smartphone using the Blynk application. These data were transmitted to users wirelessly via the ESP8266 Node MCU module. From the test results, the energy generated when the solar cell was stationary averages V = 14.28 volts, I = 0.66 A and the energy when the solar cell moved averages V = 14.63 volts, I = 0.92 A. Therefore, the comparison of electric power in the condition that the solar panels moved according to the movement of the sun has increased by 30.13% compared to the stationary condition.

KEYWORDS: *Solar cell, Photovoltaic, Arduino Mega, DHT 11, Blynk.*

NOMENCLATURE

V	*Voltage (Volt)*
I	*Current (A)*

1.0 INTRODUCTION

Renewable energy has been the focus of research since 2004, judging by the large number of published articles [1][2]. Renewable energy is an alternative energy developed to solve energy problems to replace fossil energy sources whose supply is limited in the future [3][4], and is an environmentally friendly energy with low carbon dioxide (CO2) emissions or close to zero air pollution which can reduce climate change. due to global warming greenhouse emissions up to 1.50 C which helps stabilize world climate change [1],[2],[5]-[8] Renewable energy is the best choice where its availability does not decrease, such as solar, wind and biomass [3],[7][9]-[12]. Renewable energy sourced from solar energy is a constant energy source that is used to meet increasing energy needs [13] and is the largest energy received by the earth, especially in Indonesia which is located in the equator where the sun shines throughout the year with an average of 4.8 kWh/day. m per day[14][15].

Solar cell technology is a photovoltaic absorbent material made from semiconductor materials that converts it into electrical energy [16][17]. The use of photovoltaics for renewable energy sources has experienced very rapid growth in recent years [16][18], as solar cell materials have been discovered that make maximum use of solar energy so that they work optimally. Utilization of solar energy using a photovoltaic (PV) system by increasing system performance as a reliable source of electricity by efficiently utilizing the sun's spectrum in solar cells. Many factors affect the absorption of solar energy, namely local radiation climatology, temperature, collector tilt angle [19].

In general, the installation of solar panels is only in one direction so that the absorption by the photovoltaic collector will not be maximized so that the electricity generated is also less than optimal. To optimize the absorption of sunlight, the position of the photovoltaic collector must be parallel to the sun [19]. The apparent motion of the sun causes the sun to change its position every day, rising from the east and setting in the west and is influenced by the position of the earth's orbit. For maximum absorption and optimal reception of sunlight, an active propulsion device is needed which will always direct the solar panels parallel to the sun and follow the direction of the sun's movement [19][20]. In this research a solar light tracking system with two shafts is designed to detect the direction of the sun's movement using an LDR (Light Dependent Resistor) sensor that can follow the apparent movement of the sun

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moving from east to west and from north to south [21][22]. To ensure that this tool works properly, a monitoring process is carried out. Monitoring is carried out on the voltage, current generated by the solar panel and also temperature, humidity around when the solar panel is working, in which case Blynk is used for the monitoring process by sending data to the IOT smartphone platform via the internet network to facilitate the monitoring process [23].

2.0 METHODOLOGY

The system for tracking and monitoring sunlight as a whole is designed using two shafts to detect the direction of movement of sunlight and designing program algorithms for data acquisition and control, as well as adjusting communication protocols between block diagrams. The whole system is made as shown in Figure 1.

