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# ANALYSIS OF P&O MPPT ALGORITHM FOR PV SYSTEM

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## ABSTRACT

Among the differnt Non-conversion energy resources, the photovoltaic (PV) system that is uses the solar energy to produce electricity it is one of renewable energy source. It has a great potential and developing fast compared to other renewable energies. Photovoltaic system can be either stand-alone or connected to utility grid. The disadvantage of this PV generation depended on atmospheric conditions such as solar irradiance and temperature. Maximum power point trackers (MPPTs) play an important role in photovoltaic (PV) power systems because it is maximize the output power of a PV system for a given atmospheric conditions so it is maximize the PV array efficiency. MPPT is maintaining operating point at the maximum power point using a different MPPT algorithm. MPPT can minimize the overall photovoltaic (PV) system cost. For maximize the output of a PV system, continuously tracking the maximum power point (MPP) is necessary.

**KEYWORDS:** Maximum Power Point Tracking (MPPT), Power Electronics, MPPT Efficiency, Photovoltaic (PV), Direct Current (DC), DC To DC Converter

## I. INTRODUCTION

The photovoltaic (PV) system has a non-linear current-voltage (I-V) and power-voltage (P-V) characteristics. It is continuously varies with atmospheric condition like radiation and temperature. A maximum power point tracking (MPPT) is draws maximum power from the solar array at changing the weather condition. Now a days a number of MPPT techniques have been develop for the tracking the maximum power point (MPP). Two drawbacks are considered like the generating power from PV systems, it has the efficiency is very low under low radiation condition and second one is the electric power generated by solar arrays is always changing with changing weather conditions i.e. irradiation and temperature [2]**.** Number of maximum power point tracking (MPPT) algorithms are used for the maximize the output of the PV system. There are some popular method are hill climbing method, perturbation and observation method(P&O), Incremental conductance method (INC), constant voltage method(CV), constant current method(CI), modified hill climbing method, β method, system oscillation method and the, Ripple correlation method [5]. This paper is concerned only with the electrical tracking schemes for maximum power achieve from a PV array using Perturbation and observation and incremental conduction method. Photovoltaic (PV) systems produce directly DC electricity when sunlight falls on the PV array. Photovoltaic (PV) generation has many advantages such as less any fuel costs, not produce pollution, it requiring little maintenance, and PV system have more others advantages.

## II. BASIC PRINCIPLE OF MPPT

According to the theory of maximum power transfer, the power delivered from source to the load is maximum

when the source internal impedance matches with the load impedance.

$Z_S=Z_L$

So, the impedance from the converter side needs to match the internal impedance of the solar array [2]. At that time the operating point is at the Maximum power point (MPP) so maximum power is obtain from the photovoltaic array.

## III. SYSTEM CONFIGURATION

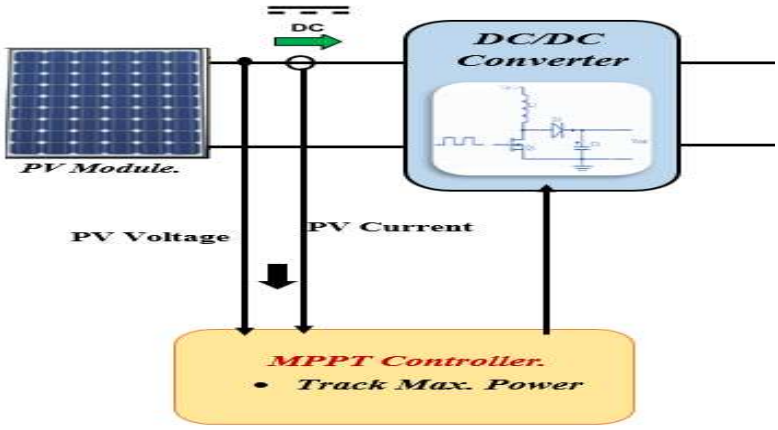
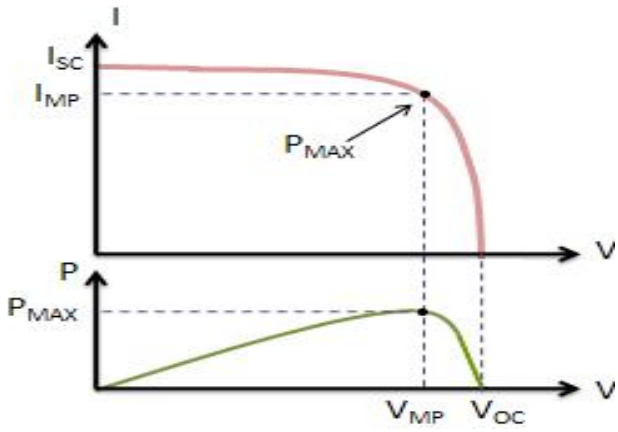



