Control of Photovoltaic Power Using MPPT

Neha Dangi
P.G. student,
Pacific University, Udaipur

Jitendra Kasera
Assistant prof. & H.O.D. (EE),
Pacific University, Udaipur

Naveen Sen
Assistant prof. (EE),
Pacific University, Udaipur

Abstract— **Maximum power point tracker (MPPT) has an important place in solar system. MPPT utilize for maximum power output & maximize the efficiency of solar system. Therefore MPPT will reduce the overall cost of the system for same power output compare to solar system directly coupled with load. Tracking of maximum power point is done with help of MPPT algorithms. There are many algorithms was developed to track maximum power point. Two commonly popular algorithms perturb & observe method and incremental conductance methods are used to track maximum power point & further compare both algorithms. Various characteristics of solar cell are drawn with help of MPPT algorithms using M-file script. The simulation of MPPT based solar system is taken with various temperature & irradiance conditions.**

Keywords— MPP, MPPT, Power, Simulation, Solar System.

1. INTRODUCTION

Energy crisis is a big challenge to the entire world. The coal, natural gas fossil fuels will be vanishing in upcoming years. The alternating sources of power need to be developed for fulfill power demands. Developments of new urban & industrial areas increase the energy demands. This energy demands will justify by renewable energy sources. One of the renewable energy source is a solar energy that is inexhausive & ultimate power source. Solar energy can fulfill various energy needs in the world when it is used in correct way. Huge amount of power approx 1.8x1011MW is reached to earth through sun rays. This power is much larger than present power consumption rate of world. Solar systems are very costly & have less energy conversion efficiency. A solar system output depends upon the solar irradiation & cell temperature. To increase the efficiency of solar system, the system always follows maximum power point (MPP) of I-V curve. Maximum power point tracker (MPPT) is used to maintain solar array operating point at MPP. The MPPT will control voltage or current without dependency on load. There are many algorithms are developed to track maximum power point. Here is two popular algorithms perturb & observe method and incremental conductance methods are used to track maximum power point.

2. SOLAR CELL/ARRAY

The solar radiation is composed of photons of different energy levels, and some are absorbed at the P-N junction. Photons with energy lower than the band-gap of the solar cell are useless and not contribute for generating voltage or electric current. Photons with energy superior to the band gap only contributes for generating electricity, but only the energy corresponding to the band gap is used. The remainder of energy is dissipated as heating the body of the solar cell.

A PV system use to converts solar energy to the electrical energy through radiation of sun light. Solar / PV cell is the main device of a PV / Solar system which are grouped in series or parallel or combination of series & parallel to form solar panels or arrays. Power electronic converters are used to process electricity from PV devices. These converters may be used to regulate the voltage and current at the load, to control the power flow in grid-connected systems, and for the maximum power point tracking (MPPT) of the device.
The accuracy of a simulation is affects by the PV cell modelling, which require the estimation of the non linear I-V & P-V characteristics curve. The efficient simulation of PV/solar system should following two criteria: (1) It should be simple & fast & able to accurately predict the I-V & P-V characteristics curve even such partial shading. (2) It should be comprehensive tool for develop and validate PV/ solar system design includes power converters & the MPPT controls.

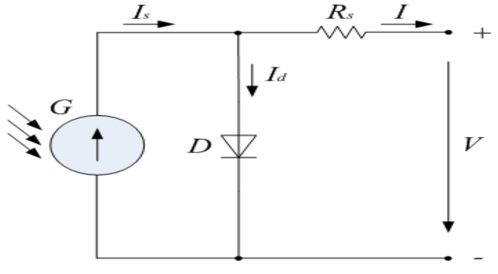

Fig. 1: Solar cell with single-diode and series resistance.

