Asian Journal of Electrical Sciences
ISSN: 2249-6297 (P) Vol.8, No.S1, 2019, pp.10-14
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DOI: https://doi.org/10.51983/ajes-2019.8.S1.2316

Maximum Power Point Tracking of PV System under Partial Shading Condition

S. M. Jaanaki[1], R. Ashika[2], Dheeraj Patil[3], R. Ganapriya[4] and P. Sinchana[5]
[1]Professor, [2,3,4&5]PG Student, [1,2,3,4&5]Department of Electrical and Electronics Engineering,
MVJ College of Engineering, Bangalore, Karnataka, India
E-Mail: jaanaki.sm@mvjce.edu.in, ashika3105@gmail.com
(Received 10 February 2019; Revised 25 February 2019; Accepted 16 March 2019; Available online 23 March 2019)

Abstract **- Over decades renewable resources such as photovoltaic systems have been used, which focuses on new growing power generation. Today cost and efficiency is the major factors of concern in order to harness and use these natural resources in a better possible way. Thus, the concept of Maximum Power Point Tracking (MPPT) has developed. Irrespective of continuous changes in temperature and irradiation maximum power point tracker plays an important role in tracking power from photovoltaic system. The Major challenge that the photovoltaic system goes through is even when PV panel is partially shaded what is the maximum power that can be tracked so that, the output power and efficiency get boosted up. MATLAB software is used to implement the P&O algorithm under partial condition under different irradiation and change in environmental condition.**
Keywords: **Maximum Power Tracking (MPPT), Partial Shading and Perturb and Observe (P&O) Algorithm**

I. INTRODUCTION

Non-renewable energy resources such as fossil fuels are the main fuel for the generation of thermal power, which gets exhausted eventually over decades. Most of the renewable energy can be taken directly or indirectly from sun which is freely available in nature at free of cost, which never gets exhausted[2]. One step ahead, alternative to conventional energy are the non-conventional energy sources, also called as renewable energy. solar is an ultimate source of energy, photovoltaic system transforms solar energy into electrical energy. The fundamental unit or device of photovoltaic system is PV cell. PV cell is a semiconductor device which converts light energy into electrical energy. PV cells of identical characteristics are wired together to create a module in order to obtain desired DC output [1]. When these cells are connected in series, voltage will add while the current remains constant similarly when the cells are connected in parallel the current will add while the voltage remains constant. Many solar panels are connected together to form the PV array. The performance of PV array is mainly on two factors, temperature& irradiance which affects the output of the PV array [1]. Partial shading on PV system is serious issue for a PV array. Uniform radiation of PV panel is not possible in all timesbecause of buildings, tree shades, atmosphere fluctuation and existence of clouds [6]. As shading changes open circuit voltage and short circuit current varies. Under partial shading, when cells are shaded, reduction in power will be proportional to area of shaded cell.

II. BLOCK DIAGRAM

Solar panel is a device which is used convert source of light into electricity [2]. The output of the panel is connected to both MPPT and the DC- DC boost converter. When both current source and voltage source from the panel is given to the boost converter in order to boost up the voltage the pulses are required which is taken from the MPPT and connected to the switch of the converter and boosted voltage is taken across the load [3]. During the partial shading condition, the uniform radiation is not possible so the output of the module will be reduced, and power is also reduced.Thus, reduced power from the solar panel is tracked from MPPT and DC- DC boost converter this voltage under partial shading and it is given to load.

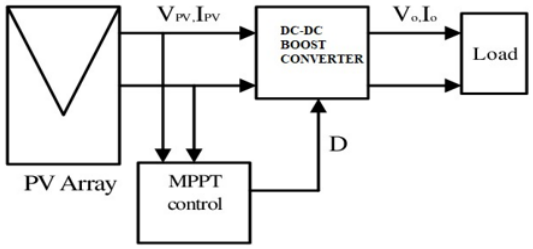

Fig. 1 Block diagram

III. SOLAR PANEL MODELING

Given below is the complete model of PV cell, which consists light intensity dependent current source I_{ph} in parallel [3]. The terminal current which is obtained from the equivalent circuit can be written as equation (1).