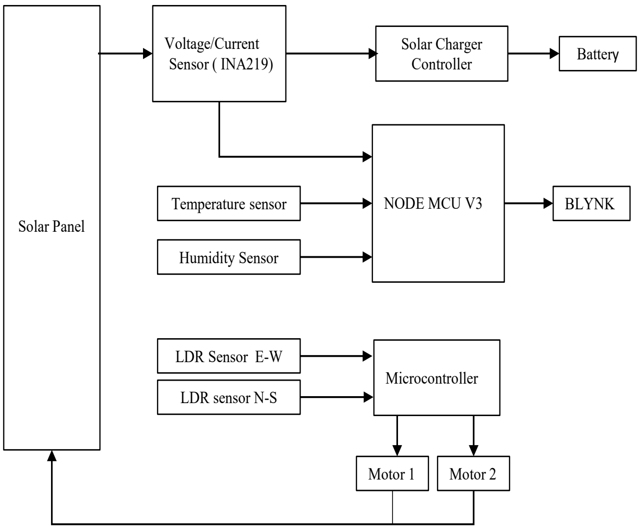

Figure 1: Block diagram of the system

The block diagram in Figure 1 shows how the tool works. The LDR (Light Dependent Resistor) sensor detects the position of the sun from east to west and north to south, so that the position of the solar panels is parallel to the sun, by sending information on the sun's position via the Arduino Atmega 2560 [24] microcontroller, which will instruct the solar panel drive motor to follow the sunlight, so that the absorption of sunlight can be maximized. The sunlight energy absorbed by the solar cell would be converted to electrical energy stored by the battery.

The voltage/current sensor (INA 219) is a sensor used to measure two parameters, namely the value of the voltage and current generated by the solar cell. The DHT 11 sensor is used to detect the temperature and humidity around the solar panel [25]. The reading results will be processed by Node MCU V3 as an IoT platform. The solar charge controller is installed between the solar panels and the battery as a charging control device. The data obtained by the Node MCU from the sensors on the solar panels is then sent to the internet network so that it can be displayed on the Android User Interface with the Blynk platform.

2.1 Mechanical Design

The mechanical design made in this study can be seen in Figure 2. The solar panels are placed as shown in Figure 2 with the LDR installed in the above position with the aim that the LDR is not blocked by other objects, so that it can directly detect sunlight without interference. The information provided by the LDR will be forwarded to the microcontroller which will instruct motor 1 and motor 2 to move according to the direction of sunlight. The design used equipment specifications as in Table 1.

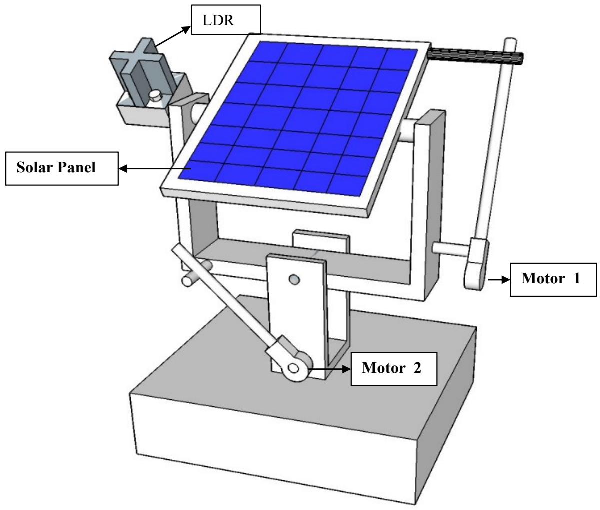

Figure 2: Mechanical Design

Table 1: Device specifications

Device	Quantity	Specification
Solar Panels	1	ST Solar 25 WP
Microcontroller	1	Arduino Mega
Microcontroller + Wifi	1	Node MCU V3 ESP8266
DC motor drivers	1	L298N dual h-bridge motor driver
DC motors	2	High Torque Worm Gear Motor DC GW4632-370
Light Sensor	4	Modul LDR
Voltage & Current Sensors	1	INA219
Temperature & humidity sensors	1	DHT 11
Solar panel chargers	1	Solar Charger Controller PWM
Displays	1	Lcd 16*2

2.2 Program Design

The program design that will be made on this tool is a program on the Arduino Mega and on the Node MCU V3. The program is designed to follow a flowchart as shown in Figure 3.

