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

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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.

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

$$I = Iph - Io - Ish \quad 1$$

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

$$Id = Io\, e^{q(V+IRs)/mkTc} - 1 \quad 2$$

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

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

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

$$Imp = Iph - Io\left(e^{\left[\frac{q(Vmp+ImpRs)}{mkTc}\right]} - 1\right) - \left[\frac{Vmp + Imp * Rs}{Rsh}\right] \quad 4$$

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

$$Pmax = Vmp[Iph - Io\left(e^{\left[\frac{q(Vmp+ImpRs)}{mkTc}\right]} - 1\right) - \left[\frac{Vmp + Imp * Rs}{Rsh}\right] \quad 5$$

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.

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.

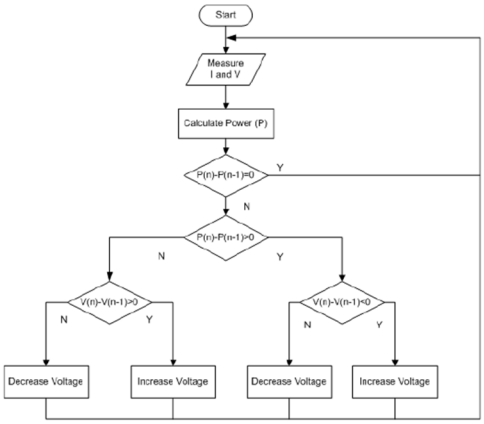

Figure 1. Flowchart of Perturb and Observe Method

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.

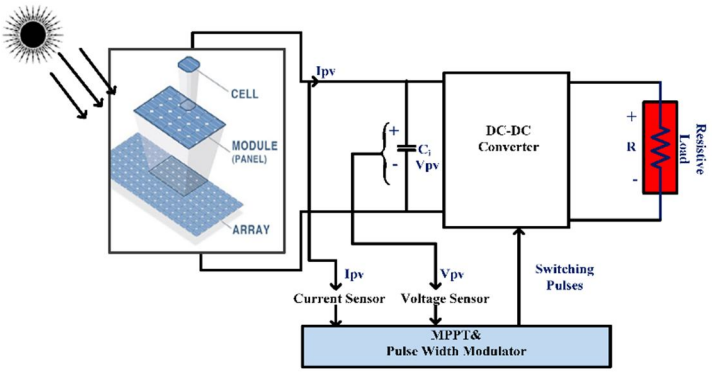

Figure-3 Outline of PV array with MPPT technique & converter

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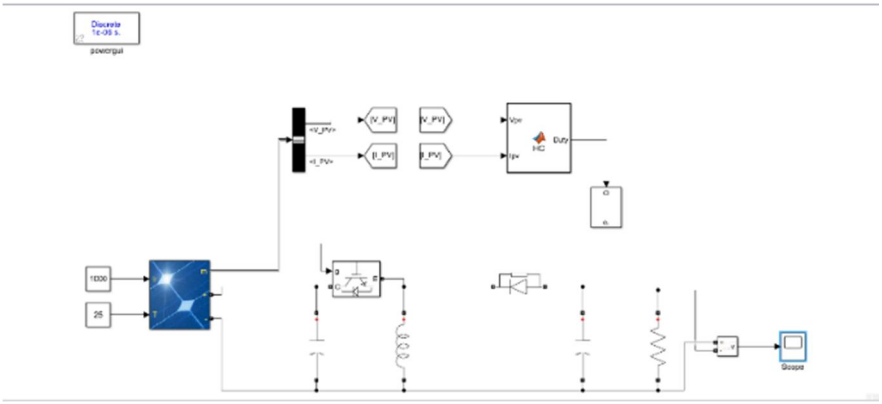

Figure-4 The Proposed Model

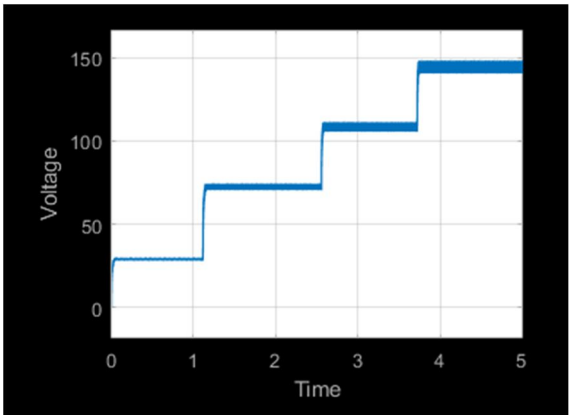

Figure-4 Waveform of Output-voltage for Hill-Climbing Method at different irradiance level.

