International Journal of Electrical, Energy and Power System Engineering (IJEEPSE)
e-ISSN: 2654-4644
Vol. 3, No. 1, pp. 13-16, February 2020
http://www.ijeepse.id

Analysis Of Power Generation Photovoltaic Array 9×10 Wp Under Shading Effect

Dwi Prima Putri Utami*
Department of Electrical Engineering
University of Riau
Pekanbaru-Riau, Indonesia

Antonius Rajagukguk
Department of Electrical Engineering
University of Riau
Pekanbaru-Riau, Indonesia

**corresponding author: Antonius Rajagukguk, Dwi Prima Putri Utami, antoniusrajagukguk@lecturer.unri.ac.id, dwiprima.putriutami@student.unri.ac.id*

***Abstract*— There are several problems that can interfere with the performance of large-scale PV. One that enhances PV performance is shading on a PV module, that make interferes PV performance. This research studied about the effect of shading on the performance of large-scale PV systems through testing a 9 × 10 Wp miniature PV array and simulation using Matlab software. The use of diodes on a PV module can be done to prevent damage to the PV module due to shading. Through the power-voltage (P-V) and current-voltage (I-V) characteristic curves the effect of shading and the use of bypass and blocking diodes can be determined. Shading effect gave in a decrease in power in the PV module. From the results of this study note that the bypass diode and blocking diode output power generated by the PV module can be optimal.**

***Keywords*— photovoltaic, partial shading, bypass diode, blocking diode, resistor variable.**

I. Introduction

The use of electric power is one of the basic needs in daily life. The limited fossil energy resources in the future as an energy source for electricity generation and its effect on environmental pollution makes the reason for the transition to renewable energy. Solar energy used in Photovoltaic (PV) systems can be an option for renewable energy electricity generation. There are several problems that can interfere with the performance of large-scale PV. One of the problems affecting PV performance is shading which can cover the PV module so that it interferes with PV performance. As a result of this there is a decrease in current, thereby reducing the output power of the PV system.

One of the problems affecting PV performance is shading which can cover the PV module so that it interferes with PV performance. As a result of this there is a decrease in current, thereby reducing the output power of the PV system. Prevention of damage to PV modules due to shading can be done by installing bypass diodes and blocking diodes.

II. Literature Review And Teoritical Basis

A. Literature Review

The history of previous studies is the basis for knowing the the performance of the photovoltaic (PV) module is disrupted due to shading to the power generated and if the shading is left it will have an impact on the damage of the PV module. to avoid damage to the PV module can be used bypass diodes and blocking diodes on the PV system

Ref state 2 that when a PV cell gets shading, the PV cell becomes equivalent to a load and absorbs the energy that has been produced by a normal working cell. The absorbed energy is converted to heat and increases the temperature of the cell and can damage the PV cell if left on continuously. Ref state 4 that to reduce power loss from partial shading is to use a bypass diode on the PV module and divide the string into sections with several blocking diodes. Ref state 7 that PV systems display non-linear characteristic P-V and I-V curves and depend on the level of radiation received by PV cells and environmental conditions.

B. Photovoltaic (PV)

Photovoltaic (PV) is a system or method of directly converting solar energy into electrical energy using semiconductor materials. The semiconductor material consists of two layers (p-side and n-side) that construct a PV cell. The principle of PV work occurs when light enters a PV cell, some photons of light are absorbed by semiconductor atoms, thus freeing electrons from the n-side to flow through the external circuit and back to the p-side. The occurrence of this electron flow that produces an electric current [4].

A number of PV cells are interconnected in a tightly closed and weather-resistant package called a PV module. When several modules are connected in series, the voltage multiplies while the current remains constant. Meanwhile, when several modules are connected in parallel, the current doubles while the voltage remains constant. To achieve the desired voltage and current, modules are connected in series

Received: February 3, 2020 | Revised: February 20, 2020 | Accepted: February 28, 2020

into strings and strings are arranged in parallel to form a PV array. The flexibility of the PV drafting system is designed based on the large power output requirements [4].

C. Shading on Photovoltaic

Large scale PV generators require a large number of PV modules, which can be arranged in series or parallel series. The preparation of modules to form series and parallel circuits tailored to the needs of voltage, current and power needed. However, the arrangement of PV modules in series on a string has the potential to cause a voltage difference. The difference in voltage between strings in the PV array is caused by the irregularity of the radiation in the PV modules. The irregularity of the radiation is caused by some PV modules getting shading [3].

