

Maximum Power Point Tracking (MPPT)

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Abstract: - This paper presents the simulation of the efficient Maximum Power Point Tracking (MPPT) in a photovoltaic (PV) array using Matlab/Simulink software. One diode equivalent circuit of solar cell is used to plot P-V and I-V characteristics. There are number of methods used to track the maximum power from the PV array.

This paper presents Perturb and Observe (P & O) method to track the maximum power from the PV array. The system includes the modelling of PV cell under different solar irradiance conditions. Proposed MPPT method will be able to track the maximum power with minimum possible oscillations around the maximum power points.

Keyword: - Maximum Power Point, PV Array, Simulink, Solar cell

I. INTRODUCTION

Energy is the basic need of all the human activities. But due to rapidly increase in population with global warming and depleting fossil resources, mankind is in desperate need of alternative renewable energy sources which are based on solar, wind energy etc.

Solar power generation is reliable which has no moving parts and has low maintenance and operation cost. A solar photovoltaic (PV) system uses solar cells to convert solar energy into electrical energy which is based on photo electric effect. The output characteristic of PV module depends on the temperature of the cell, solar irradiation, and output voltage of PV module. A PV module has a nonlinear characteristic so it is necessary to find out MPP. A solar module generates low power when solar panel is directly connected to the load, so the task of MPPT which is placed between solar panel and load is to track the maximum power from the solar panel irrespective of weather and load condition and fed it to the load. There are various methods used to track the maximum power from the solar panel, one of the method is Perturb and Observe method which is explain in this paper.

A. Basics Of Solar cell: -

A single solar cell is made by the parallel combination of current source consist a diode and shunted resistance is connected in series with the series resistance. The solar cell converts solar energy (photons) which is incident on it into electrical energy. Thus electrical characteristic like current, voltage and finally the resistance may vary when light is incident on it. This results to generation of current without any external source and power consumption when the load is connected. The equivalent circuit of solar cell is shown in fig 1.

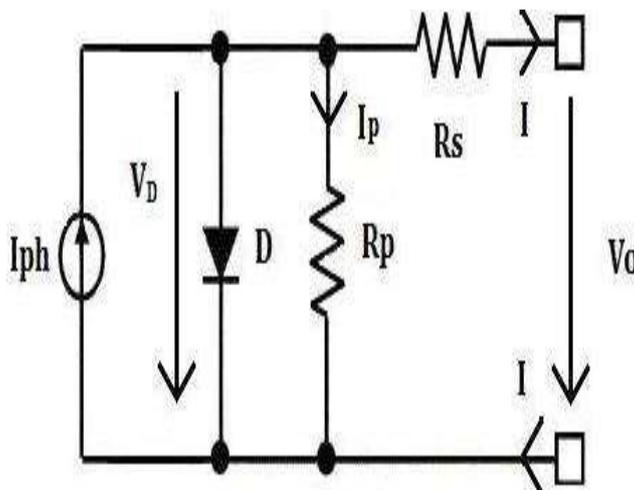


Fig 1: Equivalent circuit of solar cell.

II. SIMULINK MODELLING

For the simulation purposed “Development Of A Solar Cell Model In Matlab For PV Based Generation System” is preferred.

- A. Thermal Voltage Equation:** - Thermal voltage is the voltage corresponding to the energy of the electron. This is the average value and cause of this voltage is temperature. The Equation and Simulink model of the thermal voltage equation in MATLAB is shown in fig 2.

$V_t = \frac{kT}{q}$; Where, k Boltzmann constant (1.38×10^{-23} J/K), T Operating temperature of cell ($^{\circ}\text{C}$), q = Electron charge (1.6×10^{-19}).

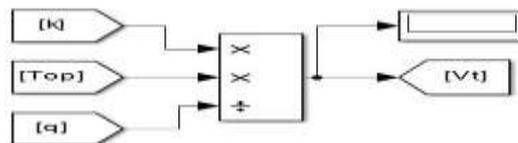


FIG 2: Thermal voltage equation model.

- B. Photo Current Equation:** - Photo current is nothing but an electric current which is flowing through a photosensitive device such as solar cell. The cause of occurring of the photo current is Photo voltaic effect. The Equation and Simulink model of the Photo Current equation in MATLAB is shown in fig 3.

$I_p = I_{sc} \left[\frac{T}{T_{ref}} - 1 \right] + I_{sc}$; Where, I_{sc} = Current proportionality constant (2.2×10^{-3}), T_{ref} Reference operating temperature (25°C), I_{sc} = Short circuit current (3.8 A).

