PSO BASED MAXIMUM POWER POINT TRACKING OF PARTIALLY SHADED SOLAR ARRAY IN INTERLEAVED BOOST CONVERTERS

N.Prasad, K.Muthuvel

Assistant Professor, Department of Electrical and Electronics Engineering, Nandha College of Technology, Tamil Nadu, India
Assistant Professor, Department of Electrical and Electronics Engineering, Nandha College of Technology, Tamil Nadu, India

ABSTRACT

Photovoltaic method of power generation is essentially important as they provide an alternative method of power generation. The solar array have a non linear voltage current characteristics where maximum power is reached. When the solar panel is partially shaded it is difficult to track the global maximum power. This paper defines a simulation circuit in MATLAB/SIMULINK for tracking of maximum power from solar panel under varying atmospheric condition and partially shaded condition. An interleaved boost converter is used which is the parallel connection of two boost converters with pulses 1800 phase shifted resulting in minimized ripple content compared to ordinary boost converter. . The maximum power varies with respect to temperature and solar radiation. MPPT algorithm is used to track the maximum power and thereby improving the efficiency of the system. By manipulating the duty cycle of the interleaved boost converter the system implements particle swarm optimization based MPPT algorithm. The particle swarm optimization is a randomly searching algorithm which generates duty cycle randomly to reach maximum power. The simulation was performed under various solar radiations and their waveforms are presented under normal operating condition and partially shaded condition.

Keyword : *- IBC , PSO, MPPT*

1. INTRODUCTION

As the day progresses, the direction of sun changes so that the solar radiation level and the temperature changes resulting in change in solar PV module output. To track more power MPPT (Maximum power point tracking) algorithm is used. MPPT algorithm is not a mechanical system to move the panel in the direction of the sun. It tracks the maximum power based on the voltage and current values of the panel. The voltage at which PV module can produce maximum power is called 'maximum power point'. Actually the solar panel is fitted in north south direction in an inclined position. There are various MPPT algorithm available namely perturb and observe algorithm, incremental conductance algorithm, voltage based peak power tracking, current based peak power tracking etc.These algorithm changes the duty cycle of the dc/dc converter to maximize the power output of the module and make it operate in the peak power point of the module. The perturb and observe algorithm is simple but the output obtained from the algorithm is not so accurate Where as in incremental conductance method the output obtained would be accurate but the system would be complex.

The ordinary MPPT algorithm works good under normal operating condition but they fail to track the power under partially shaded condition. When the solar panel is partially shaded there will be many local maxima and one global maxima. To track the global maxima particle swarm optimization based MPPT algorithm is used. Particle Swarm Optimization is an optimization technique. It models that a group of animals, like birds and fish, search for the location of food. Some search points that are called "agents" and each agent stores the best position which it searched in past: pbest, the most excellent one of the pbests is assumed to be gbest and it is shared as

information on the agent group. Distance between present position and pbest, and gbest decide the next trace direction and speed. Particle Swarm optimization is a randomly searching algorithm that searches randomly in search space looking for the best solution .Since it searches randomly it tracks the global maxima. Comparing with other optimization techniques Particle Swarm optimization is simple as it uses only two equations to maximize or minimize the objective function. It uses velocity and position update equations to update its position, so that it optimizes the function it is needed to do.

The interleaved boost converter consists of two single-phase boost converters connected in parallel. The two PWM signal difference is 180^0 when each switch is controlled with the interleaving method. The input current is the sum of the two inductor currents, I_{L1} and I_{L2}. Because the inductor's ripple currents are out of phase, they cancel each other and reduce the input-ripple current that the boost inductors cause. IBC provides additional benefits such that the ripples are reduced in both input and output circuits and the size of the components are also reduced. Higher efficiency is realized by splitting the output current into "n" paths, substantially reducing I^2R losses and inductor losses.As the two phases are combined at the output capacitor, effective ripple frequency is doubled and hence the ripple voltage is very much reduced. Since the inductor is the largest and heaviest component in a power boost converter, the use of a coupled inductor is preferred to achieve advantages such as reduced core and winding loss as well as improved input and inductor current ripple. By properly choosing the channel number with considering the duty cycle, the ripple current may be reduced to zero.

2.PV Cell

A PV cell is the building block of a solar panel. A photovoltaic module is formed by connecting many solar cells in series and parallel. Considering only a single solar cell; it can be modeled by utilizing a current source, a diode and two resistors. This model is known as a single diode model of solar cell.

