Monitoring for Photovoltaic in Outer Island

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Abstract

Photovoltaic is a renewable energy source that can optimally be used on outer islands and areas that are difficult to reach by the main electrical system network. With good solar energy intensity on a daily, it adds to the advantages of using photovoltaics. In this regard, it is necessary to make a prototype for monitoring the photovoltaic output parameters to measure photovoltaic performance. The parameters that will be monitored on 50 Wp photovoltaic used in this research are voltage using a voltage sensor, current using an ACS712 sensor, and the real power generated. The monitoring results are stored in a database and monitored in realtime based on the website's setting. So that this prototype can be used in several outer islands in Bangka Belitung, which is geographically an archipelago.

.***Keywords:*** *photovoltaic, voltage, current, real power, outer island.*

I. Introduction

One of the provinces consisting of various small islands in Indonesia is the Bangka Belitung Islands Province. Bangka Belitung Islands has an ocean area of 65.301 km^2 and a land area of 16.242 km^2 [1], and it is composed of two main islands, namely Bangka and Belitung Islands, as shown in Figure 1.

Figure 1. Map of Bangka Belitung Island Province [2]

Based on geography, Bangka Island is surrounded by Nangka, Penyu, Burung, Lepar, Pongok, Gelasa, Panjang, and Tujuh islands [1]. Also, Belitung is surrounding by Lima, Lengkuas, Selindung, Pelanduk, Seliu, Nadu, Mendanau, Batu Dinding, Sumedang, and other small islands [1].

The existence of outer islands whose position is far from the main island requires a supply of electrical energy to improve peoples' quality of life on the local island. With the intensity of sun's intensity up to 4.95 kWh/m2 day [3], the outer islands in the Bangka Belitung Province can utilize the energy's potential to be converted to electrical energy through the use of photovoltaics. This also certainly supports by diversifying the source of electrical energy for the Bangka Belitung Province, which currently has a population of 1,459,873 people and 449,450 customers [1] dominated by diesel and steam power plants also in a small amount from bioenergy. Dependence on fossil energy sources with the availability of infrastructure and limited access, as well as high prices make the use of renewable energy, including those from solar energy sources a necessity and choice in meeting the electrical energy needs of residents on small and outer islands [4]-[7].

One of the main problems in utilizing photovoltaics on the outer islands is difficult to monitor in realtime. Most citizens of the outer island do not understand photovoltaic technology well. On the other hand, photovoltaic systems need to be monitored regularly to prevent serious problems that may arise.

Several studies related to monitoring photovoltaic performance [8]-[12] include monitoring using a smartphone [13], monitoring Grid Connected Utility-Scale for PV Power Plant [14], based on the website [15]-[16] and internet-based of things [17]-[20]. Therefore, a prototype test will be carried out using one unit of 50 Wp photovoltaic equipped with ACS712 current sensor, voltage sensor, and ESP8266 module to monitor voltage, current, and real power stored a database, it can be displayed on a website in realtime.

II. Materials and Methods

This study's monitoring system measures the output voltage and current from the solar panel and solar charger controller. In this research, we are using 50 Wp solar panels with polycrystalline silicon type, and the solar panels are placed in an open place and get direct sunlight. Block diagram of system in Figure 1.

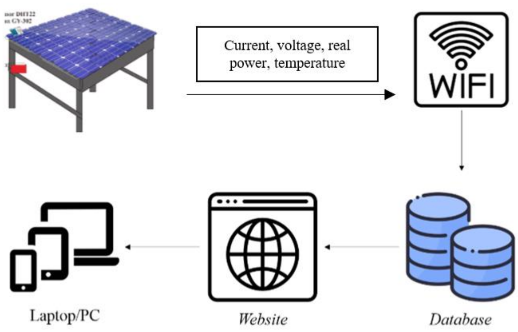


Figure 1. Block diagram

Voltage sensor and current sensor ACS712 are using to measure voltage and current. Both sensors are connected to Arduino. The voltage sensor test is done by connecting pin S on the sensor with pin A0 on Arduino and pin - on the sensor with the GND pin on the Arduino. Current sensor testing is done by connecting the OUT pin on the sensor with pin A0 on Arduino, GND pin on the sensor with GND pin on Arduino, and the VCC sensor pin with pin 5V Arduino. After the sensor reads the voltage and current, the ESP8266 module connects wifi with Arduino. If Arduino is connecting to wifi, Arduino will send voltage and current data to the database. After the data is sent, it will display the data on the website that has been built. In this research, the website created consists of realtime pages, data table pages, and graph pages.. Schematically, the circuit diagram of this study is shown in Figure 2.

