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# Analysis Of Voltage and Current Performance of 100 WP Solar Panel Using Matlab Simulink R2021a

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### ABSTRACT

The growing population increases the need for electrical energy. Development of renewable energy that is environmentally friendly and sustainable to replace fossil energy sources that are almost depleted and have an impact on global warming. Indonesia is on the equator where there is potential for the application of photovoltaic technology. However, the high cost of implementing a solar power system must be considered, as the energy supply is intermittent and highly dependent on environmental factors such as solar radiation and temperature. Therefore, it is necessary to design a solar power generation system using MATLAB Simulink 2021a software simulation method to avoid the implementation error rate and determine the success, especially the system performance. The MATLAB Simulink 2021a simulation method uses a 10 Wp monocrystalline Photovoltaic (PV) and a 12 V 20 Ah Lead-Acid battery. PV array design, PV Array, Buck Converter, Inverter, PV Controller, Battery Controller and Metering. To find out the value of the output voltage and current from solar panels, batteries, and the results of the DC to AC conversion by the inverter and using a load of 17 watts. The simulation results of a 100 Wp solar panel at MATLAB Simulink in the South Jakarta area with an intensity of 131W/m<sup>2</sup> and a temperature of 27.99 °C produce a PV array output voltage and current of 17.6 V and 5.8 A, respectively. The battery voltage and current show the highest values are 12.58 V and 4.8 A. The actual voltage and current are close to the values of V<sub>mp</sub> 17.8 V and I<sub>mp</sub> 5.2 A, so that the results of this system design can be stated to have maximum performance. Meanwhile, the inverter output has the highest voltage and current values of 218 V and 0.085 A.

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## **1. Introduction**

The demand for electrical energy continues to increase as the world population grows, including Indonesia[1-4]. The alternative energy development program continues by seeking renewable energy sources or environmentally friendly and sustainable energy to replace fossil energy sources whose reserves have been depleted[5-7] . Especially when it is associated with global warming due to exhaust emissions from power plants based on fossil energy[8-10].

Indonesia, as a country located at the equator, has the potential to utilize renewable energy, especially solar energy through the use of photovoltaic (PV) technology[11-13]. But the cost is still expensive, which forces us to be cautious in implementing solar power generation systems[14,15]. Due to the intermittent nature and highly influenced of environmental factors such as solar radiation and temperature[16-19].

The use and solution of problems can be done by designing a solar power generation system using the simulation method of MATLAB Simulink 2021a software, with the aim of knowing the failure rate in implementation can be avoided and can determine the level of success, especially the system performance[20-22]. The research method is based on the results of I-V output and Photovoltaic performance according to the capacity and type of solar panels used monocrystalline 100 WP[23-25].

Based on the results of a review of previous research that MATLAB Simulink discussed in terms of simulation, off grid connected performance and tracking surfaces[26,27]. This method has never been used in this study using the MATLAB Simulink 2021a for simulation with a 10 Wp monocrystalline photovoltaic (PV) and a 12 V 20 Ah Lead-Acid battery. PV array design, PV Array, Buck Converter, Inverter, PV Controller, Battery Controller and Metering. To find out the value of the output voltage and current from solar panels, batteries, and the results of the conversion of DC to AC by the inverter and using a load of 17 watts.

## **2. Methodology**

### *2.1 Research Process*

The research process starts from collecting data including potential solar radiation and average temperature as shown in Figure 1. Determine the type of photovoltaic (PV) and battery in MATLAB Simulink.

Furthermore, PV Array, Buck Converter, Inverter, PV Controller, Battery Controller and Measurement series designs. Then carry out system simulations and validate the simulation data analysis results [28].

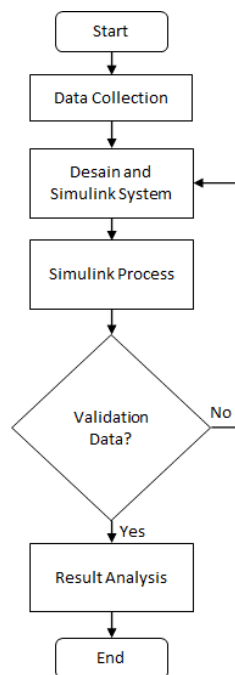


Fig. 1. Research process

## 2.2 Data Collection

Determination of the efficiency produced by solar panels is influenced by the potential of solar radiation produced on average per month [18].

