IJDACR
ISSN: 2319-4863

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary research
Website: www.ijdacr.com (Volume 2, Issue 2, September 2013)

Maximum Power Point Tracking Using Perturb & Observe Algorithm and Compare With another Algorithm

UmaShankar Patel[1]
uspatel.eee2gmail.com[1]

Ms. Dhaneshwari Sahu[2]
dhaneshwari87@gmail.com[2]

Deepkiran Tirkey[3]
rinky_486@yahoo.co.in[3]

ME Scholar, POWER ELECTRONICS[1, 3]
Assistant Professor in Dept. of Electrical Engineering[2]
RITEE Raipur (CG)

Abstract – **Compared to the traditional energy resources, photovoltaic (PV) system that uses the solar energy to produce electricity considered as one of renewable energies has a great potential and developing increasingly fast compared to its counterparts of renewable energies. Such system can be either stand-alone or connected to utility grid. While, the disadvantage is that PV generation depended on weather conditions. The major problem with photovoltaic (PV) systems is the amount of electrical power generated by solar arrays depends up on a number of conditions (i.e. solar irradiance, temperature and angle of incident light etc.). In order to maximize the output of a PV system, continuously tracking the maximum power point (MPP) is necessary. In this thesis there is a implementation of maximum power point tracking (MPPTs) algorithm for a PV system so as to extract maximum power from the solar arrays during unfavorable condition, also the effect on V-I and V-P characteristics of PV array module due to change in irradiance and temperature are delineated. MPPT algorithm plays an important role in increasing the efficiency of system. A proposed MPPT algorithm is implemented in boost converter and compared with various MPPTs Algorithm.**

Keywords – **Photovoltaic, Maximum power point tracking (MPPT), Perturb and Observe Algorithm.**

I. INTRODUCTION

The photovoltaic system has a non-linear current-voltage and power-voltage characteristics that continuously varies with irradiation and temperature. In order to track the continuously varying maximum power point of the solar array the MPPT (maximum power point tracking) control technique plays an important role in the PV systems. The task of a maximum power point tracking (MPPT) network in a photovoltaic (PV) system is to continuously tune the system so that it draws maximum power from the solar array regardless of weather or load conditions. In recent years, a large number of techniques have been proposed for tracking the maximum power point (MPP).In this literature a MPPT method is proposed. Its implementation and performance is presented. Also comparison and analysis with the other conventional methods is presented.

Two existing drawbacks encountered while generating power from PV systems are: the first one that the efficiency of electric power generation is very low, especially under low radiation states, and the other drawback is the amount of electric power generated by solar arrays is always changing with weather conditions, i.e., irradiation and temperature**.** it can be observed that the output power characteristics of the PV system as function of irradiance and temperature is nonlinear and is crucially influenced by solar irradiation and temperature. The Maximum Power Point (MPP) of the PV array changes continuously; consequently the PV system's operating point must change to maximize the energy produced. Therefore a Maximum Power Point Tracking (MPPT) is an essential part of the PV system to ensure that system operates at the maximum power of the PV array.

Basic principle

According to the theory of maximum power transfer, the power delivered to the load is maximum when the source internal impedance matches the load impedance.

$$Z_S = Z_L^* \quad (1)$$

Thus, the impedance seen from the converter side needs to match the internal impedance of the solar array.

PV system with MPPT control

The operation of MPPT cannot be achieved unless a tunable matching network is used to interface the load to the PV array. The main constituent components of a PV system are power stage and controller as shown in fig.1The power stage is realized using switch mode DC-DC converters (boost, buck-boost), employing PWM control.The control parameter is duty ratio δ which is used for the tuning of the network for maximum extraction of power.

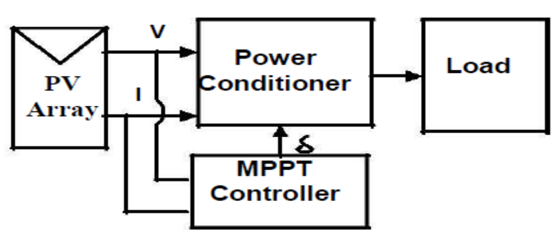

Fig.1 PV System with MPPT

IJDACR
ISSN: 2319-4863

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary research
Website: www.ijdacr.com (Volume 2, Issue 2, September 2013)

II. MPPT ALGORITHMS

(A) Hill-climbing techniques

Both P&O and INC algorithms are based on the “hill-climbing” principle, which consists of moving the operation point of the PV array in the direction in which power increases and .Hill-climbing techniques are the most popular MPPT methods due to their ease of implementation and good performance when the irradiation is constant . The advantages of both methods are the simplicity and low computational power they need. The shortcomings are also well-known: oscillations around the MPP and they can get lost and track the MPP in the wrong direction during rapidly changing atmospheric conditions. These drawbacks will be explained later.

