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MAXIMUM POWER POINT TRACKING ALGORITHM TO PHOTO-VOLTAIC SYSTEM UNDER DYNAMIC CONDITIONS

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Abstract - The rapid increasing energy demand of world has put pressure on conventional fossil fuels which are declining because of their limited stock. To fulfill worlds ever rising power demand, solar energy is becoming growing up and promising technology due to its cleanliness and abundant source of energy. But its performance is greatly affected due to dynamic weather situations which lead to power reduction. So to utilize maximum power from photo-voltaic (PV) system, maximum power point tracking is necessary. This paper deals with MATLAB simulation of photo-voltaic system with boost converter. The characteristics of solar system for different critical factors have been discussed. The MATLAB simulation of perturb and observe (PO) method has done and its effectiveness is verified for various factors.

Index terms - Maximum power point tracking (MPPT), partial shading condition (PSC), photo-voltaic (PV) system.

I. INTRODUCTION

In modern era, energy has become basic need of human being and nation for development. Electrical energy is more convenient and generated from various non renewable resources. These conventional energy sources are not secure and sustainable. The combustion of these resources leads to emission of green house gases which results in global warming, droughts and floods [3].

Increasing world population has caused the huge gap between generation and demand of customer. So to bridge this gap, it is necessary to move towards green energy sources. The power generation from solar system has become popular as it renders various benefits like everlasting origin of energy, pollution free and cheap cost of maintenance. But still PV system is facing some challenging problems like enhancement of conversion efficiency and minimizing the high installation cost [1] - [3]. Along with this, partial shading situation is of great concern nowadays as obstacles like shadows of buildings ,poles and other objects hides the some part of array. PV array under shading phenomenon minimizes power of solar panel.

The activation of bypass diode makes more complex nature of curve. So to track maximum power, there is need of effective MPPT algorithm.

M. Boder and et.al [4] have explained current sweep mechanism to track peak power of low rating solar panels. This method is applicable when consumption of extracting unit is less than rise in power for total solar system. Fractional open circuit voltage method is based on linear relationship between maximum voltage and open circuit voltage [5]-[6]. This method requires open circuit voltage measurement obtained by turning off the converter which leads to power loss. Fractional short circuit current method considers that maximum current and short circuit current are linearly related [7]-[8]. But there is difficulty in measuring the short circuit current, because it needs additional switches to short the terminals which adds to cost. Chia-hung Lin [9] has recommended fractional order incremental conductance method (FOICM) for tracking maximum power of PV system. In this method fractional order incremental changes are made in terminal voltage and current so as to draw maximum power. The transfer of energy is greatly affected by solar radiations, temperature and weather conditions. Incremental conductance (IC) method assumes that at MPP, the slope of power curve becomes zero [10]. The slope is positive on left side of MPP and negative on right side of MPP. The algorithm reaches MPP, when conductance of solar system and instantaneous conductance are equal. This method is complex and increases the expenditure of implementation.

In this paper, PO technique for maximum power point tracking is proposed. This method is simple to implement and cost effective. The remaining paper is organized as: Section II deals with modeling of PV system and the characteristics of PV structure under different solar insolations. Section III

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presents impact of bypass diode. Section IV explains PO method for MPPT of solar system. Section V discusses the results and finally, section IV provides valid conclusion for the paper.

II. MATHEMATICAL FORMULATION OF PV SYSTEM

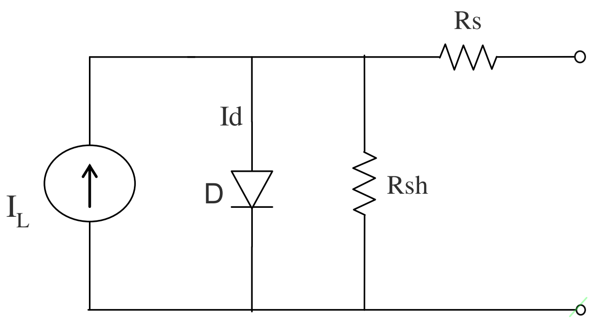

Fig.1. PV cell model

The solar cell is a p-n junction device, which absorbs energy when sunlight shines on it [3], [11] - [12]. The absorption of radiations by photons produces electron hole pairs in the device. The separation of these electron hole pair results in generation of photo-voltage. This voltage across the PV cell causes current in external load circuit and delivers power.

