ECHAHID HAMMA LAKHDAR UNIVERSITY - EL-OUED
Under the Supervision of the DGRSDT and in collaboration with the CRTI
International Pluridisciplinary PhD Meeting (IPPM'20)
23-26, 2020 1st Edition, February

Theme: Modeling the effect of partial shading in PV panel using the artificial neural networks

Khelaifa Fethi *, Lamamra Kheireddine **

* *Department of Electrical Engineering Laboratory of Electrical Engineering and Automatic Larbi Ben Mhidi University* Oum El Bouaghi, Algeria. Khelaifa.Fethi@univ-oeb.dz

** *Department of Electrical Engineering Larbi Ben Mhidi University* Oum El Bouaghi, Algeria *Laboratory of mastering of renewable Energies, University A. Mira.* Bejaia Algeria. Lamamra.Kheireddine@univ-oeb.dz. l_kheir@yahoo.fr ; IEEE Member.

Abstract

In this paper we present the modeling of the phenomenon of partial shading on electrical characteristics (current-voltage and power-voltage) using artificial neural networks. This model, based on practical measures, will allow studying the effects of partial shading on photovoltaic systems and as result to make prevention in order to keep the system functional in an acceptable way. Moreover, finding good solutions and results to facilitate future work in this area.

Keywords: Partial shading, Modeling, artificial neural networks, Photovoltaic PV system.

I. Introduction

For centuries, humans have sought to exploit the energy emitted by the sun. This energy is abundant on the entire surface of the Earth despite its attenuation as it traverses the atmosphere. Global technological advances in recent years have dramatically accelerated the market for solar PV systems, mainly due to its positive factors, such as lower power generation costs than other types. [1] In order to optimize the efficiency of PV systems, many work has been done to address problems that could lead to a decrease in the operation of these systems[2].Among these problems is the phenomenon of shadows that affect the operation of the PV system.Partial shading passes through the sun partially and is caused by various things that can cover the surface of PV modules such as snow, sand, trees etc. [3] in this type of shading; the light reaching the cells is very small compared to other cells.

In order to study the partial shading and mitigate its effect on PV system performance, a suitable energy model is required, flexible enough to estimate the response under the variety of different shading patterns that may occur during operating conditions which it can help in energy calculations, PV installation planning, array topology optimization, techno economic studies and the evaluation of the effectiveness of MPP tracking (MPPT) algorithms for partially shaded PV systems [4].In recent years, research in this field has developed and varied to propose solutions to the effects of the phenomenon of shading. [5] [6].

In this work, we present the use of artificial neural networks [7] in order to model the behavior of a polycrystalline silicon PV module STP080S PV panel when it is subjected to the phenomenon of partial shading. This model will allow further study of this phenomenon and its impact on the characteristics of PV systems for different metrological conditions and thus make predictions to avoid damage to the PV panel and accelerate its aging. The modeling method proposed here is not intended for a specific PV system model and can be applied to different types and models. However, the model obtained for a system will not be valid for other systems, but the technique used will remain the same.

II. Characteristics of the PV system under (PSC)

1. Modeling of PV cell

A photocell consists of a semiconductor material that absorbs light energy and converts it directly into an electric current. She based on the physical phenomenon called the "photoelectric effect", which consists of creating an electric impulse when the surface of this cell is exposed to light [8]. PV cells use a single-valve model to model and simulate a PV module. In order to improve system efficiency and increase power output, PV cells must be connected in parallel or in series [9]. Figure 1 shows a simplified electrical diagram of a solar cell [10]. By applying the KCL the output current (Ipv) of a PV module is described as:

$I_{pv} = Iph - I_0 [\exp (q (Vpv + I_{pv} * R_s) / A*n*K*T) -1] - (V_{pv} + I_p * R_s / R_p)$

(1)

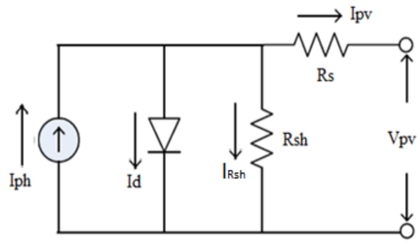


Figure.1. Solar cell diode model.

