



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: VI Month of publication: June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35585

www.ijraset.com

Call: © 08813907089 E-mail ID: ijraset@gmail.com



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429

Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Comparison of Hill Climbing and Perturb & Observe Method for PV Array using DC-DC Converter

Abhirup Dey

Student, Department of Electrical & Electronics Engineering, OP Jindal University, Raigarh, Chhattisgarh, India

Abstract: Solar Power or the Photo-voltaic Array (PV) is one of the most widely used renewable energy resources, there are two barriers while opting for the PV systems, i.e. low energy conversion efficiency and high initial cost, so it is more important to work the PV at its maximum power point. There are number of Maximum Power Point Tracking techniques under which, the Perturb-and-Observe and Incremental Conductance are widely popular. Maximum Power Point Tracking is important for the Photo-Voltaic systems as it improves the efficiency of the photo-voltaic systems. This paper presents the detailed comparison between the Hill Climbing Method, Perturb-Observe Method, Output results for each method have been recorded and these methods have been simulated in MATLAB – Math Works.

Keywords: Photo-Voltaic(PV), Maximum Power Point Tracking (MPPT), Hill Climbing Method, Perturb-Observe Method (P&O).

I. INTRODUCTION

When a phot voltaic (PV) array is connected directly to the load, the operating point of the PV solar is yielded at the maximum power point.[1] There are number of different algorithms for MPPT control, the most common MPPT methods are Perturb-Observe Method (P&O) and Incremental Conductance (InC).[2] The PV array voltage is regulated by adjusting the optimal set points which represents the voltage at maximum power point[3]. Solar Energy is considered as one of the most important sources of energy in the future and also an inexhaustible source of energy[4]. It has a zero-carbon emission during the operation of the photovoltaic system. The MPP tracker is one of the most efficient and economical way to increase the energy yielded by the PV system, so as to ensure that the system is operated at the Maximum Power Point [5,6]. There are different number of methods for tracking the maximum power point, these techniques differ by complexity, cost, range of effectiveness [7]. This paper presents the MATLAB simulation for the Perturb-Observe & Incremental Conductance MPPT, the performance of this methods is rapidly changing temperature, rapidly changing solar radiation [8,9]. For the past few decades renewable sources had been offering many challenging scopes to the researchers [10]. Maximum Power Point is a function which continuously monitors the operating point of the photovoltaic array [11]. As the demand of the electricity increases rapidly and due to the countable stock and also due to the overshooting prices of the conventional sources, thus the non-conventional resources become an alternative [12]. The demand of PV is increasing day by day (i.e., the demand of standalone and the grid-connected due) due to being economical friendly, less operational and low maintenance cost [13,14]. The main advantage of the PV system is that it does not consist any moving parts for which it doesn't produce any noise [15]. The phot-voltaic system converts the solar energy and has a low power conversion efficiency. The photo-voltaic system has a non-linear characteristic with varies with the temperature and irradiance and thus affects the PV output [16]. The silicon photovoltaic modules are mostly used as a power source in the tropical areas due to the abruptly changing of the weather [17]. The objective of this paper is to compare about the different MPPT algorithm [18]. Perturb-Observe Method involves a perturbation of the voltage in the PV array, whereas the Hill-Climbing Method works by moving the operating point of the PV array in the direction in which the power increases [19].

II. MATHEMATICAL MODEL OF A PV CELL

PV or the Photo-Voltaic Cell is the basic element of a PV system, current is been generated by the PV cell when it is exposed to sunlight as it is a p-n junction semiconductor. PV module is the connection of the cells connected electrically. The PV array comprises of various photo-voltaic cells that are connected in series and parallel connection, to increase the voltage of the PV system the cells are connected in series where as to increase the current of the PV system the cells are connected in parallel. The power supplied by the PV array depends upon the solar temperature and the irradiation intensity. In practical the electrical circuit is mathematically modelled by the photo-generated current (Iph) and the Shunt Resistor (Rsh) which is expressing leakage current as it is connected in parallel with an inverted diode, a resistance is connected in series which shows the internal loss due to the current flow.



International Journal for Research in Applied Science & Engineering Technology (IJRASET)

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429

Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

The mathematical expression of the output current produced by the solar cell is as follows:-

$$I = Iph - Io - Ish$$

Where I is the output current of the PV cell (A), Iph is the photo-generated current (A), Id is the diode current(A) and Ish is the shunt current (A).