Among these techniques, the P&O and the INC algorithms are the most common. These techniques have the advantage of an easy implementation but they also have drawbacks, as will be shown later. Other techniques based on different principles are fuzzy control, neural circuit, fractional open circuit voltage or short circuit current, current sweep, etc. Most of these methods yield a local maximum and some, like the fractional open circuit voltage or short circuit current, give an approximated MPP, not the exact one. In normal conditions the V-P curve has only one maximum, so it is not a problem. While, if the PV array is partially shaded, there are multiple maxima in these curves. According to order to relieve this problem, some algorithms have been implemented. These techniques differ in many aspects such as required sensors, cost, complexity,convergence speed range of effectiveness, correct tracking when irradiation and/or change in temperature, hardware needed for the implementation or popularity.

a) Perturb and Observe

The P&O algorithm is also called “hill-climbing”, while both names refer to the same algorithm depending on how it is implemented. Hill-climbing consist of a perturbation on the duty cycle of the power converter and P&O a perturbation in the operating voltage of the DC link between the PV array and the power converter. In the case of the Hill-climbing, perturb the duty cycle of the power converter implies modifying the voltage of the DC link between the PV array and the power converter, so both name refer to the same technique.

In this method, the sign of the last perturbation and the sign of the last increment in the power are used to decide what the next perturbation should be.on the left of the MPP incrementing the voltage increases the power whereas on the right decrementing the voltage increases the power.

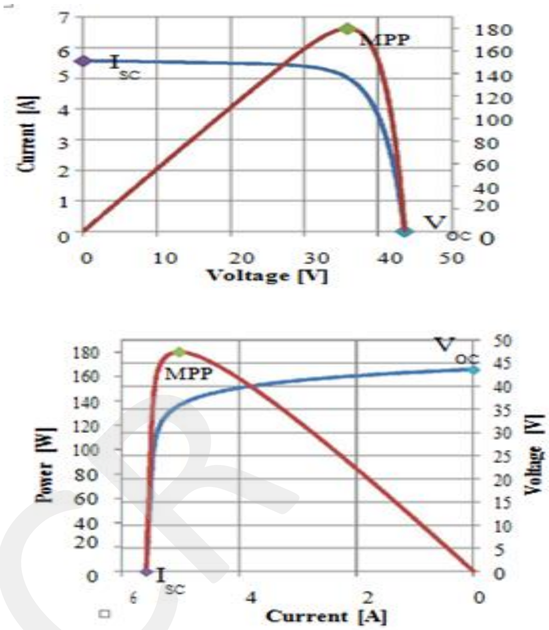

Figure 4-3- PV panel characteristic curves.

If there is an increment in the power, the perturbation should be kept in the same direction and if the power decreases, then the next perturbation should be in the opposite direction. Based on these facts, the algorithm is implemented [1]. The process is repeated until the MPP is reached. Then the operating point oscillates around theMPP. This problem is common also to the INC method, as was mention earlier. A scheme of the algorithm is shown in Figure 3

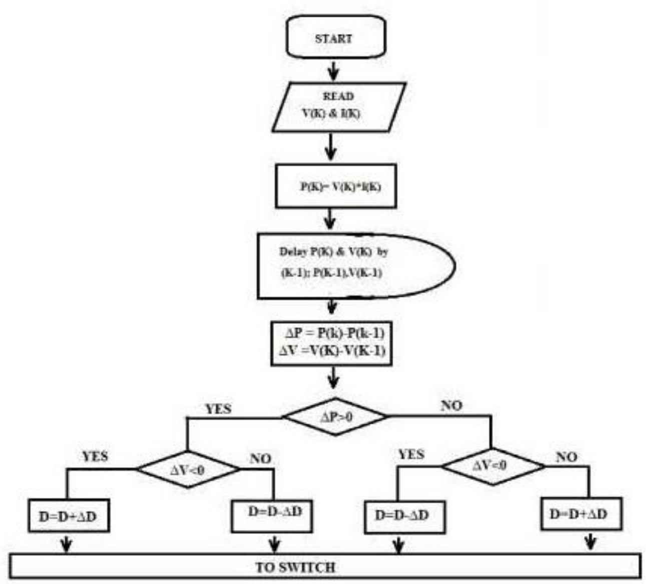

Fig. 3 Flowchart for P & O Algorithm

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary research
Website: www.ijdacr.com (Volume 2, Issue 2, September 2013)

b) Incremental conductance

The incremental conductance algorithm is based on the fact that the slope of the curve power vs. voltage (current) of the PV module is zero at the MPP, positive (negative) on the left of it and negative (positive) on the right

V P=0 (IP=0)   at the MPP V

P>0 (IP<0) on the left   V P< 0 (IP>0) on the right

By comparing the increment of the power vs. the increment of the voltage (current) between two consecutives samples, the change in the MPP voltage can be determined.

A scheme of the algorithm is shown in Figure .4

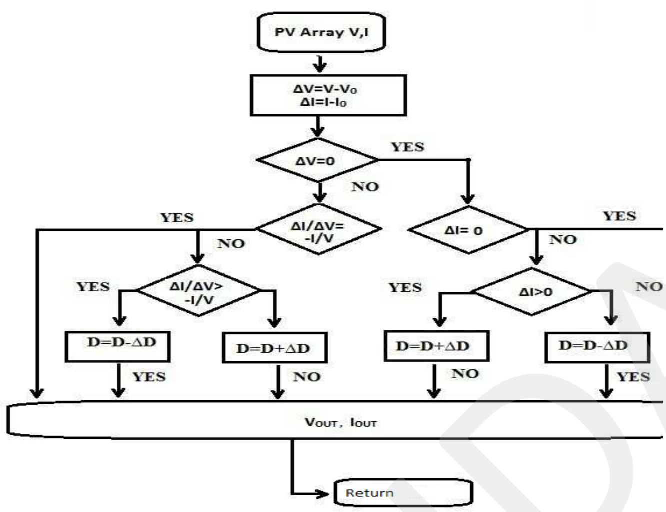

Figure. 4 Incremental Conductance algorithm

In both P&O and INC schemes, how fast the MPP is reached depends on the size of the increment of the reference voltage.

