IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-5, Issue-7, May 2019 E-ISSN: 2347-2693

Faults Detecting Defective in Photovoltaic Array under Partially Shaded Condition using Fuzzy Logic System

Chakresh Kumar Karole[1*], K. T. Chaturvedi[2]

[1]Department of Electrical Engineering, UIT-RGPV, Bhopal
[2]Department of Electrical Engineering, UIT-RGPV, Bhopal

Corresponding Author: chakreshkarole@gmail.com

DOI: https://doi.org/10.26438/ijcse/v7i5.14861490 | Available online at: www.ijcseonline.org

Accepted: 22/Apr/2019, Published: 31/May/2019

Abstract— Considering the high initial capital cost of a Solar Photovoltaic (SPV) source and its low energy conversion efficiency, it is essential to operate the SPV source at Maximum Power Point (MPP) so that maximum power can be extracted. Techniques to extract maximum power from SPV Arrays (SPVA) where some of the cells are not receiving the full insolation (partial shaded condition) has been presented in this thesis. Effects of reconfiguration of the array and tracking of load have been analyzed for maximum power availability. In this thesis the analysis of fault detection in photovoltaic array with the help of fuzzy logic system is present. The fuzzy logic system depends on three inputs, namely percentage of voltage drop (PVD), percentage of open circuit voltage (POCV), and the percentage of short circuit current (PSCC). To improve the accuracy of the PV fault detection, Fuzzy Logic system is used to increase the overall detection accuracy of the power, voltage ratio algorithm up to 99.12%. fuzzy systems were tested, and it was found that have identical performance.

Keywords:- Photovoltaic (PV) array, MATLAB Simulink, Maximum Power Point Tracking (MPPT), Fuzzy Logic System

I. INTRODUCTION

Renewable energy sources such as solar energy are acquiring more significance, due to shortage and environmental impacts of conventional fuels. The photovoltaic (PV) system for converting solar energy into electricity is in general costly and is a vital way of electricity generation only if it can produce the maximum possible output for all weather conditions. In general, a PV source is operated in conjunction with a dc– dc power converter, whose duty cycle is modulated in order to track the instantaneous MPP of the PV source. The output of the PV depends highly on an insulation condition and a surface temperature of the PV array. Moreover, there are several local maximum power points in the P-V curve under non-uniform insulation, whereas only one MPPT point is exist under uniform insulation for a given temperature and insulation. Several tracking schemes under uniform solar insulation have been proposed [1]–[2]. Among the popular tracking schemes are the perturb and observe (P&O) or hill climbing [3]-[4], incremental conductance [7], short circuit current [1], open-circuit voltage [6], and ripple correlation approaches [5]. Some modified techniques have also been proposed, with the objective of minimizing the hardware or improving the performance [6], [8]–[9]. However, these methods cannot readily track immediate and rapid changes in environmental conditions or non-uniform insulation of the PV modules. The non-uniform insulation of the PV modules which are connected both in series and in parallel depends on several factors such as the incidence angle of solar ray to the module, shadows full-or-partial, and so forth. Under partially shaded conditions, (e.g., due to clouds, trees, etc.), the P–V characteristics get more complex, displaying multiple peaks. There is a need to develop special MPPT schemes that can track the true MPP under these conditions. In order to solve this problem, several methods have been proposed. Some Literatures are based on Fuzzy theory [1], and some others use complicated techniques [3],[4]. Another Literature [7] has proposed a two-stage method to track the MPP. In the first stage, the operating point moves into the vicinity of the MPP on the load line Rpm = Vpm/Ipm, and in the second stage, it converges to the actual MPP. Vpm and Ipm are approximately equal to 80% and 90% of the open-circuit voltage VOC and short-circuit current ISC of the PV array, respectively. However, in this method, if the actual MPP lies on the left side of the load line (Rpm), i.e., Rpm > Ractual (where Ractual = Vactual/Iactual), the operating point is temporarily shifted to 90% of VOC, thereby missing the actual MPP. In this paper, we propose a simple and practical approach for commercial base use. This method is based on two stages; in the first stage the controller searches the I-V characteristic of the PV regularly at certain specified time using large value of step of the P&O method with

storing the actual maximum power point and its corresponding duty cycle. As this obtained MPPT point is not the exact one due to the used large step, a second stage of the controller is designed to oscillate around the obtained MPP point by using the conventional P&O algorithm with a small step. In another word, the algorithm during the first stage operates with large step to reduce the scanning time of the I-V characteristic curve, then after obtaining the approximated MPP, the algorithm oscillates around this MPP with a small step (delta) to provide the exact point with a small oscillation.
As mentioned above, electrical characteristics of PV module are affected by environmental conditions such as temperature, solar irradiation dusts accumulation and shadow caused by bird's clouds and so on. To study the effects of the previous environmental factors a MATLAB model was proposed the model takes into accounts most of the environmental conditions that affect the electrical characteristics of the PV.