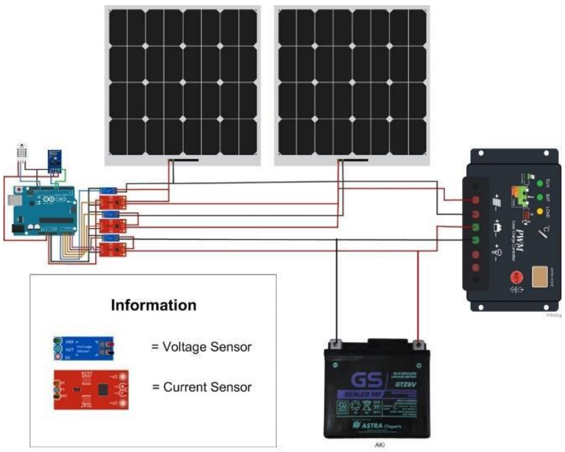


Figure 2. Circuit diagram

It made a comparison between systems and multimeters to validate the performance of the monitoring system. The accuracy level of system has expressed the difference between the measurement results and the results measured on a multimeter:

$$\%Error = \left| \frac{MS - MM}{MM} \right| \times 100\% \qquad (0.1)$$

Where *MS* is a measurement by a sensor and *MM* is a measurement by the multimeter.

III. Results and Discussions

Table 1 presents the voltage sensor validation data for voltage sources ranging from 1 to 25 V. Based on this data, and it appears that the error from the comparison between the voltage sensor with a multimeter is between 0 - 4.76%. The highest error occurs at 1 V. However, when the source voltage increases, the error decreases. According to these results, it can be stated that the voltage sensor system used has good accuracy to measure the voltage. Moreover, the output of the solar panels used is more than 1 V.

Table 1. Validation for voltage sensor

V_{source} (V)	Voltage sensor (V)	Multimeter (V)	Error (%)
1	1.1	1.05	4.76
2	2.06	2.04	0.98
3	3.14	3.11	0.96
4	4.07	4.06	0.25
5	5.15	5.12	0.59
6	6.12	6.10	0.32
7	7.09	7.08	0.13
8	8.08	8.07	0.12
9	9.05	9.04	0.01
10	9.99	10.05	0.60
11	10.95	11.04	0.60
12	11.96	12.04	0.66

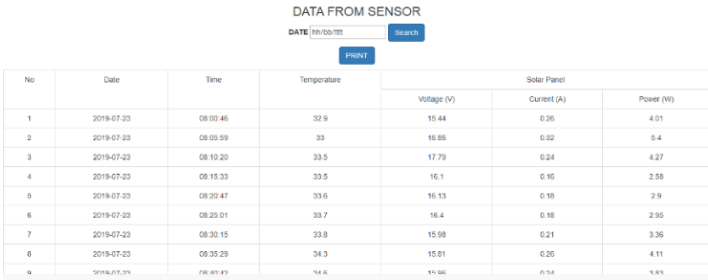
13	13.06	13.1	0.31
14	13.97	14.04	0.50
15	15.01	15.11	0.66
16	15.95	16.05	0.62
17	16.98	17.12	0.82
18	17.92	18.09	0.94
19	18.86	19.06	1.05
20	19.8	20.05	1.25
21	20.84	21.06	1.04
22	21.84	22.13	1.31
23	22.88	23.07	0.82
24	23.89	24.1	0.87
25	25	25.06	0.24

Table 2 presents the current sensor validation. This validation uses a constant voltage of 12 volts with variations in load from 1.2 to 6 Watt. The validation results show that the highest error percentage value is 25% , and it occurs when the load is 1.2 W. Ammeters measure currents of 0.12 A. While the current sensor measures currents of 0.15 A. The minimum error percentage value is 2% when the source voltage is given a load of 6 W. Thus, and it appears that the greater the measured power, the accuracy of the current sensor will increase.

Table 2. Validation for a current sensor

Source (V)	Load (watt)	Current sensor (A)	Amperemeter (A)	Error(%)
12	1.2	0.15	0.12	25
12	2.4	0.22	0.21	5
12	3.6	0.3	0.32	6
12	4.8	0.44	0.42	5
12	6	0.52	0.51	2

Figure 3 shows the website display containing a database that is stored every 5 minutes. The picture also shows the sensor's measured voltage, the measured current from the sensor, and the real power generated.


