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Comparative Study of MPPT Methods for Solar Photo voltaic Tracking system

J. S. Bhonsle

Assistant Professor, Dept. of EE, Priyadarshini Institute of Engineering & Technology, Nagpur, India

ABSTRACT: The use of solar for power generation as been progressively increased in the recent past years. But the limitation of power generation from solar photovoltaic (PV) is limited by atmospheric factors like temperature and solar irradiation. This factor ultimately affects the power output from PV modules. In order to overcome this limitations, number of conventional Maximum Power Point Tracking (MPPT) methods are explored by the researchers. This paper present comparative performance analysis of MPPT methods for solar photo voltaic tracking system in MATLAB software.

KEYWORDS: Solar Photo voltaic, Maximum Power Point Tracking (MPPT), Perturb & Observer (P&O), Incremental Conductance (INC), Adaptive P & O.

I.INTRODUCTION

Tracking the maximum power point is in an important aspect in PV array[1,2]. It is performed by implementing different kinds of methods such as perturb & observe, incremental conductance, adaptive p&o method etc.[3-5] The methods varies in complexity, sensor required, cost, etc. There are two types of sensor used i) voltage sensor and ii) current sensor. In this paper voltage sensor is used because as the voltage increase, current leads to increase therefore there is no need to use current sensor. This paper focuses on various MPPT methods. The factors that affects the power output are temperature and solar irradiation. With the increase in temperature voltage leads to increase and it is having less impact on voltage. On increasing the solar irradiation open circuit current leads to increase and its having less impact on voltage.

The P&O method involves a perturbation in operating voltage on solar array and hill climbing involves perturbation in duty ratio of power conductor. In P&O method voltage is being increased or decreased with fixed step size to reach maximum power point. The process is repeated periodically until MPP is reached. The MPP comprises of transient state and steady state. In steady state one can reached MPP slowly by increasing this more values of voltages. It is having the less oscillation than transient state where as in transient state one reached MPP faster but oscillation occurs are more. It is better to go with steady state as it reduces the energy losses.

Another method is incremental conductance which is based on the fact that the slope of PV array power curve is zero at MPP, negative on right and positive on left of MPP. Incremental conductance (INC) method increases the speed of iteration. The method is proposed to improve the performance and reduce the oscillation at MPP, but during rapid fluctuation of irradiation and temperature the tracking speed reduces significantly.

Different algorithms are proposed by researchers in [1,2,9,10,13] whereas topic review is presented in [3]. Development and comparison of algorithms are discussed in [4,5,11,12]. Microcontroller based implementation of proposed algorithms are presented in [6,7,8] by different authors.

II.PROBLEM OVERVIEW

Fig 1. shows the characteristic PV array power curve of PV module. The problem considered in MPPT techniques finds the solution for voltage V_{MPP} or current I_{MPP} at which PV array should operate at maximum power output P_{MPP} under given temperature & irradiance. Most techniques respond to the changes in both temperature and irradiance, but

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some are specifically more useful if temperature is approximately constant. In our context, the PV array will typically connected to a power converter that can be vary the current coming from the PV array.

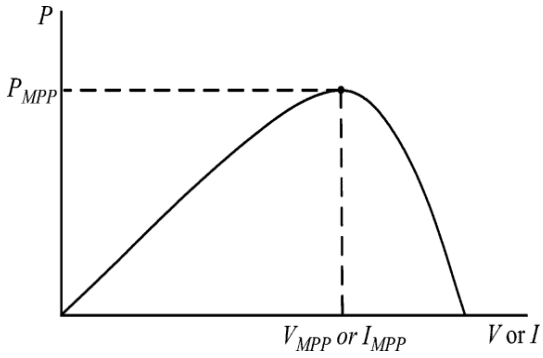

Fig.1 Characteristics PV array power curve

III.MPPT TECHNIQUES

Different MPPT techniques are introduced below in an arbitrary order:

A. Perturb & Observe method

P & O method is used for its simplicity and reasonable accuracy[6].With reference to figure 1, when operating point is on left hand side of MPP (maximum power point) the increased voltage leads to increased power, while operating point on right hand side decreases the voltage which will leads to the decreased power output. The process is repeated again and again for obtaining the maximum power point(MPP). After reaching MPP, the system will be oscillates around it and settles down thereafter. One of the important parameter for P & O method is the length of perturbation e.g. if we are having the original value of voltage as 2V then in length of perturbation we will again increase it by 2V and check the power in third step ; so by increasing the small values here we are reaching the MPP. By increasing small values of voltage we measure the power and observed that where we are getting the MPP. With the increase in the length of perturbation, it increases the tracking speed. On the other hand oscillation in steady state will cause energy loss and hence reduce the efficiency of the system. The determination of perturbation comprises of steady state and dynamic response. During transient state, we increase the voltage by larger values that means we are taking larger steps here to reach MPP faster but in this condition the disadvantage is that oscillation will occur more in the system where in steady state we take smaller steps and we reach the MPP slowly but in this oscillation will reduced as compare to the transient state.