II. CHARACTERISTICS OF PV SYSTEM

The photovoltaic cell converts the light energy into electrical energy depending on the irradiation of the sun and temperature in the atmosphere. Basically PVC is a PN junction diode [3] [4]. But in PN junction diode DCI AC source is needed to work, but here light energy is used as a source to produce DC output. PVC is a current control source not a voltage control source. The equivalent electrical circuit diagram of PVC is shown in the Figure 2.

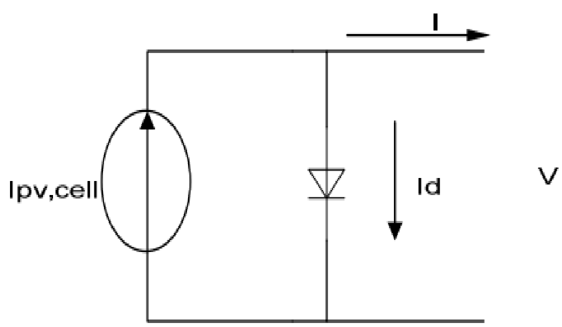

Figure 1: Show ideal photovoltaic cell equivalent circuit

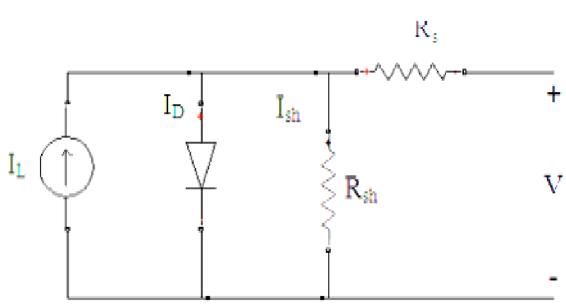

Figure 2: Equivalent Electrical Circuit of PVC

$$I_D = I_0[\exp(V + IR_S)/KT - 1] \quad (1)$$

Therefore PVC output current is given in equation 2.

$$I = I_L - I_D - I_{Sh} \quad (2)$$

$$I = I_L - I_0[\exp(q(V + IR_S))/KT - 1] - (V + IR_S)/R_{Sh} \quad (3)$$

Where I_D the diode is current, R_{sh} is the shunt resistance, I_L is the light generated current of solar array. Solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. The electromagnetic radiation of solar energy can be directly converted electricity through photovoltaic effect. Being exposed to the sunlight, photons with energy greater than the band-gap energy of the semiconductor are absorbed and create some electron-hole pairs proportional to the incident irradiation. Under the influence of the internal electric fields of the p-n junction, these carriers are swept apart and create a photocurrent which is directly proportional to solar insolation. PV system naturally exhibits a nonlinear I-V and P-V characteristics which vary with the radiant intensity and cell temperature.

