



# A Comparative Study of Perturb-Observe Method and Incremental Conductance Method

## KEYWORDS

MPPT, Insolation, Irradiance, Perturb, PVG, IncCond

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**ABSTRACT** The need of Solar Photovoltaics has increased greatly in comparison to the traditional non-renewable energy sources. These resources are a promising solution for the future day's energy requirement. Extracting maximum energy from the solar panels increases the overall efficiency of the system. Maximum power point is the point in the I-V curve of the solar module where the current and voltage corresponding to this point is maximum and more of electrical energy is extracted other than mechanical and thermal energy. In order to make best use of the PV system there are two ways i.e. orienting the panels in the direction of solar radiation and secondly electrically tracking the maximum power point by load matching. There are various methods of working of MPPT. In this paper two major methods i.e. the Perturb and Observe method and the Incremental Conductance method are taken. By using Matlab simulation of PV system using a Buck-Boost converter the two methods are tested and the energy and efficiency of both the methods are calculated. It is clear that though P and O method is simple Incremental Conductance method gives a better result.

## 1. Introduction

The efficiency Solar PV modules can be greatly increased by the use of Maximum power point tracking. Solar BP SX 150 Watt module has been taken for the testing the two methods. The entire design is simulated in Matlab simulation. There are various types of converters, but for better results Buck-Boost Converter is chosen so that the system can work both under low voltage and high voltage condition. The algorithms are tested with variable irradiance data, the MATLAB uses the data: the data is the measurements of a sunny day taken every 15 minutes during a typical day in June at campus 3 KIIT University, Bhubaneshwar, Odisha (709 km away, location: 31°36'28", North, 2°13'12", West) [18], where the irradiance changes slowly during the day.

## 2. Perturb and Observe Algorithm

Perturb and Observe method is also called as "Hill climbing method". The concept behind the "perturb and observe" method is to modify the operating voltage or current of the photovoltaic panel until you obtain maximum power from it. For example, if increasing the voltage to a cell increases the power output of a cell, the system increases the operating voltage until the power output begins to decrease. Once this happens, the voltage is decreased to get back to the maximum power output value. This process continues until the maximum power point is reached. Thus, the power output value oscillates around a maximum power value until it stabilizes. Perturb and observe is the most commonly used MPPT method due to its ease of implementation. In this algorithm the operating voltage of the PV module is perturbed by a small increment, and the resulting change of power,  $\Delta P$ , is observed. As shown in figure 5-1, if the  $\Delta P$  is positive, then it is supposed that it has moved the operating point closer to the MPP. Thus, further voltage perturbations in the same direction should move the operating point toward the MPP. If the  $\Delta P$  is negative, the operating point has moved away from the MPP, and the direction of perturbation should be reversed to move back toward the MPP. This algorithm has two parameters:

- 1) The time interval between the times when measurement is done and the time when the operating point moves from its optimal value.
- 2) The increment of the movement of the operating point

itself.

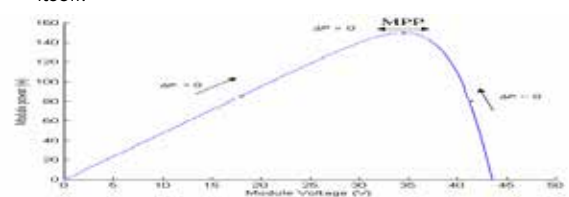


Figure 1: Plot of power vs. voltage for BP SX 150S PV module ( $1\text{KW}/\text{m}^2$ ,  $25^\circ\text{C}$ )



Figure 2 Shows the Algorithm of P and O method

## 3. Incremental Conductance method

The differentiation of the power equal to zero can be rewritten in terms of the conductance. In this form, the instantaneous conductance is equal to the incremental conductance but with the opposite sign. This equation (and each of the two inequalities that could arise) corresponds to the three regions referenced one of which being the point where  $dP/dV = 0$ . If the incremental conductance is greater than the instantaneous conductance the algorithm should continue to increase the voltage until the maximum power point is determined. Unlike the perturb and observe method, using incremental conductance a discreet value for the maximum power point can be obtained and the system will remain at this point until it undergoes a change in the environmental conditions

affecting the power. The other important advantage of the incremental conductance method is that by calculating the derivative and creating the inequality, the algorithm will know which direction to move along the curve in order to reach the maximum power point.