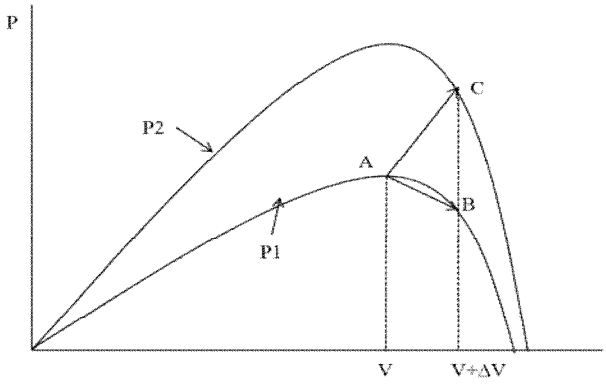

Fig. 2. Divergence of P&O

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Figure 2 shows the divergence of P&O. As shown in figure, the graph starts from an operating point A, if atmospheric conditions stays constant then perturbation in voltage will bring the operating point to B and perturbation will be reversed due to decrease in power. However, irradiance increased and shifts the power curve from P1 to P2. Within one sampling period, the operating point will move from point A to point C. Two sensors are usually needed to measure the PV array voltage and current from which power is measured, but depending upon the power converter topology one sensor might be needed that is voltage sensor. The PV array current will be estimated from the PV array voltage by reducing the need of current sensor. Figure 3 shows the flow chart for P & O algorithm.

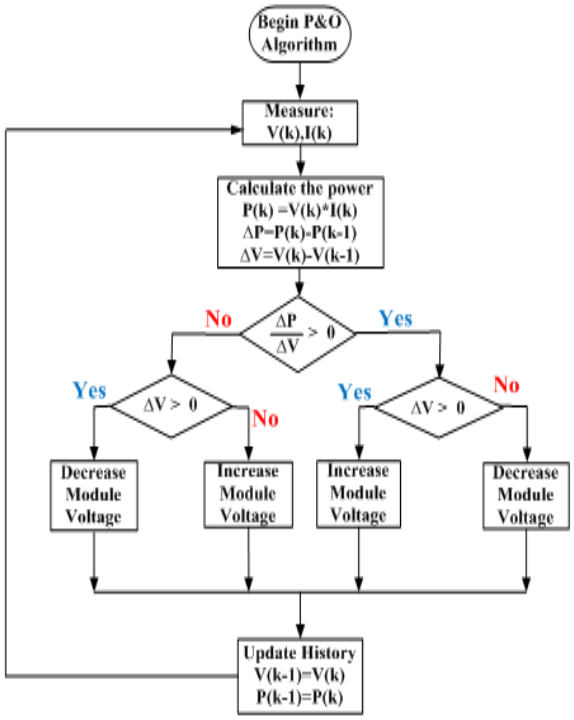

Fig 3. Flowchart of P & O Algorithm

B. Incremental Conductance method

In Incremental Conductance method, power is obtained by the ratio of change in current to the ratio of change in voltage. This algorithm is based on whether the array voltage is greater than or less than peak voltage. Maximum power point can be track by comparing the instantaneous conductance to incremental conductance. The algorithm decrements or increments to track the new maximum power point (MPP). It is faster than the perturb and observe method. Once the MPP has reached, it maintained the point of operation at which maximum output is obtained. This algorithm works on the following equation at the maximum point

$dI/dV = -I/V$ where, I and V are the PV array current and voltage respectively.

In this method, when operating of PV panel is on right hand side of MPP , we get

$dI/dV < -I/V$

And when the operating point is on left hand side of MPP we have

$dI/dV > -I/V$

Figure 4 shows the PV characteristics of incremental conductance method.