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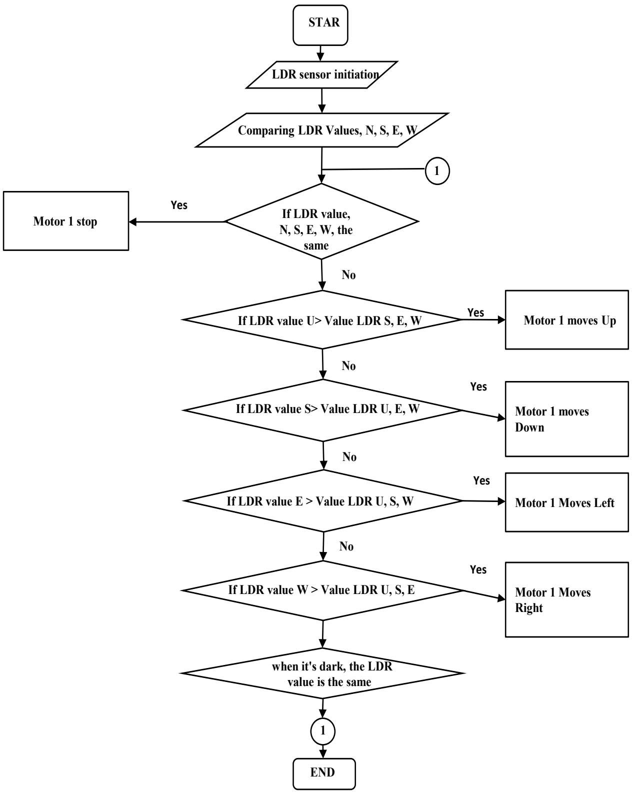

Figure 3: Flowchart of panel drive program design

2.3 System Breadboard Circuit

2.3.1 Solar panel drive circuit

This circuit is used to drive solar panels using 2 DC motors. In the circuit there are 4 LDR sensors connected to the Arduino Mega via digital pins 7, 8, 9, 10 and the signal is given to the DC motor driver module (L298N) via digital pins 22, 24, 26, 28 of the Arduino Mega. The signal given to the DC motor driver depends on the readings from each light sensor. For the speed setting process, pins 44 and 46 can be used and connected to the DC motor driver module at pins ENA and ENB. The direction of rotation of the DC motor is controlled by the readings from the four light sensors.

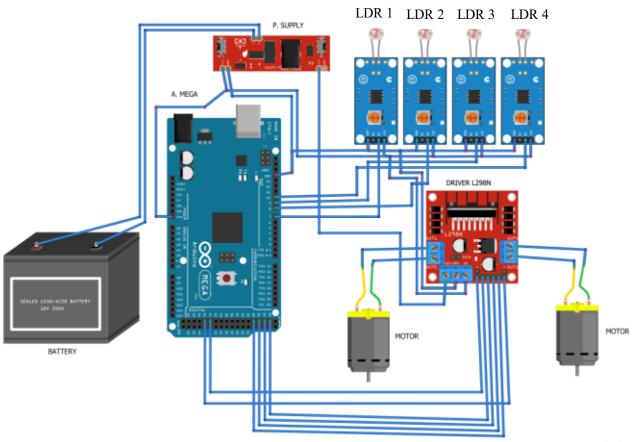

Figure 4: A circuit of solar panel driven Breadboards

2.3.2 The circuit for the process of monitoring the data

In the MCU Monitoring Node Series it is used as a tool for data processing. The MCU node is used to process data originating from the voltage/current sensor (INA219) and temperature/humidity sensor (DHT11). Data from sensors will enter the Node MCU to be processed and then the data will be displayed on the 16*2 LCD display (enhancement). Apart from being displayed on the 16*2 LCD, data is also sent via a wifi/wireless network and later the data can be accessed via the Blynk application on an Android Smartphone. The voltage/current sensor (INA219) as well as the 16*2 LCD are accessed simultaneously via I2C (Inter Integrated Circuit) communication via pins D1 (SCL (Serial Clock)) and D2 (SDA (Serial Data)). I2C is a two-way serial communication and uses two channels, namely SCL (Serial Clock) and SDA (Serial Data) channels which function to send and receive data. Meanwhile, the temperature/humidity sensor (DHT11) is accessed via pin D3 on the MCU Node.

