Voltage and Current Calculation on Hybrid PV and Microhydro Power Plant Prototypes Based on Arduino

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Abstract. Hybrid Power Plant is a combination of power plants that use solar and micro hydro power sources. The purpose of this research is to measure the value of power, measure the value of current and voltage measurements using a DC voltage sensor and ACS712 current sensor. The experiment was conducted to determine the accuracy of the sensor in measuring the value of voltage and current on the hybrid prototype. In the solar panel prototype, the power obtained is 0.80332 W with an efficiency of 66.94%, in the micro-hydro prototype, the power is 0.02554 W with an efficiency of 93.89% and the hybrid prototype is 1.3564 W.

Keywords: Efficiency · Microhydro · Prototype · Sensor · Solar Panel

1 Introduction

Indonesia has high renewable energy Based on data from the Ministry of Energy and Mineral Resources (KESDM), Indonesia has a large new renewable resource [1]. These resources can be used to produce energy evenly and hygienically. Even so, at this time the use of NRE in Indonesia only reaches about 6% of the national energy [2]. It can be seen that renewable energy is scattered, the supply of energy in Indonesia, especially in areas that do not yet have the potential for energy, can be met with local ideas [3].

Power plant hybrid in this experiment, it is a combination of a solar power source and a micro hydro power source [4]. Generators on solar panels require sunlight as a source, if sunlight is obtained maximally then this power plant can produce maximum electrical energy as well. A micro hydro generator is a generator that utilizes water as a driving medium for a dynamo or dc motor so that when the dynamo has rotated, electrical energy has been created and then stores the electrical energy into the battery [5]. Power plant hybrid is when the sky is cloudy and there is no sunlight during the day, the power plant is driven by a dc motor and vice versa. When the sun is hot, the power plant will be driven by solar panels. However, if the sun is hot and the water is fully charged and wants to turn on the micro-hydro, the power plant will be driven by solar panels and a dc motor driven by water [6].

In seeing the PV-micro hydro itself can be done by using a prototype. This prototype aims to measure the power value of the prototype made. The PV-micro hydro prototype

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is an example of a PV-micro hydro simulation where measurements are used using a current sensor and a voltage sensor. Measurements are carried out in real time where current sensors and voltage sensors are used to see the current and voltage values that can be generated by the prototype [4].

2 Methods

2.1 Methods Used

In this experiment, it is necessary to develop a research methodology. In general, the methods used are:

The observation method by observing the data generated by the measurement of the prototype.

2.2 Time, Place and Tools

This research was conducted at the end of May 2021 in Samarinda. The main tools in conducting this research are as follows:

1. Arduino Uno

With specifications:
Operating Voltage: 5 V
Input Voltage: 7–12 V
SRAM: 2 KB
EEPROM: 1 KB
Clock Speed: 16 MHz
Length: 68.6 mm

Width: 53.4 mm

2. Solar Panel

Specifications:
Voltage: 6 V
Current: 0.2 A

3. DC Motor

With Specifications:
Rated Speed: 100–6000 rev/min
Output Current: 0.01 V–5.5
DC Output Voltage: 0.01–5.5 V
Blade Aperture: 1.59 mm/0.077°
Blade Diameter: 100 mm/3.94° (After Assembly)
Motor Shaft Length: 13.5 mm/0.53°
Motor Shaft Diameter: 2 mm/0.079°
Motor Height: 34,2 mm/1.35°
Motor Diameter: 24.5 mm/0.096°

4. DC Voltage Sensor

With Specifications:
Detection Voltage: 0.02445–25 V DC
Input Voltage: 0–25 V
Measurement Accuracy: 0.00489 V
Size: 25 × 13 mm

5. Current Sensor ACS7712

With Specifications:
Size: 1.2″ × 0.5″
Total Output Error: 1.5%
Operating Voltage: 5 V
Current to Voltage Ratio: 185 mV/A
Accurate Sensing Range: -5 A h up to +5 A