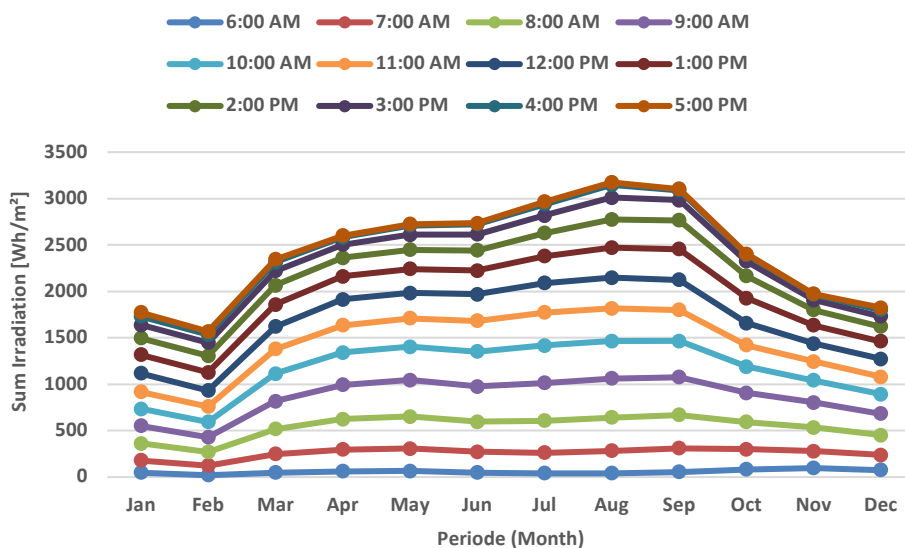
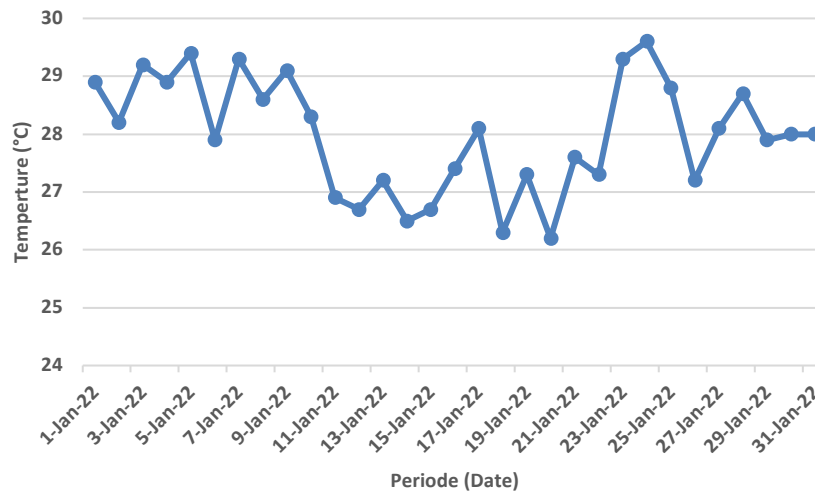


Fig. 2. Average hourly profiles direct normal irradiation [Wh/m²] [18].

Figure 2 shows the sum irradiation start increase from March until August. Data average hourly profiles direct normal irradiation [Wh/m²] from the Global Solar Atlas (GSA) report for the South Jakarta area in 2022 has the lowest solar radiation potential in February of 131 Wh/m², while the highest potential for solar radiation is in August of 265 Wh/m². While this research was conducted in January 2022 with a potential solar radiation of 148 Wh/m².



**Fig. 3.** Average temperature in January 2022 (°C)[16]

The average temperature in January 2022 is 27.99 °C with the highest temperature occurring on January 24 2022 of 29.6 °C as shown in Figure 3.

The determination of the type of photovoltaic to be used in this study is based on the existing library in the MATLAB software with a capacity of 100 Wp monocrystalline type [25]. So that the specification data is attached in Table 1. Apart from the MATLAB software, the determination of photovoltaic type results is based on Standard Test Conditions (STC) with a monocrystal type efficiency value of 12.8 % and the lowest data on the thin film type of 7 % [29,30].

**Table 1**

Specification of Photovoltaic [20]

Cell per module (Ncell)	30
Maximum Power (W)	98.256
Open Circuit Voltage (V)	21.8
Short-circuit Current (A)	5.62
Voltage at Maximum Power Point (V)	17.8
Current at Maximum Power Point (A)	5.52
Temperature Coefficient of Voc (%/deg.C)	-0.36099
Temperature Coefficient of Isc (%/deg.C)	0.102

Determination of the type of battery to be used in this study is based on the existing library in MATLAB software with Nominal Voltage 12 V and Rated Capacity (Ah) with Lead-Acid. Table 2 showed the specific data of specification of battery. Implements common battery models for the most popular battery types. Effects of temperature and aging (due to cycling) can be determined for Lithium-Ion battery types [20].