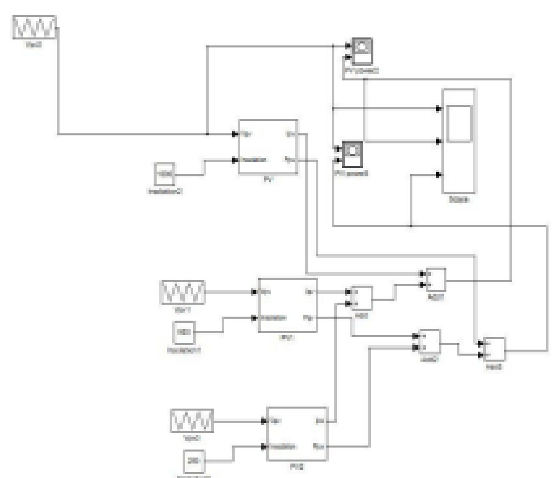

Figure 3: PV array with partial

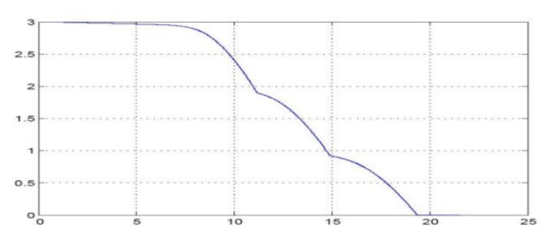

Figure 4: I-V characteristic of PV array under partial shading condition

III. MPPT ALGORITHM USING PARTIALLY SHADED CONDITION

Figure 5 indicates the characteristic output power curve for the solar cell from simulation under a given temperature and irradiance. MPPT control has been proposed and implemented for extracting the maximum power from the PV cell. PV array voltage (i.e. incrementing or decreasing) and comparing the PV output power with that of the previous perturbation cycle. If the perturbation leads to an increase/decrease in array power, the subsequent perturbation is made in the same/opposite direction. In this manner, the peak power is tracked continuously. But this algorithm has two weaknesses.

- When shading occurs, the reversal of the voltage can be observed in that specific section and now the bypass diode in parallel will conduct the current. The results are:
- The current of the un-shaded section flows through the bypass diode and the power/voltage characteristic shows a second local maximum
- The shaded cell is only loaded with that fraction of power produced by the remaining unshaded cells of that section
- When the number of cells which are bridged by the by-pass diode is not too high, the level of the breakthrough voltage will not be reached.
-

But there are also some draw backs resulting from the by-pass diodes: Higher cost for the module production and assembly problems of the by-pass diodes. Losses in the by-pass diode in the case of shading.

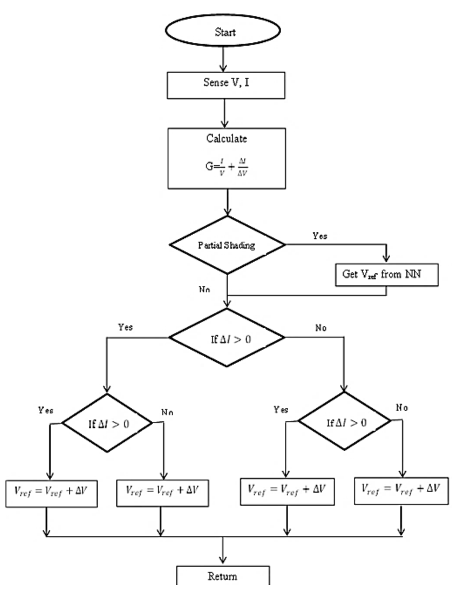

Figure 5: Flowchart of the proposed MPPT algorithm

IV. FAULT DETECTION SYSTEM

In this section, the proposed PV bypass diode fault detection system will be presented. Firstly, the fault detection system proposed in this paper is capable of detecting faults associated with bypass diodes and partial shading conditions affecting the PV modules. The detection system is based on the variations of the IV curve Vdrop, I-V curve Voc, and I-V curve Isc. Next, Mamdani fuzzy logic system is used to detect the faults in the examined PV module. The general fuzzy system architecture is illustrated in Figure 6.

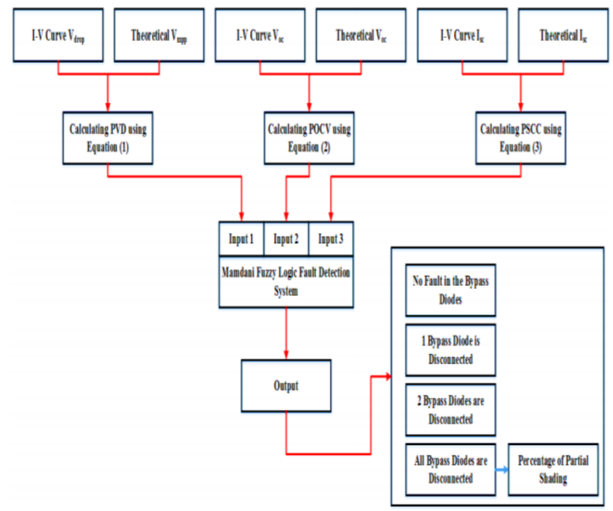

Fig. 6: Proposed fault detection system using Mamdani fuzzy logic system

Fuzzy Logic System

In crisp set theory we have the concepts of union and intersection of two sets. This concept should be extended to fuzzy sets. Also the concept of complement of a set in crisp set theory should be extended to fuzzy sets.

Definition: Let A and B be two fuzzy sets on a nonempty set X. The union of A and B denoted as A U B is defined as μ_{AUB} (x) = max

Where μ_{AUB} is the membership function of A U B is map from X to [0, 1]. Hence A U B is a fuzzy set on X. This is called the standard union of two fuzzy sets.