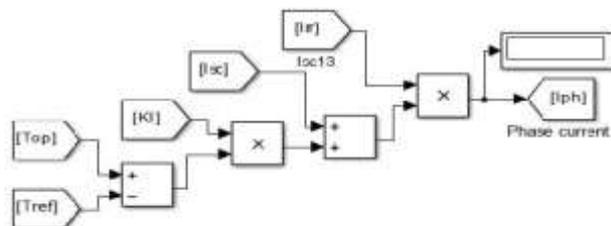


FIG 3: Photo current equation model

- C. Diode Current Equation:** - This gives the current flowing through the diode which is function of voltage. The equation and Simulink model for the diode current equation in MATLAB is shown in fig 4.

$I_d = N_s \left[\frac{V}{R_s} - I \right] \left[\exp\left(\frac{eV}{nN_p kT}\right) - 1 \right]$; Where, N_s = Number of cell in series, C = Number of cell in module, n = Ideality factor (1.36 for solar cell), R_s = Series resistance (0.18Ω), V = Operating voltage, I = Cell output current

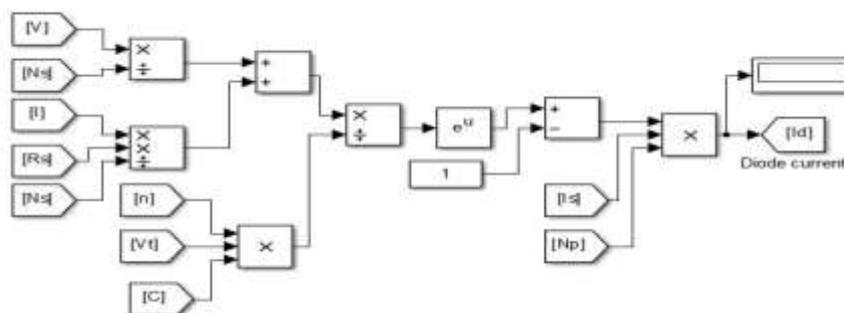


FIG 4: - Diode current equation model.

D. Shunt Current Equation: - The value of shunt resistance should be very high to prevent power loss in solar cell.

If the value of shunt resistance is less than it provides a path to current flowing through it and this diversion causes less current flowing through a solar cell and results into less voltage occurs from solar cell. The equation and Simulink model for current flowing through shunt resistance is shown in fig 5.

$I_{sh} = (V + I R_s) / R_p$ Where, R_p Shunt resistance (360.002 Ω).

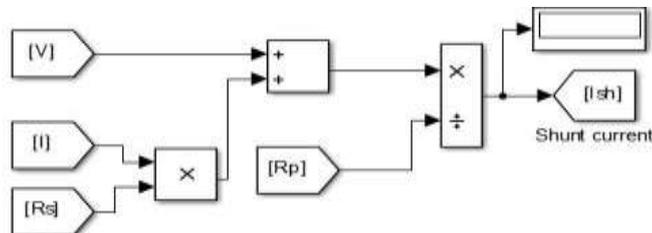


FIG 5: - Shunt current equation model.

E. Reverse Saturation Current Equation: - The current flowing through the diode when it is in reversed biased condition is given by Reverse Saturation Current (I_0). This current is also known as the leakage current which is depends on temperature (T), energy band gap (E_g), ideality factor (N), Boltzmann constant (k) etc. The equation and Simulink model is shown in fig 6.

$$I_0 = I_s \left(\frac{T}{T_0} \right)^{2N} \exp \left\{ - \frac{E_g}{k T} \right\}$$

Where, E_g = Energy band gap (1.12eV).

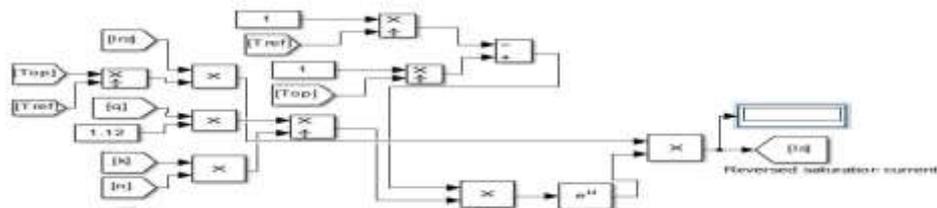
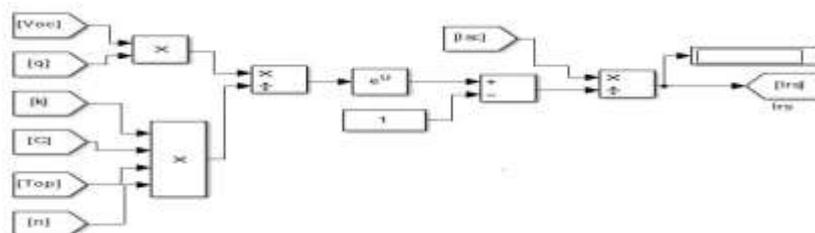


FIG 6: - Reverse saturation current equation model.