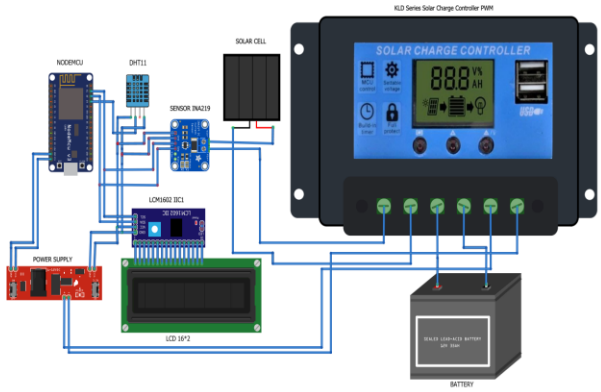

Figure 5: Monitoring data breadboard circuit

The Blynk display design on a smartphone can be seen in Figure 6. So that the Node MCU microcontroller can send data to the Blynk server.

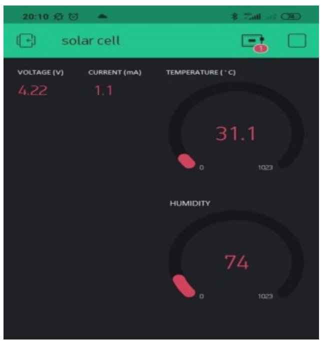

Figure 6: Display of the Blynk interface design (smartphone, monitor & laptop)

After the Blynk configurations on smart phones/monitors and laptops) are complete, then switch to Arduino IDE. Programming the ESP8266 requires several additional libraries, namely ESP8266WiFi.h to activate the communication function using a wifi signal. And the Blynk Simple Esp8266.h functions to carry out functions related to data processing related to Blynk.

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3.0 RESULT AND DISCUSSION

Tests in this study were carried out in the form of testing light sensors, current and voltage sensors (INA 219) and temperature and humidity sensors (DHT 11) [25]. Testing the output of solar panels with two designed methods.

The results of the realization of the overall tool designed in this study can be seen on the LCD. Arduino Mega microcontroller and Node MCU as a tool to process data from sensors, both light sensors (LDR), current and voltage (INA 219) and temperature and humidity sensors (DHT 11). Two dc motors will be driven by a dc motor driver where the change in the direction of movement and the speed of the dc motor depends on the input given by the microcontroller to the driver.

Display data on the LCD display for direct monitoring on solar panels as shown in Figure 7, where there are 4 parameters displayed, namely voltage, current, temperature and humidity.

Figure 7: Data display on 16*2 LCD

3.1. Sensor Testing

Light Sensor Testing

The light sensor testing was carried out to see the output voltage of the LDR sensor used and changes in motor movement with LDR conditions when there was light and when there was no light, whether the motor would move clock wise or CW or counter clock wise CCW. In Table 2 can be seen the LDR Sensor Testing. If, there was light, namely the HIGH condition, the voltage that was used as input to the microcontroller of 4.12 volts, while when there were no light or LOW conditions, the voltage of 0.12 volts. These HIGH and LOW conditions would be used as a reference to regulate the movement of the dc motor.

Table 2: LDR Sensor Testing

Condition of Sensor LDR				Condition of Motor			
LDR 1	LDR 2	LDR 3	LDR 4	Motor 1		Motor 2	
Low	LOW	LOW	LOW	-	-	-	-
Low	Low	Low	High	-	-	-	CW
Low	Low	High	Low	-	-	CCW	-
Low	Low	High	High	-	-	-	-
Low	High	Low	Low	-	CW	-	-
Low	High	Low	High	-	CW	-	CW
Low	High	High	Low	-	CW	CCW	-
Low	High	High	High	-	CW	-	-
High	Low	Low	Low	CCW	-	-	-
High	Low	Low	High	CCW	-	-	CW
High	Low	High	Low	CCW	-	CCW	-
High	Low	High	High	CCW	-	-	-
High	High	Low	Low	-	-	-	-
High	High	Low	High	-	-	-	CW
High	High	High	Low	-	-	CCW	-
High	High	High	High	-	-	-	-

Solar Panel Output Testing

Data collection was carried out using two methods, namely the stationary mechanical solar panel method and the moving mechanical solar panel method. It was hoped that with these two methods the energy produced can be compared between stationary solar panels facing the rising sun and moving solar panels following the movement of the sun. Data collection starts from 07.00 to 18.00 with a range of data collection every 30 minutes. The solar panel used is a 25 W solar panel.