From the Shockley diode equation, the current through the diode can be defined as Id

$$Id = Io e^{q(V+IRs)/mkTc} - 1$$

The expression of the current in a PV cell is as follows

$$I = Iph - Io \left[e^{\left(\frac{q(V + IRs)}{mkTc}\right)} - 1 \right] - \left[\frac{V + IRs}{Rsh} \right]$$
 3

Where Io is represented as the diode saturation current (A), q is the charge of electron (1.6*10^-19 C), K is the Boltzmann Constant (1.38 *10^-23 J/K), m is the diode quality, V is represented as the PV cell Output Voltage (V), Tc is represented as the absolute temperature of the cell (K), Rs is represented as the series resistance of the cell (Ω), Rsh is represented as the shunt resistance of the cell (Ω).

The current at the maximum power point can be calculated as

$$Imp = Iph - Io\left(e^{\left[\frac{q(Vmp + ImpRs)}{mkTc}\right]} - 1\right) - \left[\frac{Vmp + Imp * Rs}{Rsh}\right]$$

Thus, the power at maximum power point can be calculated as

$$Pmax = Vmp[Iph - Io\left(e^{\left[\frac{q(Vmp + ImpRs)}{mkTc}\right]} - 1\right) - \left[\frac{Vmp + Imp * Rs}{Rsh}\right]$$

Where Imp is the maximum panel current and Vmp is the maximum panel voltage.

MPPT Implementation Control Techniques

There is a definite point on the curve at which the photo-voltaic power is maximum (MPP), the power at this point is called at maximum Pmpp and the voltage at this

point is called as maximum Vmpp. The work of the MPP is to extract maximum energy from the PV and to make them operate in a most efficient way. When the value of the irradiance is kept in variable and by keeping the cell temperature constant we may see\ observe that the value of voltage and current varies.

In general, MPPT is a device that is connected between the PV array and the load, the MPPT is used because the efficiency of solar power is low, there are number of different algorithms that are used to track or control the maximum power point. In this paper a comparison is done between the Hill-Climbing Method (HC), Incremental Conductance Method (Inc) and the Perturb – Observe Method (P&O).

III. METHODOLOGY

A. Hill Climbing Method

The Hill Climbing Method is one of the simplest algorithms that is been used for tracking. It consists of the duty cycle of the power converter which is used to evaluate the operating point, so that it can achieve maximum power during the operation, if the condition dP/dD=0 is been accomplished, then it represents the operating point of the PV panel and the MPP has been tracked successfully. The Hill Climbing method is a direct control technique because it just operates by adjusting the duty cycle of the power converter, the concept of the Hill Climbing method is almost similar to the perturb and observe method, the single line difference between them is that the HC method involves a perturbation on the voltage and the P&O method involves a perturbation in the operating voltage of the DC link between the photo-voltaic array and power converter.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429

Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Advantage of Hill Climbing Method are as:

- 1) The Consumption of power is low compared to other techniques.
- 2) It is very simple to understand and to track the maximum power of the photo-voltaic array.

B. Perturb & Observe Method

The Perturb and Observe method is one of the most famous MPPT technique, this method works by making small incremental changes in the voltage and by measuring power. The Perturb and Observe method can fail under rapidly changing atmospheric conditions if the atmospheric prerequisites remain in constant.

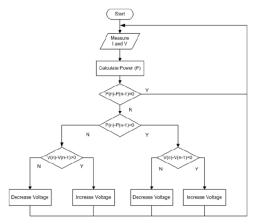


Figure 1. Flowchart of Perturb and Observe Method

- C. Advantages of Perturb & Observe Method
- 1) It gives a reliable result.
- 2) It does not depend upon the panel properties.
- D. Disadvantages of Perturb & Observe Method
- 1) The accuracy of the system and the time taken for tracking depends upon the size of perturbation.
- 2) The Perturb and Observe method is not suitable for fast changing atmospheric conditions.

IV. THE PROPOSED MODEL

In this model the PV array consists of 1 parallel string which consists of 11 "Soltech 1 STH-215-P" solar cells connected in series , the converter is been controlled/guided by the IGBT. In this model the converter used is the buck-boost converter, three models are been simulated in the MATLAB-Math Works, the Maximum Power Point controller is based on the Perturb & Observe , Incremental Conductance and Hill Climbing techniques. The function of the MPPT is to track the maximum power so that it can extract maximum voltage from the PV array.

