Simulation And Analysis Of Particle Swarm Optimization Algorithm Based MPPT For PV System Operating Under Partial Shading Condition

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Abstract: With the ever increasing demand solar energy has emerged as one of the most important renewable energy sources, so it is important to operate the photovoltaic panels in a manner that we obtain maximum efficiency from it. But there are problem associated with the photovoltaic panels like the Partial Shading Condition which greatly impacts the proficiency of PV system. MPPT performs an important role to enhance the power of PV systems. During PSC PV trajectories will be distinct and very complex due to various peaks available .The conventional MPPT methods will fail to reach the Global Maximum Power Point and it usually stays at the Local Maximum Peak Point which surely would decline the efficiency and performance of the PV module. This research focuses on Particle Swarm Optimization approach for tracking peak power to identify the GM PP. This approach provides a high reliability robustness and proficiency towards Maximum Power Point. The authenticity of this proposed algorithm is done using MATLAB /Simulink.

Index terms : Partial Shading Conditions ,Photovoltaic, Maximum Power Point MPP ,Maximum Power Point Tracking MPPT ,Global PowerPoint GMP, Particle Swarm Optimization (PSO) ,DC-DC Boost Converter ,Local Maximum Power Point.

I. INTRODUCTION

With the ever increasing electricity demand ,the electricity bills needs to be taken care of which can be minimized by using PV panels. Moreover, Renewable energy from the sun can be best way to produce electricity bills to provide the opportunity to the producers to sell surplus of electricity to the local electricity suppliers from PV panels. As the demand keeps on increasing PV technology will become more efficient and provide more benefits in the near future. Due to the higher capital cost of solar panels it is desired that the zenithal amount of power is extracted from the PV panels .PV output deliberately depends on intensity of radiation from the sun and temperature. These constraints change with time, So it is mandatory to propose a MPPT method that can trace the maximum power from the PV. Partial Shading Condition is one of the important area of concern for achieving maximum power out of PV system .This condition happens because of obstacles like buildings trees clouds towers etc. The partial shading condition leads to the origination of hotspot in the solar module. In order to eliminate the self heating there are bypass diodes that are crosswise connected in the array. The partial shading condition will result in devaluation of power from PV module which is caused by bypass diodes utilized, arrangement of the PV array and the patterns of shading. The bypass diodes will create complex shapes and display numerous peaks in the PV trajectory. The conventional algorithm gets confused among the Global and Local Maxima points and cannot distinguish between Global Maxima and Local Maxima which will decrease the proficiency of maximum power extraction. The P&O and INC maximum power point tracking approach are mostly used for PV systems. In the P&O algorithm on checking the last power pattern value of MPP the assigned voltage is either subtracted or added regularly. In INC approach for achieving MPP we differentiate two quantities that is power against voltage and keeping the resultant value equal to zero. When partial shading happens the conventional algorithms are able to detect only the Local Maximum Peak Power which in turn reduces the total power .The researches are also going on for the ANN and direct search algorithm fuzzy logic control [3-7].But these methods are time-consuming complex in hardware designs and are very expensive. For dealing with multi dimensional and multimodal problems naturally encouraged techniques that is swarm intelligence and evolutionary algorithms have been proposed by the researchers [8] ,[9]. Genetic algorithms are used by MPPT system but they take much time in execution as location of constraints is attained by trial and error. Swarm intelligence like the ant optimization and particle swarm optimization are also used in the optimization . ANO helps in tracking GMPP, yet it takes long time so it convergence slowly and is user dependent[10],[11],[12]. This paper utilizes Particles Swarm Optimization technique for tracking the maximal power point to identify GMPP also gripping the complicated and non linearity issues of PV Modules. This PSO algorithm provides high robustness reliability and efficiency towards attaining the GMP of PV system. This paper is organized in the following manner .In Section II we will discuss the PV System Formulation .In Section III we have discussed about the Bypass diodes for PV system. In Section IV we discussed the different parameters used in standalone PV module. In Section V we will see the Influence of PSC on PV system. In Section VI we have discussed the PSO algorithm for tracking GMPP.In section VII we have discussed Simulation results and analysis and finally in Section VIII we have draw the Conclusion.