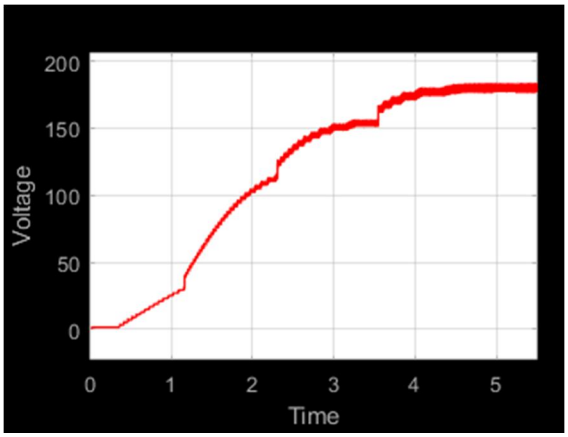

Figure-5 Waveform of Output-voltage of P&O Method at different Irradiance level.

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

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

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.

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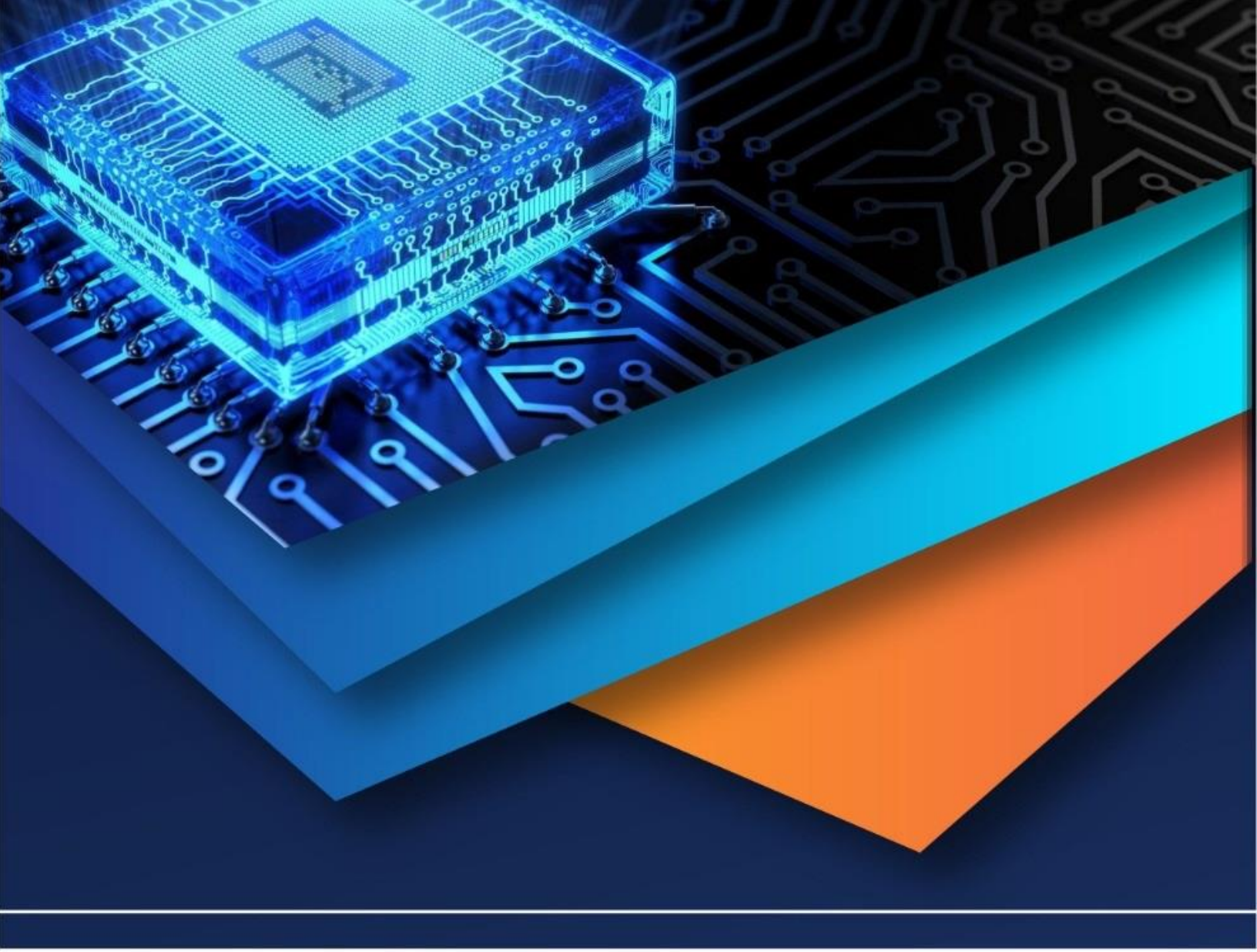

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