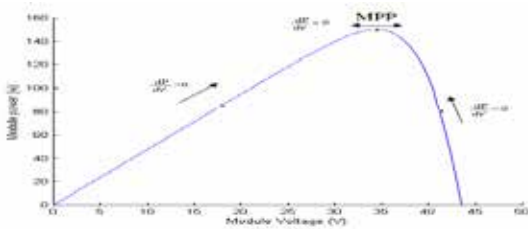


Figure 3: Plot of power vs. voltage for BP SX 150S PV module (1KW/m<sup>2</sup>, 25 °C).

The Incremental and Conductance Algorithm uses the following equations:

$$dP/dV = 0 \text{ at MPP} \tag{1}$$

$$dP/dV > 0 \text{ at the left of MPP} \tag{2}$$

$$dP/dV < 0 \text{ at the right of MPP} \tag{3}$$

The above equations can be written in terms of voltage and current as follows:

$$dP/dV = d(VI)/dV = I \cdot dV / dV + V \cdot dI / dV \tag{4}$$

If the operating point is at Mpp the equation 5.4 becomes:

$$I + V \cdot dI / dV = 0 : dI / dV = - I / V \tag{5}$$

If the operating point is at left of Mpp the equation 5.4 becomes:

$$I + V \cdot dI / dV > 0 : dI / dV > - I / V \tag{6}$$

If the operating point is at right side of Mpp the equation 5.4 becomes

$$I + V \cdot dI / dV < 0 : dI / dV < - I / V \tag{7}$$

The flow chart describes the operation of this algorithm.

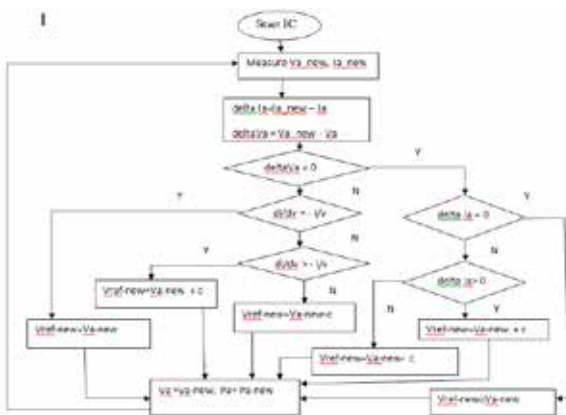


Figure 4 Shows Algorithm of Incremental Conductance Method

In the figure 4 it is seen that the algorithm starts with the measuring of a particular voltage and current value. Then it calculates the value of change in voltage and change in

current i.e. the incremental changes, which the difference of new value minus the previous values. This method goes for a two way round checking. It not only determines the MPPT point but also useful for rapidly changing weather conditions. The main check is carried out using the relationship in the equation (5), (6),(7). If the condition satisfies the equation (6) it is assumed that the operating point is at the left side of the Mpp thus the photovoltaic module voltage has to be increased. Similarly if the condition in the equation (7) is satisfied it is assumed that the operating point is at the left side of the Mpp thus the photovoltaic module voltage has to be decreased. The operating point reaches the Maximum power point when the condition satisfies the equation (5.5), thus the algorithm bypasses the voltage adjustment [6]. At the end of the cycle it updates the history by storing the voltage and current data that will be used as previous values in the next cycle. The other way round checking which the algorithm does is the detection of the weather conditions. If the Mpp is still operating at Mpp condition i.e.  $dV = 0$  and the irradiance has not changed, i.e.  $dI = 0$ , there is no voltage change. But if the irradiance has increased,  $dI > 0$ , it raises the Mpp voltage. Then the algorithm will increase the operating voltage to track the Mpp. Similarly in case the irradiance has decreased,  $dI < 0$  the Mpp voltage will be lowered.

Then the algorithm decreases the operating voltage. Incremental Conductance method can be used for tracking rapidly changing irradiance conditions with higher and better accuracy than Perturb and Observance method. One of the disadvantages of this method is that the algorithm is more complex than any other methods.

**4. Simulation model of PV system with controlled gate pulse using Mppt Methods**

In this model Temperature and Irradiance are used as input to Solar Module and the output of the module is fed to a DC to DC converter, here a Buck-Boost converter is used. The controlled gate pulse to the Power switch is obtained from the control circuit.