The complete circuit of PV system is shown in fig.1. After applying KCL, equation for load current I become:

$$I = I_L - I_d - I_{sh} \qquad (1)$$

Where I_L is current generated by source, I_d is current flowing through diode and I_{sh} is shunt current.

An expression for load current is given by:

$$I = I_L - I_s\left(\exp\left(\frac{V + I\,Rs}{n\,K\,T/q}\right) - 1\right) - \frac{V + I\,Rs}{Rsh} \qquad (2)$$

For number of series and shunt arrangements Eq. (2) becomes:

$$I = NpI_L - NpI_s\left(\exp\left(\frac{V + \frac{Np}{Ns} I\,Rs}{n\,K\,T\frac{Ns}{q}}\right) - 1\right) - \frac{V + \frac{Np}{Ns} I\,Rs}{\frac{Np}{Ns} Rsh} \qquad (3)$$

III. EFFECT OF CRITICAL FACTORS ON SOLAR CHARACERISTICS

There are several factors that contribute to power loss such as radiation intensity, temperature and parasitic resistances (shunt and series) [3].

A. Effect of Radiation Intensity and Temperature:

Solar radiation is the main source of PV system to generate the electrical energy. An approximate expression for efficiency of solar system is stated below:

$$\text{efficiency} = \frac{nI_L\,FF\ln\left(\frac{I_L}{I_s}\right)\,K\,T/q}{P_{in}} \qquad (3)$$

Current produced by solar cell is linear function of solar isolations and voltage is logarithmic function of radiations.

From fig.2 it is observed that as radiation intensity decreases then current and voltage decease which in turn decreases the output power and efficiency of the system.

Fig.3 shows that as temperature of cell increases short circuit current rise because of decrease in band gap and voltage reduces due to recombination of carriers. With increase in temperature of cell, solar output power and efficiency of cell decreases.

B. Effect of Series and Shunt resistances:

Series and shunt resistances are account for energy loss due to heat dissipation. From fig.4, it is cleared that as series resistance increases and shunt resistance decreases then maximum point of curve changes to lower value. For lower value of Rsh voltage drop is more and for higher values of Rs current fall is more. The efficiency of solar system is higher for squarer curve, so values of Rs and Rsh should be such that curves are squarer in nature.