**Figure 1: The Block Diagram of Solar System**

The PV array produce the electrical energy from the solar energy directly and its output is changes by changing the atmospheric condition i.e. temperature and irradiance. The figure 1 shows a PV system where the PV array feeds to the DC-DC converter. The output of the converter is giving a constant DC voltage. This kind of converter with constant output voltage is used in battery charging systems or in systems with a second conversion stage (DC-AC). The output power of the PV array is regulated by the converter. The MPPT block observes the power at the terminals of the array and controls the input voltage or the input current of the converter forcing the PV array to operate at the maximum power point [13].

## IV. NEED OF MPPT

- Efficiency of Solar PV Cells It is very low about (10% to 20% commercially) so by using MPPT, it will increase the overall efficiency of the PV system.( PVcell, Converter, Inverter)
- In general the operating point is not at the MPP. So different algorithm are used to achieve the maximum power.
- The MPPT has non linear characteristic of solar PV cell. It has one maximum power point (MPP) depend upon irradiation and temperature. So it is necessary to track continuously the MPP in order to maximize the power output from a PV system.




## V. CONSTRUCTION OF P-V AND I-V CHARECTRISTICS

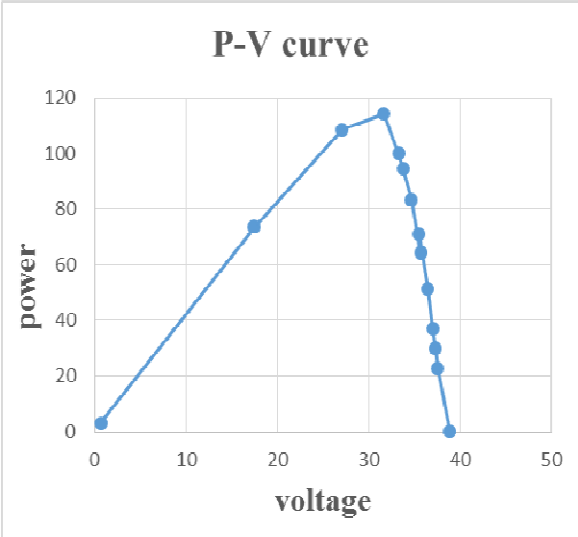
**PARAMETER SPECIFICATIONS OF 74W PV MODULE**

| Parameters | Specifications |
|---|---|
| Maximum output power | 74W |
| Voltage at maximum power | 17.0 V |
| Current at maximum power | 4.4 A |
| Open circuit voltage Voc | 21.8 V |
| Short circuit current Isc | 4.9 A |
| Minimum Bypass Diode | 6 A |
| Maximum Series Fuse | 15 A |

