Journal of Science and Technology (JST)
Volume 2, Issue 6, Nov - December 2017, PP 28-32
www.jst.org.in *ISSN: 2456 - 5660*

A Comprehensive Review of Maximum Power Point Tracking Algorithm for Photovoltaic System

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Abstract : *PV arrays has non-linear I-V characteristic and its output power generally depends upon environmental conditions such a solar radiation and temperature. There is a point on I-V, P-V characteristic curve of PV array which is called as Maximum Power Point (MPP), in which the PV system produces its maximum output power. Location of MPP changes with variation in environmental condition. The purpose of Maximum Power Point Tracking (MPPT) is to vary the solar operating voltage close to MPP under changing environmental conditions. In order to continuously abstract the maximum power from PV array they have to operate at their MPPT despite of the homogeneous variation in environmental conditions. The two algorithms for PV applications are Perturb and Observe (P & O), Incremental Conductance (Inc. Con.). An enhanced review of various MPPT algorithms is proposed with more focus on above two algorithms.*

Keywords - *MPPT,P&O ,PHOTO VOLTAIC CELL*

I. INTRODUCTION

Fossil fuels like gas and oil square measure non-renewable supply of energy, unclean and not eco-friendly supply of energy. alternative energy is considered one amongst the foremost necessary renewable energy sources. electrical phenomenon System(PV) system is split into 2 categories: complete and Grid connected PV system. For the places that square measure aloof from the utility grid, complete PV systems square measure used at those places. during this system, the performance of a PV system that depends on the in operation conditions. the utmost power abstracted from the PV supply depends powerfully on 3 factors like radiation, load profile and temperature [Salas, 2006]. an area wherever utility grid is definitely on the market, grid-connected PV system is employed there.

The most power that is generated by the star module at some extent of the I-V characteristic wherever the merchandise of voltage and current is maximum. now is thought because the most Power Point(MPP).. The importance of the MPPT is to make sure the operation of the PV module at its MPP, extracting the utmost on the market power. If there's a decent irradiance condition, the electrical phenomenon system will generate most power dependably whereas a good MPPT algorithmic rule is employed with the system. plenty of MPPT algorithms are developed and mentioned by Researchers everywhere the planet like Differential technique, Perturb and Observe (P & O), progressive electrical phenomenon (Inc. Con.), Curve fitting, Open-Circuit Voltage PV generator, contact PV generator technique. The potency of a PV plant is affected principally by 3 factors: the potency of the PV module, potency of electrical converter and therefore the most electrical outlet trailing (MPPT) algorithmic rule.

II. Maximum Power Point Tracking Algorithms

MPPT algorithms are important in PV applications because the MPP of the solar panel directly varies with the irradiation and temperature, so the use of MPPT algorithms is always required in order to obtain the maximum power from the solar array. Among all the algorithms which are available P & O and Inc Con algorithms are most common as they have the advantage of an easy implementation. In very normal conditions the P-V curve have only one maximum point, so it will be not a problem. However, if the PV array is partially shaded, there will be multiple maxima in these curves.

Curve Fitting method

The curve-fitting method is the method where PV module characteristics and all data and manufacturing details

which are required, for mathematical modelling and equations describing the output characteristics are pre-decided. PV module characteristic is given by eq. (1), where a, b, c and d are coefficients which are determined by sampling m values of PV voltage V_{PV}, PV current I_{PV} and output power P_{PV} [Salas, 2006]. Once these coefficients are calculated, the voltage at which power become maximum is obtained by eq. (2).

$$P_{PV} = a\,V_{PV}^3 + b\,V_{PV}^2 + c\,V_{PV} + d \qquad (1)$$

At maximum power point, $dP_{PV}/dV_{PV} = 0$.

$$V_{MPP} = \frac{-b \pm \sqrt{b^2 - 3ac}}{3a}$$

The advantage of this method is its very simplicity. Disadvantage is that it requires prior and accurate knowledge of physical parameters. It requires large memory as number of calculation is more and the Speed is less.