Solar Panel Output Testing with Static Mechanical Method

Testing was done by looking at the output voltage and current from the solar panel itself. Output measurement is done by using measuring devices and sensors. Sensor data is processed by the program in the microcontroller and the results are displayed on the 16*2 LCD and also on the blynk interface. The position of the solar panel is towards the rising sun, to be exact, to the east with a tilt angle of ± 45°. In this case the panel will just stay still and there would be no movement following the sun. The following is test data with a stationary solar panel.

Table 3: Solar panel output with static mechanical method

No	Time	Current(Amp)		Voltage(Volt)		Temperature(° C)		Humidity (%)	
		Measurement	Appearence LCD 16*2	Measurement	Appearence LCD 16*2	Measurement	Appearence LCD 16*2	Measurement	Appearence LCD 16*2
1	07:00	0,55	0,54	13,47	13,69	32,4	32,1	62	60
2	07:30	0,64	0,634	13,55	13,38	34,3	33,5	58	57
3	08:00	0,88	0,876	13,67	13,53	34,8	33,8	54	55
4	08:30	0,98	0,97	13,79	13,63	34,4	35	54	50
5	09:00	1,03	1,027	16,54	16,46	34,3	34,8	54	55
6	09:30	1,09	1,104	15,38	15,3	41,7	41,6	40	35
7	10:00	1,2	1,207	14	13,92	30,2	31	56	57
8	10:30	1,35	1,357	17,24	17,43	34,9	34,8	54	54
9	11:00	1,19	1,194	16,93	16,8	42,1	42	36	32
10	11:30	1,16	1,165	14,19	14,1	37,8	38	44	41
11	12:00	1,12	1,126	14,11	14,11	41,3	41,4	30	30
12	12:30	1,11	1,091	14,23	14,12	36,8	37	41	37
13	13:00	0,51	0,515	14,09	14,13	39,5	39,3	41	42
14	13:30	0,54	0,537	14,23	14,14	39,8	40,6	41	36
15	14:00	0,53	0,533	14,22	14,15	42,5	41,9	42	40
16	14:30	0,52	0,516	14,23	14,16	41,5	41,2	41	39
17	15:00	0,26	0,264	13,92	14,17	39	40,6	42	37
18	15:30	0,22	0,219	13,55	14,18	34,3	35,2	45	38
19	16:00	0,16	0,156	13,57	14,19	35	37	43	37
20	16:30	0,12	0,121	13,51	14,2	31	32	54	51
21	17:00	0,02	0,02	13,41	14,21	31,2	32	56	55
22	17:30	0,02	0,021	13,38	14,22	31,1	32	55	56
23	18:00	0,005	0,0053	13,28	14,23	31,1	31,6	57	60
TOTAL		15,205	15,198	328,49	14,24				
Average		0,661087	0,660796	14,282174	14,25				

From Table 3, the measurement results can be seen that at 7.00 to 12.30 the surface of the stationary mechanical solar panel still gets direct sunlight with conditions only at certain times the position of the panel and the sun are parallel. At 13.00 - 18.00 the position of this silent mechanical solar panel is facing away from the sun so that the energy produced is not optimal. There is a condition that this stationary mechanical solar panel is parallel to the sun, namely at 9.00 – 9.30, where this condition is obtained from a comparison of stationary and moving measurement data. The current generated by the solar panel from 7.00 will always rise until 10.30 and at 11.00 – 18.00 the current generated by the solar panel will always decrease because the sun has begun to leave the surface of the mechanical solar panel.

When compared between the measurement data of stationary and moving mechanical solar panels, at 10.00 the sun's position was starting to be out of alignment with the solar panel, it can be seen from the measurement data, when the solar panel is stationary I = 1.20 A, V = 14.00 V, when the solar

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panel moving I = 1.35 A, V = 13.61 V. The maximum energy generated with this stationary solar panel is at 10.30 with a value of I = 1.35 A, V = 17.24 and at the time of measurement the light conditions are very hot because previously the sun was covered by clouds and suddenly the clouds left the sun so that the focused light shone on the earth very hot.