The drawbacks of these techniques are mainly two. The first and main one is that they can easily lose track of the MPP if the irradiation changes rapidly In case of step changes they track the MPP very well, because the change is instantaneous and the curve does not keep on changing. However, when the irradiation changes following a slope, the curve in which the algorithms are based changes continuously with the irradiation, as can be seen in Figure , so the changes in the voltage and current are not only due to the perturbation of the voltage. As a consequence it is not possiblealgorithms to determine whether the change in the power is due to its own voltage increment or due to the change in the irradiation.

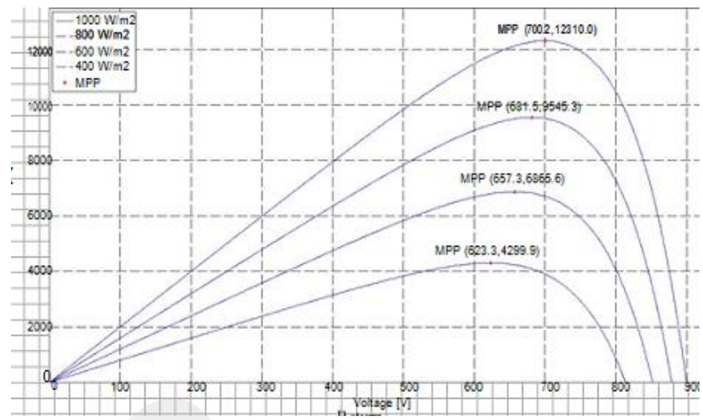

Figure.5 P-V curve depending on the irradiation

The other handicap of both methods is the oscillations of the voltage and current around the MPP in the steady state. This is due to the fact that the control is discrete and the voltage and current are not constantly at the MPP but oscillating around it. The size of the oscillations depends on the size of the rate of change of the reference voltage. The greater it is, the higher is the amplitude of the oscillations.

(B)   Fuzzy logic

Fuzzy logic control [2][3]generally consists of three stages: fuzzification, rule base lookup table and defuzzification. During fuzzification, numerical input variables are converted into linguistic variables based on a membership function. The inputs to a MPPT fuzzy logic controller are usually an error *E* and a change in error *E*. The user has the flexibility of choosing how to compute *E* and   *E*. In the defuzzification stage, the fuzzy logic controller output is converted from a linguistic variable to a numerical variable still using a membership function .This will provide analog signal that will control the power converter to the MPP.

$$E(k) = P(k) - P(k-1) \div V(k) - V(k-1) \qquad (2)$$

$$E(k) = E(k) - E(k-1) \qquad (3)$$

Fuzzy logic controllers have the advantages of working with imprecise inputs, not needing an accurate mathematical model, and handling nonlinearity but the basic drawback is high cost of implementation.

(C)Neural Network

Neural networks commonly have three layers: input, hidden, and output layers. The input variables can be PV array parameters like V_{OC} and I_{SC}, S and T, or any combination of these. The output is usually one or several reference signal(s) like a duty cycle signal used to drive the power .Since most PV arrays have different characteristics, a neural network has to be specifically trained for the PV array with which it will be used. It also has high cost of implementation.

(D)   Fractional open circuit voltage

IJDACR
ISSN: 2319-4863

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary research
Website: www.ijdacr.com (Volume 2, Issue 2, September 2013)

This method uses the approximately linear relationship between the MPP voltage (V_{MPP}) and the open circuit voltage (V_{OC}), which varies with the irradiance and temperature [1]:

$$V_{MPP} K_I V_{OC} \qquad (4)$$

Wherek_1 is a constant depending on the characteristics of the PV array and it has to be determined beforehand by determining the V_{MPP} and V_{OC} for different levels of irradiation and different temperatures. According to [1] the constant k_1 has been reported to be between 0.71 and 0.78.

Once the constant of proportionality, k_1, is known, the MPP voltage V_{MPP} can be determined periodically by measuring V_{OC}. To measure V_{OC} the power converter has to be shut down momentarily so in each measurement a loss of power occurs. Another problem of this method is that it is incapable of tracking the MPP under irradiation slopes, because the determination of V_{MPP} is not continuous. One more disadvantage is that the MPP reached is not the real one because the relationship is only an approximation.

To overcome these drawbacks, some solutions have been proposed, as is reported in [1]. For example, pilot cells can be used to obtain V_{OC}. They are solar cells that represent the PV array's cells and which are not used to produce electricity but to obtain characteristics parameters such as V_{OC} without interfering with the power converters. These pilot cells have to be carefully chosen and placed to represent the PV array characteristics and the irradiation conditions. One drawback of using these pilot cells is that the cost of the system is increased.Depending on the application, this technique can be used because it is very easy to mplement and it is cheap - it does not require DSP or microcontroller control and just one voltage sensor is used [1]. However, according to [8] this method is not valid under partial shading of the PV array because then the constant k_1 changes. To update voltage sweep is proposed though this increases the complexity of the system, the cost increases and there are more power losses during the sweep.