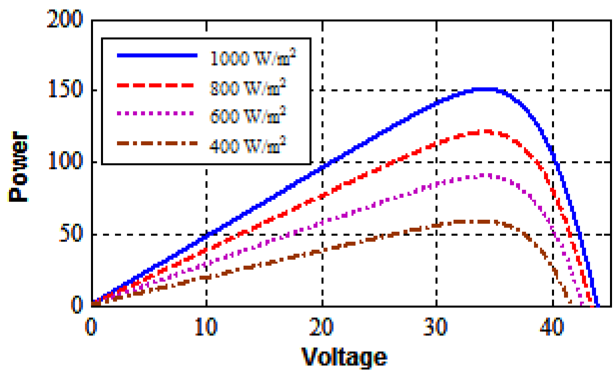

Fig.2. P-V curve for different radiations

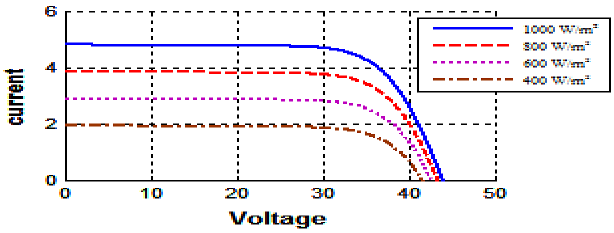

Fig.2. P-V and I-V curves for different radiations

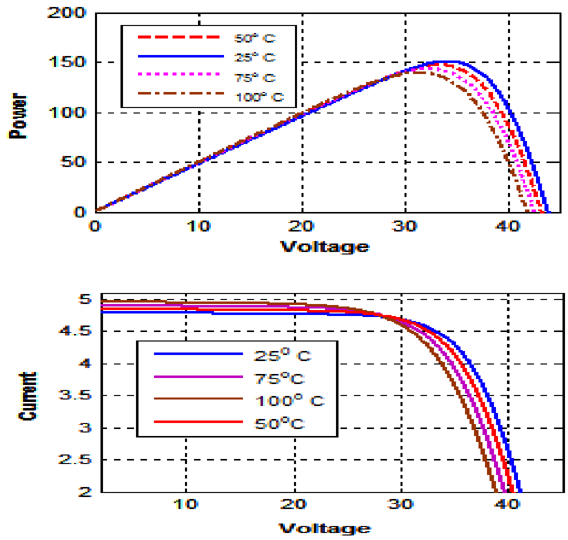

Fig.3. P-V and I-V curves for different temperatures

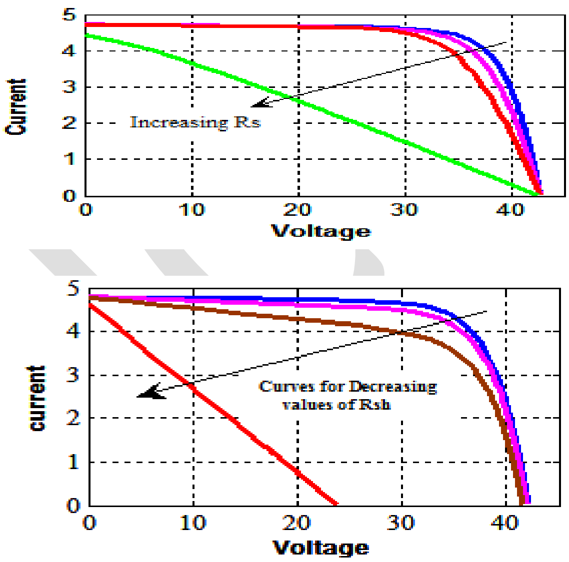

Fig.4. I-V curves for different Rs and Rsh

III. IMPACT OF PSC ON PV SYSTEM

There are many factors which are responsible for reduction of PV output power such as mismatch problem and shadow situations. Due to partial shading situation, a hot spot phenomenon happens in the module. When some cells in solar module don't receive solar radiations, then cells are in reverse bias condition and releases power as form of heat. If dissipated power exceeds the restriction then module gets destructed and acts as open circuit. To overcome this problem bypass diodes [13] is connected across module which prevents damage of module. Bypass diode is in reverse state under uniform solar insolations and becomes forward biased in case of partial shadow conditions.

Though bypass diode provides solution to hot spot phenomena in solar panel, it leads to another problem. The activation of bypass diode results in multiple peaks instead of single peak as shown in fig.5. So to draw optimum power, it is necessary to execute effective MPPT mechanism.

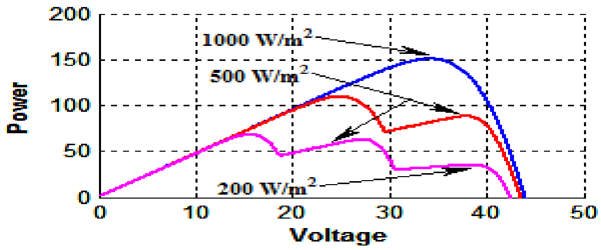

Fig.5. P-V curves under PSC

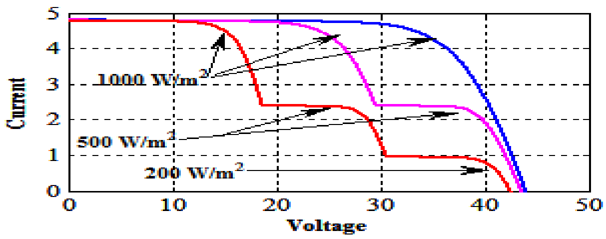

Fig.6. I-V curves under PSC

IV.OERVIEW OF PERTUB AND OBSERVE (PO) METHOD

Perturb and observe method has simple ease of implementation. It requires only one sensor for sensing PV voltage. In this method, perturbation in voltage is made. If change in voltage increase power then succeeding perturbation is carried out in that way and if increment in power decreases the voltage then following perturbation is in reverse direction. The process is continued until there is no change in power. The overall process is displayed though table I. This technique is also hill climbing as there is rise in power against voltage up to MPP and reduction in power beyond that point.

