International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:8, No:2, 2014

DPSO Based SEPIC Converter in PV System under Partial Shading Condition

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***Abstract*—**This paper proposes an improved Maximum Power Point Tracking of PhotoVoltaic system using Deterministic Partical Swarm Optimization technique. This method has the ability to track the maximum power under varying environmental conditions i.e. partial shading conditions. The advantage of this method, particles moves in the restricted value of velocity to achieve the maximum power. SEPIC converter is employed to boost up the voltage of PV system. To estimate the value of the proposed method, MATLAB simulation carried out under partial shading condition.

***Keywords*—**DPSO, Partial shading condition, P&O, PV, SEPIC.

I. Introduction

SOLAR energy power generation is playing an important role to produce electric power with zero percent carbon emission. To make use of Photo Voltaic (PV) system, implementing the technique as Maximum Power Point tracker (MPPT).

Maximum power point tracking technique is used to extract the maximum power of PV system. The techniques are P&O method, Incremental Conductance method, Ripple Correlation method, etc. Those methods can extract the PV panel's voltage or current in order to preserve the maximum power of PV to get higher efficiency [1], [2].

But to varying environmental conditions tracking power of PV diminished. Partial shading conditions not only affect the output power of the PV but also affect the security and reliability of the system. A shaded cell will act as a load. It draws current from the main load. The voltage across the unshaded cell gets reduced.

In order to get maximum power in a PV system, intelligent technique as Deterministic Particle Swarm Optimization (DPSO) is implemented [3]. Considering the state of normal condition in a PV system, P&O technique is employed. During normal conditions, only one global peak i.e. only one maximum power point is present. But in case of partial shading condition, multiple peaks and one global peak is present [4]-[6].

To track the maximum power for the duration of the partial shading condition, soft computing technique is employed. Particle Swarm Optimization (PSO) is implemented to track the maximum power. However, in the presence of random number, maximum power can achieve with higher number of iterations. It results in some significant power loss.

To reduce power loss and obtain maximum power, DPSO technique is initiated. Comparing to other soft computing techniques, from DPSO maximum power can be achieved with less convergence time. So, the efficiency of the system will be improved and also power loss will be minimized. Once the DPSO technique is instigated, it will produce a duty signal to the SEPIC converter. The output voltage of a PV boosted up and given to the load. Thus, load can be utilized with help of renewable source i.e. solar energy.

The SEPIC is a DC/DC converter topology which offers a positive regulated output voltage from an input voltage that varies from above to below the output voltage [7]-[9]. The SEPIC converter is correlated to buck-boost converter, but the output has the same voltage polarity as the input, using a series capacitor to couple energy from the input to the output [10].

II. Proposed Method

In DPSO method, the velocity of particle restricted to a particular value to keep the distance among the peaks. So that Conventional PSO is making over into the deterministic structure. The basic concept of this method is removing the random no in the velocity equation.

$$V_i^{k+1} = WV_i^k + \{P_{besti} - x_i^k\} + \{G_{besti} - x_i^k\} \quad (1)$$

(for $0<v<V_{max}$)

$$V_i^{k+1} = WV_i^k + \{P_{besti} + G_{besti} - 2x_i^k\} \quad (2)$$

From MPPT technique, gating signal is generated and given to SEPIC converter. During normal conditions P&O technique is used. In case of partial shading condition DPSO method is employed.

By implementing DPSO method, following parameters are used:

Particle size is about 20, inertia w=0.5.Initially, the duty cycle of the converter is initiated. Fig. 1 represents flow chart of the overall MPPT algorithm. The whole MPPT algorithm operates based on two conditions. When the PV cells are equally illuminated, P&O technique is employed to track the maximum power. At the time of partial shading condition i.e. PV cells are not illuminated, DPSO technique is used to get maximum power with reduced number of iteration. Power loss will be minimum compared to other intelligent control techniques.