(E) Fractional short circuit current

Just like in the fractional open circuit voltage method, there is a relationship, under varying atmospheric conditions, between the short circuit current I_{SC} and the MPP current, I_{MPP}, as is shown by:$I_{MPP} K_2 I_{SC}$

The coefficient of proportionality k_2 has to be determined according to each PV array, as in the previous method happened with k_1. According to [1]the constant k_2 has been reported to be between 0.78 and 0.92.

Measuring the short circuit current while the system is operating is a problem. It usually requires adding an additional switch to the power converter to periodically short the PV array and measure I_{SC}. In [4]I_{SC} is measured by shorting the PV array with an additional field-effect transistor added between the PV array and the DC link capacitor.

One other option is shown in [5] a boost converter is used and the switch of the converter is used to short the PV array. Short circuiting the PV array also leads to a loss of power. One last handicap is that the real MPP is not reached because the proportional relationship is an approximation. Furthermore, $k_2$changes if the PV array is partially shaded, which happens due to shades or surface contamination. To overcome this problem, [4] proposes an online tuning of k_2 and [6] a periodical sweep of the PV voltage from open circuit to short circuit to update k_2 and guarantee that the real MPP is reached in the presence of multiple maxima which obviously increases the complexity of the system. Most of the literature using this MPPT technique uses a DSP as controller [1].

LIMITATIONS OF PERTURB & OBSERVE ALGORITHM

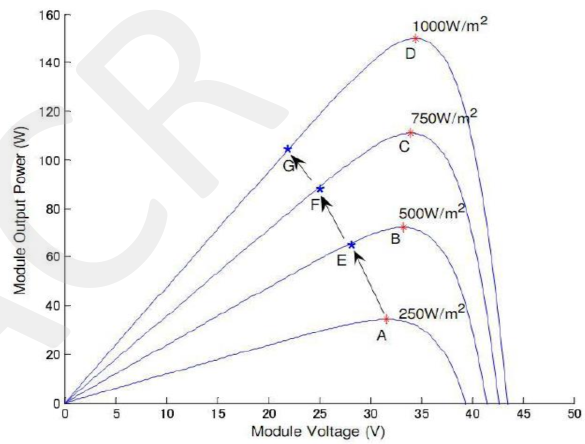

Figure.6 P-V curve depending on the irradiation.

In a situation where the irradiance changes rapidly, the MPP also moves on the right hand side of the curve. The algorithm takes it as a change due to perturbation and in the next iteration it changes the direction of perturbation and hence goes away from the MPP as shown in the figure 6.

However, in this algorithm we use only one sensor, that is the voltage sensor, to sense the PV array voltage and so the cost of implementation is less and hence easy to implement.The time complexity of this algorithm is very less but on reaching very close to the MPP it doesn't stop at the MPP and keeps on perturbing in both the directions. When this happens the algorithm has reached very close to the MPP and we can set an appropriate error limit or can use a wait function which ends up increasing the time complexity of the algorithm.

Proposed Method

The proposed method solves the problem caused in hill-climbing process from those caused by irradiance changing by decoupling the PV power fluctuations. This method adds an irradiance-changing estimate process in every perturb process to measure the amount of power change caused by the change of atmospheric condition, and then compensates it in the following perturb process. There are two operation modes named: Mode 1 for estimate process; and Mode 2 for perturb process as shown

IJDACR
ISSN: 2319-4863

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary research
Website: www.ijdacr.com (Volume 2, Issue 2, September 2013)

in fig.4.8.
Mode 1 measures the power variation due to the previous voltage change and atmosphere change, and keeps the PV voltage constant for the next control period.
Mode 2 measures the power variation and determines the new PV voltage based on the present and the previous power variations.