## V.1. CONSTRUCTION OF P-V CHARECTRISTICS

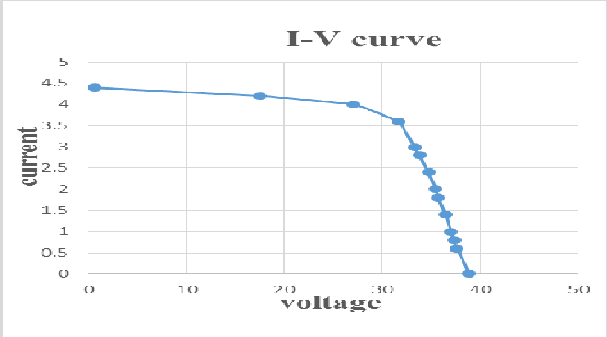
| V | P |
|---|---|
| **38.9** | **0** |
| **37.6** | 22.56 |
| **37.3** | 29.84 |
| **37** | 37 |
| **36.5** | 51.1 |
| **35.5** | 71 |
| **35.7** | 64.2 |

| | |
|---|---|
| **34.7** | 83.28 |
| **33.8** | 94.64 |
| **33.3** | 99.9 |
| **31.7** | 114.12 |
| **27.1** | 108.4 |
| **17.5** | 73.5 |
| **0.7** | 3.08 |




## V.2. CONSTRUCTION OF I-V CHARECTRISTICS

| V | I |
|---|---|
| **38.9** | 0 |
| **37.6** | 0.6 |
| **37.3** | 0.8 |
| **37** | 1 |
| **36.5** | 1.4 |
| **35.7** | 1.8 |
| **35.5** | 2 |
| **34.7** | 2.4 |
| **33.8** | 2.8 |
| **33.3** | 3 |
| **31.7** | 3.6 |
| **27.1** | 4 |
| **17.5** | 4.2 |
| **0.7** | 4.4 |



## VI. MATHEMATICAL MODELING OF PHOTOVOLTAIC CELL

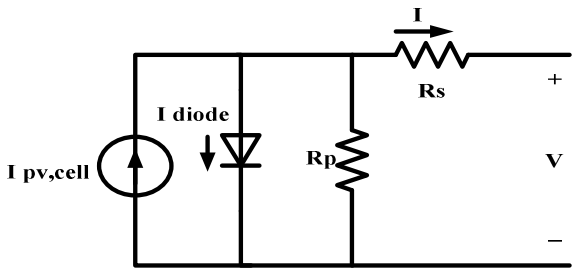



**Figure 2: Equivalent Circuit of a Photovoltaic Cell**

The solar cells directly convert the solar energy to the electrical energy. Solar cells consist of a p-n junction in thin wafer or layer of semiconductors. The simplest equivalent circuit of a solar cell is shown in figure 2. A current source is connected parallel with a diode as shown in figure 2. The output of the current source is directly proportional to the light falling on the cell. So the process of modeling the PV solar cell can be developed by below equation,

$$I = I_{pv,cell} - I_{diode} = I_{pv,cell} - I_{0,cell}\left[exp\left(\frac{q * V}{\alpha * k * T}\right) - 1\right]$$

Where:

IPV, cell =Current generated by the falling light.

Idiode = Shockley diode current.

I0,cell =Reverse saturation current of the diode.

$q$ = Electron charge. [1.60217646 $*10^{-19}$C].

$k$= Boltzmann constant. [1.3806503$*10^{-23}$J/K].

$T$ =Temperature of the p-n junction.

α = diode ideality constant

In a maximum power point tracker (MPPT) a power electronic DC-DC converter inserted between the PV arrays and its load to achieve maximum output power of PV system. By using different MPPT algorithm, the operating point of the PV module always operates at its maximum power point. Different algorithms are used and a number of DC-DC converter topologies are possible to use for maximize the output of the PV system. The PSIM model is developed for achieving maximum power from the actual power using P&O and INC algorithm in this paper.

## VII. MPPT USING P&O ALGORITHM

In the P & O algorithm continuously taking increments or decrements the reference voltage depending on the value of the previously taking power sample. The P&O algorithm is the simplest method and cost of implementation is less and so it is easy to implement. The disadvantages are that the operating point is oscillating around the MPP.