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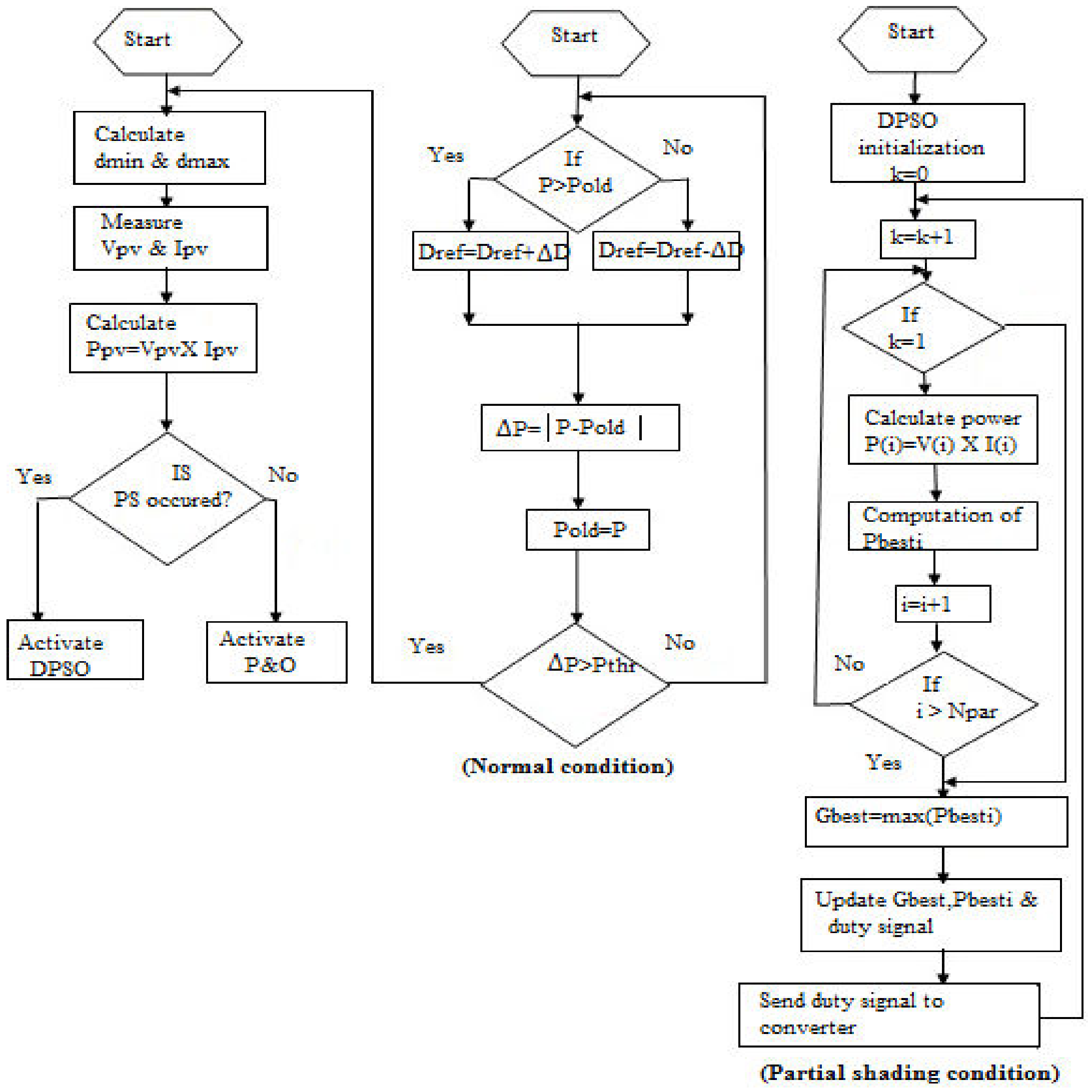

Fig. 1 Flow chart for MPPT algorithm

Minimum and maximum duty signal values can be calculated by using following formulas,

$$d_{\min} = \frac{\sqrt{\eta_{bb} R_{L\min}}}{\sqrt{RPV_{\min}} + \sqrt{\eta_{bb} R_{L\min}}} \tag{3}$$

$$d_{\max} = \frac{\sqrt{\eta_{bb} R_{L\max}}}{\sqrt{RPV_{\min}} + \sqrt{\eta_{bb} R_{L\max}}} \tag{4}$$

Fitness function is chosen be,

$$f(x_i^k) > f(P_{besti}) \tag{5}$$

Once duty signal is generated by MPPT technique, it is given to the SEPIC converter. The SEPIC converter exchanges energy between the capacitors and inductors in order to convert from one voltage to another. The amount of altered energy is controlled by switch i.e. MOSFET which is in the action when the Duty signal obtained from the MPPT technique (either P&O or DPSO).