With:

I: The first is the current of the solar PV module; Iph: current generated image [A]; V: voltage in PV module terminals [V]; I0: current of saturation diode [A]; q: electron charge [C]; RS: cell resistance of the cell [Ω]; Rsh: parallel resistance of the cell [Ω]; K: Boltzmann is constant; T: intersection temperature [K]; Ns: The number of cells in the string; n: It is an ideal factor for diode.

2. *partial shading condition*

When producing partial shading, the shaded cell becomes weaker and therefore will have an effect on the performance of other cells. [11] Thus, shading some cells can make the entire PV module ineffective. However, if PV panels are installed in series, the panel that produces the least determines the performance of the panel branch. [12].

Manufacturers and users of PV systems give importance to the operation of these systems when they are shaded. Because in such situations, a malfunction of the photovoltaic system is inevitable, especially if a solar production facility is shaded for a long time or it may be permanently shaded. In recent years, research in this field has developed and diversified to provide solutions to the effects of the phenomenon of shading [13]. In this work, we used artificial neural networks to model the effect of partial shading on the operation of the PV system.

III. *Artificial Neural Networks (ANN)*

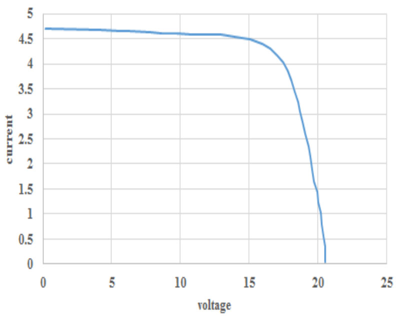
The neural network is a computational model. Its design is inspired by real human neurons and is one of the most common Artificial intelligence techniques that allow decision-making based on rainfall rather than formal logical thinking. [14] This approach is the subject of research in many areas such as understanding and synthesis of natural language, classification, diagnosis, etc. [15]. A simple artificial nerve is a computational element with one or more numerical inputs and outputs. From an architectural point of view, artificial neural networks can be classified into two types; multilayer Perceptron (MLP) and radial basis function networks (RBF) [16][17]. In this work, we used a network of MLP neurons consisting of three layers. Input layer with two neurons: "voltage when entering the PV panel (practical measurements) and immediate error", a hidden layer with a variable number of neurons between (1 and 20) and the output layer: "the current provided by the neural model of the PV panel." For the hidden layer, we used the experimentation method, so we tested several values of neurons in order to choose the number that gives the error in smaller modeling.

IV. *Results and discussions*

We then selected a STP080S module to study the properties of I-V and P-V without and under the presence of partial shading.

- *The characteristics without shading*

Figure 2 (a; b) shows the properties of I-V and P-V in the PV module specified in the health condition without any shading on the cells.



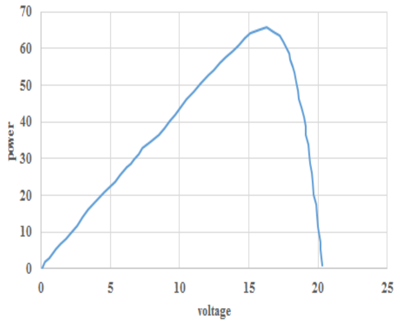


Figure.2. I-V and P-V characteristics of the used PV module without shading.

- *Characteristics with shading:* The following curves illustrate the I-V and P-V curves associated with different shading types for each case.

Case (A): Table 1 illustrate the modeling errors obtained for different numbers of neurons in the hidden layer.

Table 1: Number of neurons and corresponding error.