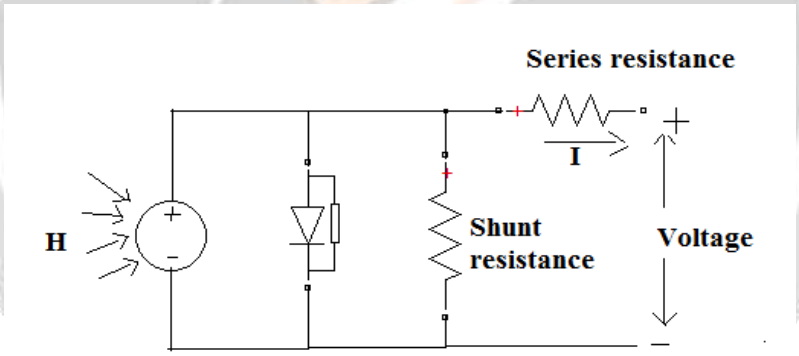

Figure 1 Single diode model of the PV Cell

When the solar panel is partially shaded the power produced in the un shaded areas would be more than the shaded areas so that the power produced in the un shaded areas would be of higher potential and the power produced in the shaded areas would be of lower potential so that the charge gets accumulated in the shaded areas resulting in increase of temperature in shaded areas resulting an effect known as hotspot. To avoid hot spotting effect feedback diode and bye pass diodes are used to disconnect those shaded cells.