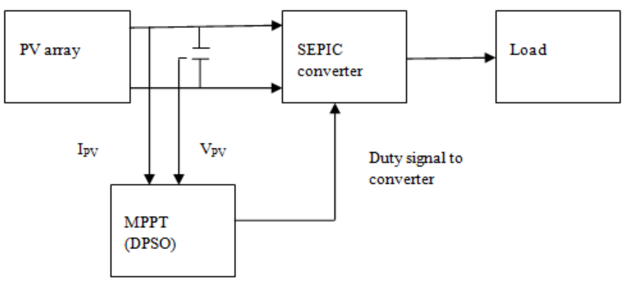

Fig. 2 Block Diagram for proposed method

Fig. 2 indicates the block diagram of the proposed method. Output voltage of PV is given as input to the SEPIC converter. Because of clouds, trees, etc. PV cells are not equally illuminated. In this condition, power generated from PV gets reduced. MPPT technique is more important to track the maximum power. Here, soft computing technique is used to track maximum power and produce duty signal to converter.

III. Design of SEPIC Converter

In DC-DC conversion, SEPIC converter allows the output voltage to be greater or less than or equal to the input voltage. Output voltage of the converter can be controlled with help of duty signal of the switch [4], [15].

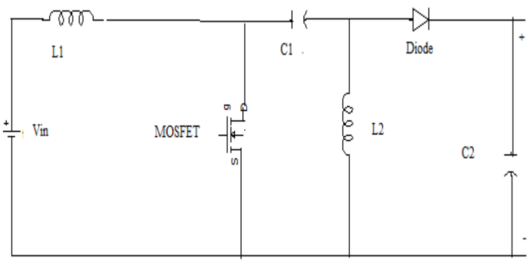

Fig. 3 Circuit diagram for SEPIC converter

Fig. 3 demonstrates the circuit diagram of SEPIC converter. With MOSFET is closed current increases through L_1 and C_1 discharges (C1 charged in previous state) increasing the current in L_2. When the switch is turned off, the current I_{C1} becomes the same as the current I_{L1}, since inductors do not allow an instantaneous change in current. Current through the L_2 in the negative direction and it will never reverse the direction of flow of current. From observed that, negative I_{L2} will add to the current I_{L1} to increase the current delivered to the load. Voltage spikes across the inductor can be avoided by using fast switching diode such as schottky diodes [11]-[14].

TABLE I
Design Specification

Parameters	Value
L1	4.89 mH
C1	32.4 F
C2	324 F

The Inductor is sized to ensure that inductor current is continuous at minimum load and that the output voltage ripple does not concern the current that the converter is powering. Large value of C_2 may need particularly if the load current is composed of high energy pulses. SEPIC topology has the properties of filtering. So the input capacitor can be very small.

IV. Result and Discussion

PV systems able to meet almost any electric power need, whether small or large. Maximum power of PV can be obtained by MPPT technique. MPPT is to automatically vary a PV array's load condition so it can produce its maximum output power.