This is a simplified model of solar cell. The I-V characteristic of the cell is given by:

$$I = I_{sc} - I_0[e^{\{q(V+IR_S)/nkT\}} - 1] \quad \text{.............. (1)}$$

Where: I is the cell current
I_{sc} is the short-circuit current

I_o is the reverse saturation current of diode,
V is the cell voltage
T is the cell temperature
q is the electron charge (1.6022 10^{-19} C)
k is Boltzman's constant (13,807 10^{-23} Jk^{-1}).
Evalute the short-circuit current (I_{sc}) at any cell temperature (T)

$$I_{sc}|_T = I_{sc}|_{T_{ref}} \left[1 + a\left(T - T_{ref}\right)\right] \quad ...... (2)$$

The short-circuit current (I_{sc}) is directly proportional to the intensity of irradiance, thus I_{sc} at a any irradiance (G) is

$$I_{sc}|_G = \left(\frac{G}{G_o}\right) I_{sc}|_{G_0} \quad .... (3)$$

Where: G_o is the nominal value of irradiance, which is normally 1 KW/m^2.

The reverse saturation current of diode (I_o) at the reference temperature (T_{ref}) is given by:

$$I_0 = \frac{I_{sc}}{\left(e^{qV_{oc}/nkT} - 1\right)} \quad .... (4)$$

The reverse saturation current (I_o) is dependent on temperature and the I_o at a any temperature (T) is evalute by the following equation

$$I_0|_T = I_0|_{T_{ref}} \left(\frac{T}{T_{ref}}\right)^{\frac{3}{n}} e^{\frac{-qE_g}{nk}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)} \quad .... (5)$$

3. MAXIMUM POWER POINT TRACKING

The output power of solar cell is affected by solar irradiations & temperature of cell. Single MPP is exist on P-V curve of solar cell for a certain condition. Solar cell must operate near MPP to increase the output power. A process in which solar cell always operate near MPP is called maximum power point tracking (MPPT). There are many algorithms was developed to track maximum power point. Two commonly popular algorithms perturb & observe algorithm and incremental conductance algorithm are used to track maximum power point.

3.1. perturb & observe algorithm

perturb & observe (P&O) algorithms is known by another name "hill climbing method" & has most commonly used in MPPT due to simplest structure with less parameter requirement. The perturb & observe algorithms is based on constant measurement of solar cell current & voltage when cell operating point is going to reach the MPP. The P&O algorithms perturb solar cell operating voltage by small increment hence output power will change by ΔP that's observed. ΔP is taken positive when operating point moving closer to MPP. So again voltage perturbation will move operating point towards MPP. ΔP is taken negative when operating point moves away from MPP & that time direction of perturbation should be reversed to again reach towards MPP. P & O algorithm have two important parameters:

- Time duration between the time taken to measurement of voltage & current and time taken to shift operating point.
- Increment size of the operating point.

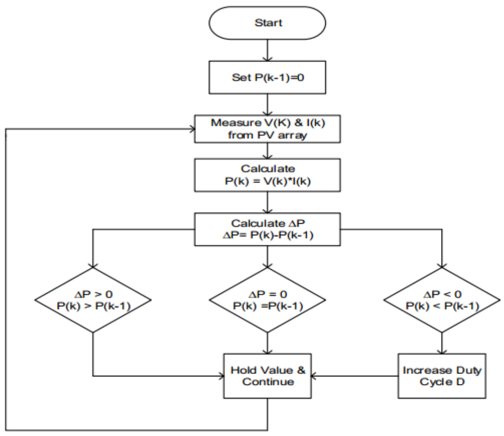

Fig. 2: Perturb and Observe algorithm.

3.2. Incremental conductance algorithm

Incremental conductance dI/dV is used to find out the sign of dP/dV in solar array. for maximum power point condition dP/dV must be equal to zero means dI/dV has equal & opposite value on compare to value of I/V. As soon as reaches to MPP algorithm terminate the process & return the corresponding value of voltage. This method known as incremental conductance algorithm. This method capable to track more accurately fast changing irradiation level compared to P&O algorithm. This algorithm requires so many sensors for observation hence increasing capital cost of MPPT device.

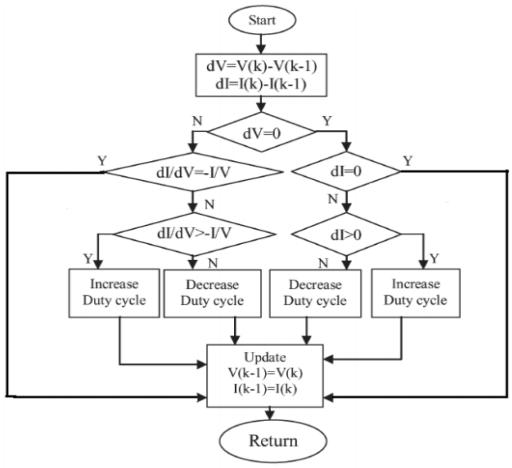

Fig. 3: Incremental Conductance algorithm.