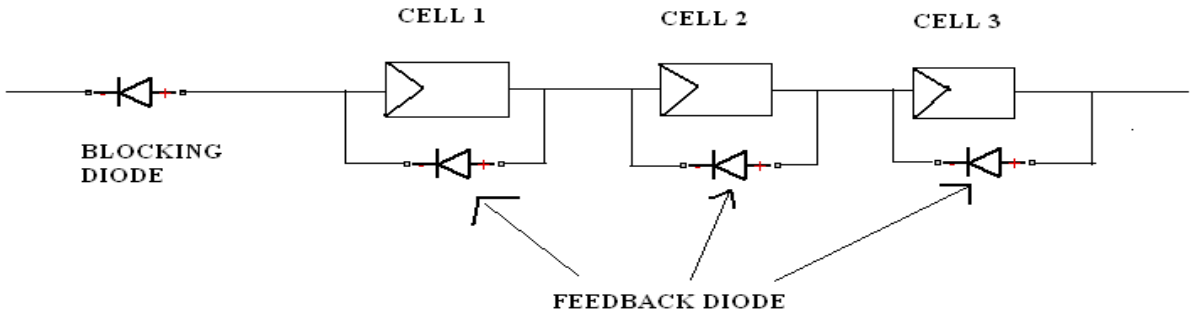

Figure 2 Solar cell with feedback and blocking diode

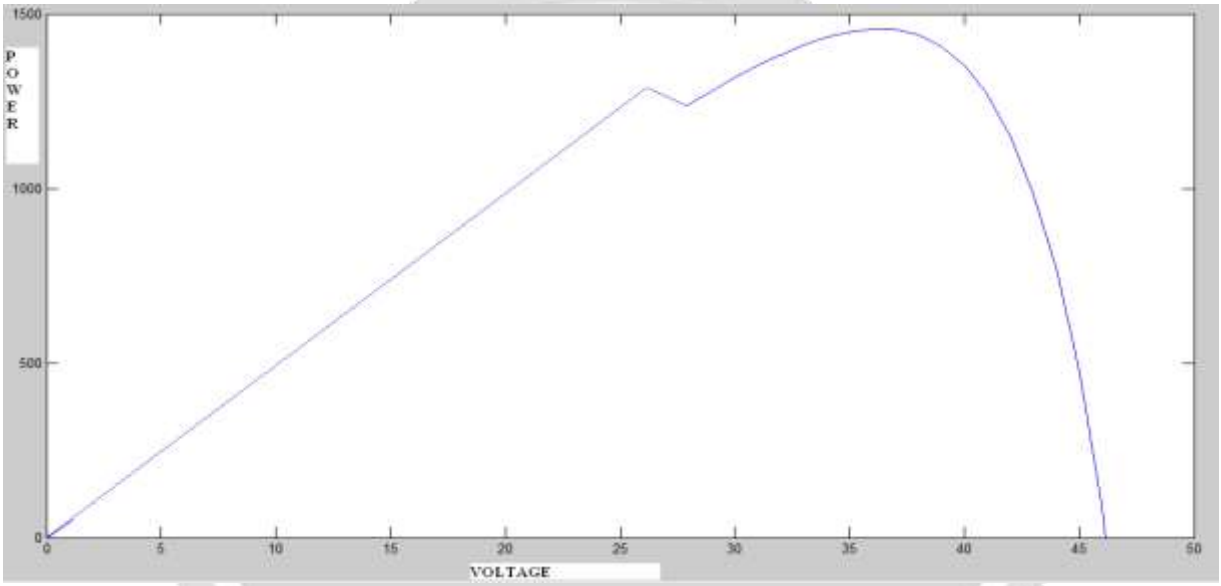

Figure 3 P-V Curve of a partially shaded solar panel

3. PARTICLE SWARM OPTIMISATION BASED MPPT ALGORITHM

The concept of particle swarm optimisation is that the particles are placed randomly at initial position and these particles are allowed to search for a better fitness value in search space. The key point in particle swarm optimisation is that it seaches randomly and analyses an objective function. The particle Swarm optimisation is based on two main equations named as velocity update equation and position update equation as shown in equation 4.1 and 4.2.

Velocity update equation,

$$V(k+1)=w\times V(k)+C1\times R1\times(P_{best}-x(k))+C2\times R2\times(G_{best}-x(k))$$

Position update equation,

$$x(k+1)=x(k)+V(k+1)$$

where

w is inertia weight

R1 and R2 are random numbers in search space

C1 and C2 are correction factors

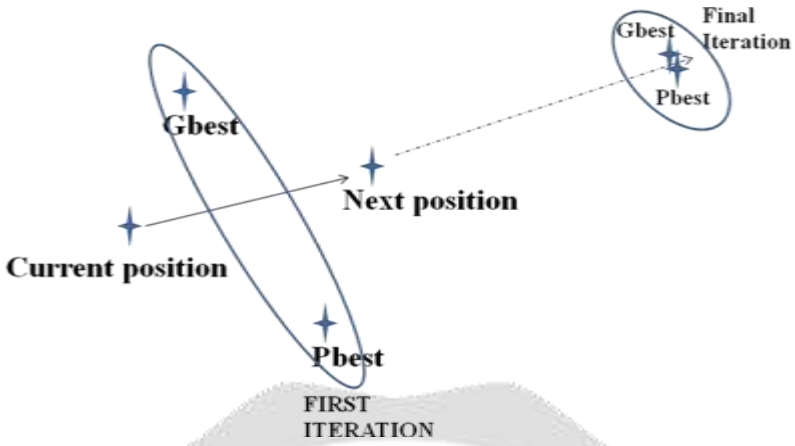

Figure 4. Particle movement in Particle Swarm Optimization

The above figure shows the particle movement in PSO. During the first iteration the particle moves relative to the position of Pbest and Gbest so that it reaches the next position and as the iteration goes on the distance between the Pbest and Gbest reduces and at the end of the iteration it nearly reaches the same position so that at the end of the iteration Pbest or Gbest reaches the same destination point. So for obtaining an optimal value it is done by either following the Pbest or Gbest value.

The variants of PSO uses some modifications in the velocity equation some of the variants are listed below,

- Cognitive PSO
- Social PSO
- Modified PSO

Table 1 Power tracked by MPPT algorithm under Standard testing condition

PERTURB AND OBSERVE ALGORITHM	ORDINARY PSO ALGORITHM	COGNITIVE PSO ALGORITHM	SOCIAL PSO ALGORITHM	MODIFIED PSO ALGORITHM
385W	**415W**	**375W**	**390W**	**400W**

The power tracked by the perturb and observe during partially shaded condition is shown