Differential Method

In this method, eq. (3) must be solved very fast in order to provide the accurate operating point.

$$\frac{dP_{PV}}{dt} = V_{PV}, \frac{dI_{PV}}{dt} + I_{PV}\frac{dV_{PV}}{dt} = 0 \qquad (3)$$

Disadvantage of this method is that it requires extensive calculation time as after calculating eq. (3) parameters, sum + is calculated and a comparison of these sum to an equal perturbation on the opposite side of the operating point or the operating point power. This will be done till final sum becomes zero and if not than more calculations are required [Salas, 2006].

Open-Circuit Voltage method

In this method the ratio of PV array's maximum power voltage (VMPP) to its open-circuit voltage (VOC) is approximately constant as given by eq. (4).

$$V\_MPP/V\_OC \cong K\_1 < 1 \qquad (4)$$

The Open-Circuit method will be implemented using the flowchart as shown in fig. 1. The PV array is transitory isolated using from MPPT then VOC is measured. After that VMPP is calculated according to eq. (4), finally the operation voltage is set for the maximum voltage point. This process is repeated periodically

The core Advantage of this method is that it is simple and very cheap. Disadvantage is that it is quite difficult to choose an optimal value of constant K1.

The literature [Salas, 2006 & Eltawil, 2013], reports K1 values ranging from 0.73 to 0.80 for Polycrystalline PV modules.

Short-Circuit Method

This method is very similar to Open-Circuit Voltage method, in this the current in MPP (IMPP) and it is linearly proportional to Short-Circuit current (ISC) given by eq. (5). The value of K2 is considered to be around 0.85 [Salas, 2006].

$$I\_MPP/I\_SC \cong K\_2 < 1 \qquad (5)$$

The way of evaluating K2 is quite more complicated than any of fixed value. The flowchart, advantages and disadvantages are similar to that of Open-Circuit Voltage method.

Hill Climbing Techniques

P & O and Inc Con algorithms operate on Hill Climbing Principle, in which operating point of the PV module moves in the increasing direction of power [Morales, 2010].

Perturb and Observe (P&O) method

P&O is an iterative repetitive method. It senses the panel operating voltage repeatedly and will compares the PV output power with that of the previous power; the resulting change in power (ΔPPV) is measured. If ΔPPV is positive, the perturbation of the operating voltage be in the same direction of the step incremental. However, if it will be negative, the system operating point obtained moves away from the MPPT and the operating voltage should be in the opposite direction of the increment [Salas, 2006], perturbation should be reversed to move back

towards the MPP. This process will continues till $dP_{PV}/Dv_{Pv}=0$ regardless of the and PV module's terminal voltage. Fig. 1 shows the P -V characteristics of PV module.

A scheme of the algorithm is shown in Fig. 2, according to which PV module output voltage VPV and output currents IPV are sense. Then the power is calculated P (n) and will compared with the power measured at the previous sample P(n -1) in order to calculate ΔP. Then according to the sign of ΔP and ΔV, MPP is tracked which is summarized in Table I, calculations are done according to I-V characteristics in Fig. 1

The advantages of this algorithm, as stated above, are its simplicity and ease of implementation. However, P&O hve its limitations that reduce its MPPT efficiency and One such limitation is that as the amount of sunlight decreases, the P–V curve saturates out. Another limitation of P&O is that it will oscillates around the MPP, as this method will becomes unstable with rapid change in atmospheric conditions such as irradiance and temperature. The oscillation will be minimized by reducing the perturbation step size. However, with a smaller perturbation size slows down the MPPT. A solution to this conflicting situation is to have a variable perturbation size that gets smaller towards the MPP [Esram, 2007].

Incremental Conductance (Inc Con) Method.