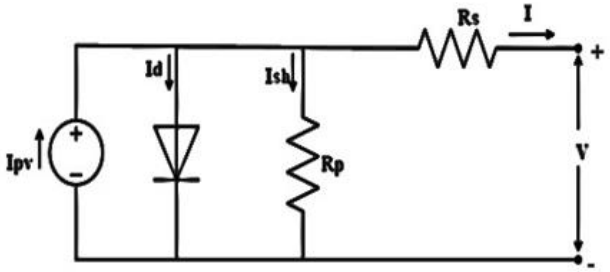

Fig. 2 Equivalent circuit of PV cell

$$I = I = I_{ph} - I_o\left[e^{\frac{q(V+Irs)}{N1aKT}} - 1\right] - \left[\frac{V+I_{rs}}{R_{sh}}\right] \qquad (1)$$

As the cell temperature increase the short circuit current also increases slowly while the open circuit voltage decreases.This light intensity dependent current source is proportional to the cell temperature and solar irradiation.
Which is expressed as in (2),

$$I_{ph} = \frac{I_{sc} + ki\,(Tc - Tref)\,\lambda}{1000} \qquad (2)$$

The saturation current of the cell increase with increasing in the temperature of the cell, it is expressed as in (3)

$$I_S = I_{RS}\left(\frac{Tc}{Tref}\right)^3 \exp\left(\frac{qE\left(\frac{1}{Tref} - \frac{1}{Tc}\right)}{Km}\right) \qquad (3)$$

Where,
I_{ph}= Photocurrent
ki = short circuit current of cell at 25^0Cand 100 w/m^2
Tref = Reference temperature in kelvin Tc Absolute temperature of the cell in kelvin m
Ideality factor of the diode q = electron charge (1.602*1O-19C)
I_S = Saturation current
K = Boltzmann's constant (1.3022e-23j.kl\-1)
E = Band gap energy of the semiconductor

PV cells of identical characteristics are wired together to create a module in order to obtain desired DC output. When these cells are connected in series the voltage will add while the current remains constant. The performance of PV array is mainly dependent on three factors temperature, irradiance and Shading [2]. Temperature and irradiance are the two important factors that effects the output of the of PV array. As this cell temperature increases the short circuit current increases slowly while open circuit voltage decreases rapidly, and power output will decrease as well.

IV. DC-DC BOOST CONVERTER

Boost converter is a step-up converter that steps up input voltage to its load by switched mode power supply [3]. It contains at least two semiconductors (diode, transistors) and at least one energy storage element (capacitor, inductor or combination of both).

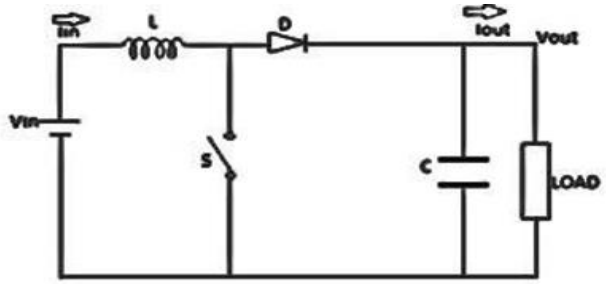

Fig. 3 Basic circuit of the DC-DC Boost converter

A. Working: Working can be classified, based on switch ON and OFF positions.

Case (i): When Switch is ON

Supply voltage will charge the inductor and the current flows corresponding to T_{ON} time. The inductor will charge with the polarity plus to minus. As switch is ON, the circuit will be short circuited and hence output voltage is zero.

Case (ii): When Switch is OFF

Inductor will reverse its polarity and current will flow from the supply as well as inductor. Ultimately voltage appearing across the load will be due to supply voltage and the inductor voltage.

$$V_{OUT} = V_{in} + V_l \qquad (4)$$

The ON-OFF period of switch is defined by Pulse Width Modulation (PWM).

B. Design Parameter

ΔI_L= ripple current
Consider the rating of converter to be

1. Duty ratio(D) = $1 - \frac{V_S}{V_o} \times \eta$
2. Inductor $L \geq \frac{V_{S(min)} \times D}{f_s \times \Delta I_L}$
   ΔI_L Vary from 20 % - 40%

If ΔI_L is very low it may lead to unstable operation.
If ΔI_L is high it may lead to sensitive to EMI.

3. Capacitor $\geq \frac{I_{o\,(max)} \times D}{f_s \times \Delta V_C}$

ΔV_c = ripple voltage.
$v_c = v_o$
As capacitor and load is parallel ΔV_cvaries from 1 % to 5%. If we reduce ripple in output voltage further the size and cost of the capacitor will increase, we keep it 1% of voltage across the capacitor
ΔV_c = 1% of V_c.

4. Rated Power

$P = \frac{V^2}{R}$

$R = \frac{V^2}{P}$

V. MPPT (MAXIMUM POWER POINT TRACKING)

Solar energy is freely available in the earth atmosphere but harnessing this energy is difficult, which is the main goal of MPPT. In case of photovoltaic module, there is one single point with respect to time and that point has to be tracked to seethe operating point of PV module which lies nearer or exactly at that point.This is called as Maximum Power Point Tracking (MPPT) [5].