4. SIMULATION RESULTS

For simulation result the MPPT based model of solar cell is implemented in MATLAB using M-file. The BPSX150S PV module is used to take data. The manufacturer provided data for BPSX150S PV module are:

1. Maximum power (Pmax) = 150W

ISSN: 2278-0181
Vol. 3 Issue 4, April - 2014

2. Voltage at Pmax (Vmp) = 34.5V
3. Current at Pmax (Imp) = 4.35A
4. Warranted minimum Pmax = 140W
5. Short-circuit current (Isc) = 4.75A
6. Open-circuit voltage (Voc) = 43.5V
7. Maximum system voltage = 600V
8. NOCT = 47±2°C

Following characteristics are obtained:

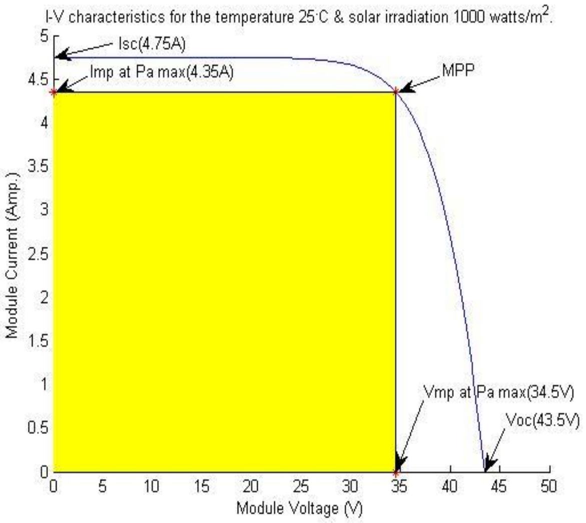

Figure 4.1: I-V characteristics for temperature 25°C & solar irradiation 1000W/m^2.

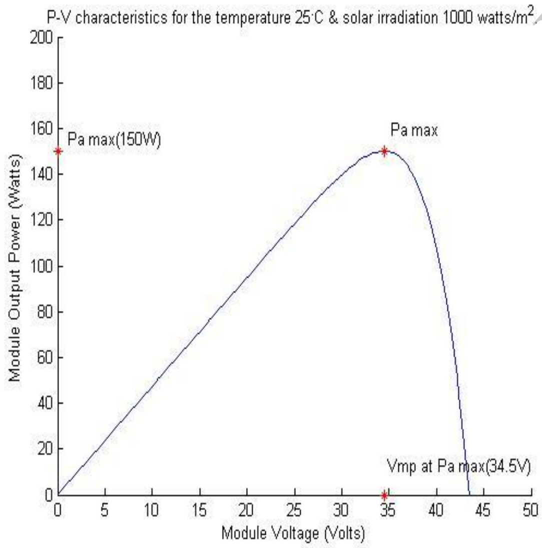

Figure 4.2: P-V characteristics for temperature 25°C & solar irradiation 1000W/m^2.

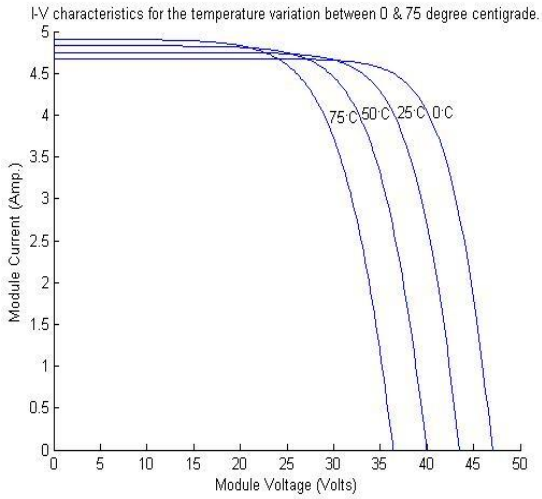

Fig. 4: I-V characteristics for temperature variation from 0°C to 75°C.