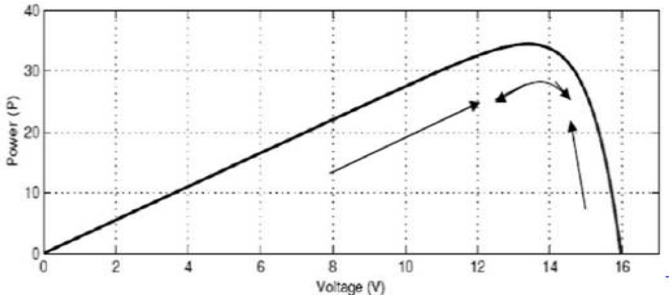



**Figure 5: Perturb and Observe Algorithm**

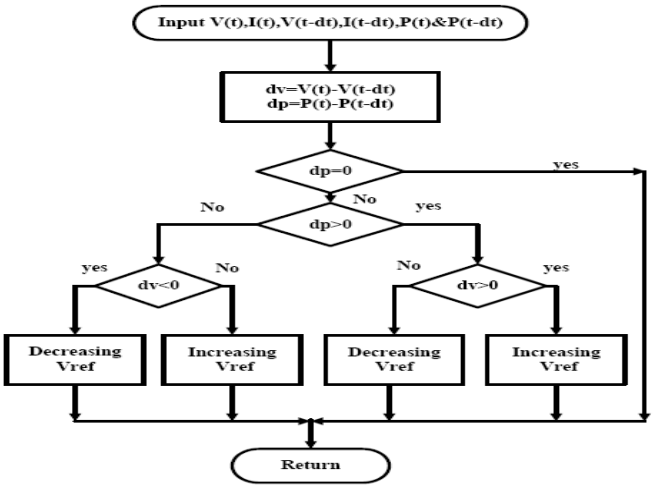



**Figure 6: Flow chart for P&O Algorithm**

The flow chart For P&O Algorithm first of all measures the actual voltage and current from that the product of voltage and current give the actual power of PV System. Then it will check condition what whether dp=0 or not. If this condition is satisfied then operating point is at MPP. If it is not satisfy than check another condition that dp>0, If this condition is satisfied than checkout that dv>0, if it is satisfied than it indicate that operating point is at the left side of the MPP. If dv>0 condition is not satisfied than it indicate that operating point is at the right side of the MPP. This process is continuously repeated until it reaches at MPP. So there is always a compromise between the increments and the sampling rate in the P&O Method.

## VIII. SIMULATION OF MPPT USING P&O ALGORITHAM

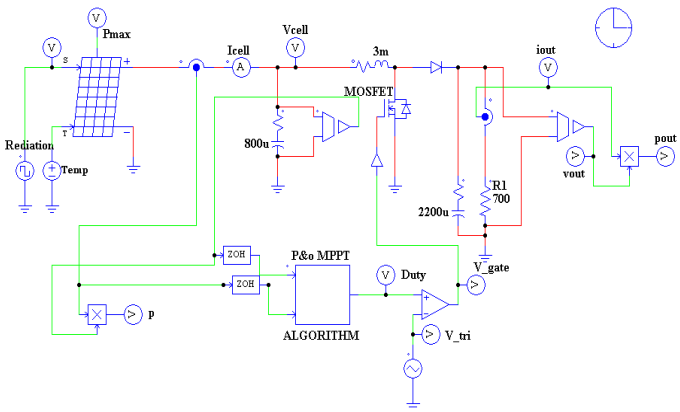



**Figure 7: Simulation of PV Module with P&O Algorithm Using 'C' Code**

**Table 1**

| Parameter of Circuit | Values |
|---|---|
| Load resister | $R_1$=700 Ω |
| Filter Capacitor | $C_1$=800 micro F |
| Filter Capacitor of boost converter | $C_2$=2200 micro F |
| Inductor of boost converter | $L_1$=3 mH |

**Table 2**

| Parameter of PV Module | Values |
|---|---|
| Number of cell (Ns) | 36 |
| Standard light intensity( So) | 1000 W/m$^2$ |
| Ref.Temperature( Tref) | 25°C |
| Series Resistance( Rs) | 0.008 Ω |
| Shunt Resistance( Rsh) | 1000 Ω |
| Short circuit current (Iso) | 2.16e$^{-8}$A |
| Band energy( Eg) | 1.12 eV |
| Ideality factor( A) | 1.2 |