The disadvantage of P&O algorithm will be of oscillating the operating point around MPP is removed by Inc Con method by that comparing the instantaneous panel conductance (IPV/VPV) with the incremental step by step panel conductance (dIPV/dVPV). The voltage of MPP is tracked to satisfy dPPV/dVPV=0, which is MPP [Bhatnagar, 2013]

Output power of PV module PPV Is given by eq. (6).

$$P_{PV} = I_{PV}\, V_{PV} \quad (6)$$

Differentiating eq. (6) with respect to VPV gives the basis of Inc Con algorithm

$$dP_{PV}/dV_{PV} = I_{PV} + V_{PV}\, dI_{PV}/dV_{PV} \quad (7)$$

The advantage of this incremental conductance method, which is superior to those of the other MPPT algorithms, is that it will calculate and find the exact perturbation direction for the operating voltage of PV modules and Also it is very easy to implement and has high tracking speed and highly efficient [Bhavnagar, 2013]. Disadvantage is that itrequires complex control circuits [Salas, 2006].

III. FIGURES AND TABLES

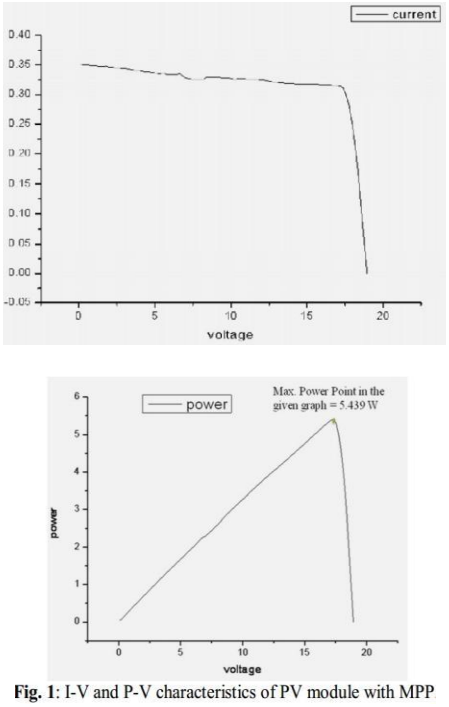

Fig. 1: I-V and P-V characteristics of PV module with MPP

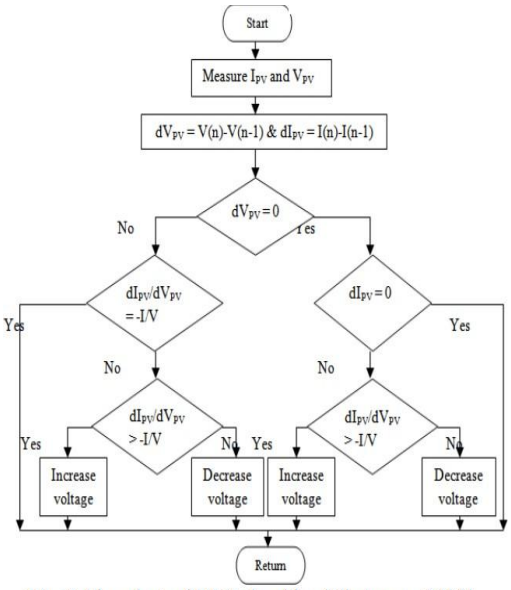

Fig. 2: Flowchart of P&O algorithm [Bhatnagar, 2013].

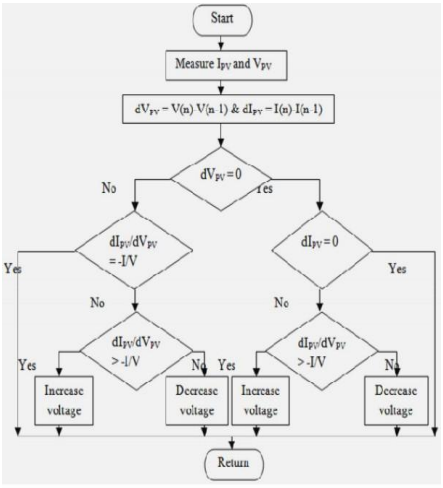

Fig. 3: Flowchart of Inc Con algorithm [Salas, 2006].

IV. CONCLUSION

In this paper, various MPPT algorithms have been reviewed. It has been demonstrated, that there are various ways of distinguishing and grouping the methods for tracking of MPP to the PV generator. Finally, it has been shown that other methods also exist by which the MPP of PV module can be tracked.

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