6. Charger module

with specifications:
Input Voltage: 3.7–5.5 V
Voltage Output: 5 V
Current Input: 1 A
Current Output: max 1 A
Current Standby: 8 A
Full stop charging voltage: 4.2 V ±1%
Stop discharge voltage: 2.9 V
Efficiency: 85% (input 3.7 V, Output 5 V 1 A)

Working temperature: 10 to 85 °C

7. Batteries

With specifications:
Size: 18650
Nominal Capacity: 2100 mAh
Discharge: 30 A
Nominal Voltage: 3.7 V
Positive: Flat

8. Battery Holder

With specifications:
Battery Type: 18650
Dimensions: Battery Holder for 1 × 18650: approx. 7.6 cm × 2 cm/3.0″ × 0.8″

9. Jerry

With Specifications:

10 liters

10. Hose

With specifications:
Size 14 = Hole Hole circumference in 5 mm

11. LED lamp

With specifications:
Voltage: 1.6 V

12. Laptop

2.3 Stages of the Study

The following is a flow chart in the research that will be used (Figs. 1, 2, 3, 4, 5, 6 and 7).

Data retrieval is needed in order to know the current value and voltage value on the sensor, the data needed are:

1. Current value and voltage value on PV through sensors and laptops.
2. Current and voltage values on Mikrohydro through sensors and laptops.
3. Current and voltage values on PV-Mikrohydro through sensors and laptops.
4. The values on the current and voltage sensors are constant or not.

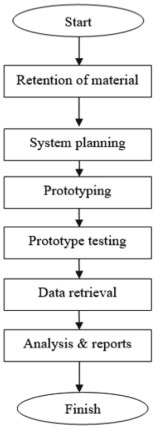


Fig. 1. Flowchart of Research Stages

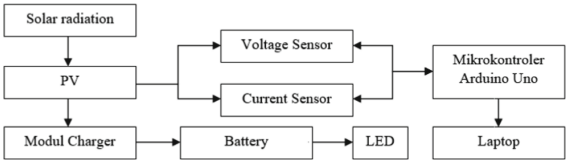


Fig. 2. Block Diagram of PV Prototype with current and voltage sensors

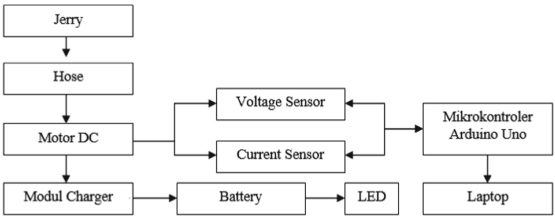


Fig. 3. Block Diagram of Microhydro Prototype with current and voltage sensors

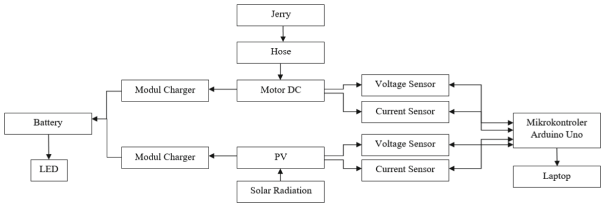


Fig. 4. Block Diagram of PV Prototype – Microhydro with current and voltage sensors

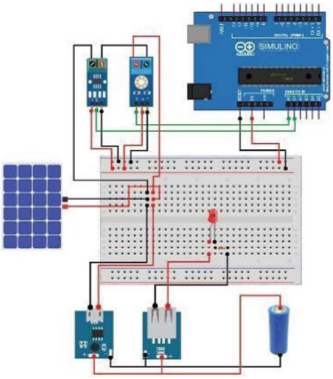


Fig. 5. PV Prototype Circuit on Arduino

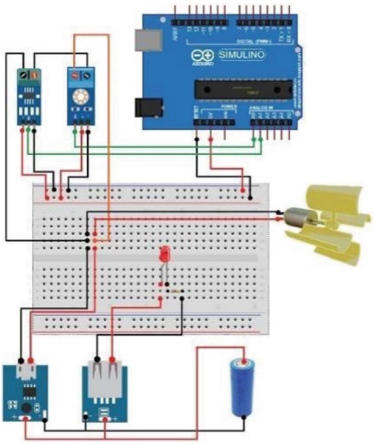


Fig. 6. Microhydro prototype circuit on Arduino

2.4 Data Analysis Stages

In this study there are several stages to analyze the data are:

1. Analyzing the results of calculations with the results obtained in the prototype.
2. Analyzing time on observational data.