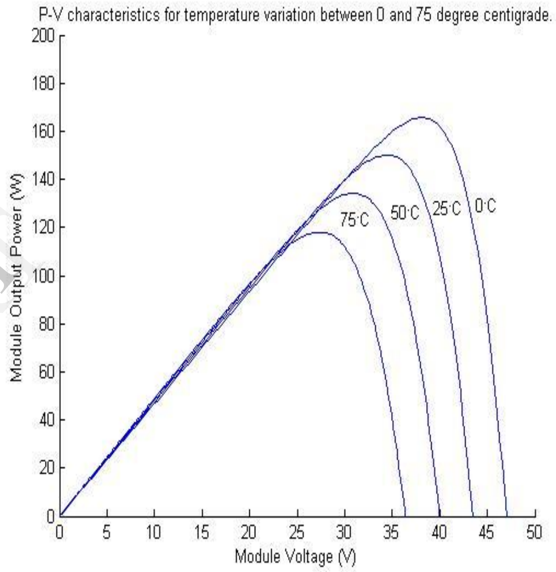

Fig. 5: P-V characteristics for temperature variation from 0°C to 75°C.

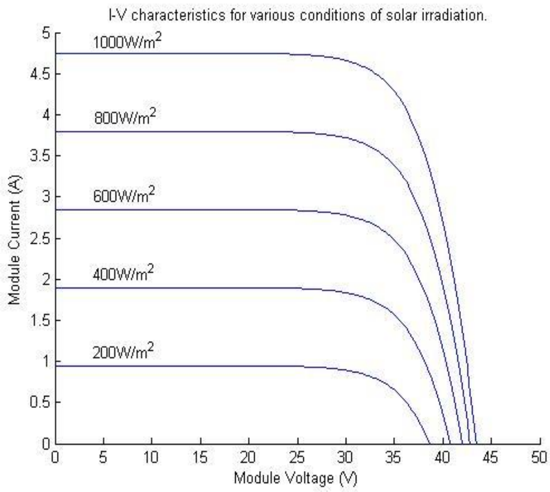

Fig. 6: I-V characteristics for various condition of solar irradiation.

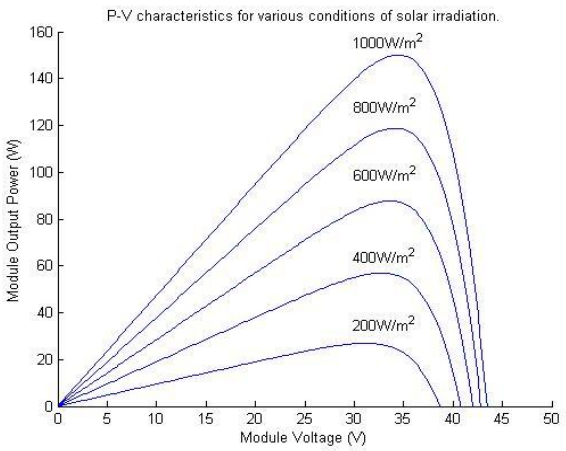

Fig. 6: P-V characteristics for various condition of solar irradiation.

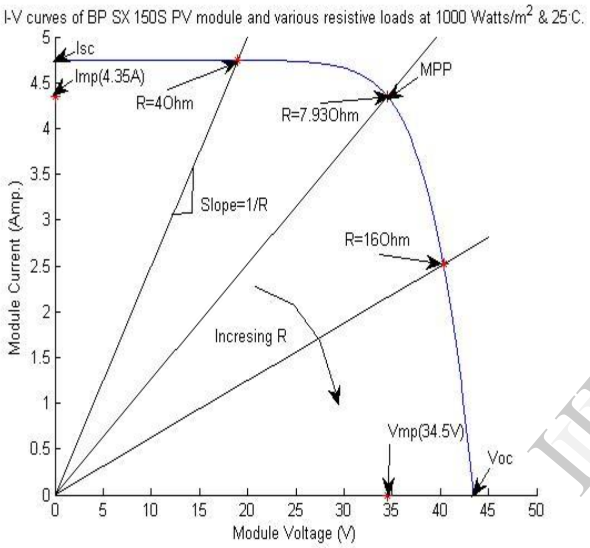

Fig. 7: Tracing MPP on I-V curve at various load resistance.