From the test results in Table 3, it can be seen that the voltage, current and temperature values measured by the measuring instrument and the program are not much different, this means that the % error produced would be small, but with humidity measurements the differences in the values of the measuring instrument and the program were quite different. This was caused by measuring devices or sensors that are less sensitive to ambient humidity. The sensor and measuring instrument also have a tolerance value in the measurement so that this can lead to inaccurate measurements. In addition, the output produced by the panel would be smaller when the sun was behind the solar panel.

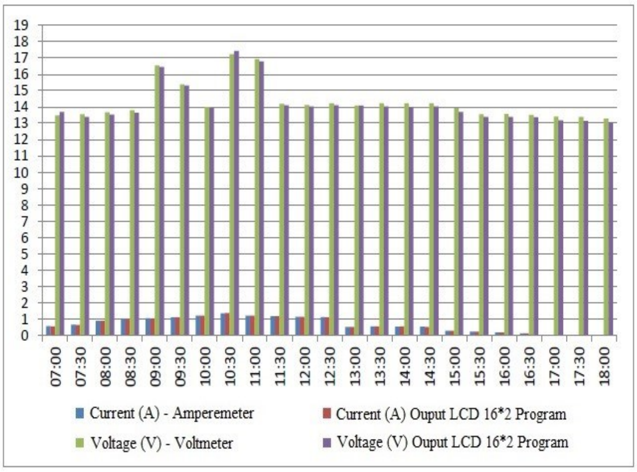

Figure 8: Solar panel output graph with static mechanical method

Panel Output Testing with the Moving Mechanical Method

This second test was carried out using the solar panel method to follow the sun's motion, so that the solar panel will always move and be aligned with the sun. Testing procedure in this second test was the same as the first test. Measurements were still carried out using measuring instruments and using sensors, where sensor data was processed by the program on the microcontroller and the results were displayed on the 16*2 LCD and on the Blynk interface. In this moving panel method, the measurement starts at 7.00 with the initial condition of the panel leaning maximally towards the rising sun and there has been no movement of the panel.

Movement begins when the sensor receives enough light, because the sensitivity of the sensor was set at a certain light level to move. If the sensitivity was set too sensitive to light, then if there was not too hot sunlight, the four sensors would be active and no movement from the solar panel. In Table 4 is depicted the test of data with moving solar panel. This method can be maximizing the work of the solar panel themselves. With this mechanism, the surface of the panel can always receive sunlight and its position would not be facing away from the sun.

Table 4: Solar panel output table with the mechanical moving method

No	Time	Current(Amp)		Voltage(Volt)		Temperature(° C)		Humidity (%)	
		Measurement	Appearence LCD 16*2	Measurement	Appearence LCD 16*2	Measurement	Appearence LCD 16*2	Measurement	Appearence LCD 16*2
1	07:00	0,6	0,590	13,42	13,54	29,5	30,7	65	69
2	07:30	0,75	0,744	13,65	13,48	34,7	34	56	56
3	08:00	0,92	0,914	13,68	13,54	34,6	34,1	54	55
4	08:30	1	1,000	13,75	13,60	34	35	53	50
5	09:00	1,06	1,053	15,94	15,73	37,7	37,1	54	55
6	09:30	1,09	1,102	15,41	15,25	39,2	39,3	46	40
7	10:00	1,35	1,359	13,61	14,41	36,5	36,2	56	57
8	10:30	1,46	1,477	17,60	17,69	37	37,7	53	47
9	11:00	1,25	1,255	17,09	17,24	42,1	41,2	39	35
10	11:30	1,26	1,269	14,27	14,17	39,1	38,8	37	39
11	12:00	1,28	1,284	14,23	14,15	42	39,9	38	36
12	12:30	1,40	1,398	14,60	14,50	42,1	40,3	35	31
13	13:00	1,38	1,376	14,52	14,40	39,4	40,1	35	30
14	13:30	1,27	1,273	15,06	15,00	39,3	39,4	34	29
15	14:00	1,20	1,214	14,45	14,38	46	44,4	25	21
16	14:30	1,13	1,135	15,92	15,78	40,9	39,8	38	37
17	15:00	1,10	1,096	16,20	16,14	36,02	36,4	51	51
18	15:30	0,85	0,847	15,46	15,32	38,8	38	48	43
19	16:00	0,48	0,477	13,91	13,71	34,1	36,8	45	39
20	16:30	0,25	0,253	13,50	13,38	31,2	33,2	51	47
21	17:00	0,08	0,082	13,54	13,32	31,3	32,4	55	55
22	17:30	0,07	0,0719	13,43	13,18	31,4	32,3	55	56
23	18:00	0,01	0,01039	13,32	13,07	31,1	31,6	57	60
TOTAL		21,24	21,280	336,56	334,98				
Average		0,92347826	0,92523	14,63304348	14,56434783				