II.PV SYSTEM FORMULATION

The PV panels consist of PN junction made of thin wafers or layers of semiconductors. At night or in dark the output characteristic i.e,IV of a solar cell has exponential characteristics similar to a diode. When exposed to sun photons with greater energy than the band gap of semiconductor are absorbed and they create electron-hole pairs. Under the influence of internal electric fields this carriers are swept apart in a PN junction which creates a current proportional to the the incident radiation. When open circuited this current is circulated internally by intrinsic PN junction diode and when short circuited this current flows in the external circuit .The cells are made of crystalline silica materials the proportionate model of PV cell presented in Figure 1

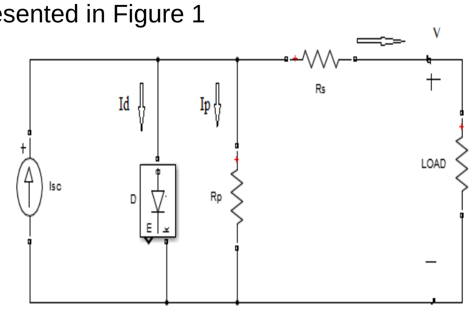

Figure 1. *Single Photovoltaic Cell Equivalent Circuit Diagram*

By using Kirchhoff's current law we can get the load current from equation 1

$$I = Isc - IR\left[e^{\frac{q(I \cdot Rs+V)}{A \cdot K \cdot T}} - 1\right] - \left[\frac{I.RS+V}{Rp}\right] \qquad (1)$$

Where
I : output cell current (A)
V : output cell voltage(V)
P : cells power (W)
ISC: short circuit current of the cell (A)
IR : reverse saturation current (A)
q : electron charge C
K : Boltzmann constant (1.38 * 10 ^- 23 J/K)
T : temperature of module (K)
A : diode identity factor (1.3)
The bypass current IP is close to zero and the resistance in parallel R p is Fusion amount the equation 1 for the output current is re written as

$$I = Isc - IR[e^{\frac{q(I \cdot Rs+V)}{A \cdot K \cdot T}} - 1] \qquad (2)$$

Single PV cell unit is not enough to extract sufficient power for satisfying for fulfilling the different demands .Many PV cells are stacked in parallel and series combination to obtain the maximum energy for utilisation. Thisarchitecture of cells is called PV module, they have the capability to produce power as per the demand.Let's assume Np is the quantity of cells arranged in parallel while Ns is the cells in series equation(2) is transformed into equation (3)

$$I = N_p \cdot Isc - Np \cdot IR[e^{\frac{q\left(\frac{Np}{N_S} I \cdot Rs+V\right)}{A \cdot K \cdot T \cdot N_S}} - 1] \qquad (3)$$

III .BYPASS DIODES FOR PV SYSTEM

When the models are installed some of the portion of the modules might get covered by clouds tall buildings Shadow of other PV Panels one over the another, shadows from trees, etc. This might cause less current supplied by the PV cell which are covered than those which are non covered [13]. Contrary to this solar cells must have same current for all branches of PV models. If the output of the cell is close to zero or zero this will cause the cell to work in negative region of voltage. Consequently the voltage of the entire outlet will reduce. This will cause a hotspot as the cells now start absorbing power and will heat up. Figure 2 shows partial shading conditions due to non uniform radiation intensity on PV systems due to clouds. Result of this is lot of power will be consumed and most of the power of shaded PV array will be condensed with significant amount. To reduce these self-heating effects of the modulus bypass diodes are connected crosswise with the array. The PV trajectory establishes many maxima or peak and displays the difference of maximum power point in the models. Figure 3 the first peak shows the maximum power point with bypass diodes while the second peak demonstrates the NPP without presence of bypass diodes.