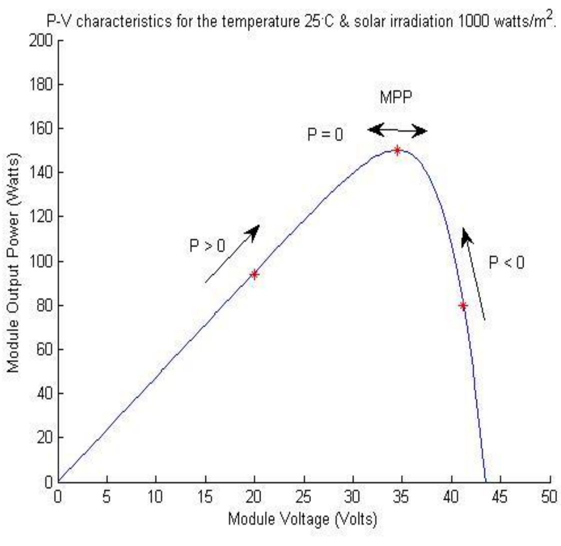

Fig. 8: P-V characteristic at temperature 25°C & irradiation 1000W/m^2 with P & O Algorithm.

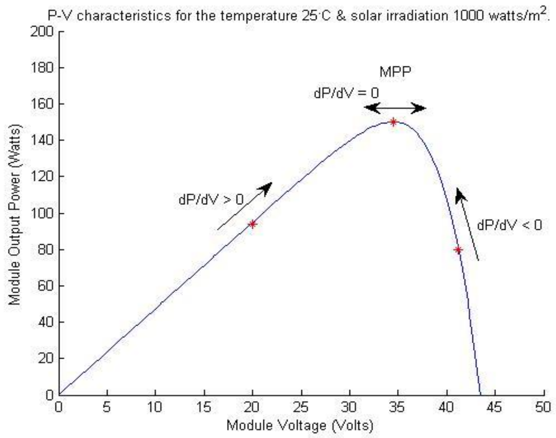

Fig. 9: P-V characteristic at temperature 25oC & irradiation 1000W/m2 with Incremental Conductance algorithm.

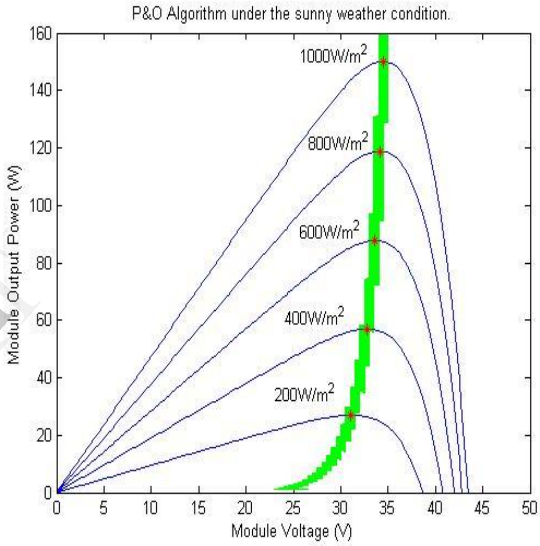

Fig. 10: P-V curve with P & O algorithm with different irradiation data of sunny day.

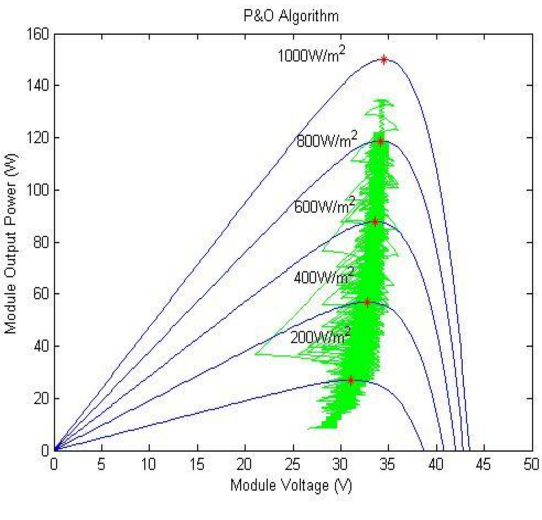

Fig. 11:-P V curve with P & O algorithm with different irradiation data of cloudy day.