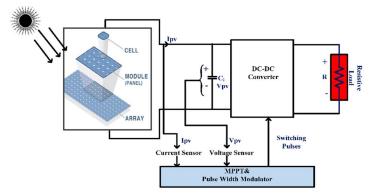


Figure-3 Outline of PV array with MPPT technique & converter

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429

Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

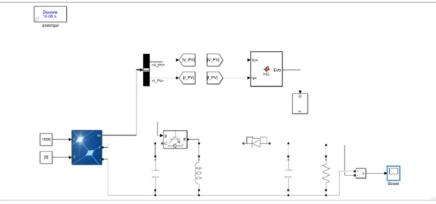


Figure-4 The Proposed Model

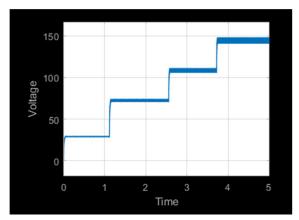


Figure-4 Waveform of Output-voltage for Hill-Climbing Method at different irradiance level.



 $Figure - 5\ Waveform\ of\ Output-voltage\ of\ P\&O\ Method\ at\ different\ Irradiance\ level.$

Table-1 Observation of Voltages at different irradiance level for different techniques/methods.

Irradiance	Voltage-of-Hill	Voltage-of-Perturb-
Level(W/m^2)	Climbing Method	Observe Method
200	29.68V	30.00V
500	73.55V	113.10V
750	110.30V	154.50V
1000	146.30V	183.70V



International Journal for Research in Applied Science & Engineering Technology (IJRASET)

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429 Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

V. CONCLUSION

The MPPT method plays a very essential role while designing a PV system, without these MPPT strategies or methods we would have very low energy and less efficiency and thus by applying this methods expanded efficiency and energy output is been achieved. The Hill Climbing method, InC method and the P&O method these methods are been simulated under equal conditions, whenever the atmospheric conditions is been varied the P&O oscillates close to the MPP where as the InC find the MPP at a precise point and the output that is generated from the HC method is comparatively less if compared to P&O and Inc method.

It is been proved that Perturb and Observe method has a better performance than the Hill Climbing method under the changing atmospheric conditions.