Solar panel works on photovoltaic principle,which statesthat whenever a light of frequency falls on the solar cell, voltage is generated and when load is connected across it, the power gets transferred to the load and hence electrical energy is generated. As this solar panel is a current source, the source

will be available to deliver the maximum power to the load.If the load resistance is equal to source resistance than only tracking of maximum power can be done.

There are different types of MPPT control methods in order to improve the efficiency of solar energy. There are many algorithms to perform MPPT. At different points on solar panel irradiance vary which leads to multiple local maxima points. The MPPT algorithm used here is Perturb and Observe (P&O) algorithm.

A. Perturb and Observe (P&O Algorithm)

This method works on varying the system by increasing or decreasing the PV module operating voltage and observing the output power by the module. It is easy to implement as this is the only voltage which is sensed and varied. System output is observed, and input voltage is varied accordingly.

On increasing the voltage (V), power (P) increases then duty ratio (D) starts decreasing. Similarly, while decreasing the voltage (V), if power (P) increases duty cycle (D) decreases. Above steps are repeated till maximum power point is reached.

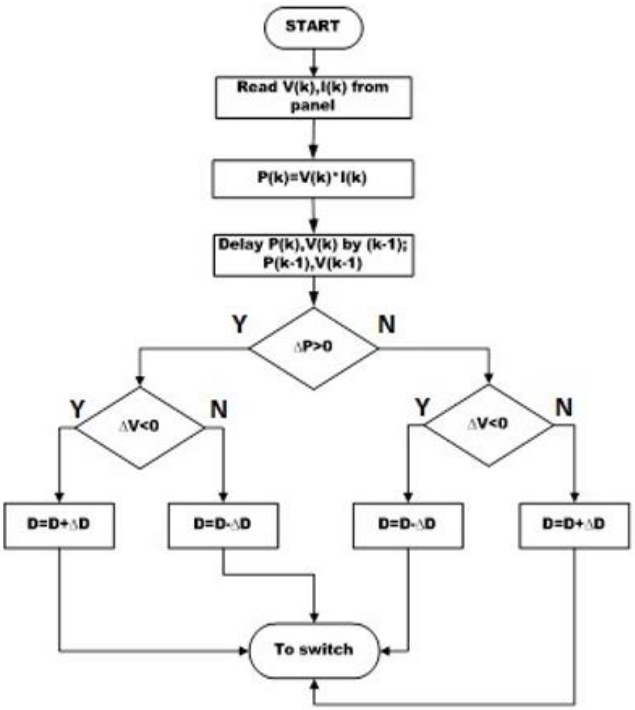

Fig. 4 Flowchart of Perturb and Observe (P&O) method

VI. SIMULATION RESULTS

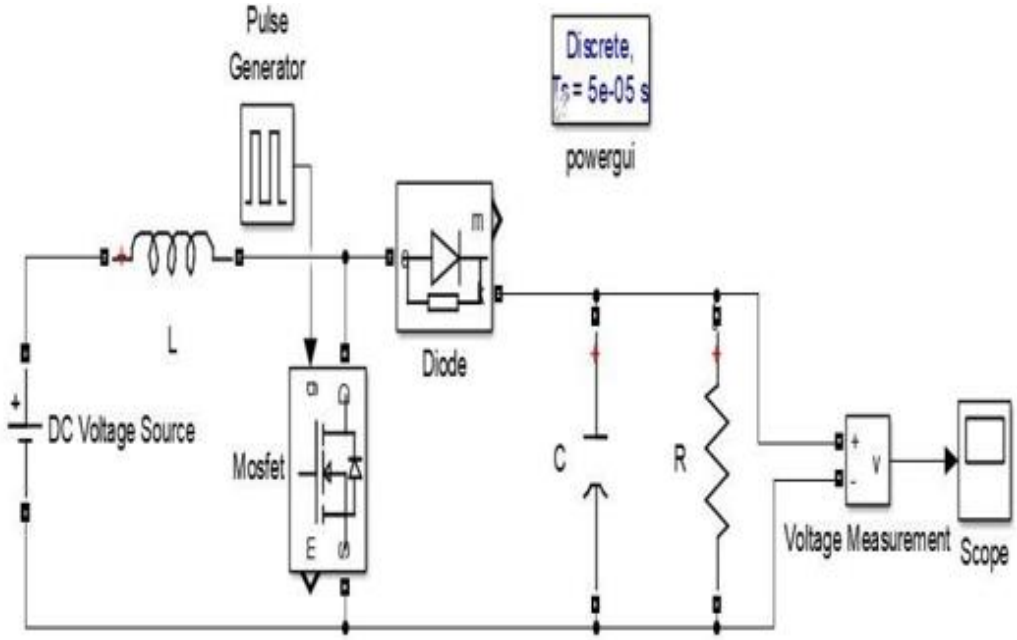

Fig. 5 DC- DC boost converter

TABLE I COMPARISON TABLE BEFORE IMPLEMENTATION OF P&O ALGORITHM

	Without shading	**With shading**
Input voltage	28	20
Output voltage	185	176
Power	345	325