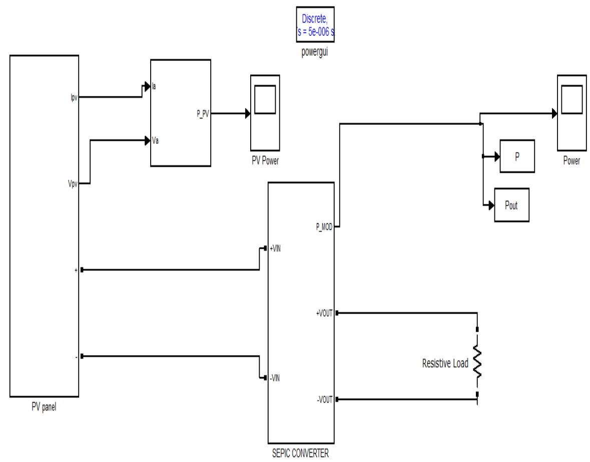

Fig. 4 Simulation of DPSO based MPPT

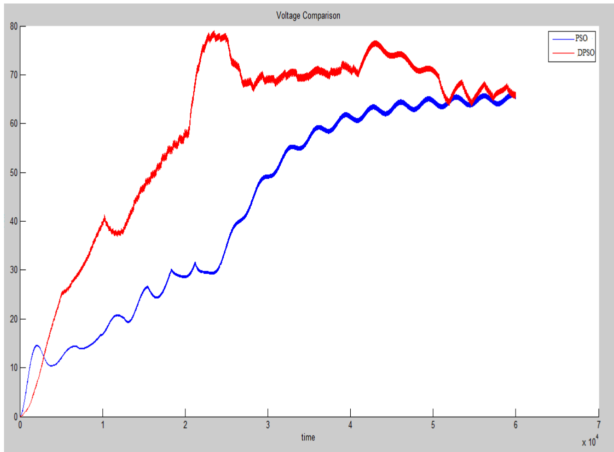

Fig. 5 Voltage comparison of PSO&DPSO technique

During partial shading condition, MPPT fails to track the maximum power of PV system because non-linear characteristics of the system. So, maximum power can attain by using intelligent technique i.e. DPSO technique. The particle moves deterministic manner to reach maximum power. Fig. 4 shows a Simulink diagram of DPSO based MPPT technique.

TABLE II
Comparison of PV Array Output

Parameters	Normal condition	Partial shading condition	
	P&O	PSO	DPSO
Voltage(V)	468.74	714.41	725.26
Current(A)	15.62	23.81	23.56
Power(kW)	3.121	1.501	2.138
Duty cycle	0.8997	0.8530	0.9000
No. of iteration	-----------	35	8

V = Volt, A = Ampere, kW = kilo Watt

Table II represents the comparison of PV array output and the obtained result of P&O is only applicable for normal condition. The PSO algorithm is most preferred method for partial shading condition. The main drawback of this method is that the presence of random number. Higher number of iterations is used track maximum power.

Output of PV is given to the SEPIC converter. Switch on SEPIC converter conducts when duty signal obtains from the MPPT (P&O or DPSO) technique. Figs. 4-6 represent voltage, current, and power comparison of PSO and DPSO techniques. Each and every instant DPSO method check whether the available power is global maxima or not. But in case of P&O technique, once maximum power is tracked it will remain constant during all the conditions.

Output Current, Voltage and Power of PSO and DPSO compared. Maximum power of PV can be achieved in a small number of iterations (4) by using DPSO technique. In this method particles moves in a deterministic manner.

Generation of Power from PV is important as well as utilization of produced power is more important. PV power utilized effectively with the help of Deterministic Particle Swarm Optimization. Consider, if particle away from the best position, large changes in velocity is required to reach the maximum power point. But a large change in velocity requires a higher number of iterations to reach maximum power. It results significant power loss in PSO method. By comparing the PSO and DPSO techniques, DPSO can track the MPP effectively with reduced number of iterations as well as power loss reduced significantly. Compared PSO method, DPSO technique able to track maximum power and power loss will be low.

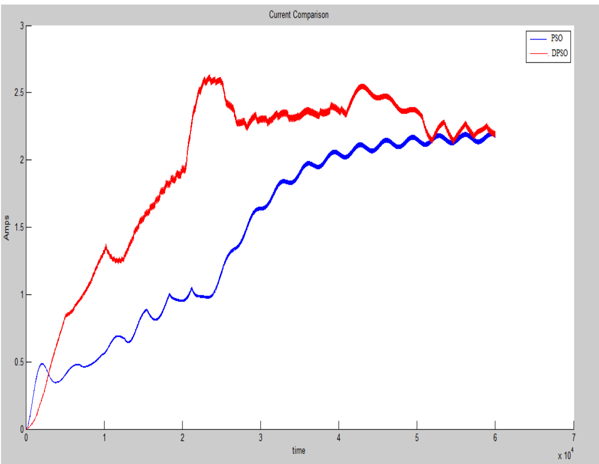

Fig. 6 Current comparison of PSO&DPSO technique

TABLE III
SEPIC CONVERTER OUTPUT VOLTAGE

Methods	PV system condition, V_{PV}=110 V	
	α	V_{OUT}
P&O	0.8997	241.46
PSO	0.8703	165.47
DPSO	0.8770	166.23

V = Volt

Table III represents output voltage of SEPIC converter. During normal condition, P&O technique is activated to track maximum power point. In case of partial shading condition, PSO& DPSO implemented to track the global point. But DPSO gives the best result when compared to PSO method.