**Table 2**

Specification of Battery [20]

Type	Lead-Acid
Nominal Voltage (V)	12
Rated Capacity (Ah)	20
Initial State-of-Charge (%)	40
Battery Response Time (s)	1

### 2.3 System design

The PV Array is a block that functions as a solar panel with a total of 5 terminals where the Ir terminal is for the radiation value and the T terminal is for the temperature value where the values are taken as in Figure 4, the m terminal functions for measurement and the (+) and (-) terminals as poles positive and negative to be connected to the solar panel control circuit [31].

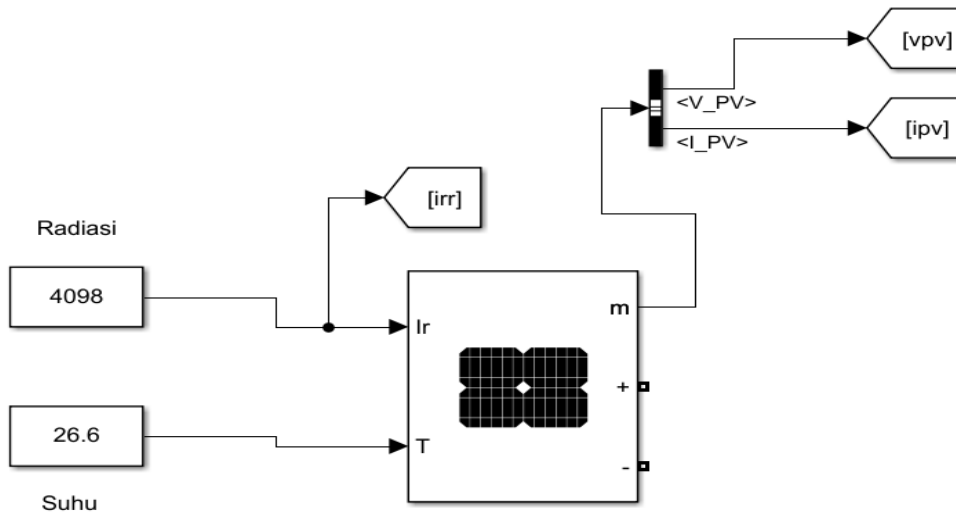
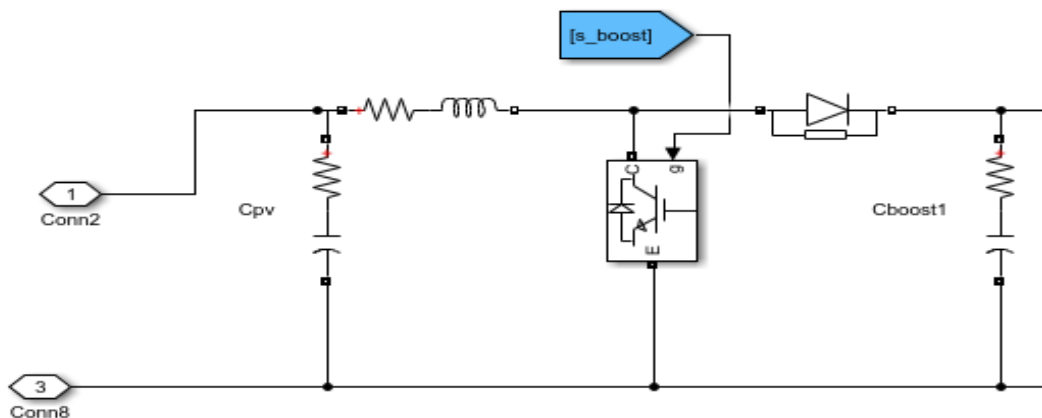
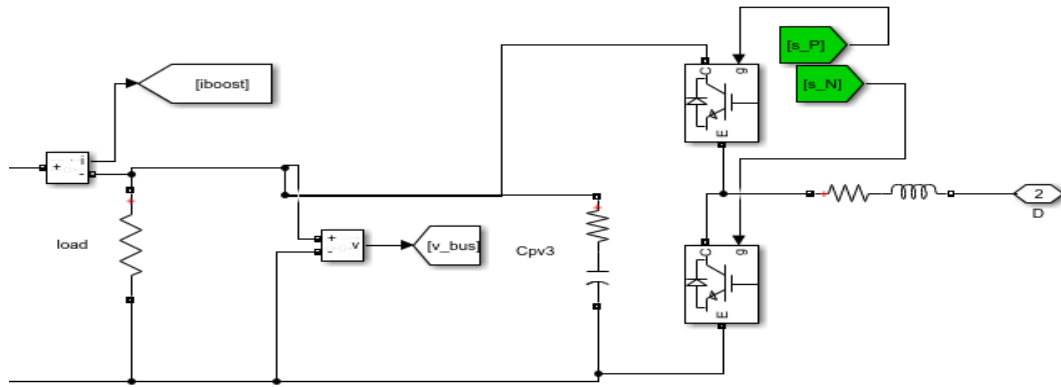