F. Reverse Current Equation: - The equation and Simulink model for Reverse current equation is shown in fig 7.

$$I_r = I_0 \left(\exp \left(\frac{q V}{k T} \right) - 1 \right)$$

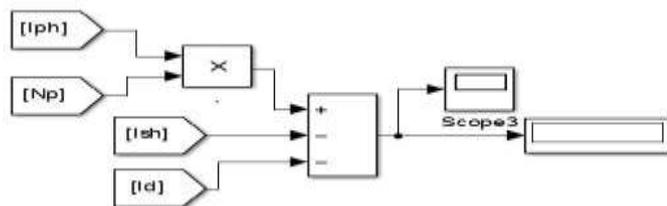


- 1); Where, V_{oc} = Open circuit voltage (21.1).

FIG 7: - Reverse current equation model.

G. Load Current Equation: - The equation and Simulink model for the load current equation is shown in fig 8. It is nothing but difference of current of current source and diode.

$$i_d = (I_{ph} - I_{sh}) - I_d$$



III. PERTURB AND OBSERVE METHOD.

Perturb and Observe method is most widely used method among all the methods to track the maximum power from PV Array. This method is also known as the hill climbing method because this is depends on the rise of curve of power against the voltage. In this method the controller will adjust the voltage by controlling the duty cycle of the MOSFET in DC to DC converter. If duty cycle is increase the output voltage of DC to DC converter is also increases. According to the IV characteristic of PV array the current is constant up to V_{mpp} . The voltage is increase by increasing duty cycle and observe the power. If power is increases, further increase in voltage in that direction and observe the power. The point at which the power start to decreasing is the point V_{mpp} and algorithm stops. The flowchart and results of Perturb and Observe method is shown in fig11 and fig 12. [1]

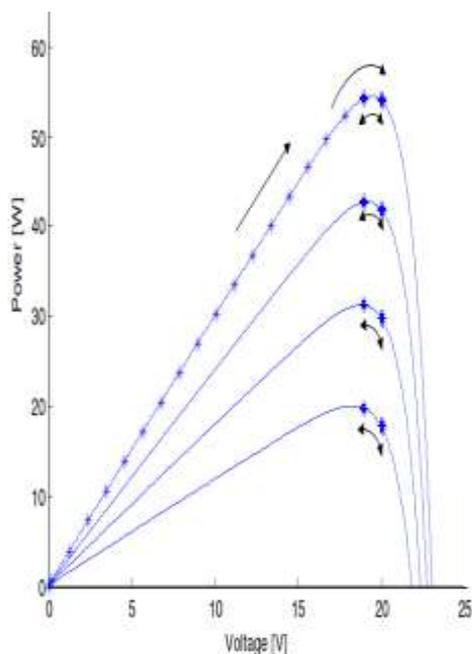


FIG 11: - MPP tracking by P & O.

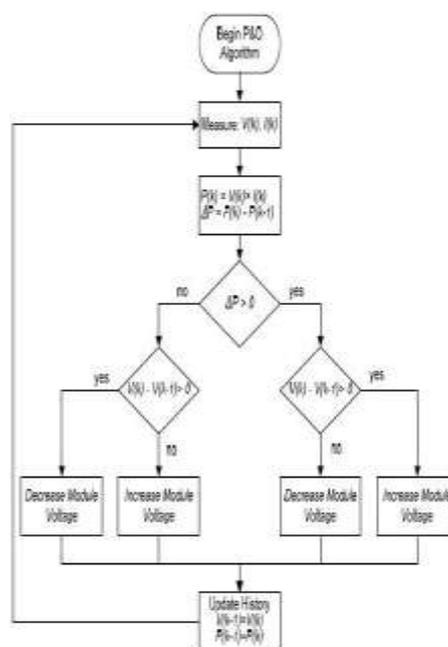


FIG 12: - Flowchart of P&O method.

IV. SIMULATION RESULTS.

In order to verify the Perturb and Observe method, the simulation is carried out in MATLAB/SIMULINK Software. Simulation results shows the P-V and I-V graph of the PV array for different Irradiations conditions. From the simulation result it is clear that for different irradiations the maximum power point is shifted.