Number of neurons	Cumulative quadratic error	Number of neurons	Cumulative quadratic error
1	62.7429	5	0.3892
2	1.7415	6	0.0705
3	0.4023	10	0.1618
4	0.3116	20	0.3421

Figures 3 represent the characteristic of the PV module we has noticed that the excellent cumulative quadrature modeling error is equal to 0.0705 for the current-voltage for neurons six (6) in the hidden layer

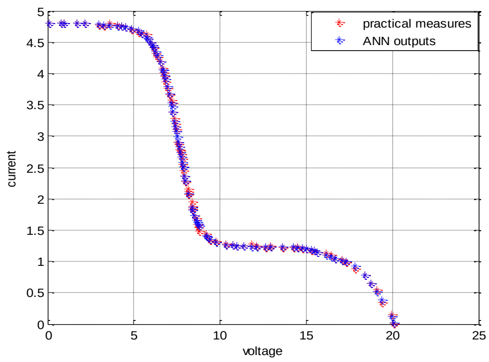


Figure.3. I-V properties in the PV module shading.

Case (B): Table 2 illustrate the modeling errors obtained for different numbers of neurons in the hidden layer.

Table 1: Number of neurons and corresponding error.

Number of neurons	Cumulative quadratic error	Number of neurons	Cumulative quadratic error
1	37.4380	5	0.8061
2	73.3311	6	45.6632
3	5.8624	10	5.9913
4	1.3345	20	4.3962

Figures 4 represent the characteristic of the PV module we has noticed that the excellent cumulative quadrature modeling error is equal to 0.8061for the current-voltage for neurons six (5) in the hidden layer.

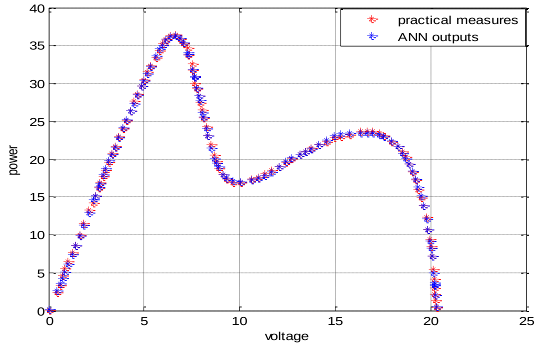


Figure.4. P-V properties in the PV module are shading.

- Table 2 shows the results obtained after the experiment and modeling the PV panel using the intelligent neural network method.

Table 2: PV panel modeling results.

Case	cumulative quadrature error	Moyen error	maximum quadratic error	Number of neurons
A	0.0705	2.0922e-05	0.0081	6
B	0.8061	3.2536e-04	0.9179	5

After the results obtained, we can consider that the neural model obtained has already reversed the effect of partial shading on the electrical properties of shaded diodes. These results are acceptable, and the resulting model will enable us to infer the effects of partial shading on the overall behavior of PV systems.

I. Conclusion and perspectives

In this paper, we introduced modeling the effect of partial shading on the PV unit in order to study its effect on the performance of shaded PV cells. For this reason, we have used artificial neural networks that are widely used in modeling and that generally provide models well suited to model systems. The results showed that the resulting I-V and P-V curves were strongly influenced by partial shading conditions. The behavior of the photoelectric system decomposes under partial shading and distortion of electrical properties (current and voltage). Distortion of the characteristics of I-V and P-V reveals a decrease in short-circuit current and maximum power. As a result, the increase in partial shading in this system leads to a decrease in current and energy at the reflection point and thus affects its efficiency.