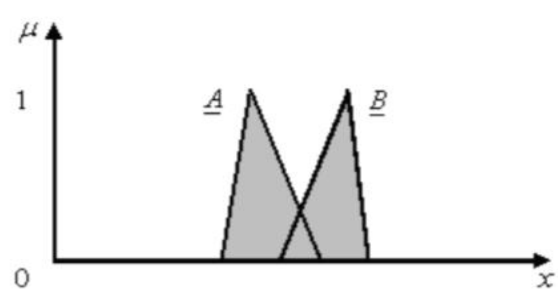

Figure 7: Union of Fuzzy Sets A and B

Definition: Let A and B be two fuzzy sets on a nonempty set X. The intersection of A and B denoted as A ∩ B is defined by $\mu_{A\cap B}(x) = \min$

Where $\mu_{A\cap B}$ is the membership function of A ∩ B is fuzzy set on X. This is called the standard intersection of two fuzzy sets.

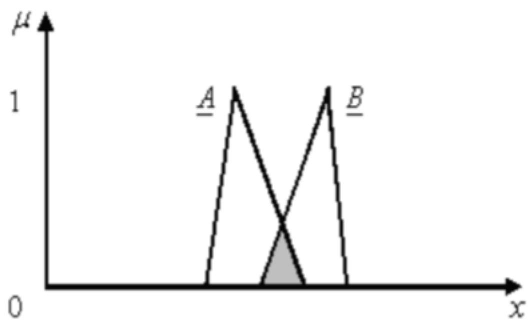

Figure 8: Intersection of Fuzzy sets A and B

Fuzzy Decision Making Procedure

Mechanism of fuzzy decision making involves manipulation of fuzzy variable through linguistic equations or fuzzy rules. The below Figure 3.4 explains the whole mechanism.

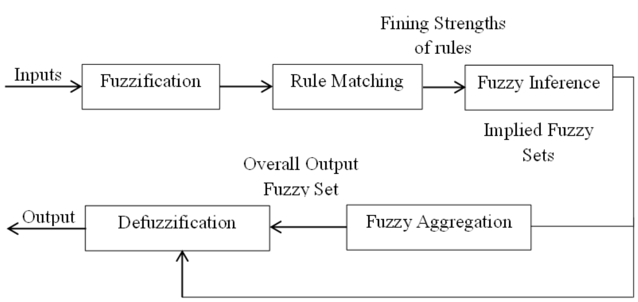

Figure 9: Fuzzy Decision Making Procedure

Fuzzification: In fuzzification, membership degree is computed for each input variable with respect to its linguistic term.

Rule matching: In rule matching, the firing strength (degree of satisfaction) of individual rule is calculated.

Fuzzy Inference: The recommendation of rules according to firing strengths and rule conclusions are determined in fuzzy inference.

Fuzzy Aggregation: Fuzzy aggregation combines recommendations from individual rules into an overall implied fuzzy set.

Defuzzification: Defuzzification involves determination of a crisp value based on implied fuzzy sets derived from the rules, as final result or solution.

V. SIMULATION RESULT

As shown in table 1 the maximum power result are obtained for the proposed By-pass diode based PV array algorithm and previous algorithm. From the analysis of the results, it is found that the By-pass diode based PV array algorithm gives a superior performance as compared with previous algorithm. The proposed By-pass diode based PV array algorithm gives a maximum power 3685 for PV array.

Figure 10 shows the graphical illustration of the performance of proposed method discussed in this research work in term of maximum power. From the above graphical representation it can be inferred that the proposed By-pass diode based PV array algorithm gives the best performance for PV array.

Table 1: Comparison of power generated in previous algorithm and proposed configuration for different shading conditions

	Different Shading Condition	Maximum Power	Total Power	Power Improvement (%)
Previous Algorithm et al. [1]	Side and Wide	3097	4000	71.42
	Long and Wide	2696	4000	67.4
	Short and Narrow	3565	4000	89.125
	Long and Narrow	3227	4000	80.675
Proposed	By pass Diode	3685	4000	92.125