Fig. 4. PV array circuit MATLAB Simulink

Figure 5 shows the buck converter circuit is a series of lowering the direct current voltage from the solar panel to be channelled to the battery. The components used are IGBT as a voltage switch, diodes as a voltage converter, inductors and capacitors as energy transfer.



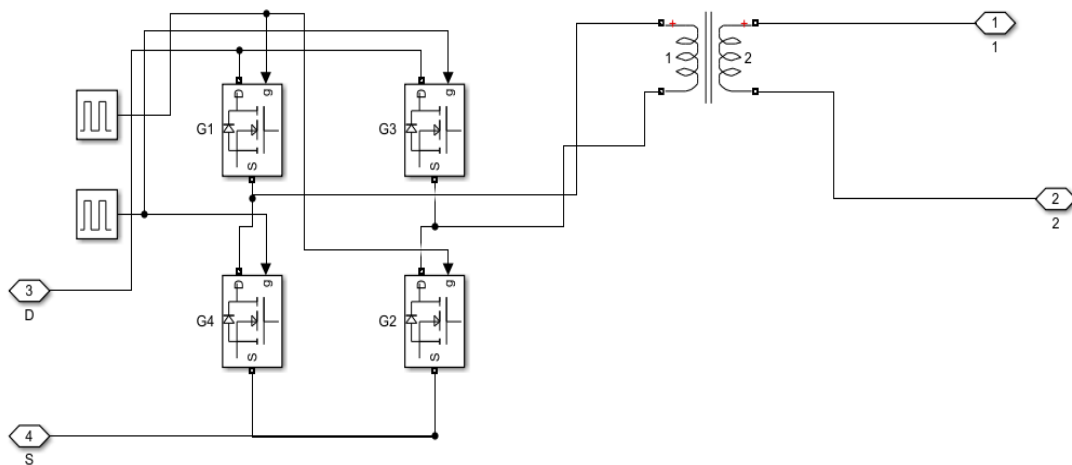
(a)



(b)

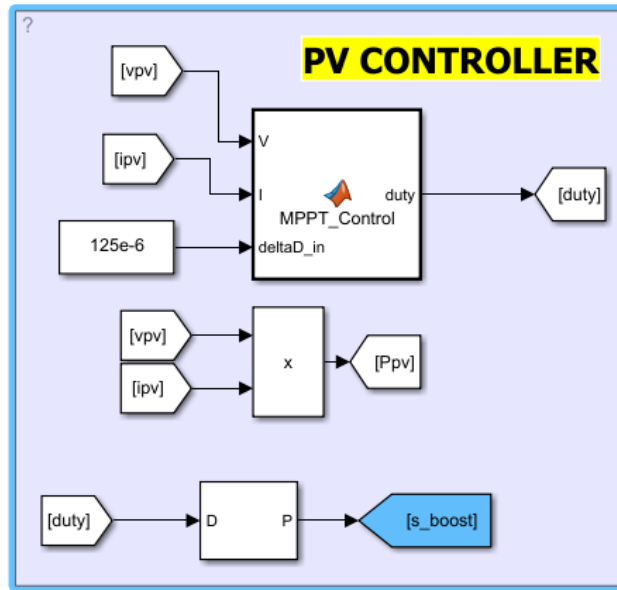
**Fig. 5.** Buck Converter circuit MATLAB Simulink where (a) and (b) in a circuit

This inverter circuit functions to convert the DC voltage from the battery into AC voltage to be connected to a 17-watt load. In the inverter circuit there is a Pulse Generator component to make signals, 4 mosfet units for the process of changing DC to AC and connected to a step-up transformer to increase the voltage as in Figure 6 below.