The shading effect on the PV array causes a decrease in the absorption of solar radiation and an increase in temperature in the modules in the PV array. The reduced absorption of solar radiation results in reduced voltage on the PV string and disrupts the performance of the PV array system. PV modules that do not receive irregular radiation become a burden on the PV modules that work normally. The PV module which becomes a burden will dissipate the power generated through heat and cause the PV module to be damaged if forced to work continuously [1].

D. Bypass Diode and Blocking Diode

Prevention of damage to PV modules due to shading can be done by installing bypass diodes and blocking diodes. For each PV module, a parallel bypass diode is installed. The bypass diode installation is used to pass the current generated by the PV module which is not working normally due to shading. Whereas in the case of strings, a blocking diode is used which is installed in series with the string. This is done to block the voltage produced by strings that work abnormally due to shading [5].

III. Research Methodology

The research was conducted through testing of a 9×10 Wp prototype photovoltaic (PV) array and simulation using Matlab software. For testing, used a PV module with 10 Wp power and table 1 shows photovoltaic module specification sheet used in this research for prototype.

Table 1. Photovoltaic Module Specification Sheet

Merk	DEKADE (Model : PD–10)
Cell Type	*Polycrystalline silicon*
Pmax (Maximum Power)	10 W
Vmp (Voltage at Pmax)	17,6 V
Imp (Current at Pmax)	0,58 A
Voc (Open Circuit Voltage)	22,0 V
Isc (Short Circuit Current)	0,60 A
Max System Voltage	700 V
Temperature Range	-45°C ~ +80°C
Dimension	354 × 251 × 17 mm

Prototype PV array 9×10 Wp arranged by series as many as 3 pieces into a string and as many as 3 pieces arranged in parallel to form a PV array. Bypass diodes parallel across with PV module and blocking diodes series with PV string used are type 1N4002 and 3N4002. Research flowchart Methodology of this research is shown in Figure 1.

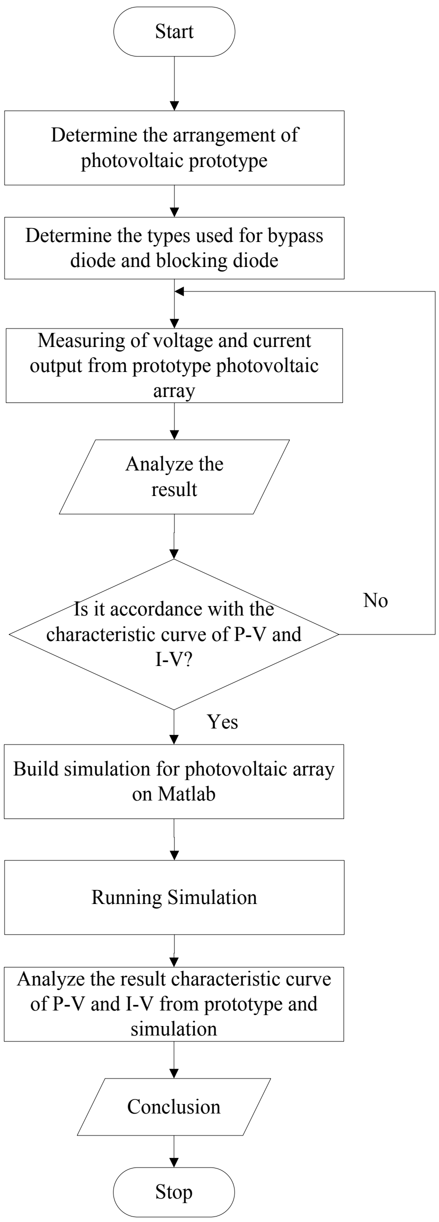

Figure 1. Research Flow Chart

IV. Result And Discusion

The research was conducted on November 2, 2019 at 13.38-13.40 West Indonesia Time and located in the Electrical Engineering Laboratory of the University of Riau, Indonesia, which tested prototypes and simulations on software Matlab in a condition without shading and five variations of shading conditions, that shading conditions 2 0 0 (44.4%), shading 2 1 1 (44.4%), shading 2 1 0 (33.3%), shading 0 1 1 (22.2%) and shading 1 0 0 (11.1%). Figure 2 show modelling simulation on Matlab.