TABLE I

SUMMARY OF PO TECHNIQUE

Perturbation	**Change in power**	**Next perturbation**
Positive	Positive	Positive
Positive	Negative	Negative
Negative	Positive	Negative
Negative	Negative	Positive

The flowchart of PO algorithm is given below:

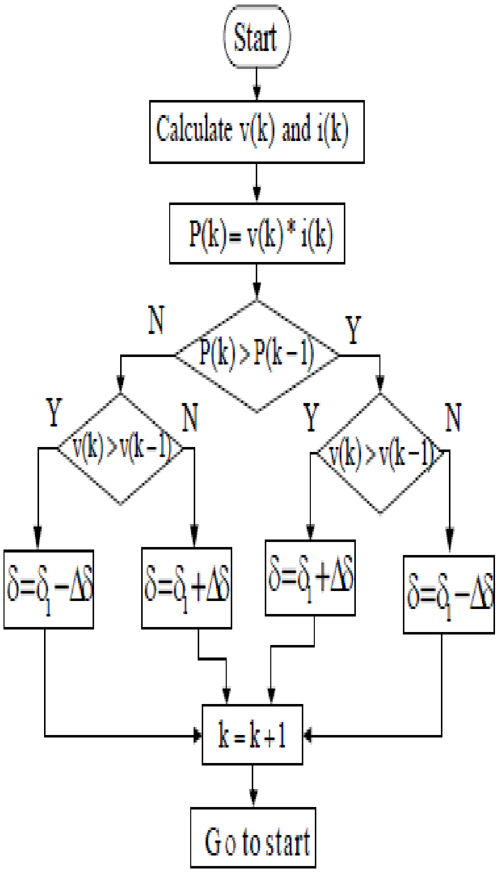

Fig.7. Process flow of PO technique

V. RESULTS AND DISCUSSIONS

The modeling of PV system with and without MPPT has been performed in MATLAB Simulink environment. The results of simulation and comparative analysis for PO and constant duty are given it table II

TABLE II

COMPARATIVE ANALYSIS

Algorithm	**Solar Radiations (W/m^2)**	**PV Power (Watt)**
P& O Algorithm	1000	61.25
	500	33
	500 on one module	42.5
D =0 .63	1000	58
	500	31
	500 on one module	38

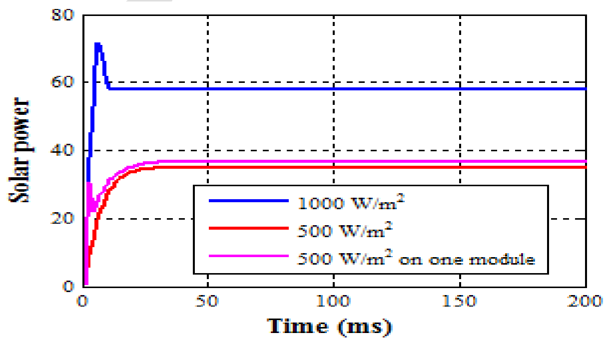

Fig.8.Solar power for constant duty cycle under different radiations

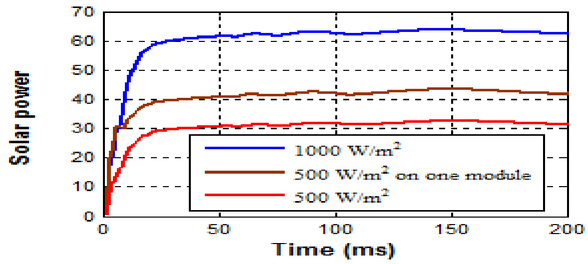

Fig. 9.Solar power with PO technique under different radiations

From results it is clear that, constant duty cycle is tracking less power under normal and changing conditions as compared to MPPT with PO technique. It shows that MPPT improves the performance of solar system in dynamic situations.

Results of PO algorithm also display their oscillatory nature in steady state but extracting intense power from solar system. The choice of algorithm depends on simplicity and cost effective solution.

VI. CONCLUSION

The intense use of energy from PV system is important under dynamic environmental conditions. The chief intension of paper is to present the influence of various parameters on solar characteristics. Finally, a comparison of MPPT algorithm with constant duty reveals that MPPT improves the efficiency of PV system.

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