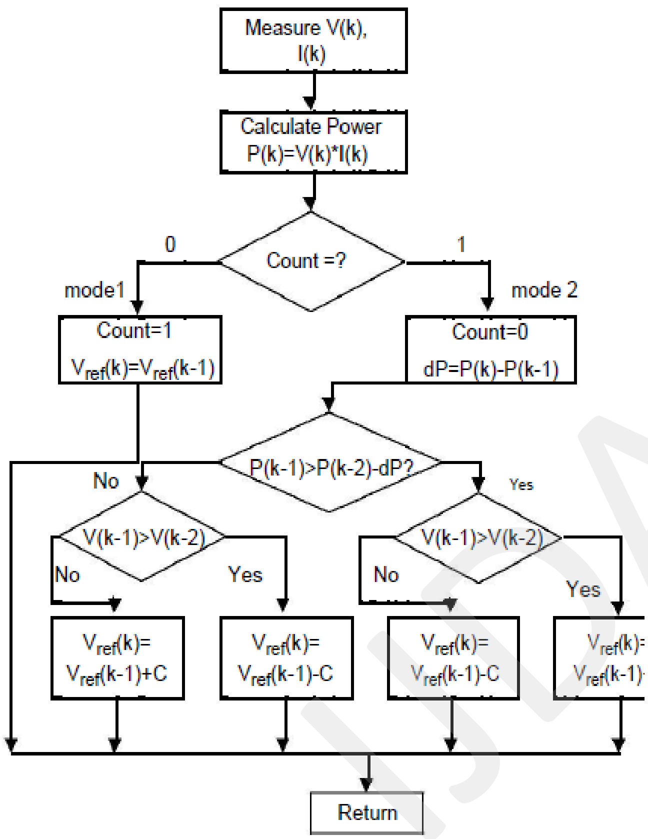

Fig. 7 Proposed method

Table 1: Characteristics of different MPPT techniques

MPPT techniques	Convergence speed	Implemen-tation complexity	Periodic tuning	Sensed Para-meters
Perturb & observe	varies	Low	No	voltage
Incremental conductance	varies	Medium	No	Voltage , current
Fractional Voc	Medium	Low	Yes	voltage
Fractional Ioc	Medium	Medium	Yes	current
Fuzzy logic control	Fast	High	Yes	varies
Neural network	Fast	High	Yes	varies

III. SIMULINK MODEL

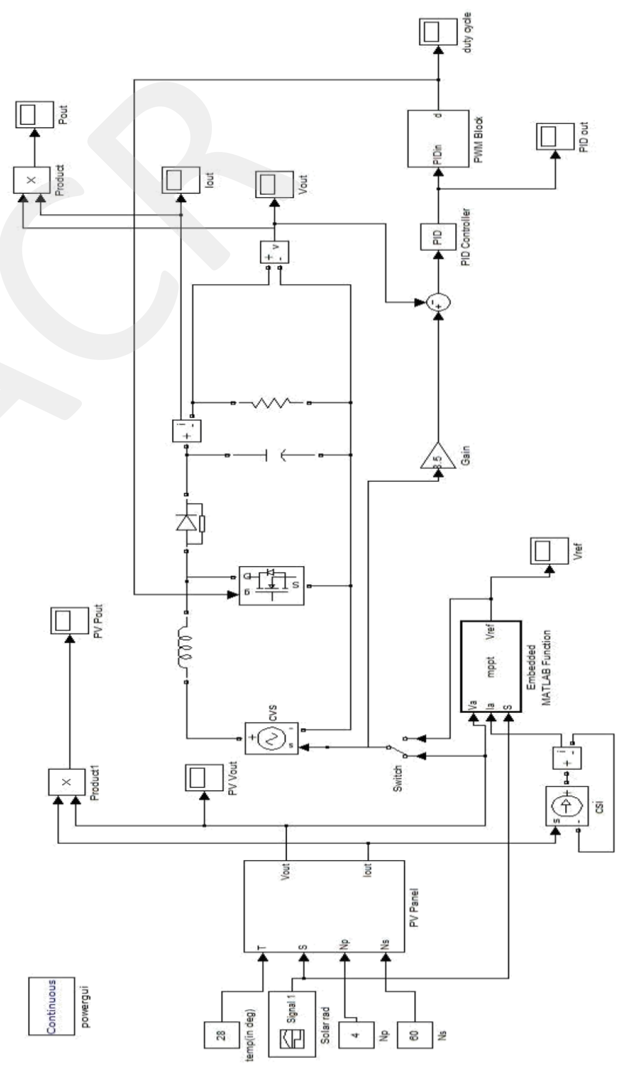

Fig. 8 SIMULINK™ Model of MPPT system using P&O algorithm

IJDACR
ISSN: 2319-4863

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary research
Website: www.ijdacr.com (Volume 2, Issue 2, September 2013)