## IX. RESULTS

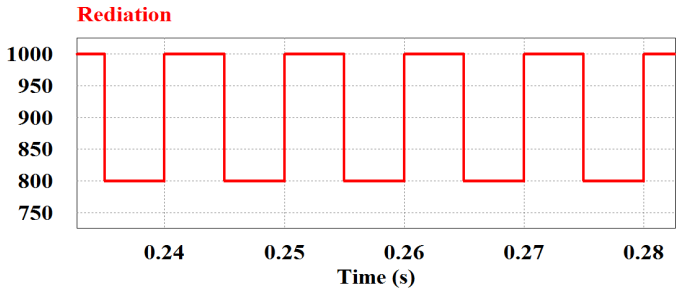



**Figure 8: (A) Radiation from 1000 W/M$^2$ to 800 W/M$^2$**

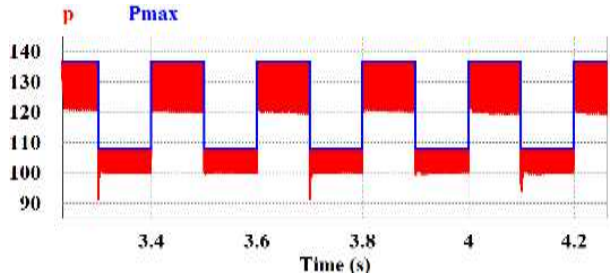



**Figure 8: (B) Maximum Output Power of Solar Module (Pmax=420.0953 W) and Actual Output Power of Solar Module (P=404.4389W)**

Radiation and temperature are the input of PV module. In the simulation radiation is change from 1000W/m$^2$ to 800W/m$^2$ and temperature is at 25°C. Due to this change in radiation the maximum power of PV module will changing from 48W to 60W. Figure 8(b) shows that due to P&O algorithm the actual power (P) of a PV module track the maximum power (P max).

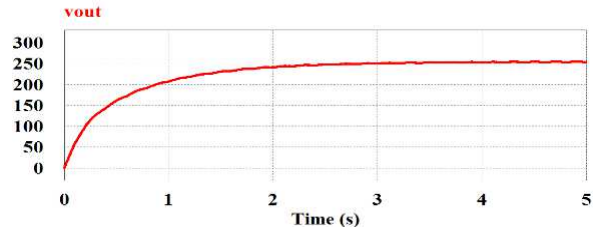



**Figure 9: (A) Voltage Output of Boost Converter (Vout=618.5289V)**

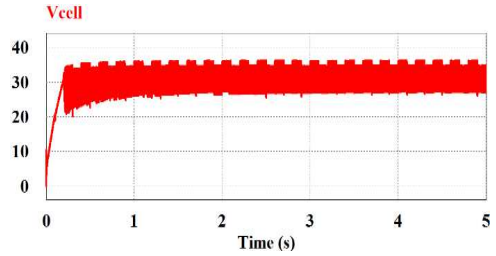



**Figure 9: (B) Voltage Output of PV Module (VCell=76.9158V)**

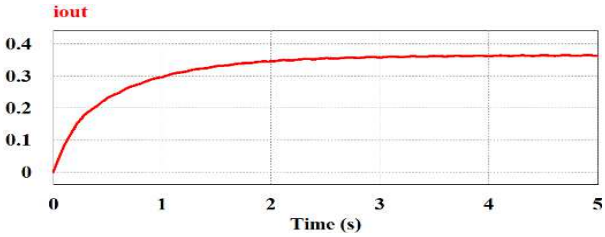



**Figure 9: (C) Current Output of the Boost Converter (Iout=2.06176 A)**

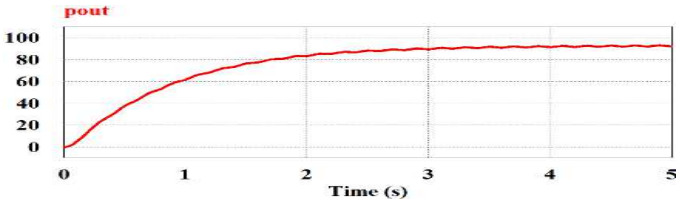



**Figure 9: (D) Power Output of Boost Converter (Pout=1359.8029W)**

Figure.-9(a),(b)shows the output of boost converter(V_boost) and output of PV module (Vcell). The boost converter boost the output voltage of PV module by 78%.the actual power (P) is boost by 73%.

