TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol. 14, No. 3, June 2015, pp. 376 ~ 380
DOI: 10.11591/telkomnika.v14i3.7900

An Advanced High Performance Maximum Power Point Tracking Method with Ant Colony and Particle Swarm Optimization Method Using Interleaved Boost Converter

Nivetha V*, G. Vijaya Gowri, Elamathy A
K.S.Rangasamy College of Technology, Tiruchengode, India
*Corresponding author, e-mail: nivethameped@gmail.com

Abstract

To obtain efficient maximum power point tracking operation under varying and steady state environmental conditions which is based on Ant Colony Optimization (ACO) combined with Particle Swarm Optimization (PSO) that controls an interleaved DC-DC converter connected at the output of PV array and maintains a constant input-power load. The operation of maximum power point tracking is to adjust the power interfaces so that the operating characteristics of the load and the photovoltaic array match at the maximum power points. The simulation is based on the computed algorithms which show very good perspectives. The searching routine is done in less than 15 steps and takes less than 50ms. The tracking accuracy is better than those found in conventional methods.

Keywords: *PV system, maximum power point tracking, interleaved boost converter*

1. Introduction

The installation of photovoltaic (PV) generation systems is rapidly growing as an energy security, and causes environmental issues such as global warming. PV generation system is clean and eco-friendly source of energy and it is operated either in standalone or grid connected modes. But the power–voltage characteristics of photovoltaic panel (PV) have a non-linear output due to some temperature and irradiation operating under partial-shading conditions. So, there is a need of MPPT system to sample the output of the cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions. The maximum power point tracking (MPPT) is the automatic control algorithm to adjust the power interfaces and harvest the greatest possible power, during variations of temperature, photovoltaic module characteristics, light level and shading for every moment. It has become an essential component to evaluate the design performance of photovoltaic panel. Maximum Power Point Tracking (MPPT) usually is implemented with power electronic converters which act as an interface between PV arrays. Usually a PV system may be a standalone system or grid connected. In the first case it is necessary to keep the output voltage of the system in the standard range for avoiding power cut. A module of MPPT controller is shown in Figure 1 in which it consists of a DC-DC interleaved boost converter and a microcontroller.

The maximum power point (MPP) of a PV module can be detected by a microcontroller which is driven by an MPPT algorithm. Once the MPP is obtained, a triggering signal with a specific duty cycle is generated and used to trigger the boost converter switches in order to ensure that the converter operates as close as possible to the PV MPP.

To obtain an efficient maximum power point tracking, two considerations can be made, firstly by developing an improved algorithm for maximum power point tracking and by designing an efficient interleaved boost converter circuit which is an important component in the controller.

Many MPPT techniques have been proposed in the literature; examples are the Perturb and Observe methods, Incremental Conductance (IC) methods, Fuzzy Logic Method, etc. In this paper two most popular of MPPT optimization technique (Ant colony and particle swarm) are introduced. Ant colony algorithm optimization (ACO) is a nonlinear problem based technique not

Received March 2, 2015; Revised April 26, 2015; Accepted May 15, 2015

only ensures the ability to find the global maximum power point (MPP), but also gives a lower system cost and simpler control scheme.

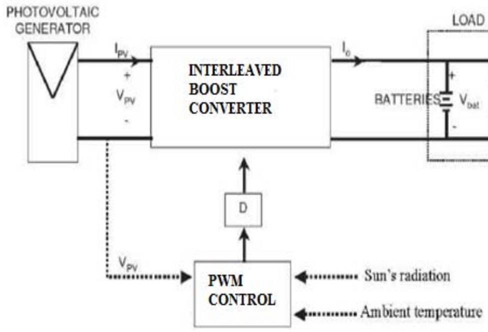

Figure 1. MPPT Controller

PSO is a population based stochastic optimization technique which is initialized with a population of random solutions and searches for optima by updating generations.

This paper proposes the combined algorithms to finding MPPs during oscillation and power decreases condition. Initially, the ACO is employed to track the maximum target value rapidly. And PSO is employed to obtain the exact target value. The global MPPs value is obtained in shortest path in DC-DC converter.

2. Conventional Method

For the implementation of MPPT system, the choice of the appropriate DC-DC converter is based on three basic topologies of three different DC-DC converters (Buck and Boost converter) and MPPT tracker. The characteristics and properties of DC-DC converters is especially as regards the input impedance that they present under certain operating conditions. Based on three topologies the best configuration is to be used.

While using buck converter in MPPT controller it has a maximum power point at minimum irradiation hours. Also buck DC–DC converter has a discontinuous input current and a continuous output current. So, buck topology requires a large and expensive capacitor to smooth the discontinuous input current from the photovoltaic module and to handle significant current ripple. On contrary, the boost converter has a continuous input current and a discontinuous output current. But the photovoltaic current in the boost converter is as smooth as its inductor current, without any input capacitor. But the ripple content is high due to the usage of power electronic switches and inductor.