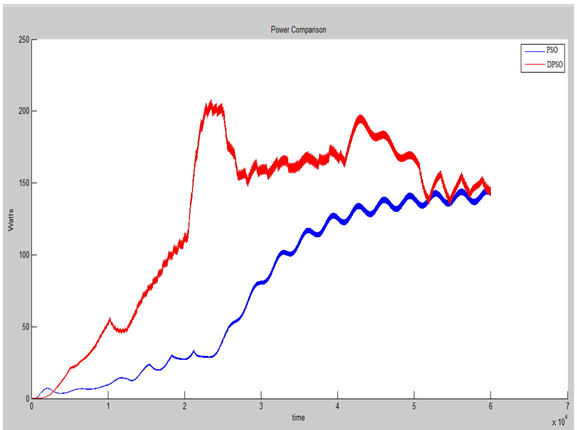

Fig. 7 Power comparisons of PSO&DPSO technique

V. CONCLUSION

This paper compares the intelligent techniques for tracking the global point during partial shading conditions. Duty signal obtained from the MPPT technique is given to the SEPIC converter. Comparing all techniques, Deterministic Particle Swarm Optimization technique gives the best result under partial shading condition. P&O method is used to track the power at normal condition.

REFERENCES

[1] Kashif Ishaque and Zanial Salam,” A Deterministic particle Swarm Optimization MMPT for PV system under partial shading condition,” IEEE Trans. Ind. Electron., vol. 60,NO.8, pp.3195-3205,Aug.2013
[2] T. L. Nguyen and K.-S. Low, “A global maximum power point tracking scheme employing DIRECT search algorithm for photovoltaic systems,” IEEE Trans. Ind. Electron., vol. 57, no. 10, pp. 3456–3467, Oct. 2010.
[3] M.Miyatake, M. Veerachary, F. Toriumi, N. Fujii, and H. Ko, “Maximum power point tracking of multiple photovoltaic arrays: A PSO approach,” IEEE Trans. Aerosp. Electron. Syst., vol. 47, no. 1, pp. 367–380, Jan. 2011.
[4] V. F. Pires, J. Fernando, and A. Silva, “Teaching nonlinear modeling, simulation, and control of electronic power converters using MATLAB/SIMULINK,” IEEE Trans. Educ., vol. 45, no. 3, pp. 253–261, Aug.2002.
[5] D. Nguyen and B. Lehman, “An adaptive solar photovoltaic array using model-based reconfiguration algorithm,” IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2644–2654, Jul. 2008.
[6] S. Cuk, “A new zero-ripple switching DC-to-DC converter and integrated magnetics,” IEEE Transaction on magnetics, vol.19, no.2, pp.57-75, March1983.
[7] D. S. L. Simonetti, J. Sebastian, “The discontinuous conduction mode SEPIC and Cuk power factor preregulators: analysis and design” IEEE Trans.on Industrial electronics,vol,44 no.5,pp 630-637,oct.1997.
[8] Fawzan Salem, Mohamed S. Abdel Moteleb*, Hassan T. Dorrah, ”An Enhanced Fuzzy-PI Controller applied to the MPPT Problem”, Electronics Research Institute, Dokki, Egypt,2003.
[9] V.Quaschning and R.Hanitsch, “Numerical simulation of current–voltage characteristics of photovoltaic systems with shaded solar cells,” Solar Energy, vol. 56, no. 6, pp. 513–520, Feb. 1996.

[10] C. Dorofte, U. Borup, and F. Blaabjerg, "A combined two-method MPPT control scheme for grid-connected photovoltaic systems," in Proc. Eur. Conf. Power Electron. Appl., Sep. 11–14, 2005, pp. 1–10.
[11] S. Cuk and R. D. Middlebrook, "A new optimum topology switching+33 DC-to-DC converter," in Conference Rec. 1977 IEEE Power electronics Specialist Confe.,pp. 160-179.
[12] F. S. Dos Reis, J. Sebastian, and J. Uceda, "Characterization of conducted noise generation for SEPIC, Cuk and Boost converters working as power factor preregulators,"in conf. Rec. 1993 IEEE, pp. 965-970.
[13] B. Axelrod, Y. Berkovich, and A. Ioinovici, "Transformerless DCDC converters with a very high DC line-to-load voltage ratio," in 2003 IEEE International Symposium on circuit and system, vol.3,pp.435-438.
[14] H. Nomura, K. Fujiwara, and M. Yoshida, "A new DC-DC converter circuit with larger step-up/down ratio" in conf. Rec.2006 IEEE Power electronics specialist conf.pp.1-7.
[15] R. W. Erickson and D. Makismovic, "Fundamentals of power electronics".2nd ed,Spinger Science.USA,2001.ch.6.