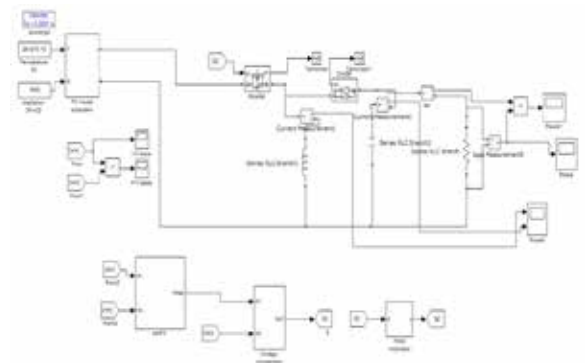


Figure 5 shows the simulation model of the entire system using resistive load

**5. Simulation Results**

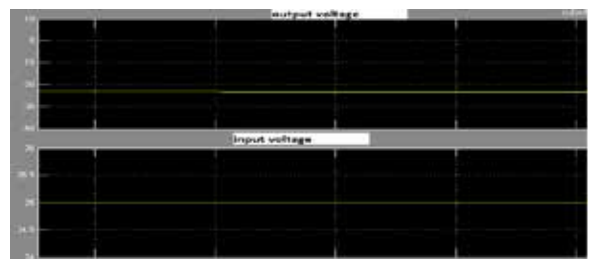


Figure 6 shows the input and output voltage of the converter

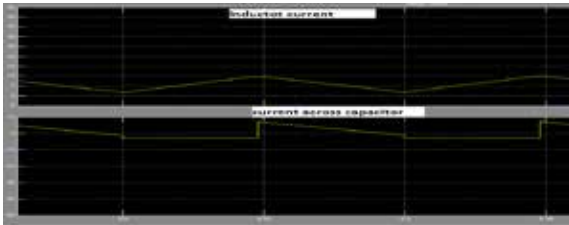


Figure 7 shows the Ripple current across the inductor and charging current across the capacitor

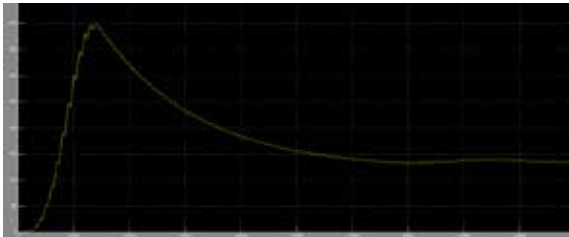


Figure 8 shows the output power by using P and O method

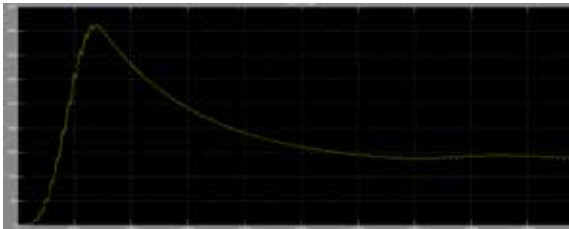


Figure 9 shows the output power obtained using IC method

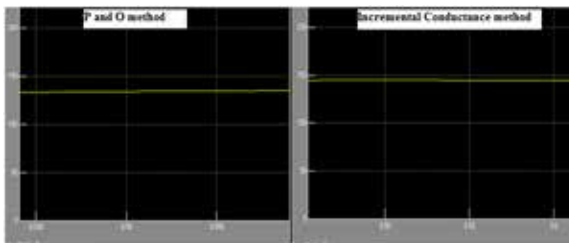


Figure 10 shows the comparative analysis of the power output of both the method

6. Calculation of Energy and Efficiency

To see the results of using MPPT in our system and how it increase the efficiency by extracting the maximum power from the PV module, a comparison is made between the system with MPPT using both Perturb and Observance method and Incremental conductance method and that without MPPT.

$$\text{Efficiency} = (\text{simulated energy}/\text{theoretical energy}) * 100$$

	Energy(Wh)	Efficiency (%)
Theoretical energy	3600	
Without Mppt	2968.8	82
P and O method	3278.4	91.06
Incremental Conductance method	3379.2	93.86

Table 1 shows the energy production and efficiency of PV module with and without MPPT

The results show that the PVG system without MPPT has poor efficiency (82 %) because of mismatching between the PV module and the resistive load. On the other hand, it shows that the system with MPPT can utilize more than 90 % of PVG capacity.

7. Conclusion

Comparative tests for the two MPPT algorithms, the perturbation and observation (P&O) algorithm and the incremental and conductance (IncCond) algorithm using actual irradiance data in the two different weather conditions have been undertaken. The IncCond algorithm shows slightly better performance in terms of efficiency compared to the P&O algorithm under cloudy weather conditions. Even a small improvement of efficiency could bring substantial savings if the system is large. However, it could be difficult to justify the use of IncCond algorithm for small low-cost systems as the cost and availability are the two major aspect of system design and the IncCond algorithm will require four sensors more than the P&O algorithm and also it need more control loops.

A comparative study of the PV system with resistive load with MPPT vs. direct-coupled system has been undertaken. The results show that the system with MPPT can utilize more than 90 % of PVG capacity. On the other hand the system without MPPT has poor efficiency (82 %).

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