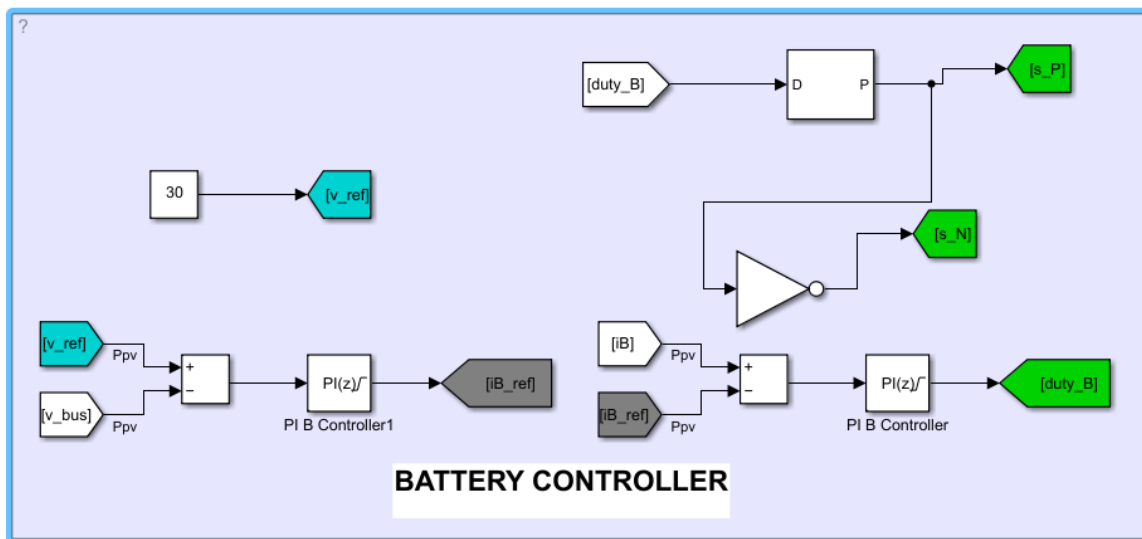
**Fig. 6.** Inverter circuit MATLAB Simulink

The PV Controller circuit is a circuit to control the system from a working solar module. Using the MATLAB Function associated with block from and Go To for the input signal and output signal. Figure 7 shows the output signal from the MATLAB Function will be processed by the PWM Generator and then connected to the IGBT/Mosfet output of the solar panel.



**Fig. 7.** PV controllers MATLAB Simulink

Figure 8 shows the battery controller circuit to control the input of the battery from the solar panel so that the voltage from the solar panel is stable so that it is safe in the process of charging the battery. This circuit uses Block PID and PWM Generator as the control.



**Fig. 8.** Battery controllers MATLAB Simulink

Measurement circuit for measuring voltage, current and electric power. Figure 9 the parts that are the object of measurement in this system are solar modules, batteries and AC loads.

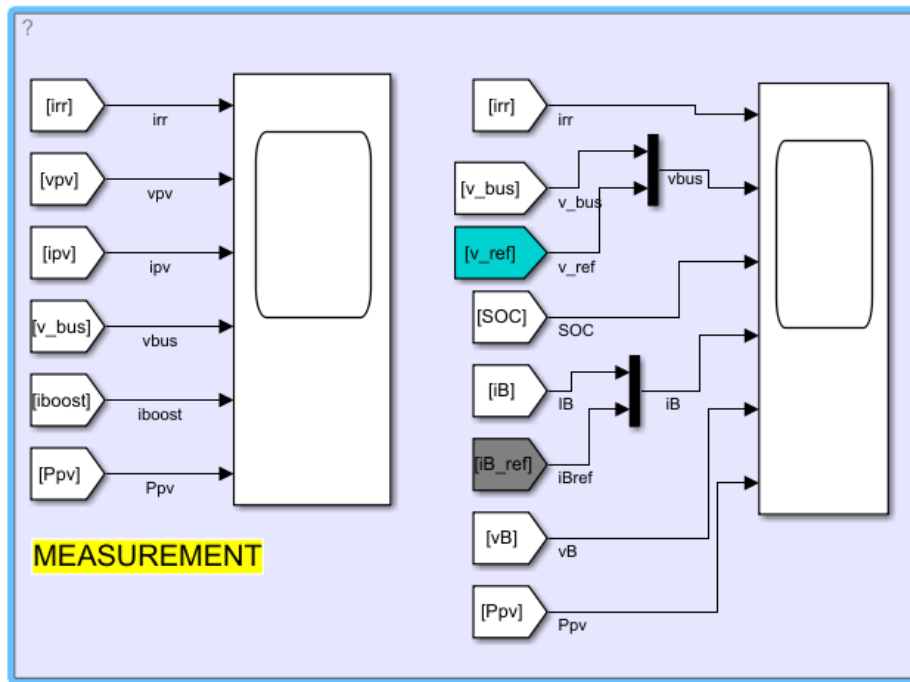


Fig. 9. Measurement circuit MATLAB Simulink

The PV Array is connected to the PV controller circuit as a subsystem, then connected to the battery and connected to the inverter input terminal. The inverter output terminal is connected to a load with a capacity of 17 watts and a Voltage Measurement is installed for measuring voltage and Current Measurement for measuring load current. Added Block Power Graphical User Interface (GUI) so that simulation can be done as in Figure 10.