IV. Simulation Result

Case 1: RUNNING THE SYSTEM WITHOUT MPPT

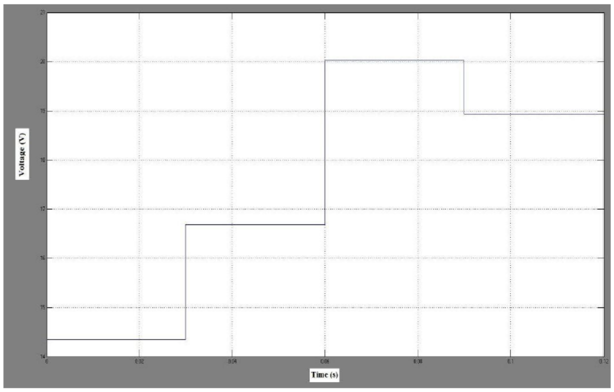

Fig 9 Plot of O/P voltage of PV panel v/s time without MPPT

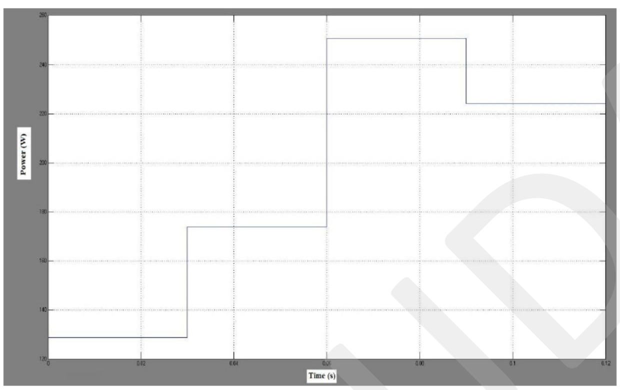

Fig.10 Plot of Power O/P of PV panel v/s time without MPPT

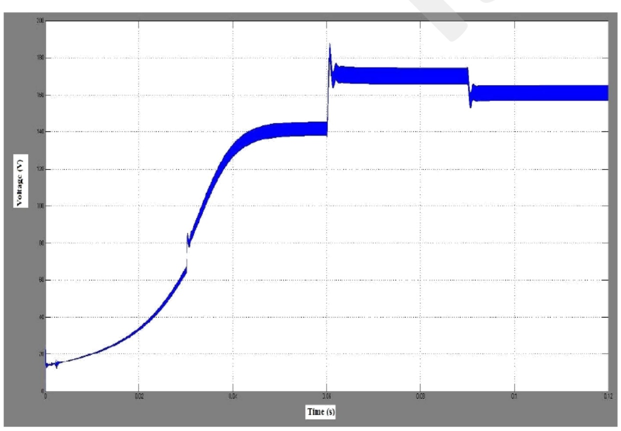

Fig.11 Plot of O/P Voltage at load side v/s time without MPPT

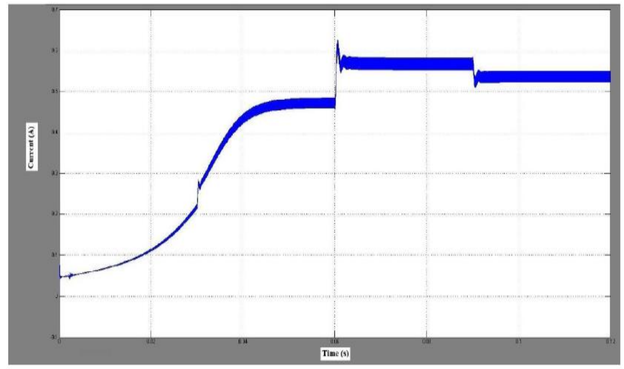

Fig.12 Plot of Output current at load side v/s time without MPPT

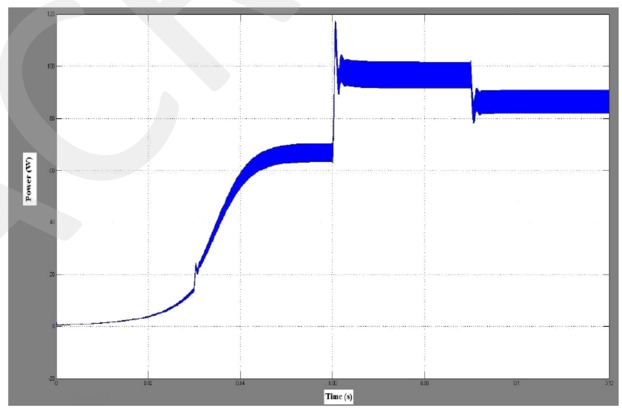

Fig.13 Plot of Power obtained at load side v/s time without MPPT

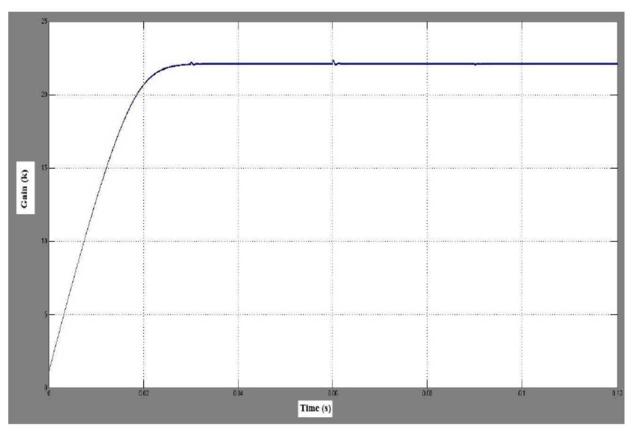

Fig. 14 Plot of PI Control gain v/s time without MPPT

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary research
Website: www.ijdacr.com (Volume 2, Issue 2, September 2013)