REFERENCES

- [1] Chaitanya S. Thakare, R. D. Kulkarni," Innovative MPPT Algorithm for PV based Solar Tracking System", 2020 International Conference for Emerging Technology (INCET) Belgaum, India. Jun 5-7, 2020.
- [2] Er. Amanpreet Kaur Sandhu, Er. Dilsher Singh," Comparative Study of Perturb & Observe Method and Incremental Conductance Method for Maximum Power Point Tracking System", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 7 Issue 05, May-2018.
- [3] Sumedha Sengar," Maximum Power Point Tracking Algorithms for Photovoltaic System: A Review", International Review of Applied Engineering Research. ISSN 2248-9967 Volume 4, Number 2 (2014), pp. 147-154.
- [4] UmaShankar Patel, Ms. Dhaneshwari Sahu," Maximum Power Point Tracking Using Perturb & Observe Algorithm and Compare With another Algorithm", International Journal of Digital Application & Contemporary research, Volume 2, Issue 2, September 2013.
- [5] SACHIN VRAJLAL RAJANI, VIVEK J PANDYA," Simulation and comparison of perturb and observe and incremental conductance MPPT algorithms for solar energy system connected to grid", revised 25 October 2014; accepted 27 October 2014.
- [6] Vibhu Jately, Sudha Arora," A Comparative Study of Hill-Climbing Based Peak Power Point Tracking Techniques", International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 11 | Nov -2016.
- [7] Tuffaha, T. H., Babar, M., Khan, Y., & Malik, N. H. (2014). "Comparative study of different hill climbing MPPT through simulation and experimental test bed". Research Journal of Applied Sciences, Engineering and Technology, 20(7), 4258-4263.
- [8] Abraham Dandoussou, , Martin Kamta, Laurent Bitjoka, Patrice Wira, Alexis Kuitché." Comparative study of the reliability of MPPT algorithms for the crystalline silicon photovoltaic modules in variable weather conditions". A. Dandoussou et al. / Journal of Electrical Systems and Information Technology. JESIT117 1–12.
- [9] R. Boukenoui, , R. Bradai, A. Mellit, M. Ghanes, and H. Salhi." Comparative Analysis of P&O, Modified Hill Climbing-FLC, and Adaptive P&O-FLC MPPTs for Microgrid Standalone PV System".4th International Confrence on Renewable EAnergy Research and Applications. Palermo, Italy, 22-25 NOV, 2015.
- [10] S. J. Deshmukh, Dr. P. B. Shelke." Comparative Study of Perturb and Observe Method and Incremental Conductance Method under Atmospheric Perturbations". Journal of Network Communications and Emerging Technologies (JNCET), Volume 7, Issue 5, May (2017).
- [11] William Christopher and Dr.R.Ramesh," Comparative Study of P&O and InC MPPT Algorithms". American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-02, Issue-12, pp-402-408.
- [12] Tiong Meng Chung*, Hamdan Daniyal, Mohd Herwan Sulaiman, Mohd Shafie Bakar," COMPARATIVE STUDY OF P&O AND MODIFIED INCREMENTAL CONDUCTANACE ALGORITHM IN SOLAR MAXIMUM POWER POINT TRACKING", Sustainable Energy & Power Electronics Research Cluster, Faculty of Electrical & Electronics Engineering, Universiti Malaysia Pahang, Pekan, Pahang, Malaysia.
- [13] Søren Bækhøj Kjær, Member, IEEE "Evaluation of the "Hill Climbing" and the "Incremental Conductance" Maximum Power Point Trackers for Photovoltaic Power Systems", IEEE TRANSACTIONS ON ENERGY CONVERSION, VOL. 27, NO. 4, DECEMBER 2012.
- [14] Hesheng Chen, Yuanhui Cui, Yue Zhao and Zhisen Wang," Comparison of P&O and INC Methods in Maximum Power Point Tracker for PV Systems", IOP Conf. Series: Materials Science and Engineering 322 (2018) 072029 doi:10.1088/1757-899X/322/7/072029.
- [15] Ahmed M. Atallah, Almoataz Y. Abdelaziz, and Raihan S. Jumaah," IMPLEMENTATION OF PERTURB AND OBSERVE MPPT OF PV SYSTEM WITH DIRECT CONTROL METHOD USING BUCK AND BUCKBOOST CONVERTERS", Emerging Trends in Electrical, Electronics & Instrumentation Engineering: An international Journal (EEIEJ), Vol. 1, No. 1, February 2014.
- [16] Mario Fortunato, Alessandro Giustiniani, Giovanni Petrone, Giovanni Spagnuolo, Member, IEEE, and Massimo Vitelli," Maximum Power Point Tracking in a One-Cycle-Controlled Single-Stage Photovoltaic Inverter", IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 55, NO. 7, JULY 2008.
- [17] Shazly A. Mohamed and Montaser Abd El Sattar." A comparative study of P&O and INC maximum power point tracking techniques for grid-connected PV systems", SN Applied Sciences (2019) 1:174 | https://doi.org/10.1007/s42452-018-0134-4.
- [18] M.Fortunato, A.Giustiniani, G.Petrone, G.Spagnuolo, M.Vitelli." Multi-objective optimization and MPPT in a Single Stage Photovoltaic Inverter", 978-1-4244-1666-0/08/\$25.00 '2008 IEEE.
- [19] Altwallbah Neda, Mahmod Mohammad, Mohd Amran Mohd Radzi, Norhafiz Azis, Suhaidi Shafie and Muhammad Ammirrul Atiqi Mohd Zainuri," An Enhanced Adaptive Perturb and Observe Technique for Efficient Maximum Power Point Tracking Under Partial Shading Conditions", Appl. Sci. 2020, 10, 3912; doi:10.3390/appl0113912.
- [20] Javier Muñoz, Daniel Apablaza, Manuel Diaz and Carlos Restrepo," Study of MPPT algorithms for a Boost Interleaved three-level converter", ICA-ACCA 2018, October 17-19, 2018, Greater Concepci´on, Chile.









45.98



IMPACT FACTOR: 7.129



IMPACT FACTOR: 7.429



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call: 08813907089 🕓 (24*7 Support on Whatsapp)