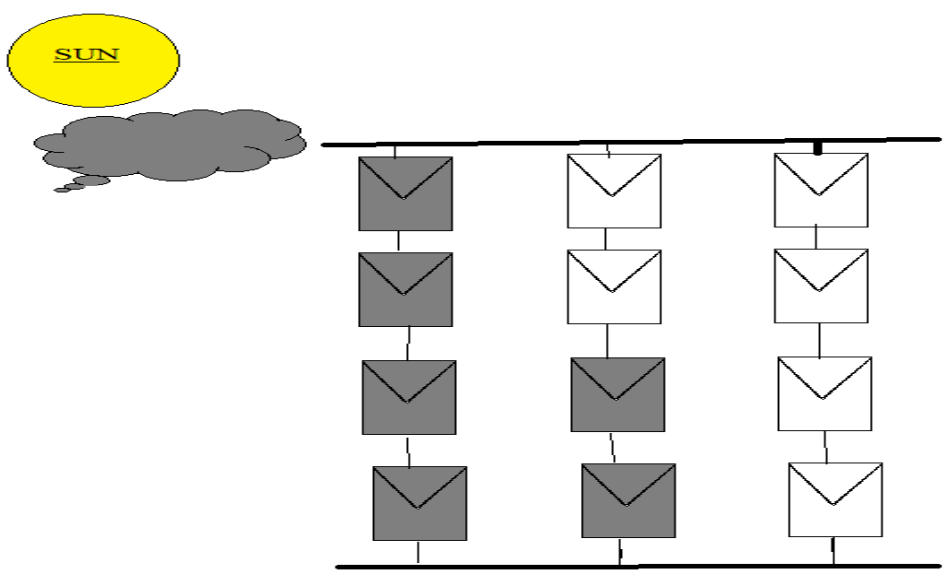

Figure2.*PSC caused by the clouds on PV System*

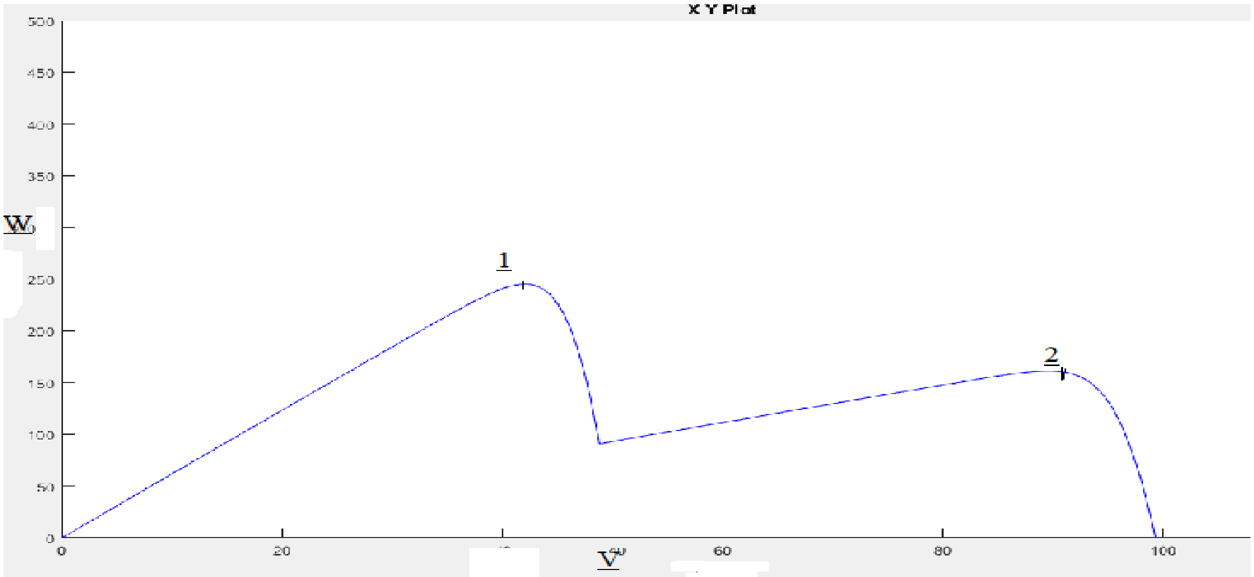

Figure 3.*PV Characteristics Under PSC of PV Array*

IV.DIFFERENT PARAMETERS USED IN STANDALONE PV MODULE

The Tata power solar system TP 250 MBZ PV module is used , the electrical characteristics are Np=4,
Tref =25 °C, Voc=36.8Volt ISC=8.83 amps, K =1.380658e^-23,q=1.6*10^-19 Eg=1.1, Ir =[500 800 1000 1000]