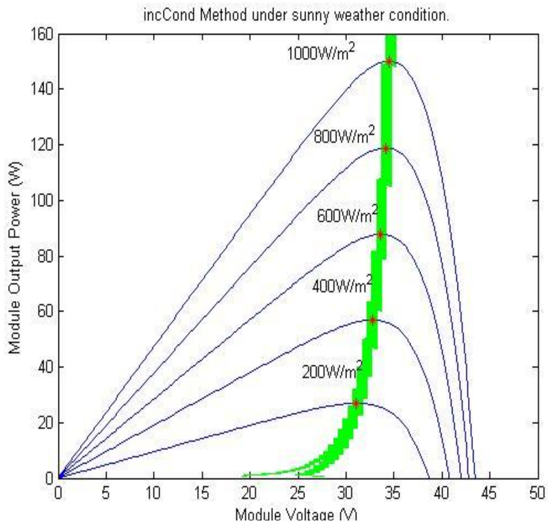

Fig. 12: P-V curve with incremental conductance algorithm With different irradiation data of sunny day.

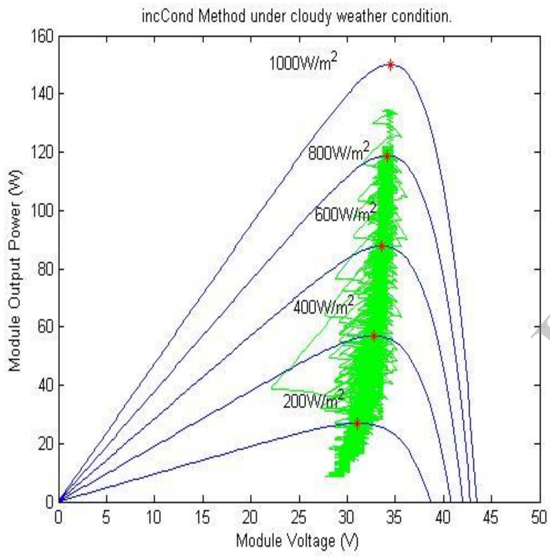

Fig. 13: P-V curve with incremental conductance algorithm with different irradiation data of cloudy day.

5. CONCLUSION

The I-V & P-V characteristics of solar cell with different irradiation & different temperature are obtained. The P-V characteristics with P&O algorithm and incremental conductance algorithm are also obtained. The MPPT algorithm increase system efficiency more than 97% while system has 33% efficiency without MPPT. P&O algorithm is simple to implement while incremental algorithm works more accurately in cloudy condition.

REFERENCES

[1] Yetayew, T.T. and Jyothsna, T.R., “Improved single-diode modeling approach for photovoltaic modules using data sheet”, Annual IEEE India Conference (INDICON), pp. 1-6, 2013.

[2] Hansen, C.W, “Estimation of parameters for single diode models using measured IV curves”, IEEE 39th Conference on Photovoltaic Specialists (PVSC), pp. 223-228, 2013.

[3] Bal S. and Babu B.C., “Comparative study between P&O and Current Compensation method for MPPT of PV energy system”, IEEE Students Conference on Engineering and Systems (SCES), pp. 1-6, 2012.

[4] Zhang Yang, Sch Lin Heyun, Yan Jianhu and Feng Yi, “Photovoltaic non-linear model solution and improved P&O method for MPPT”, IEEE Conference on Renewable Power Generation (RPG), pp. 1-6, 2013.

[5] Zhou Xuesong, Song Daichun, Ma Youjie and Cheng Deshu, “The simulation and design for MPPT of PV system Based on Incremental Conductance Method”, IEEE International Conference on Information Engineering (ICIE), pp. 314-317, 2010.

[6] Kish G.J., Lee J.J. and Lehn P.W., “Modelling and control of photovoltaic panels utilising the incremental conductance method for maximum power point tracking”, IEEE Transactions on Renewable Power Generation (IET), pp. 259-266, 2012.

[7] http://re.jrc,ec.europa.eu/pvgis/apps/radmonth,php?en=&europe=, this sit was perpetrated by Thomas Huld and Marcel Suri, PVGIS © European Communities, 2001-2007.