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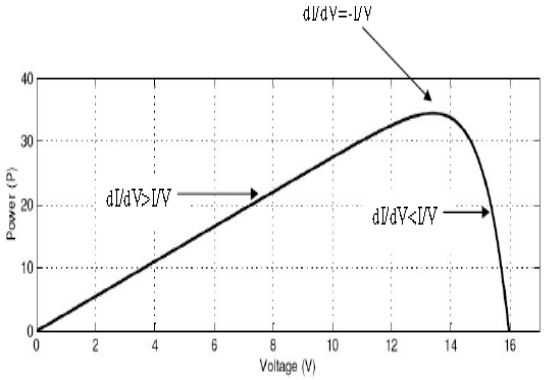

Fig. 4. P/V characteristics of Incremental conductance

This methods have following advantages:
Incremental conductance algorithm requires less iteration, faster time response and accuracy at oscillations are more.
In incremental conductance algorithm, the MPP can be tracked by comparing the instantaneous conductance i/v to incremental conductance di/dv. The correct direction of perturbation leading to the MPP is achieved by the sign of quantity of di/dv + i/v . The operation of PV array is maintained at point when MPP reached and then perturbation stopped unless a change in di is noted. In this case, the algorithm increments and decrements are done to track the new MPP. The size of increment shows how fast the MPP can be obtained. From this algorithm, it is theoretically possible to know when the MPP has been reached and thus when the perturbation can be stopped. The method have the good performance under rapidly changing atmospheric conditions.
There are two different INC methods: i) classic INC algorithm which determine the perturbation direction a, measurement of the voltage v and measurement of the current I and ii) the two model MPPT control algorithm which is the combination of CV and INC methods. If the irradiation is lower than 30% of the irradiance level, the CV methods is used otherwise the INC method is used. Thus this method requires the additional measurement of solar irradiance. Figure 5 shows the flow chart for incremental conductance algorithm.

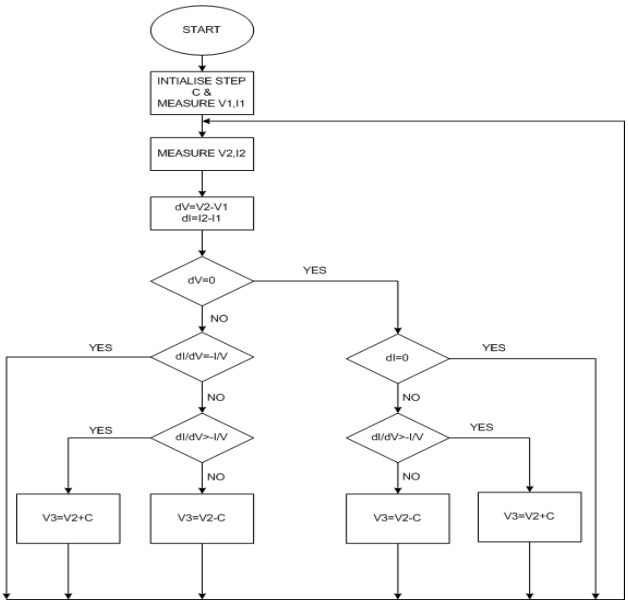

Fig 5. Flowchart of Incremental conductance algorithm

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IV. RESULT AND DISCUSSION

There are many MPPT techniques such as P&O, INC, adaptive P&O etc. These techniques varies with aspects such as simplicity, convergence speed, hardware implementation, sensors required, cost requirement for parameterization and range of effectiveness. The MPPT techniques are comparing by using MATLAB tool, considering different types of insulation and solar radiations variations. The partially shaded condition is not considered. The radiation is uniformly spread over the PV array.

Figure 6 and 7 shows the V- I and P-V characteristics of maximum power point tracking (MPPT) respectively for perturb and observe (P&O) method. In P & O method we say that in the left of MPP the power leads to increase while in right of the MPP power leads to decrease and the point which we get on the center of the curve is the peak point that is MPP. In the right side of the maximum power point, after certain point, increasing the voltage, power leads to decrease. So we need to go again in reverse direction to get the PV curve.