## X. CONCLUSIONS

This paper described the simulation and analysis of the P&O algorithm discussed in the literature. The results are given on the basis of maximum power point tracking. The simulation is done for a PV system to obtain maximum power with varying radiation. The result shows that the maximum power is track by actual power(P) using P&O algorithm.

## REFERENCES

1. D. P. Hohm and M. E. Ropp, “Comparative Study of Maximum Power Point Tracking Algorithms,” Prog. Photovolt: Res. Appl. 2003; 11:47–62 pp.459.
2. UmaShankar Patel Ms. Dhaneshwari Sahu Deepkiran Tirkey,” Maximum Power Point Tracking Using Perturb & Observe Algorithm and Compare With another Algorithm,” Volume 2, Issue 2, September 2013 pp:2319-4863.

3. Trishan Esram, and Patrick L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques," IEEE Transactions On Energy -Conversion, Vol. 22, No. 2, June 2007 pp:439-449.
4. Weidong Xiao, William G. Dunford, "A Modified Adaptive Hill Climbing MPPT Method for Photovoltaic Power Systems," 2004 35th Annual IEEE Power Electronics Specialisrs Conference.
5. 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
6. Geoff Walker, "Evaluating MPPT Converter Topologies Using A MATLAB PV Model,"
7. Bikram Das,Anindita Jamatia, Abanishwar Chakraborti Prabir Rn.Kasari & Manik Bhowmik, "New Perturb And Observe MPPT Algorithm And Its Validation Using Data From PV Module" Vol. 4, Issue 1, pp. 579-591
8. Ahmed M. Atallah, Almoataz Y. Abdelaziz, and Raihan S. Jumaah, "Implementation Of Perturb And Observe MPPT Of PV System With Direct Control Method Using Buck And Buck boost Converters," Vol. 1, No. 1, February 2014
9. Hairul Nissah Zainudin,Saad Mekhilef, "Comparison Study of Maximum Power Point Tracker Techniques for PV Systems," December 19-21, 2010, Paper ID 278. pp: 750-755
10. Trishan Esram, and Patrick L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques," VOL. 22, NO. 2, JUNE 2007 pp:439-449
11. Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo, and Massimo Vitelli, "Optimization of Perturb and Observe Maximum Power Point Tracking Method" Vol. 20, NO. 4, JULY 2005 pp:963-973
12. Steven L. Brunton, Clarence W. Rowley, Sanjeev R. Kulkarni, and Charles Clarkson, "Maximum Power Point Tracking For Photovoltaic Optimization Using Extremum Seeking"
13. T.Chaitanya,Ch.Saibabu, J.Surya Kumari, " Modeling and Simulation of PV Array and its Performance Enhancement Using MPPT (P&O) Technique" Vol 1(1),September-October 2011 pp: 9-16
14. Samer Alsadi, Basim Alsayid, "Maximum Power Point Tracking Simulation for Photovoltaic Systems Using Perturb and Observe Algorithm" Volume 2, Issue 6, December 2012 pp: 80-85
15. Ch. Kalpana, Ch. Sai Babu, J. Surya Kumari, "Design and Implementation of different MPPT Algorithms for PV System" Volume 2, Issue 10, October 2013 pp: 1926-1933
16. A. Yafaoui., B. Wu and R. Cheung, "Implementation of Maximum Power Point Tracking Algorithm for Residential Photovoltaic Systems" June 10 – 14, 2007 pp: 1-6