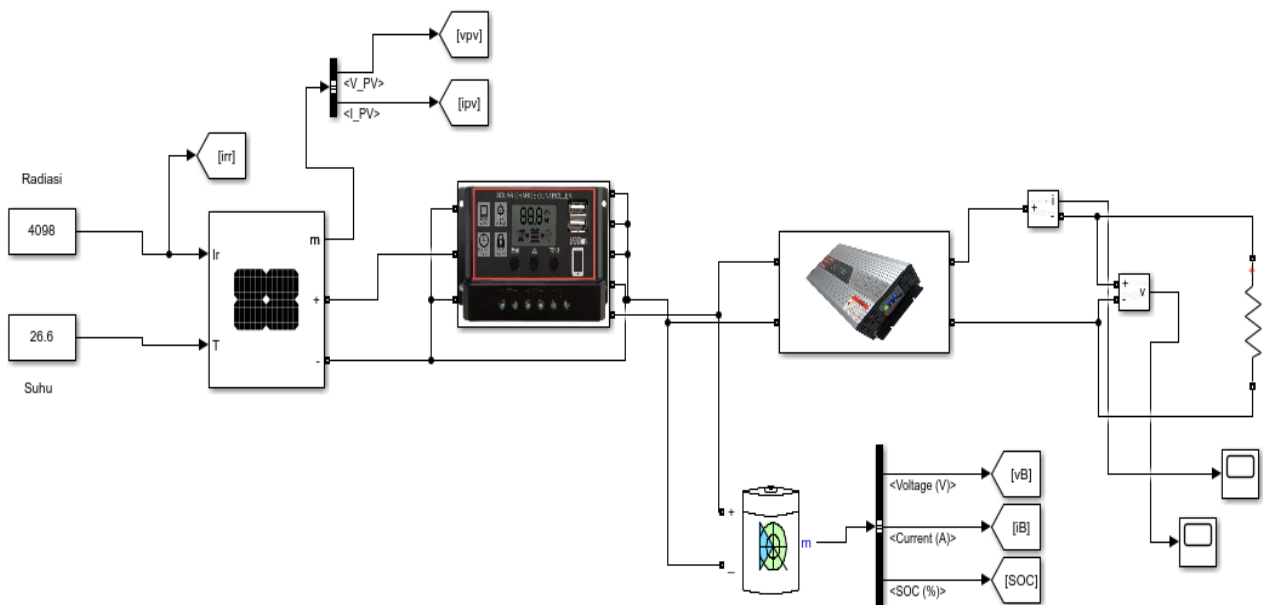


Fig. 10. Solar panel design 100 Wp MATLAB Simulink



### 3. Results

The PV array circuit simulated by MATLAB Simulink reads the voltage and current values generated by the solar panel.