V. INFLUENCE OF PSC ON PV SYSTEM

The PSC has two impacts on solar modules ,first the hotspot phenomena due to partial shading causes damage and as a result the output power of the system will be reduced ,secondly the local peaks in the PV trajectory causes conventional techniques like INC and P&O to fail as they cannot distinguish between LMPP and GMPP and it will remain in LMPP which will result in lot of loss in the power. During partial shading the PV trajectory of module has various peaks as shown in Figure 3. The INC algorithm will track LMPP if it is positioned near it and will cause lot of power loss so it is compulsory to implement GMP tracking algorithms which can ignore all LMP in PV systems. This paper presents the dynamic PSO approach for tracking of GM PP.

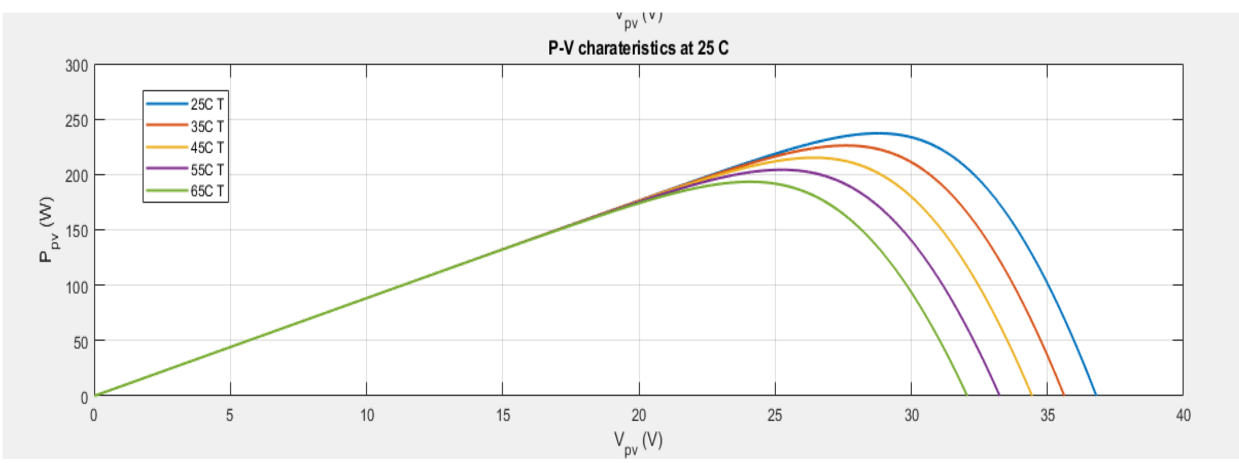

Figure 4: *PV curve for different Solar Irradiance*

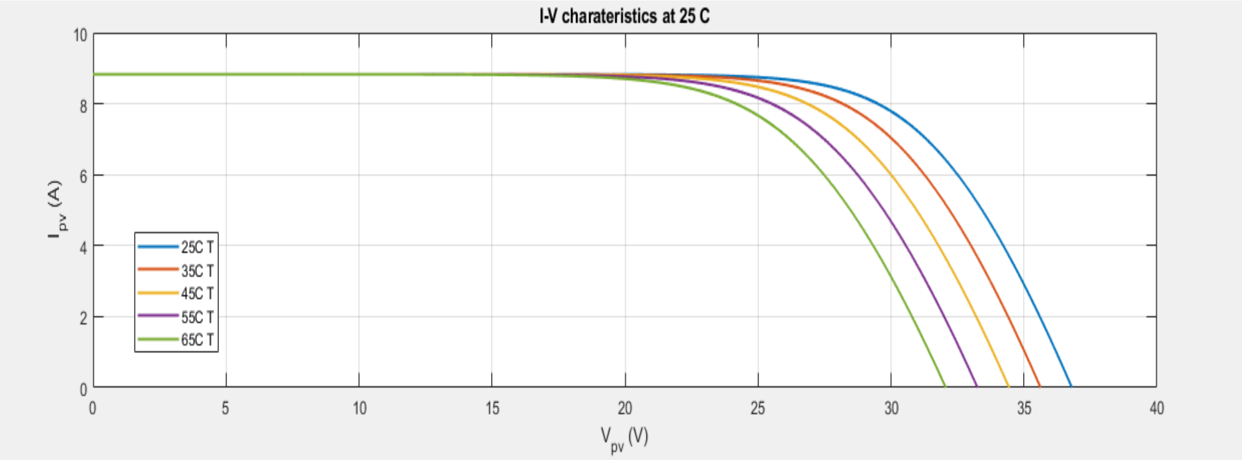

Figure 5: *IV curve for different Solar Irradiance*

VI.PSO ALGORITHM FOR TRACKING GMPP

PSO is simple intelligent meta heuristic optimization approach it was proposed by Ebehard and Kennedy in 1995 [13].PSO is an evolutionary algorithm search optimization technique. The idea is inspired by attitude of birds in a group to solve difficulties involved during a search process or in optimization .In PSO each particle of the swarm will evaluate at