2.5 Stages of Observing and Analyzing

Energy Data Results that can be generated by prototypes on solar panels:

In the solar panel prototype using a solar cell as a power source from a 3.7 V battery, the voltage required for charging is 3.7 V with a current that can be carried out how to measure using a current sensor, the solar cell in this prototype has a power of 1.2 WP and a voltage when charging is 3.7 V then:

$$I = P/V$$

$$I = 1,2\ \text{Wp}/3.7\ \text{V}\ I = 0.32\ \text{A}$$

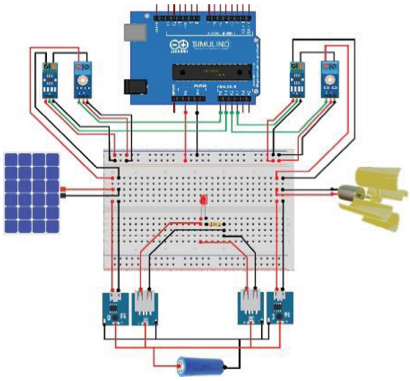


Fig. 7. PV Prototype Circuit – Mikrohydro on Arduino

Where:

I = Current (A)
P = power (watts)
V = Voltage (Volts)

The solar cell gets solar radiation for 5 h and produces a power of:

$$1,2\ \text{Wp} \times 5\ \text{h} = 6\ \text{watt hours}$$

With a voltage of 3.7 V it is able to flow 1.6 A for 5 h.
After getting the power value, you can find the percentage with the formula:

$$\text{Efficiency} = P_{out}/P_{in} \times 100\%$$

Where:
P_{out} = Output power P_{in} = Power input.
Energy that can be generated prototype at mikrohydro:
In the prototype mikrohyro using a dc motor as a power source. In this prototype using a jerry can with a volume of 10 L with a targeted time of 3,600 s with a water descent speed of 0.01 m/s, the water discharge is 2.77 × 10 - 6 with a gravity of 9.8, the density of water 1000 and a height of 1 m is estimated to get a power of:

$$P = Qg \cdot H$$
$$P = 2.77 \times 20 - 6.\ 9,8,\quad 1000.1\ P = 0.0272\ \text{watts}$$

Where:

P = power (watts)
Q = water discharge (m^3s)
g = acceleration due to gravity (ms^2) H = effective height (m)

ρ = density water (kgm^3)

Energy that can be generated by the prototype on PV - Microhydro:

$$P_{load} = V_{load} \cdot I_{load}$$

Where:

P_{load} = power on load (Watt) Vload = voltage on load (Volt)
I_{load} = current on load (A)

Energy that can light an LED lamp:

$$P = V \times I$$
$$P = 1.6 \times 0.01 \; P = 0.016 \text{ Watt}$$

Calculation to measure power:

$$P = V \times I$$

Where:

P = power (watts) V = voltage (Volt)
I = strong current (A)

3 Result and Discussion

3.1 Measurements on Solar Panels Using Sensors

Measurements on solar panels use current sensors and voltage sensors. The sensor used to determine the current value is the ACS712 sensor and to determine the voltage value using a voltage sensor. From the measurements on the solar panels, it can be seen that the measurement results are as follows:

In Table 1 the results of measurements on solar panels are obtained for 5 h. In the first test at 10.00 it was read by the sensor with a voltage of 3.76 V and a current of 0.13 A, in the second test at 11.00 it was read by a sensor with a voltage of 4.54 V and

Table 1. Measurement Results on the Solar Panels

Testing	Time	Voltage (Volts)	Current (A)
1	10.00	3.76	0.13
2	11.00	4.54	0.19
3	12.00	4,25	0.2
4	13.00	4.27	0.16
5	14.00	4.32,	0.27
Average	**-**	**4,228**	**0.19**