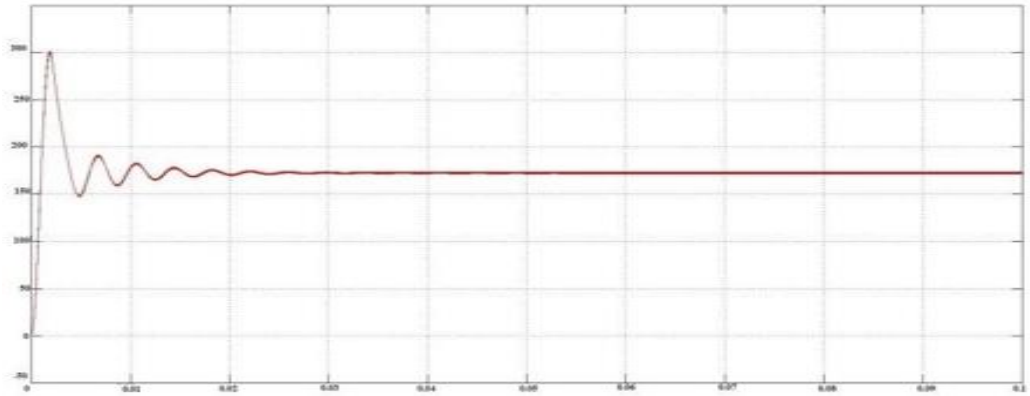

Fig. 6 Dc Voltage v/s Time

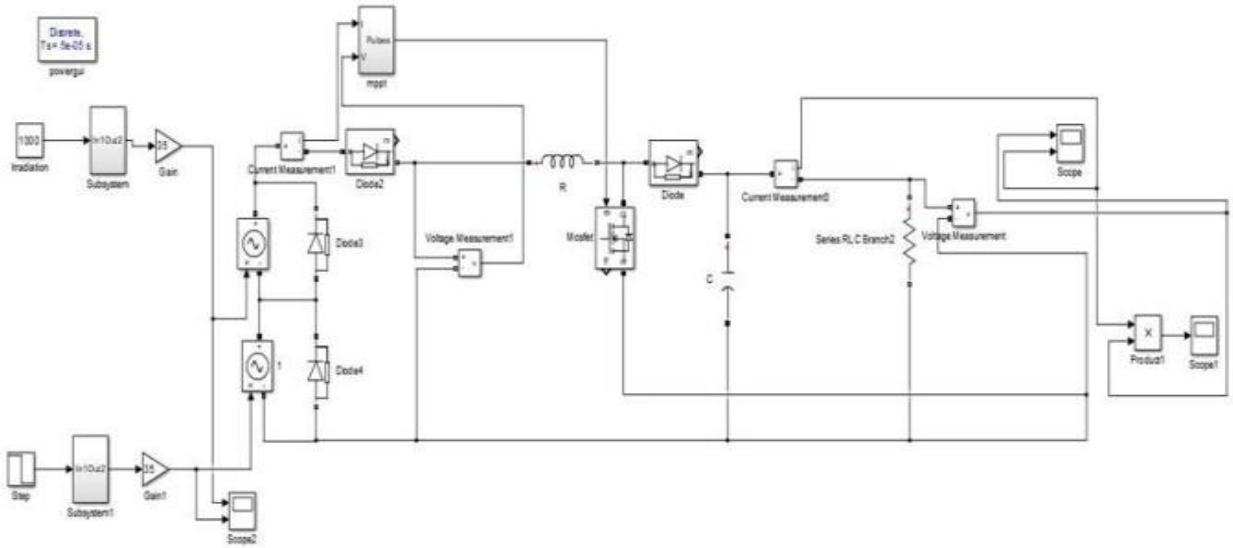

Fig. 7 Simulink model of the complete system

This section shows the simulation results where P & O algorithm is implemented.