References

1. J. Bai, Y. Cao, Y. Hao, Z. Zhang, S. Liu, and F. Cao, “Characteristic output of PV systems under partial shading or mismatch conditions,” Sol. Energy, vol. 112, pp. 41–54, 2015.
2. Y. Chaibi, A. Allouhi, M. Malvoni, M. Salhi, and R. Saadani, “Solar irradiance and temperature influence on the photovoltaic cell equivalent-circuit models,” Sol. Energy, vol. 188, pp. 1102–1110, 2019.
3. L. Liu, X. Meng, and C. Liu, “A review of maximum power point tracking methods of PV power system at uniform and partial shading,” Renew. Sustain. Energy Rev., vol. 53, pp. 1500–1507, 2016.
4. M. Angel Cid Pastor, ‘’Conception et réalisation de modules photovoltaïques électroniques’’. Thèse de doctorat, Institut National des Sciences Appliquées de Toulouse, septembre 2006.
5. Z. Liying, M. Liang, L. Zhigang, C. Mingxuan, and W. Jianwen, “Implementation and simulation analysis of GMPPT algorithm under partial shadow condition,” Energy Procedia, vol. 158, pp. 418–423, 2019.
6. Y.-J. Wang and P.-C. Hsu, “An investigation on partial shading of PV modules with different connection configurations of PV cells,” Energy, vol. 36, no. 5, pp. 3069–3078, May 2011.
7. E. Koutroulis and F. Blaabjerg, “A new technique for tracking the global maximum power point of PV arrays operating under partial-shading conditions,” IEEE J. Photovolt., vol. 2, no. 2, pp. 184–190, 2012.
8. W. R. Baron and P. F. Virobik, “Solar array shading and a method of reducing the associated power loss,” NASA Tech. Rep. Serv. Doc. 19640022825 Httpntrs NASA Govindex Jsp, 1964.
9. Mekhilef, and A. Stojcevski, “New ARMO-based MPPT Technique to Minimize Tracking Time and Fluctuation at Output of PV Systems under Rapidly Changing Shading Conditions,” IEEE Trans. Ind. Informatics, vol. PP, no. c, pp. 1–1, 2019.
10. J. Bai, Y. Cao, Y. Hao, Z. Zhang, S. Liu, and F. Cao, “Characteristic output of PV systems under partial shading or mismatch conditions,” Sol. Energy, vol. 112, pp. 41–54, 2015.
11. K. S. Tey, S. Mekhilef, M. Seyedmahmoudian, B. Horan, A. T. Oo, and A. Stojcevski, “Improved Differential Evolution-Based MPPT Algorithm Using SEPIC for PV Systems Under Partial Shading Conditions and Load Variation,” IEEE Trans. Ind. Informatics, vol. 14, no. 10, pp. 4322–4333, 2018.
12. X. Liu, X. Qi, S. Zheng, F. Wang, and D. Chen, “Model and analysis of photovoltaic array under partial shading [J],” Power Syst. Technol., vol. 11, 2010.
13. N. Kumar, I. Hussain, B. Singh, and B. K. Panigrahi, “Rapid MPPT for Uniformly and Partial Shaded PV System by Using JayaDE Algorithm in Highly Fluctuating Atmospheric Conditions,” IEEE Trans. Ind. Informatics, vol. 13, no. 5, pp. 2406–2416, 2017.
14. Z. Liying, M. Liang, L. Zhigang, C. Mingxuan, and W. Jianwen, “Implementation and simulation analysis of GMPPT algorithm under partial shadow condition,” Energy Procedia, vol. 158, pp. 418–423, 2019.
15. E. Koutroulis and F. Blaabjerg, “A new technique for tracking the global maximum power point of PV arrays operating under partial-shading conditions,” IEEE J. Photovolt., vol. 2, no. 2, pp. 184–190, 2012.
16. Z. Liying, M. Liang, L. Zhigang, C. Mingxuan, and W. Jianwen, “Implementation and simulation analysis of GMPPT algorithm under partial shadow condition,” Energy Procedia, vol. 158, pp. 418–423, 2019.
17. H. Mekki, A. Mellit, and H. Salhi, “Artificial neural network-based modelling and fault detection of partial shaded photovoltaic modules,” Simul. Model. Pract. Theory, vol. 67, pp. 1–13, 2016.