Table 2. Measurement Results on Micro hydro

Testing	Time (minutes)	Voltage (Volts)	Current (A)
1	1	2.61	0.01
2	2	2.69	0.01
3	3	2.66	0.01
4	4	2.69	0.01
5	5	2.12	0.01
Average	**-**	**2.554**	**0.01**

a current strength of 0.19 A, in the third test at 12.00 it was read by a sensor with a voltage of 4.25 V and a current strength of 0.2 A, in the fourth test at 13.00 it was read by a sensor with a voltage of 4.27 V and a current strength of 0.16 A, in the fifth test at 14.00 it was read by a sensor with a voltage of 4, 32 V and current strength 0.27 A and from the five tests obtained an average voltage of 4.228 V and an average value of current strength of 0.19 A.

3.2 Measurements on Micro Hydro Using Sensors

Measurements on micro hydro use current sensors and voltage sensors. The sensor used to determine the current value is the ACS712 sensor and to determine the voltage value using a voltage sensor. From the measurements on the micro hydro, it can be seen that the measurement data are as follows:

In Table 2 the measurement results on micro hydro are obtained for 5 min. In the first test the first minute value is obtained voltage 2.61 V and current strength 0.01 A, in the second test the second minute obtained a voltage value of 2.69 V and a current strength value of 0.01 A, in the third test the third minute obtained a voltage value of 2.66 V and a strong current 0.01 A, in the fourth test the fourth minute obtained a voltage value of 2.69 V and a current strength value of 0.01 A, in the fifth test the fifth minute obtained a voltage value of 2.12 V and a current strength value of 0.01 A and from the five tests obtained an average value with a voltage value of 2.554 V and a current strength value of 0.01 A.

3.3 Measurements on PV-Micro Hydro Using Sensors

Measurements on hybrid PV-micro hydro use current sensors and voltage sensors. The sensor used to determine the current value is the ACS712 sensor and to determine the voltage value. From the measurements on the PV-micro hydro, it can be seen that the measurement data are as follows:

In Table 3 the measurement results on hybrid PV-micro hydro obtained for 5 h. In the first test at 10.00 the voltage value was 6.37 V and the current strength value was 0.14 A, in the second test at 11.00 the voltage value was 7.23 V and the current strength value was 0.2 A, in the third test at 12.00 the voltage value was obtained 6.91 V and the value

Table 3. Measurement Results on the PV-micro hydro

Test	Time	Voltage (Volts)	Strong Current (A)
1	10.00	6.37	0.14
2	11.00	7.23	0.2
3	12.00	6.91	0.21
4	13.00	6.96	0.17
5	14.00	6.44	0.28
Average	**-**	**6.782**	**0.2**

of the current strength of 0.21 A, in the fourth test at 13.00 the voltage value was 6.96 V and the current strength value was 0.17 A, in the fifth test at 14.00 the voltage value was 6.44 V and the current strength value 0.28 A and from the five tests, the average voltage value is 6.782 V and the average current strength is 0.2 A.

Calculation of Power Value Measurement in Solar Panels:

$$P = V \times I$$
$$P = 4.228 \times 0,19 \quad P = 0.80332 \text{ Watt}$$

Efficiency Measurement in Solar Panels:

$$\text{Efficiency} = \text{Pout/Pin} \times 100\%$$
$$\text{Efficiency} = 0.80332/1.2 \times 100\%$$
$$\text{Efficiency} = 66.94\%$$

Calculation of Power Value Measurement in micro hydro:

$$P = V \times I$$
$$P = 2.554 \times 0.01$$
$$P = 0.02554 \text{ Watt}$$

Measurement Efficiency in micro hydro:

$$\text{Efficiency} = \text{Pout/Pin} \times 100\%$$
$$\text{Efficiency} = 0.02554/0.0272 \times 100\%$$
$$\text{Efficiency} = 93.89\%$$