Case 2: Running the system with MPPT

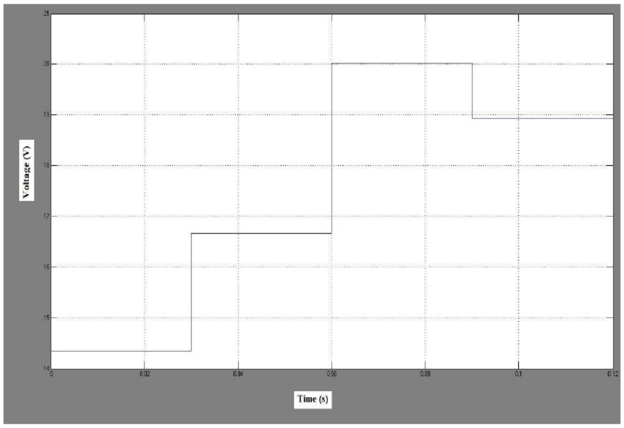

Fig.15Plot of O/P voltage of PV panel v/s time with MPPT

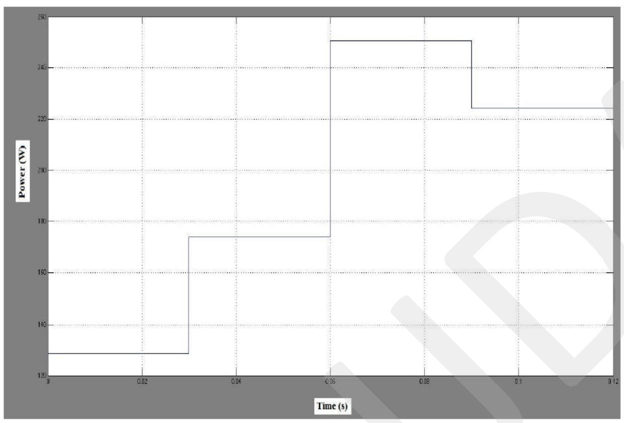

Fig.16 Plot of Power output of PV panel v/s time with MPPT

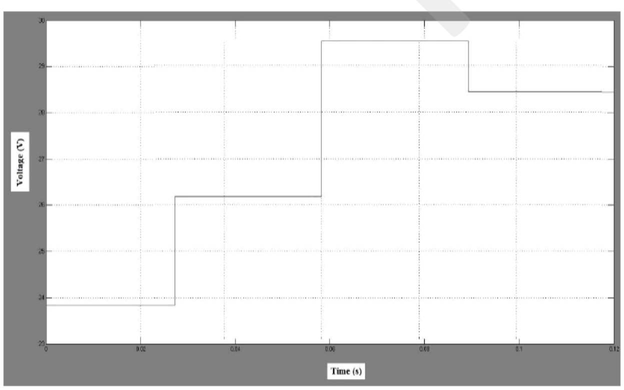

Fig 17 Plot of cal MPPT V_{ref} voltage v/s time with MPPT

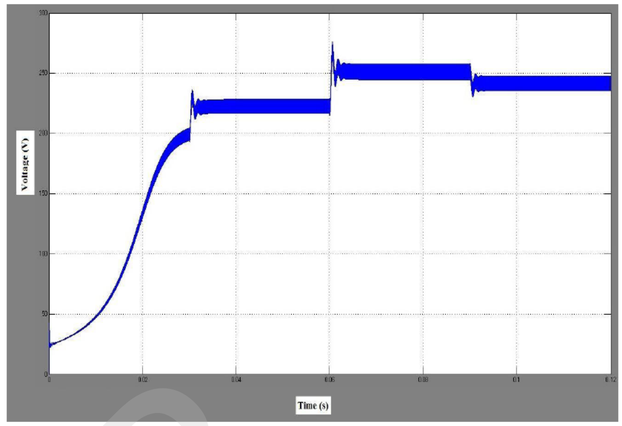

Fig. 18 Plot of O/P Voltage at load side v/s time with MPPT

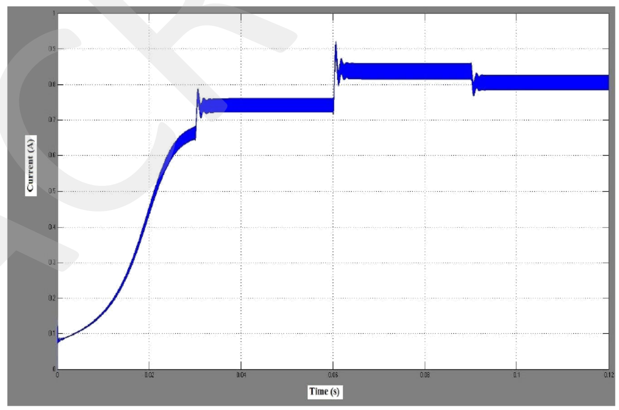

Fig. 19 Plot of O/P current at load side v/s time with MPPT

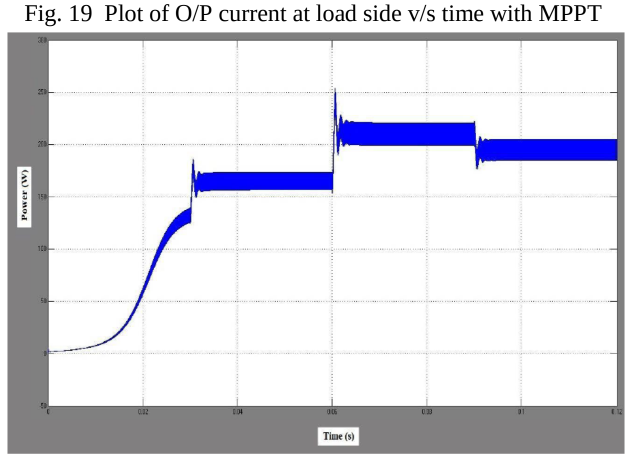

Fig.20 Plot of Power obtained at load side v/s time with MPPT

IJDACR
ISSN: 2319-4863

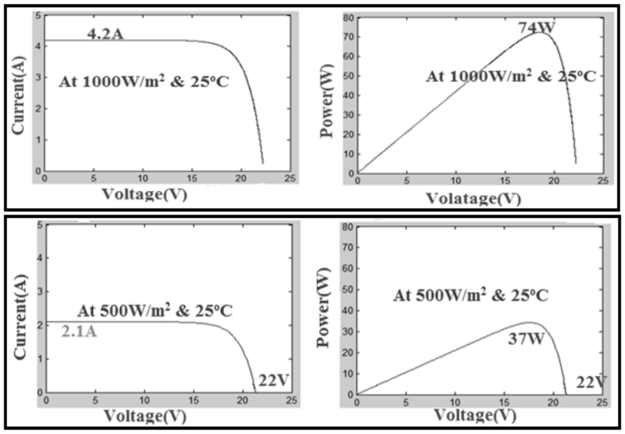

Fig. 21 V – I, V-P Characterstic under different Radiation (MATLAB Simulation results)