TABLE II COMPARISON TABLE AFTER IMPLEMENTATION OF P&O ALGORITHM

	Without shading	**With shading**
Input Voltage	28	20
Output Voltage	155	135
Power	250	185

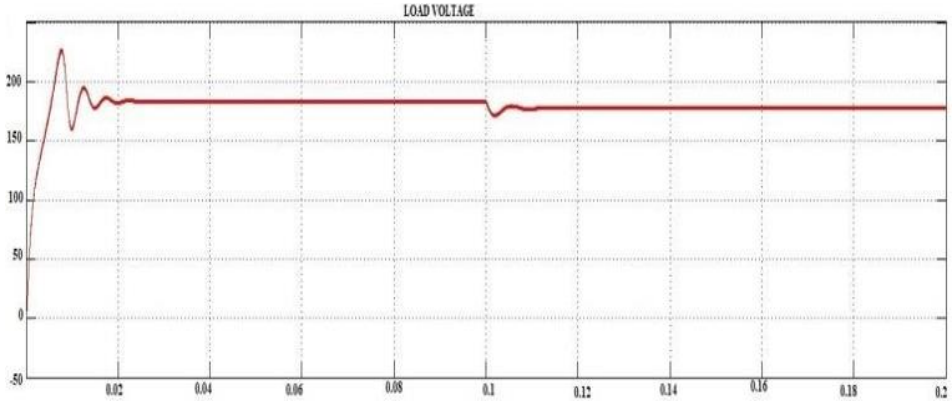

Fig. 8 Load voltage v/s Time

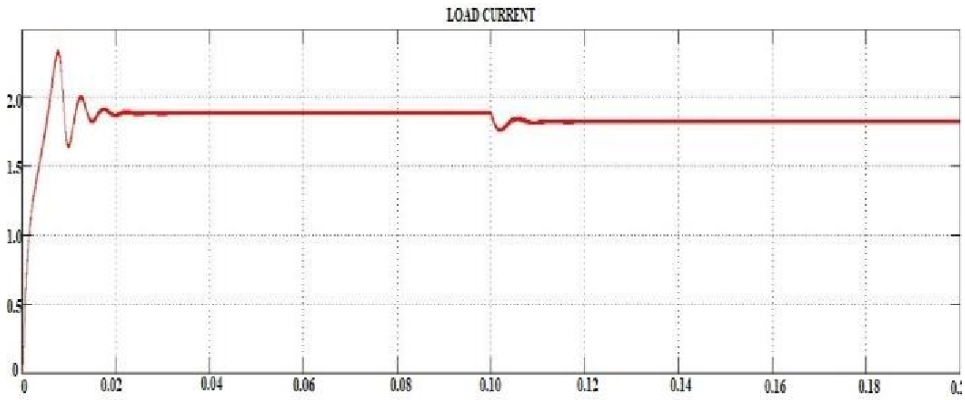

Fig. 9 Load current v/s Time

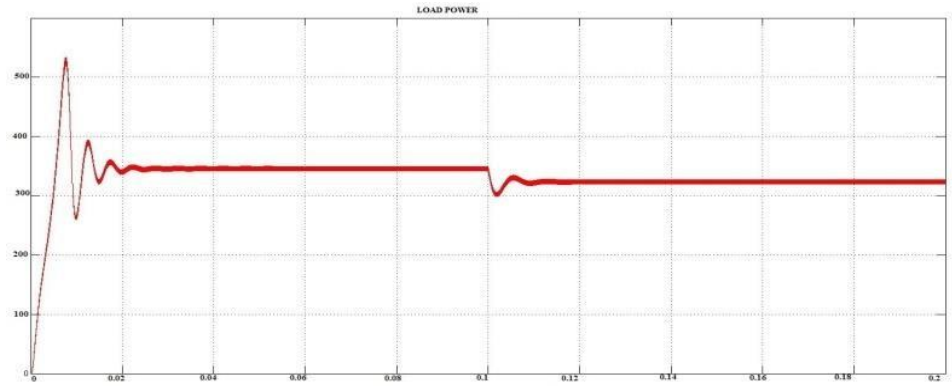

Fig. 10 Power v/s Time

VII. CONCLUSION

This paper gives a detailed study of effect of irradiance and temperature variations caused by partial shading on PV system. The system simulation is modelled by using MATLAB under various irradiance and temperature change. Hence the output current of the PV system varies linearly with radiation level than temperature.Output power of the shaded cells decreases hence causes the global and local maximum peaks in PV characteristics curve. Magnitude of global maximum is decided by the array configuration and shading patterns. Therefore, conventional perturbation and observation (P&O) based MPPT techniques precisely locate maximum power point. Thus the (P&O) MPPT scheme is proposed here and the obtained simulation results confirm the effectiveness of the formulated solution.

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