Calculation of Power Value Measurement in Hybrid PV-micro hydro:

$$P = V \times I$$
$$P = 6.782 \times 0.2$$
$$P = 1.3564 \text{ Watt}$$

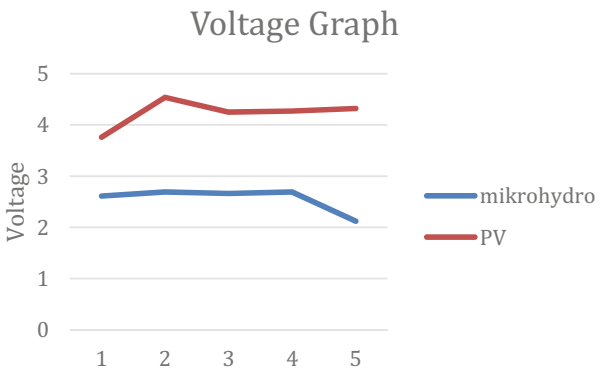
The solar panel prototype experiment, the power is 0.80332 W, while the micro hydro shows a power of 0.02554 W. In experiments on solar panels and micro hydro

show that the power generated on the solar panels is greater than the power generated on the micro hydro. The difference in power on the prototype of solar panels and micro hydro is 0.77778 W, on the measurement of solar panels using sensors obtained power efficiency of 66.94% while on micro-hydro using sensors obtained power efficiency of 93.89%. In the experiment of solar panels and micro-hydro, it can be seen that the power efficiency of micro-hydro is greater than the efficiency of solar panels. The difference in power efficiency is 26.95. The efficiency of solar panels is 66.94% due to the lack of sunlight and the placement on solar panels is also one of the factors for reducing efficiency in solar panels.

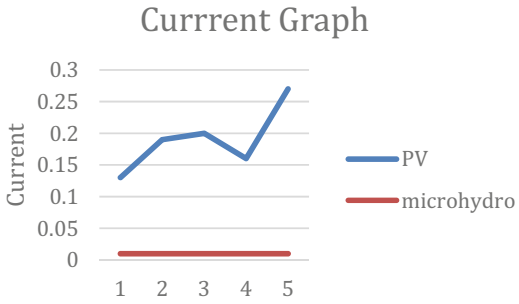
In the experiment of solar panels and micro hydro using sensors, it can be seen that the average voltage and average current, on solar panels, the average voltage is 4.228 V and the average current strength is 0.19 A, while the micro hydro shows the average voltage. the average is 2.554 V and the average current is 0.01 A so that the total average voltage is 6.782 V and the total current strength is 0.2 A.

The Graph 1 shows the voltage generated by the PV generator is greater than the voltage generated by the micro hydro generator. In the first test at 10.00 the voltage generated by PV is 3.76 V. While in the first test the voltage generated by the micro-hydro generator is 2.61 V. Data collection on both PV and Micro-hydro plants is carried out five times a day with the average voltage generated by the PV generator is 4.228 V. At the micro hydro power plant, the average value of the voltage is 2.554 V. Data collection at the PV plant is carried out from 10.00–14.00 WITA.

The Graph 2 shows the current value generated by the PV generator is greater than the current value generated by the micro hydro generator. In the first test at 10.00 the current generated by the PV generator was 0.13 A. While in the first test the micro-hydro power generated was 0.01 A. Data collection on both PV and Micro-hydro plants was carried out five times a day with an average current of generated by a PV generator is 0.19 A. In a micro hydro power plant, the average current strength value is 0.01 A. experiment hybrid, solar panels and micro hydro can be done alternately, if during the



Graph 1. Voltage on PV and micro hydro



Graph 2. Currents in PV and micro hydro

day solar panels can be used and if during the day there is no light sun (cloudy) or at night, you can use micro hydro.

4 Conclusion

1. The power plant in this experiment is electricity based on new renewable energy.
2. electric power source *hybrid* by combining solar power and micro hydro power.
3. In this experiment, measurements were made in *real time* where current sensors and voltage sensors were used to see the current and voltage values generated in the prototype.
4. The power on the solar panel prototype produces 0.80332 W, the power on the micro hydro prototype produces 0.02554 W and the power on the PV-micro hydro hybrid prototype produces 1.3564 W.
5. The efficiency of the solar panel prototype is 66.94% while the efficiency of the micro hydro prototype is 93.89%

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