DATA FROM SENSOR

DATE hh/bb/tttt Search

PRINT

No	Date	Time	Temperature	Solar Panel		
				Voltage (V)	Current (A)	Power (W)
1	2019-07-23	08:00:46	32.9	15.44	0.26	4.01
2	2019-07-23	08:05:59	33	16.86	0.32	5.4
3	2019-07-23	08:10:20	33.5	17.79	0.24	4.27
4	2019-07-23	08:15:33	33.5	16.1	0.16	2.58
5	2019-07-23	08:20:47	33.6	16.13	0.18	2.9
6	2019-07-23	08:25:01	33.7	16.4	0.18	2.95
7	2019-07-23	08:30:15	33.8	15.98	0.21	3.36
8	2019-07-23	08:35:29	34.3	15.81	0.26	4.11

Figure 3. Database from Photovoltaic Monitoring

Whereas in figure 4 shows the website graphic display on a database. The graph displays the real voltage, current, and power at the vertical axis, while on the horizontal axis, the data is taken when the current data, voltage ,and real power

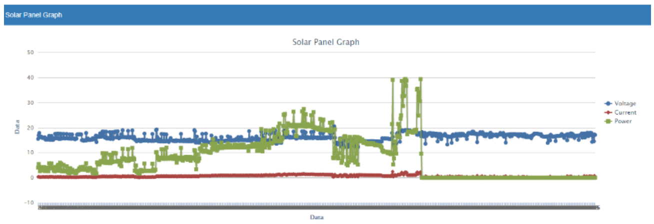


Figure 4. Result of Photovoltaic Monitoring

Figure 5 is the result of measurements on July 23, 2019 for the photovoltaic temperature and voltage. Measurements were made from 08.00 A.M. to 04.00 P.M. By taking data from the measurements, it was carried out every 5 minutes. At 08.00 A.M. with a temperature of 32.9 ° C, the measured voltage from the sensor is 15.44 V. At 10.50 A.M., an increase in temperature becomes 33.3 ° C with a measured voltage from the sensor 15.08 V. At 04.00 P.M. at a temperature of 30.8 ° C, the measured voltage from the sensor 14.17 V.

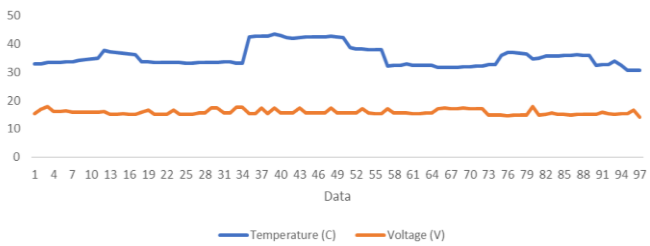


Figure 5. Voltage and Temperature from photovoltaic on July 23

Figure 6 shows the measurements on 23 of 2019 for the measurement results of the current sensor. Data is collected every 5 minutes from measurements made from 08.00 A.M. to 04.00 P.M . At 08.00 A.M., the output current is 0.26 A, and at 09.30 A.M., the output current is 0.34 A. While at 04.00 P.M., the output current from photovoltaic is 0.11 A.

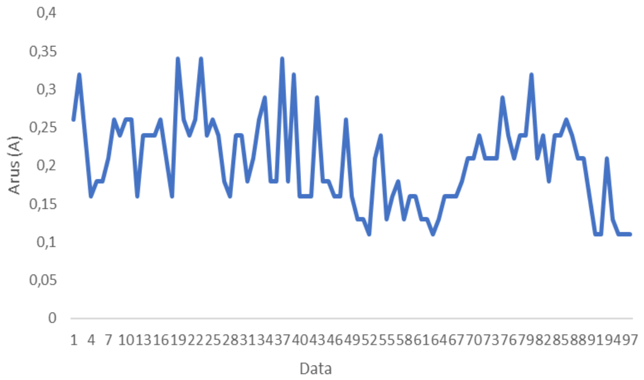


Figure 6. Current from photovoltaic on July 23

In Figure 7 is a measurement of temperature and voltage carried out on July 24, 2019. Data collection is carried out every 5 minutes which measurements are taken at 08.00 A.M. to 04.00 P.M. At 08.00 A.M. with a temperature of 35.7°C, the measured voltage of the solar panel is 16.3 V. Temperature at 11.05 A.M. is measured 40.5 ° C with the voltage of the solar panel 15.86 V. Then at 04.00 P.M. with a temperature of 36 .8 ° C measured solar panel voltage 14.76 V.