Received: February 3, 2020 | Revised: February 20, 2020 | Accepted: February 28, 2020

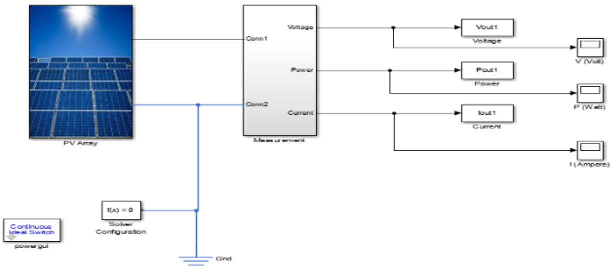

Figure 2. Modelling Simulation on Matlab

Under uniform radiation conditions without shading, the prototype test results in the P-V and I-V characteristic curves which show the peak power value of the PV module with uniform irradiation when the average irradiation condition is 717 W/m^2 is 66,0 Wp when the voltage is 51,2 V and the current 1,29 A, shown in Figure 3 and Figure 4.

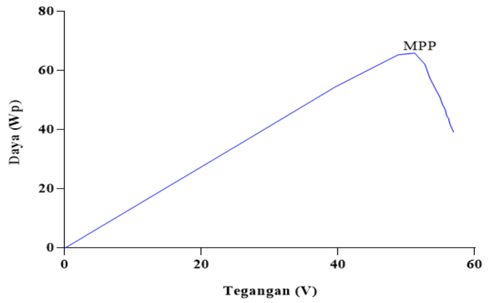

Figure 3. P-V Characteristic Curves of Prototype Photovoltaic Array 9×10 Wp Without Shading

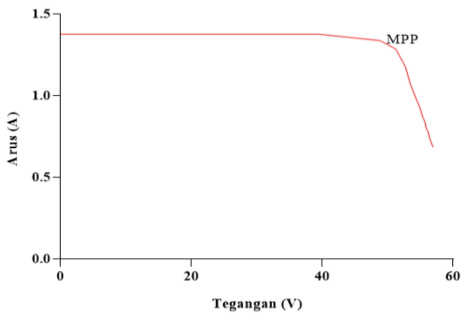

Figure 4. I-V Characteristic Curves of Prototype Photovoltaic Array 9×10 Wp Without Shading

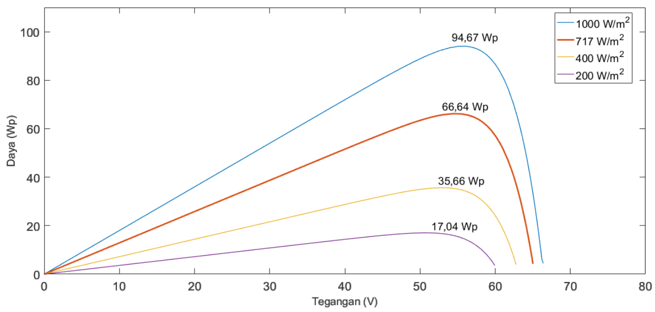

Figure 5. P-V Characteristic Curves of Simulation Photovoltaic Array 9×10 Wp Without Shading

Figure 5 and Figure 6 show the test results based on simulations with variations in irradiation. The peak power when irradiated 717 W/m^2 is 66,64 Wp when the voltage is 55,45 V and the current is 1,20 A. Calculation of measurement errors from the test and simulation results can be seen in this equation.

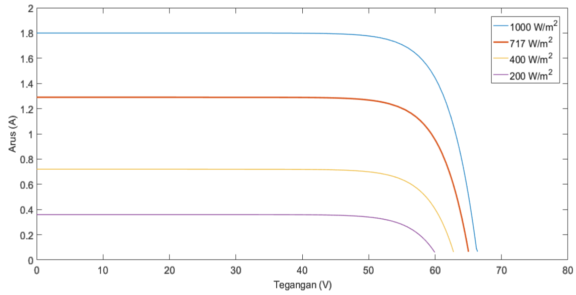

Figure 6. I-V Characteristic Curves of Simulation Photovoltaic Array 9×10 Wp Without Shading

$$\%error = \frac{|66,00Wp - 66,64Wp|}{66,64Wp} \times 100\%$$

$$\%error = 1\%$$

Figure 7 shows an example of a 0 1 1 shading condition (22.2%), which is 0 is mean nothing PV get shading on PV string and 1 is mean one of PV module at PV string get shading. Tests carried out on a prototype PV array with five shading variation conditions produce the output power summarized in Table 2. The power generated from the five shading variation conditions tested through simulation can be summarized in Table 3.