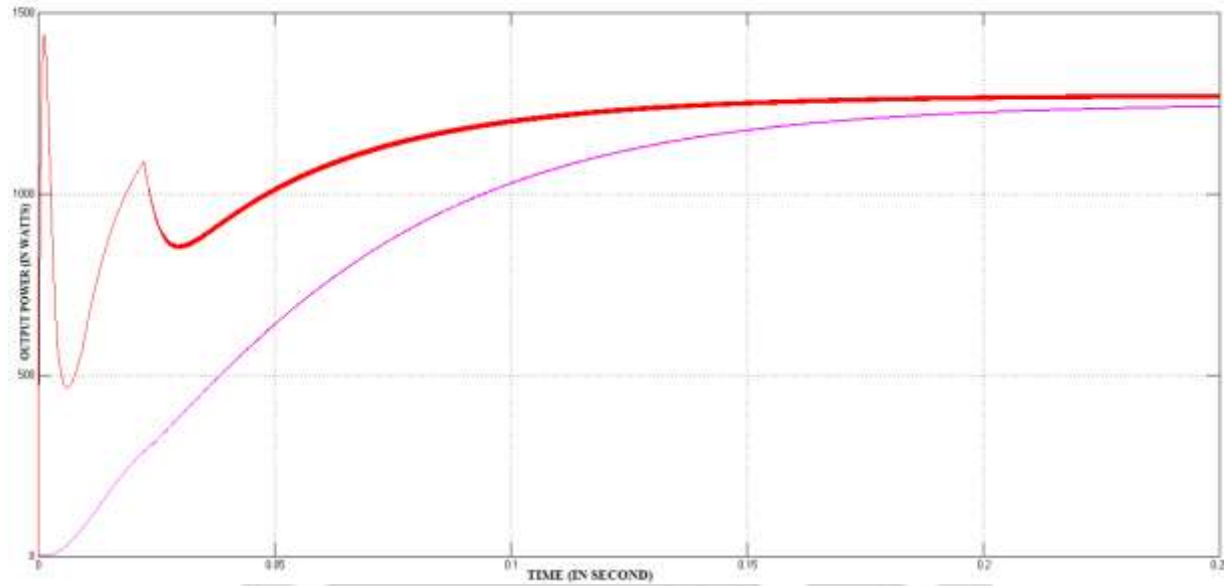

Figure 5. Output power of P and O algorithm under partially shaded condition

The power tracked by PSO algorithm during partially shaded condition is shown

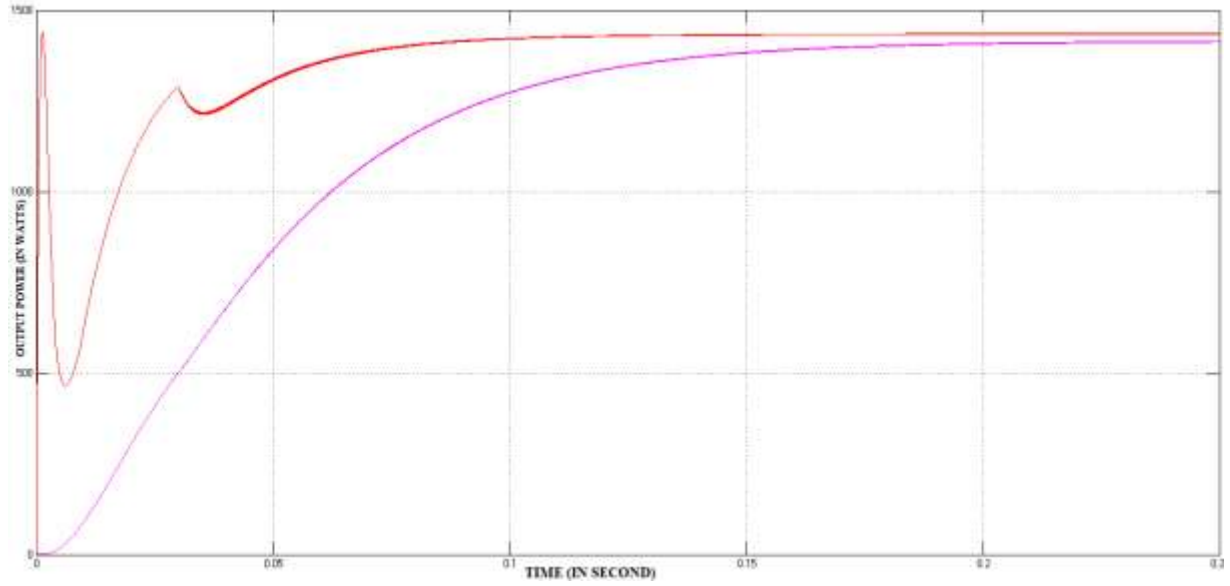

Figure 6. Output power of PSO algorithm under partially shaded condition

The results shows that the power tracked by P and O algorithm is 1220W and the power tracked by PSO algorithm is 1440W which shows that P and O algorithm gets trapped in local maxima where as PSO algorithm tracks global maxima.