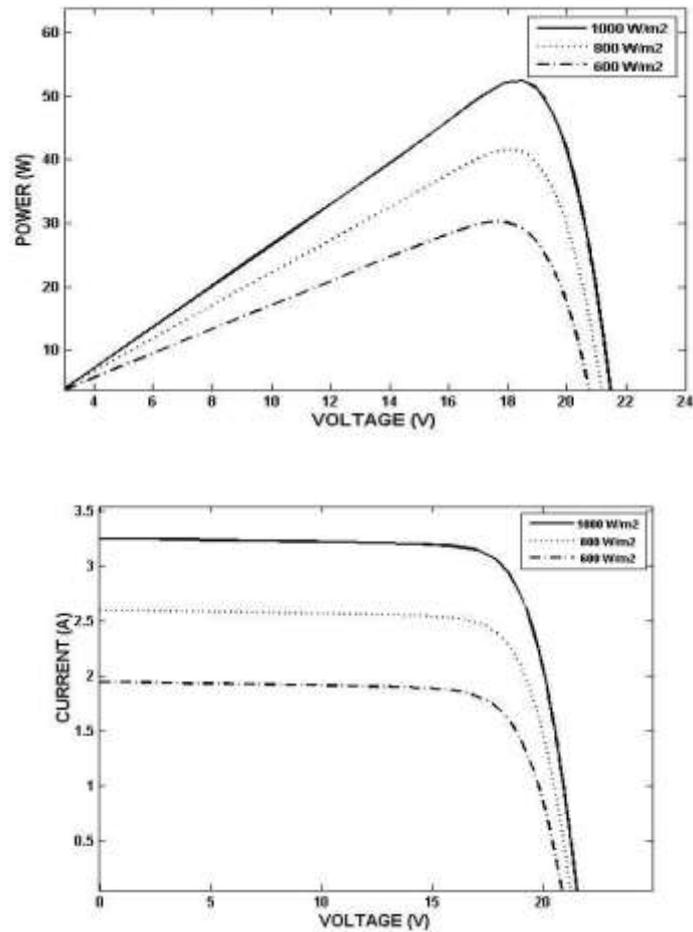


FIG 14: - I-V graph for different irradiance.

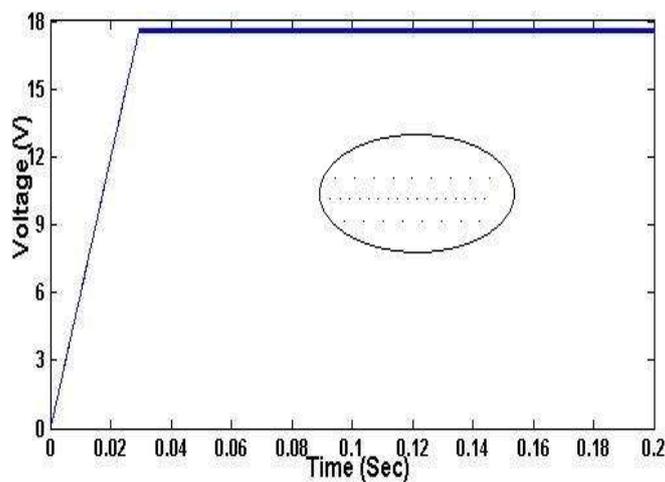


FIG 15: - Graph of V_{mpp} .

V. CONCLUSION

In this paper, the simulation of maximum power point tracking from the PV array is implemented for

different irradiance. The Perturb and Observe method is used to extract the maximum power from PV array. The simulation of P & O method gives oscillations around MPPs, by taking the average of that oscillations it is possible to find out MPP.

REFERENCES

- [1]. "Analysis And Simulation Of The P&O Mppt Algorithm Using A Linearized Pv Array Model", Marcelo Gradella Villalva, Jonas Rafael Gazoli, Ernesto Ruppert Filho University of Campinas (UNICAMP), Brazil
- [2]. "Modeling of PV Module with Consideration of Environmental Factors" Nand Kishor, Member, IEEE, Marcelo Gradella Villalva, Soumya Ranjan Mohanty, Member, IEEE, Ernesto Ruppert.
- [3]. " Modeling Solar Photovoltaic Cell and Simulated Performance Analysis of a 250W PV Module" Md.
- [4]. Aminul Islam, Graduate Student Member, IEEE, Adel Merabet, Member, IEEE, Rachid
- [5]. Beguenane and Hussein Ibrahim.
- [6]. "PV Solar System with Series Output Connection and MPPT control "Yuncong Jiang*, Student Member, IEEE, Jaber A. Abu Qahouq*, Senior Member, IEEE, and Mohamed Orabi**, Senior Member, IEEE.
- [7]. "A Variable Step Maximum Power Point Tracking Method Using Differential Equation Solution" Fang Luo
- [8]. , Pengwei Xu , Yong Kang , Shangxu Duan College of Electrical and Electronics Engineering , Huazhong
- [9]. University of Science and Technology Wuhan,Hubei,P.R.China 430074
- [10]. "Development Of A Solar Cell Model In Matlab For PV Based Generation System" G.Bhuvaneshwari and R. Annamalai, Indian Institute of Technology, Delhi, India.