Figure 7. Prototype Photovoltaic Array 9×10 Wp With Shading Condition 0 1 1 (22,2%)

Based on Tables 2 and Table 3 will produce the same characteristic P-V and I-V curve patterns that are more than one MPP point depending on the shading pattern on the surface of the PV module in the PV array.

Received: February 3, 2020 | Revised: February 20, 2020 | Accepted: February 28, 2020

Table 2. Output Power Variation of Shading used Prototype PV Array 9 × 10 Wp

	Daya (Wp)		
	MPP_1	MPP_2	MPP_3
Shading 2 2 0	11,8	21,5	
Shading 2 1 1	14,9	24,1	
Shading 2 1 0	9,6	20,5	20,7
Shading 0 1 1	29,4	22,4	
Shading 1 0 0	35,9	41,5	

Table 3. Output Power Variation of Shading used Simulation PV Array 9 × 10 Wp

	Daya (Wp)		
	MPP_1	MPP_2	MPP_3
Shading 2 2 0	20,35	23,38	
Shading 2 1 1	21,41	29,86	
Shading 2 1 0	18,98	27,38	20,62
Shading 0 1 1	40,54	20,29	
Shading 1 0 0	52,45	51,08	

V. CONCLUSION

In conclusion, this paper explained the results show that the shading effect gives the effect of decreasing the power generated by the photovoltaic array system. Based on the results of prototype testing and simulation of PV array using bypass diodes and blocking diodes, prove that when receiving partial shading effects there are more than one MPP point depending on the shading pattern on the surface of the PV array.

ACKNOWLEDGMENT

The authors gratefully thanks to God and would like to convey a great appreciation to Riau University, Indonesia for supporting this research.

REFERENCES

[1] Yunlin Sun, X. L. (2013). Analysis on the Effect of Shading on the Characteristics of Large-Scale On-Grid PV System in China . Energy and Power Engineering , 215-218.

[2] Larbes, F. B. (2015). Modelling, Analysis and Comparison of Solar Photovoltaic Array Configuration Under Partial Shading Conditions. Elsevier, 399-418.

[3] Antonius Rajagukguk, C. W. (2017). New Approach of Maximum Power Point Tracking for Static Miniature Photovoltaic Farm Under Partially Shaded Condition Based on New Cluster Topology. IEEE, 444-449.

[4] Bhatia, S. (2014). Advanced Renewable Energy Systems: Part 1. New Delhi, India: Woodhead Publishing India Pvt Ltd.

[5] Koizumi, K. K. (2015). A Study on Effect of Blocking and Bypass Diodes on Partial Shaded PV String with Compensating Circuit Using Voltage Equalizer. IEEE, 241-244.

[6] Hossain, R. K. (2013). Effects of Internal Resistance on the Photovoltaic Parameters of Solar Cells. ICMIME, 733-739.

[7] Luis Hernandez-Callejo, S. G.-S.-G. (2019). A Review of Photovoltaic Systems: Design, Operation and Maintenance. Elsevier: Solar Energy, 426-440.

[8] Mohammadmehdi Seyedmahmoudian, S. M. (2013). Analytical Modeling of Partially Shaded Photovoltaic Systems. Energies , 128-144.

[9] Samah Laamami, M. B. (2017). Analysis of Shading Effects on a Photovoltaic Array. IEEE.

[10] Antonius Rajagukguk, D. R. (2018). Performance Characteristics of Miniature Photovoltaic Farm Under Dynamic Partial Shading. *Indonesian Journal of Electrical Engineering and Computer Science*, 400-408.

[11] Huan-Liang Tsai, C.-S. T.-J. (2008). Development of Generalized Photovoltaic Model Using MATLAB/SIMULINK. WCECS.

[12] Ciptian Weried Priananda, A. R. (2017). New Approach of Maximum Power Point Tracking for Static Miniature Photovoltaic Farm Under Partially Shaded Condition Based on New Cluster Topology. *IEEE.*

[13] Antonius Rajagukguk. (2015). Optimization of Photovoltaic Farm Under Partial Shading Effects Using Artificial Intelligent Based Matrix Switch Controller. *ICITACEE*

[14] Stegun, M. A. (1965). Handbook of Mathematical Functions: with Formulas, Graphs, and Mathematical Tables (Dover Books on Mathematics) . New York: Dover.

[15] William H.Hayt, J. J. (2005). *Rangkaian Listrik Jilid 1*. Jakarta : Erlangga.

Received: February 3, 2020 | Revised: February 20, 2020 | Accepted: February 28, 2020