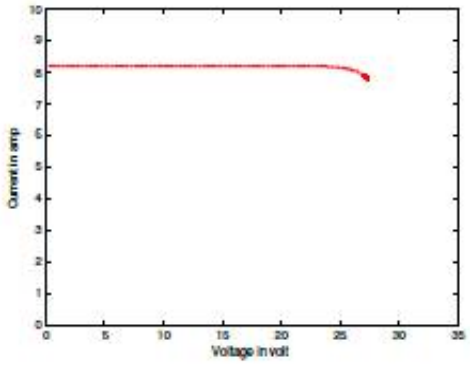

Fig 6. V-I Characteristics of P & O Algorithm

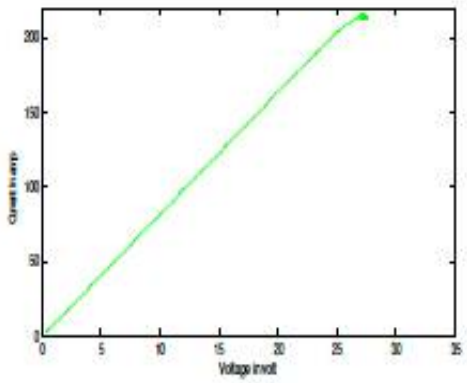

Fig 7. P-V Characteristics of P & O Algorithm

Figure 8 and 9 shows the V-I and P-V characteristics of maximum power point tracking (MPPT) respectively for incremental conductance (INC) method. The INC method overcomes drawbacks of P&O by computing the sign of dP/dV without perturbation. Although this method has the drawback that it increases the complexity compared to P&O method and requires more time for computation. The iteration depends upon the ratio of change in current and change in voltage. Accuracy at oscillations is more as compared to conventional P&O.

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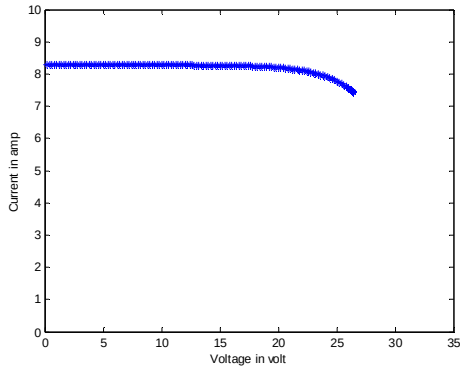

Fig 8. V-I Characteristics of Incremental Conductance

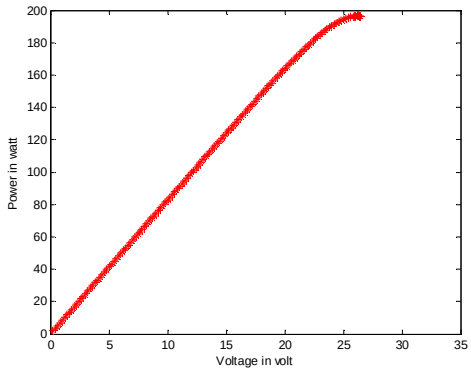

Fig 9. P-V Characteristics of Incremental Conductance

Figure 10 and 11 shows the V-I and P-V characteristics of maximum power point tracking (MPPT) respectively for adaptive P&O method. From the result obtained from Adaptive P& O algorithm, it is concluded that algorithm offers high tracking speed, less oscillation and more stable operation at MPP.

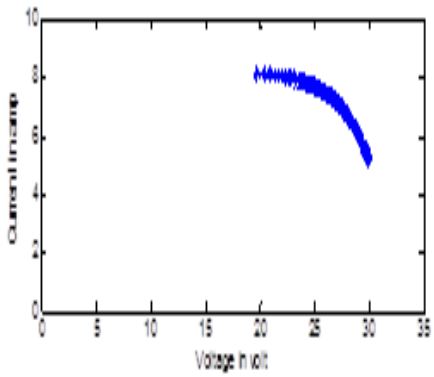

Fig 10. V-I Characteristics of Adaptive P&O

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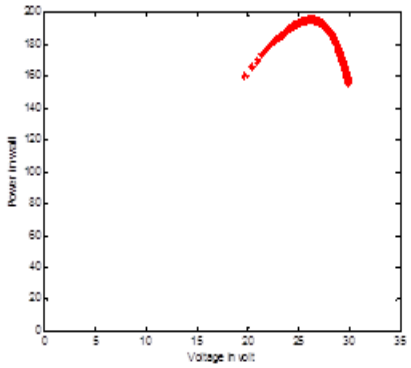

Fig 11. P- V Characteristics of Adaptive P&O

V. CONCLUSION

There are several techniques explored for the maximum power point tracking in literature by many of researcher. This paper presents the comparative result of MPP using perturb and observe method, incremental conductance method and adaptive P&O method. P&O is simple and widely used MPP method but have slow tracking speed and more oscillation at MPP. Incremental conductance method is used for faster speed of iteration and to reduce the complexity. Whereas Adaptive P& O method is presented in this paper which offers high tracking speed, less oscillation and more stable operation at MPP.

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