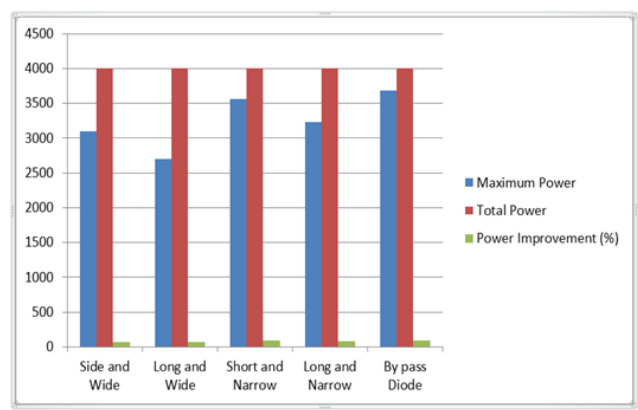

Figure 10: Maximum power for Different shading condition for PV array

VI. CONCLUSION

In this paper, a simple technique of maximum power generation systems based on partial to realize a simple control system to track the real maximum power point even under non-uniform or for rapidly changing insulation conditions. The proposed technique in the first stage implements a survey for the I-V characteristic of the PV arrays to detect an approximated MPP.

A MATLAB-Simulink based PV module model is presented in this paper, which includes a controlled current source.

Various PV array simulation schematic could be created by the proposed model, and parameters of irradiance and temperature of each PV module model can be set independently. The PV array simulation model allows us to investigate the characteristics of a PV array under various conditions of different irradiance and temperature, especially under condition of partially shading.

REFERENCE

[1] R. Hariharan, M. Chakkarapani, G. Saravana Ilango and C. Nagamani, “A Method to Detect Photovoltaic Array Faults and Partial Shading in PV Systems”, IEEE Journal of Photovoltaics, IEEE 2016.

[2] H, imanshu Sekhar Sahu and Sisir Kumar Nayak, “A Novel Approach to Extract Maximum Power from Partially Shaded PV Array”, 2015 IEEE Power, Communication and Information Technology Conference (PCITC) Siksha ‘O’ Anusandhan University, Bhubaneswar, India.

[3] Alonso-Garcia, M.C., Ruiz, J.M. and Chenlo, F. “Experimental study of mismatch and shading effects in the I-V characteristic of a photovoltaic module”, Solar Energy Materials & Solar Cells, Vol. 90, No. 3, pp. 329- 340, 2006.

[4] Alonso-Garciaa, M.C. and Ruizb, J.M. “Analysis and modelling the reverse characteristic of photovoltaic cells”, Solar Energy Materials & Solar Cells, Vol. 90, No. 7-8, pp. 1105-1120 , 2006.

[5] Alonso-Garciaa, M.C., Ruiz, J.M. and Herrmann, W. “Computer simulation of shading effects in photovoltaic arrays”, Renewable Energy, Vol. 31, No. 12, pp. 1986-1993, 2006.

[6] Altas, I.H. and Sharaf, A.M. “A photovoltaic array simulation model for MATLAB–SIMULINK GUI environment”, in Proceedings of International Conference on Clean Electrical Power (ICCEP), pp. 341–345, 2007.

[7] Azab, M. “Global maximum power point tracking for partially shaded PV arrays using particle swarm optimization”, International Journal on Renewable Energy Technology, Vol. 1, No. 2, pp. 211-235, 2009.

[8] Benavides, N.D. and Chapman, P.L. “Modeling the effect of voltage ripple on the power output of photovoltaic modules”, IEEE Transactions on Industrial Electronics, Vol. 55, No. 7, pp. 2638–2643, 2008.

[9] Benson. E., Phelpsell, R. and Sherif, M. “Evaluation and Testing of the solar cell Measurement System Onboard the Naval Postgraduate school Satellite NPSAT1”, 22nd AIAA International Communication Satellite Systems Conference and Exhibit, pp. 1-8, 2004.

[10] Bishop, J.W. “Computer Simulation of the effect of electrical mismatches in photovoltaic interconnection circuits”, Solar Cells, Vol. 25, No.1, pp. 73-89, 1998.

[11] Bruendlinger, R., Bletterie, B., Milde, M. and Oldenkamp, H. “Maximum power point tracking performance under partially shaded PV array conditions”, in Proceedings of 21st European Photovoltaic Solar Energy Conference (EUPVSEC), Dresden, Germany, pp. 2157-2160, 2006. 185.

[12] Carrero, C., Amador, J. and Arnaltes, S. “A single procedure for helping PV designers to select silicon PV module and evaluate the loss resistances”, Renewable Energy, Vol. 32, No. 15, pp. 2579-2589, 2007.