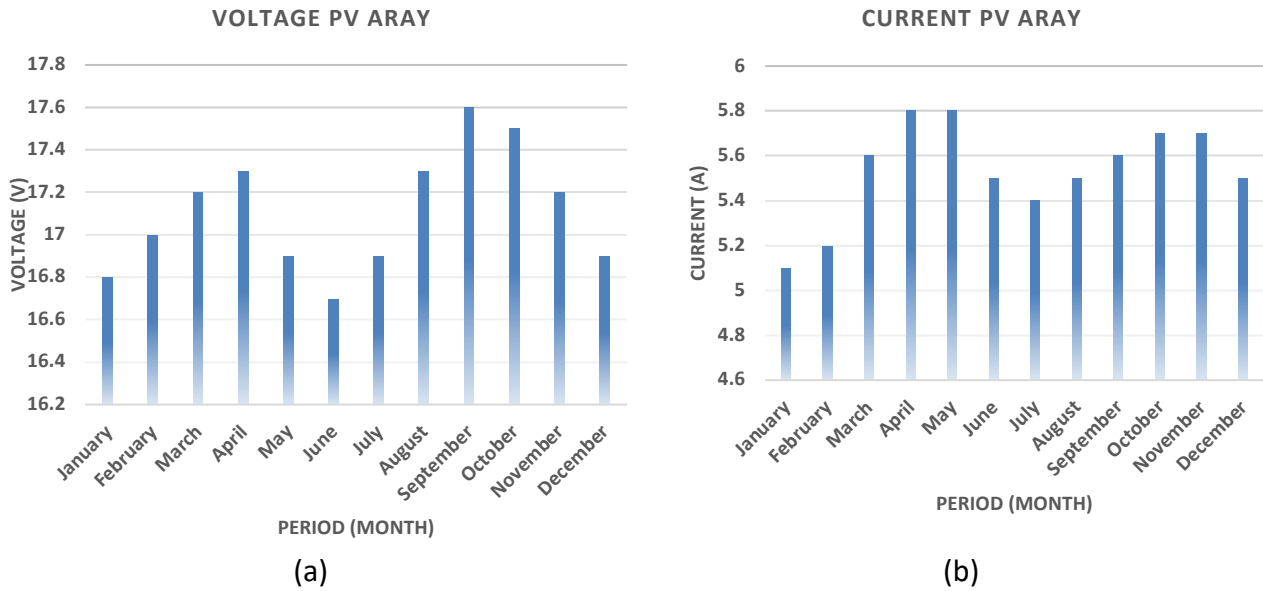


Fig. 11. PV array voltage and current value reading

The voltage values in Figure 11 (a) it can be seen that the solar panel has the smallest value of 16.7 V in June 2022 and the largest value of 17.6 V in September 2022. Meanwhile in Figure 11 (b) the lowest current value of 5.1 A occurred in January 2022 and the highest value occurred in April and May 2022 of 5.8 A.

The Battery Controller simulated by MATLAB Simulink reads the voltage and current values generated by the solar panel.

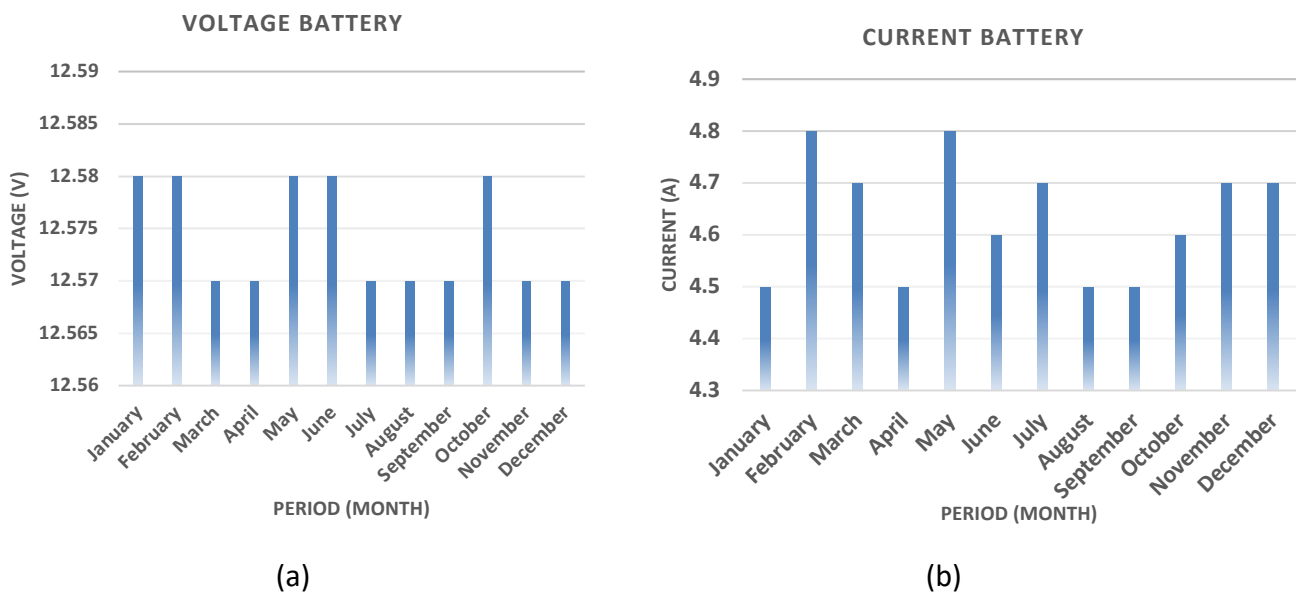


Fig. 12. Battery voltage and current value reading

The voltage value in Figure 12 (a) shows that the solar panel experiences insignificant fluctuations in the voltage value with a value between 12.57 V to 12.58 V. Meanwhile in Figure 12 (b) the highest average current value occurs in February and May 2022 of 4.8 A and the lowest value of 4.5 A occurred in January, April, August and September 2022. This value is a normal condition for a battery with a capacity of 20 Ah 12 V.