4. CONCLUSIONS

The simulation results of solar panel, interleaved boost converter are presented. The output Voltage and output power of the PV panel are obtained. All simulations are performed in matlab/simulink modeling and simulation platform. The power tracked by the various maximum power point tracking algorithm namely particle swarm optimization based MPPT, cognitive PSO based MPPT, Social PSO based MPPT, Modified PSO based MPPT and perturb and observe algorithm are presented. These MPPT algorithms are tested under standard testing condition and the results shows that Particle Swarm Optimization based MPPT tracks more power.

Under partially shading condition there will be multiple peaks in P-V curve which makes MPPT complex and the results shows that ordinary perturb and observe algorithm got trapped in local maxima and tracks a power of 1220W but Particle Swarm Optimization based Maximum Power Point tracking algorithm tracks the global maxima and tracks a power of 1440W.In future particle swarm optimization and neural network can be combined together so that the values obtained in the particle swarm optimization can be used to train the neural network so that the tracking of maximum power can be done in a faster way.

5. REFERENCES

1. Doo-Yong Jung, Young-Hyok Ji, Sang-Hoon Park, Yong-Chae Jung, and Chung-Yuen Won (2011) 'Interleaved Soft-Switching Boost Converter for Photovoltaic Power-Generation System', IEEE Transactions on Power Electronics, Vol. 26, No. 4, pp: 1137-1145.
2. Eftichios Koutroulis and Frede Blaabjerg (2012),"A New Technique for tracking the Global maximum power point of PV Arrays operating under partial-shading conditions", IEEETrans.Ind.Electron.,vol.59,no.3,pp.1588–1596,.
3. L. Gao, R. A. Dougal, S. Liu, and A. P. Iotova,(2009) "Parallel-connected solar PV system to address partial and rapidly fluctuating shadow conditions," IEEE Trans. Ind. Electron., vol. 56, no. 5, pp. 1548–1556,.
4. Luiz Fernando Lavado Villa, Damien Picault, Bertrand Raison, Seddik Bacha and Antoine Labonne (2012), "Maximizing the power output of partially shaded photovoltaic plants through optimization of the interconnections among its modules", IEEE Trans. Energy Convers.,vol.27,no.1,pp.173–183,.
5. Liang-Rui Chen, Chih-Hui Tsai, Yuan-Li Lin, and Yen-Shin Lai, (2010), "A Biological Swarm chasing algorithm for tracking the PV Maximum Power Point", IEEE Trans. EnergyConvers.,vol.25,no.2,pp 484–493,.
6. M. Z. Shams El-Dein, and Mehrdad Kazerani, (2011), "Optimal photovoltaic array reconfiguration to reduce partial shading losses", IEEE Trans. Energy Convers., vol. 26,no.4,pp.1210–1218.
7. N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli (2005), 'Optimization of perturb and observe maximum power point tracking method,' IEEE Trans. Power Electron., vol. 20, no. 4, pp. 963–973,.
8. O. Lopez-Lapena, M. T. Penella, and M. Gasulla,(2010) "A new MPPT method for low-power solar energy harvesting," IEEE Trans. Ind. Electron., vol. 58, no. 9, pp. 3129–3138,.
9. S. Bacha, Bratcu, I. Munteanu, D. Picault, and B. Raison (2011), 'Cascaded DC-DC converter photovoltaic systems: Power optimization issues,' IEEE Trans. Ind. Electron., vol. 58, no. 2, pp. 403–411, .
10. Yi-Hwa liu,shyh-ching huang,jia-wei huang and wen cheng liang (2012) "A particle swarm optimization based maximum power point tracking algorithm for PV systems operating under partially shaded conditions" IEEE Transactions On Energy Conversion,Vol.27,No.4,.
11. Kashif Ishaque, Zainal Salam, Muhammad Amjad, and Saad Mekhilef,(2012) 'An Improved Particle Swarm Optimization (PSO)–Based MPPT for PV With Reduced Steady-State Oscillation', ieee transactions on power electronics, vol. 27, no. 8,.
12. Hiren Patel and Vivek Agarwal (2008), 'MATLAB-Based Modeling to Study the Effects of Partial Shading on PV Array Characteristics' IEEE transactions on energy conversion, vol. 23, no. 1.