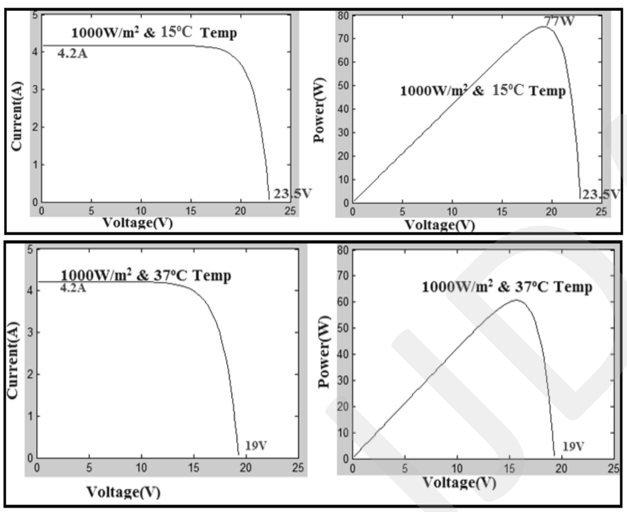

Fig. 22 V – I, V – P Characterstics under different Temperature (MATLAB Simulation result)

V. Conclusion

This paper presented one of the most important requirements of Photovoltaic system, Maximum Power Point Tracking system. Need, Importance, basic principles of operation of MPPT arediscussed. Also discussed various conventional methods for MPPT and proposed a method which is a modificationof Perturb & Observe algorithm. Implementation of proposed MPPT method in Boost converter, and the simulation results (V-I ,V-P, Load Characteristics) for different temperature and irradiation are presented and comparison of results (without MPPT & with MPPT controller) which shows 126% of increase in efficiency of PV module.

REFRENCES

[1] V. Di Dio , D. La Cascia, R. Miceli .”A Mathematical Model to Determine the Electrical Energy Production in Photovoltaic Fields Under Mismatch Effect,” 2009 IEEE, pp 46-51.

[2] S. Jain and V. Agarwal,” Comparison of the performance of maximum power point tracking schemes applied to single-stage grid-connected photovoltaic systems,” IET Electr. Power Appl., 2007, 1, (5), pp. 753–762.

[3]Mario Fortunato, Alessandro Giustiniani, Giovanni Petrone, Giovanni Spagnuolo Maximum Power Point Tracking in a One-Cycle-Controlled Single-Stage Photovoltaic Inverter,” IEEE Transactions on Industrial Electronics,VOL.55, NO. 7, JULY 2008.

[4] M. G. Villalva, et al., "Comprehensive Approach to Modeling and Simulation of Photovoltaic Arrays," IEEE Transactions on Power Electronics, vol. 24, pp. 1998.

[5] Roberto Faranda,SoniaLeva “Energy comparison of MPPT techniques for PV Systems **“**Wseas Transactions on Power Systems.

[6]TrishanEsram Patrick L. Chapman“Comparison of Photovoltaic Array Maximum PowerPoint Tracking Techniques” IEEE Transactions on Energy Conversion,vol.22 No.2 2007.

[7]Dave Freeman ,” Introduction to Photovoltaic Systems Maximum Power Point Tracking,” Texas Instruments Application Report .

[8] Doo-Yong Jung, Young-HyokJi, Sang-Hoon Park, Yong-Chae Jung and Chung-Yuen Won ,”Interleaved Soft Switching Boost Converter for Photovoltaic Power Generation System”, 2010 IEEE.

[9] DimosthenisPeftitsis, Georgios Adamidis and AnastasiosBalouktsis ,”An investigation of new control method for MPPT in PV array using DC – DC buck – boost converter”.

[10] A.Durgadevi,S. Arulselvi and S.P.Natarajan ,”Study and Implementation of Maximum Power Point Tracking (MPPT) Algorithm for Photovoltaic Systems.

[11] ChihchiangHua and ChihmingShen,” Control of DC/DC Converters for Solar Energy System with Maximum Power Tracking”.

[12] K.H. Hussein,I. Muta,T. Hoshino ,M.Osakada, “Maximum photovoltaic power tracking: an algorithm for rapidly changing atmospheric conditions”, Vol. 142, No. J, January 1995.

[13] Subiyanto, A Mohamed, M ,A Hannan, ”Maximum Power Point Tracking in Grid Connected PV System Using A Novel Fuzzy Logic Controller” at Student Conference on Research and Development (SCOReD 2009), pg 349-352.

[14] T.Shanthi , N.AmmasaiGounden,”Power Electronic Interface for Grid-Connected PV array using Boost Converter and Line-Commutated Inverter with MPPT,” at International Conference on Intelligent dvanced Systems 2007,pp 882-886.