The Inverter simulated by MATLAB Simulink reads the voltage and current values generated by the solar panel with a load of 17 watts.

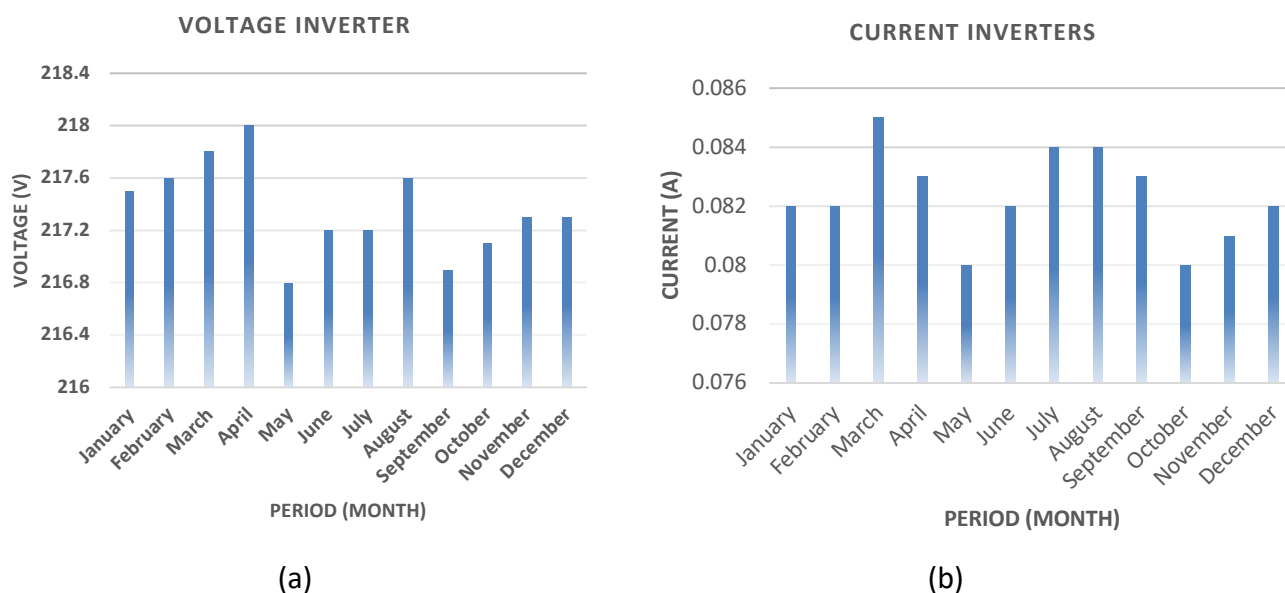


Fig. 13. Inverter voltage and current value reading

The value of the voltage coming out of the inverter in Figure 13 (a) has the largest value of 218.0 V occurring in April 2022 and the lowest value of 216.8 V occurring in May 2022. Meanwhile in Figure 13 (b) the value of the current coming out of the inverter connected to a load of 17 watts has the largest current value in May 2022 of 0.085 A and the lowest value of 0.08 A in March 2022.

#### 4. Conclusions

Monocrystalline 100 Wp photovoltaic and 12 V 20 Ah Lead-Acid battery, PV Array circuit design, Buck Converter, Inverter, PV Controller, Battery Controller and Measurement can be simulated using MATLAB Simulink version R2021a. The simulation results of a 100 Wp solar panel on MATLAB Simulink in the South Jakarta area with an average intensity in January 2022 of 131 W/m<sup>2</sup> and an average temperature of 27.99 °C on the DC side produce a PV array output voltage with the highest value of 17.6 V and the current is 5.8 A. The battery voltage shows the highest value of 12.58 V and the current is 4.8 A. This shows that the actual voltage and current values are close to the Voltage at Maximum Power Point (V<sub>mp</sub>) value of 17.8 V and the Current value at Maximum Power Point (I<sub>mp</sub>) of 5.2 A so that the results of this system design can be declared to have maximum performance. Meanwhile, on the AC side, the Inverter output has the highest value of 218 V and a current of 0.085 A. This is influenced by load conditions that only use 17 watts.

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