From the measurement data, it can be seen that solar panel in mobile conditions have started to produce an average electric current of 1 A from 8.30 to 15.00 except in the morning and evening, because the sunlight in the morning just starts to come out and in the afternoon the sun would tend to away or start sinking.

Comparison between the two systems was carried out by testing the output of solar panel, where the test conditions were carried out on the same day. So that, it can be seen with the same weather conditions on the same day the difference in the output of the solar panel itself. From the data obtained, the output can be very weak in the afternoon, because in the afternoon the distance of the sun was far from the position of the solar panel. The panel can receive little sunlight or even a little sun shade.

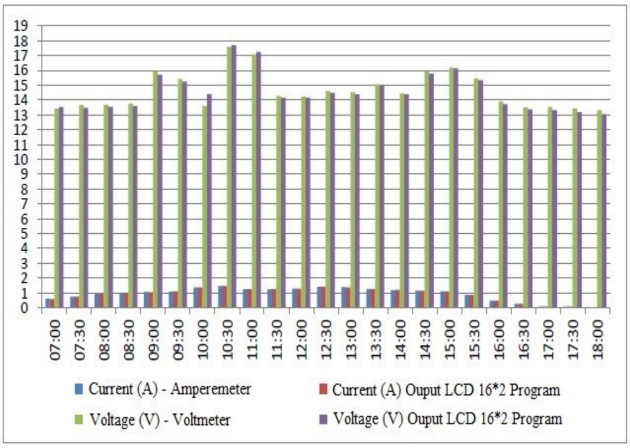

Figure 9: Solar panel output graph with the mechanical moving method

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Based on the two measurements data previously, it can be seen that the solar panel can produce maximum voltage when it was parallel to the sun. This was clearly proven in the data obtained. From these two solar panel testing methods, it can be concluded that testing with the moving mechanical method was more effective than testing solar panel with the stationary mechanical method. Solar panel using the movement method maximize the existing sunlight.

Percentage of Improvement for Both Methods

From the two methods used, it was clear that solar panel can work optimally when using the mechanical moving method. The solar panels used can produce maximum output in a relatively long period of time. One way to achieve, this was the moving panel method. So in this case the comparison made was purely the output value of the solar panel itself without any reduction from the use of the load from the device. The following is the percentage increase in voltage repair between the two methods.

The average output of the panel with the two methods where the mechanical method was stationary the average output was V = 14.28 Volts, I = 0.66 A and the power of 9.44 Watt, while the output of the moving mechanical method was the average of V = 14 .63 Volts, I = 0.92 A and a power of 13.51 Watts. So, the percentage increase in energy improvements was produced 30.13%.

4.0 CONCLUSION

This paper aims to analysis solar panel tracking control monitoring system. After develop and testing the system, it can be concluded:

The moving panel method is an efficient way to increase the energy output of solar panels than the stationary panel method with an energy improvement of 30.13%. The size of the output produced by the solar panel depends on the conditions of sunlight received by the solar panel, where when the panel method is stationary the average energy is V = 14.28 volts, I = 0.66 A and the energy when the solar cell is moving is average V = 14.63 volts, I = 0.92 A. The use of a light sensor (LDR) can only work in certain light conditions (sensor sensitivity), with the sensor output voltage when high conditions (there is light) 4.12 volts and low conditions (no light) 0.12 volts.

The use of IoT (Internet of Things) techniques in the designed system is capable of facilitating monitoring of electrical energy. This can be seen from the remote monitoring process that can be carried out and the Blynk interface software design is also able to interpret actual data in the field in real time.

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