various positions in a search space of n dimension and will travel with the velocity depending on its personal best position ie (Pbest) and the best position among the group that is Global best (Gbest)[14]. Each particle in a specified group exchanges the information in its process of search ,that is each group will try to reach close to the optimum solution. The velocity and position of each particle is expressed as equation[4] and [5]
[15]

$$v_i(k+1) = wg.vi_1^{(k)} \cdot + c1^{(k)}.r1\left(P_{bi}^{(k)} - Si^{(k)}\right) + \quad c2^{(k)}.r2.\left(G_b^{(k)} - Si^{(k)}\right)$$
(4)

$$s^{[k+1]} = s_i^{(k)} + v_i^{(k+1)} \quad (5)$$

Where
I: The number of particles
wg :The weighting function
vi :The particle I velocity at iteration k
cj :Time bearing social and cognitive factor
ri: The random variable is distributed uniformly (0to1)
Sj: The current position of agent I at iteration k
Pbi: The best position of agent I
Gb: The best position in the group

The value of inertia weight should be kept low so that the careful optimization can be made and this will make the algorithm tracking capacity strong enough to achieve the precise solution. Its value usually ranges from .4 to .9.

$$w(k) = w_H - \frac{k}{k_H} \cdot (w_H - w_L) \quad (6)$$

In equation (6) WH and WL are the higher and lower values of w and KH is the highest number of iteration.