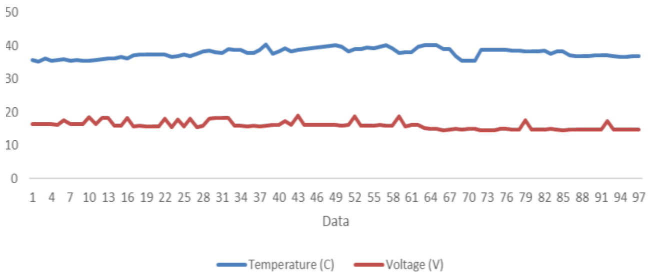


Figure 7. Voltage and Temperature from photovoltaic on July 24

Figure 8 shows the measurements on July 24 2019 for the measurement results of the current sensor. Data is collected every 5 minutes from measurements made from 08.00 A.M. to 04.00 P.M.. At 08.00 A.M. the photovoltaic current was 0.37 A, while at 11.30 A.M. the measured 0.61 A. At 01.50 P.M. the measured current value was 0.11 A.

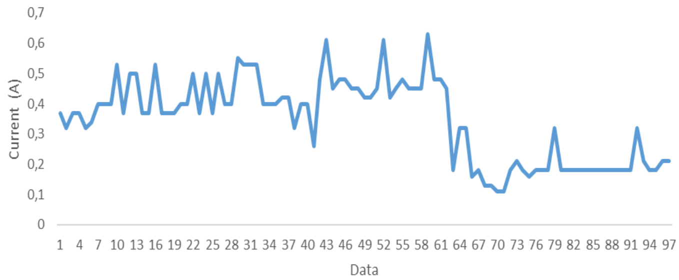


Figure 8. Current from photovoltaic on July 24

The results of voltage and temperature measurements in Figure 9 are the results of measurements on July 25 at 08.00 A.M. to 04.00 P.M. every 5 minutes. At 08.05 A.M. with a measured temperature of 34.9 ° C, the photovoltaic voltage is 19.19 V. Then at 11.05 A.M. the measured temperature is 35.5 ° C with a measured voltage of photovoltaic 14.74 V. At 04.00 P.M., the measured temperature is 35. 8 ° C with a photovoltaic voltage of 14.54 V.

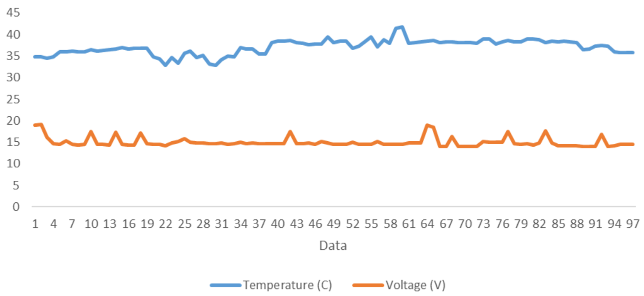


Figure 9. Voltage and Temperature from photovoltaic on July 25

Figure 10 Results from the photovoltaic currents' measurement on July 25 from 08.00 to 04.00 every 5 minutes. At 08.00 A.M. the current measured from photovoltaic 0.53 A, while at 02.05 noon, the current measured from photovoltaic 0.78 A.

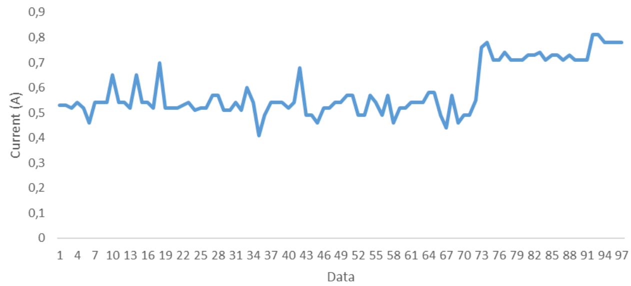


Figure 10. Current from photovoltaic on July 25

The photovoltaic efficiency in Figure 11 is the ratio between the measured real power to the potential real power generated with a maximum value of 36%, a minimum value of 4%, and an average of 11%.

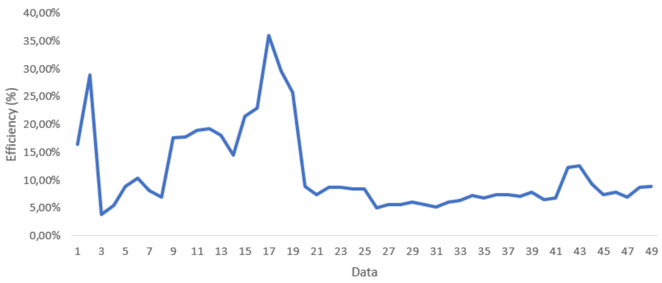


Figure 11. Efficiency of photovoltaic

IV. Conclusions

This research built realtime photovoltaic monitoring through the website for the outer islands in Bangka Belitung islands to display the results of monitoring currents, voltages, real power, and can also measure photovoltaic's efficiency by comparing the measured real power with the potential real power that can be generated

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