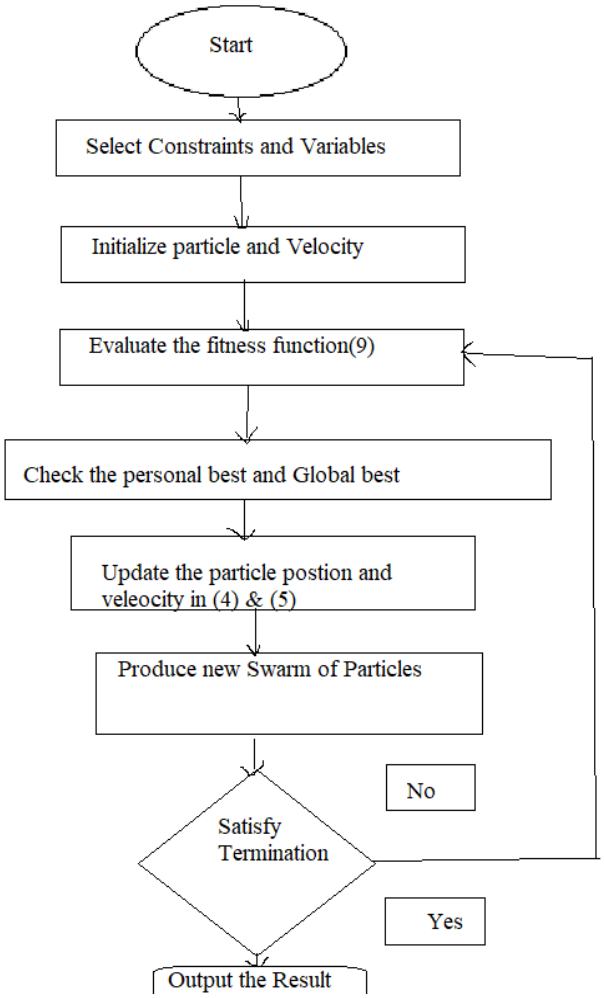

Figure.6 *Flow diagram for GM MPT PSO algorithm*

$$c1(k) = C_1 \cdot H - \frac{k}{k_H} \cdot (C_1 \cdot H - C_1 L) \quad (7)$$

$$c2(k) = C_2 \cdot L - \frac{k}{k_L} \cdot (C_2 \cdot H - C_2 L) \quad (8)$$

In equation (3) c1 and c2 can distribute the tracking capabilities of PSO they do so by influencing the directions of different particles. Usually c1 and c2 range from 0 to 2. The algorithm described above of the PSO will be utilized to preserve the GM PP tracking techniques during PSC for PV system .The PV trajectory will become very complex and more distinct due to the availability of various peaks. To solve this issue the PSO must be changed to encounter the applied observations regarding PV system. The elaborated flowchart of the PSO algorithm is presented in Fig. 6. The important constraints used in the PSO are listed in Table 1. The proposed PSU approach is very efficient , independent of the systems and can be executed by means of controller. The fitness function of PSO algorithm for tracking GMPP is express as eq,9

$$\text{fitness}(Vp, Ip) = Vp.Isc - Vp.IR[e^{\frac{q(Vp+Ip \cdot Rs)}{A \cdot K \cdot T}} - 1] \quad (9)$$

Table 1 *Constraints for PSO Algorithm*

Parameters	Symbol	Value
No of Particles	u	4
Weight of Inertia	w	.4
Cognitive Coefficient	c1	1.2
Social Coefficient	c2	2

Steps involved in PSO algorithm for extracting GMPP are as follows

1. Initially random particles in the search space originated in PSO .the velocity of these particles are also randomly chosen.
2. Provide the solution of candidates to fitness function for evaluation and obtaining the fitness values among the particles
3. Find out the particles global best and personal best among the entire particles.
4. Evaluate and update the velocities and position of each particles using eq (4) and (5)
5. If convergence is achieved stop the search process if condition is not fulfilled raise the iteration count and once again start the evaluation of fitness process.

VII. SIMULATION RESULTS AND ANALYSIS

To evaluate the efficiency and reliability of the suggested method MATLAB/Simulink is used. The modeling of PSO algorithms DC-DC converter solar module is designed in MATLAB environment. Figure 7 shows the simulink model of the proposed MPPT_PV_SYSTEM Using PSO Algorithm . The algorithms dynamic codes are developed in S function builder .The constraints of solar module are recorded in Table 2 while the parameters of DC-DC Boost Converter circuit in Table 3 respectively [16].Figure.10 used to visualize values of results of power and voltages by using PSO algorithms. In the PSO algorithm the GMPP is traced around 589.7 W From this we can conclude PSO algorithm is robust under PSC conditions and also during sudden changes in weather.

Table 2: *Details Of PV System*

Parameter	Value
Maximum Power	249W
Open Circuit Volatge	36.8V
Short Circuit Current	8.83A
Maximum Voltage	30V
Maximum Current	8.3A

Table 3: *Parameter of DC-DC Boost Converter*

Parameter	Value
Output Voltage	176.8V
Output Current	3.36A
Boost Capacitor	.4676e-3F
Boost Inductor	1.1478e-3H
Switching Frequency	10KHz

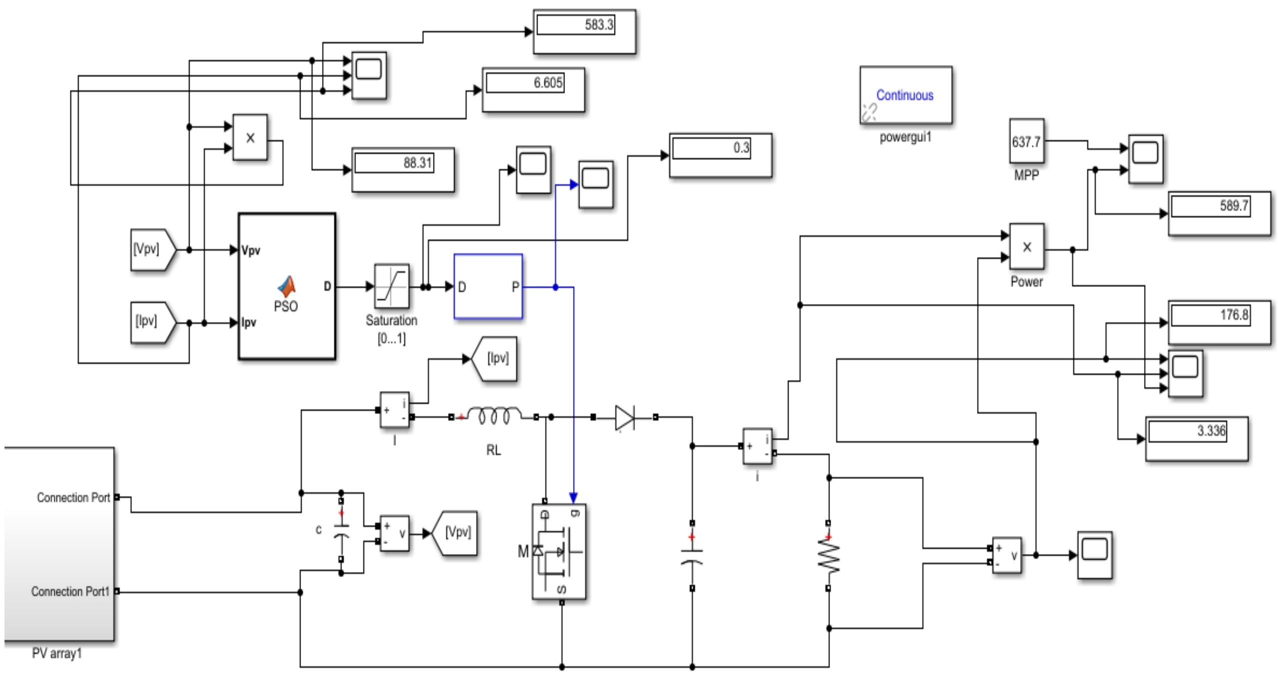

Figure.7 *.Simulink Model of the MPPT_PV_SYSTEM Using PSO Algorithm*

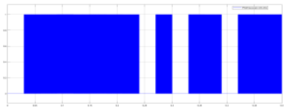

***Figure.8**.PWM Pulses Given to MOSFET*

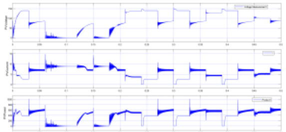

***Figure 9.**Results of Voltage, Current and Power of the PV System Under Partial Shading Condition*

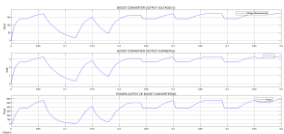

***Figure 10.** Output Voltage ,Current and Power from Boost Converter*

VIII .CONCLUSION

In this paper calculation of PV System and Boost converter parameters are done and also MPPT Tracking is obtained by using PSO Algorithm .The main objective of this paper is to present maximum power point tracking method based on PSO Algorithm by tracking Global Maximum Power Point for the PV system. Figure .8 shows the PWM applied to the boost DC-DC converter. The proposed PSO algorithm could be performed appropriately during PSC condition. The PSC condition generated multiple peaks and all other algorithms fail to differentiate between GMPP and LMPP and give power around LMPP .So, PSO Algorithm is thus effective, it has high convergence rate which makes it remarkable as matched to many conventional algorithms [17].

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