In conventional method maximum power point tracking was achieved by using some popular algorithms like, incremental conductance algorithm, Perturb-and-observe Algorithm (P&O) combined with Particle Swarm Optimization Algorithm (PSO).But it has the disadvantage of longer convergence time and failure to track global maximum point, when the panel is subjected to shade or cloudy conditions. And both P&O and INC algorithms are prone to failure in case of large changes in irradiance. Some other disadvantage of conventional perturb and observe method is, it can produce oscillations of power output around the maximum power point even under steady state illumination. The incremental conductance method also produces oscillations and can perform erratically under rapidly changing atmospheric conditions.

3. Proposed Method

In proposed system DC-DC converter is a interleaved boost converter topology for reducing the ripple current, it also improve the reliability of the system and increase its efficiency. The schematic diagram of interleaved boost converter is shown in Figure 2.

In proposed system, to overcome the difficulties in conventional method, perturb and observe algorithm is replaced by Ant Colony Optimization (ACO) algorithm, which can track the global maximum power point effectively in shortest path. The Ant Colony Algorithm (ACO) is combined with Particle Swarm Optimization algorithm (PSO). The ant colony optimization (ACO) algorithm is inspired by real ant behavior, which is used to find the global optimal solution for a nonlinear problem. ACO mimics the foraging behavior of the ants to achieve optimization of the path in a graph. The collective behaviors of a large number of ants form a positive feedback phenomenon and ants initially search the path randomly and lay down pheromone for other ants to follow. If ants find the higher density of pheromone on the path, then more ants that travel on the same path, and as a result, the subsequent ants will choose the path.

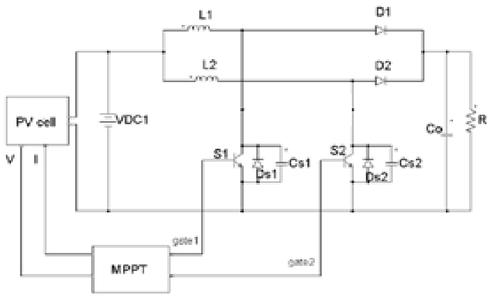

Figure 2. Schematic Diagram of Proposed System

Finally, the trail path is followed by most of the ants until individual ants find the shortest path through the exchange of such information. Initially, the ACO algorithm is used to tackle combinational problems.

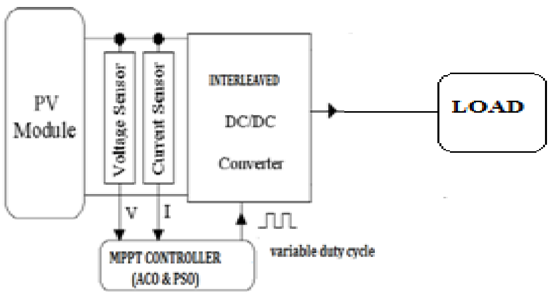

Figure 3. ACO & PSO Controller for Interfacing PV Panel DC-DC Converter

The ACO is a combination of positive feedback mechanism, distributed computing, and a greedy search algorithm. To search the optimal solution it has a strong ability such as, the positive feedback mechanism ensures that the ant colony algorithm is capable of detecting the optimal solution in earlier stage. By using the greedy search the acceptable solution is quickly found and efficiency of the system is improved. The MPPT problem in PV systems is now solved through modified ACO-based optimization. The system structure is shown in Figure 3.

The flow chart of the proposed ACO-based MPPT algorithm for PV systems is shown in Figure 4.

The PSO is an optimization theory inspired by the foraging behaviour of birds and problems related to search and optimization, this phenomenon is suitable to resolve that problem. PSO is derived from the behaviors of bird flocking. Like, a group of birds are searching for a food randomly in an area; instead there is only one piece of food in the area being searched. All the birds do not know where the food is, but they know distance of food for each iteration. The capable one is to follow the bird which is nearest to the food. In PSO, each single solution is a "bird" in the search space. We call it "particle". All of particles have fitness values which are evaluated by the optimized fitness function and have velocities which direct the flying of the particles. By following the current optimum particles, the particles fly through the problem space.Two memory values influence the movement of the particles: Pbest and Gbest. The particle updates its velocity and positions, after finding the two best values. Pbest is the individual optimum of particle i; and Gbest is the swarm or global optimum. Stop tracking if the stop conditions are met. Otherwise, the process is repeated again. The stop conditions are either locating the global optimum.

The search efficiency and success rate of PSO are determined primarily by the values assigned for the weights and the learning factors. When the weight is too high, the particle search might lack accuracy due to the large step sizes

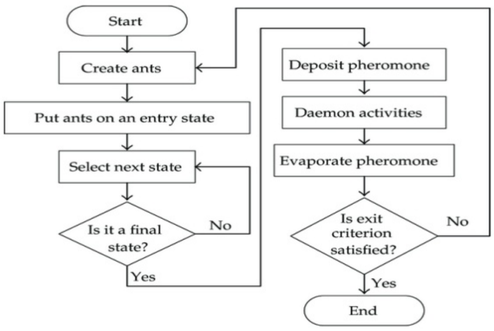

Figure 4. Ant Colony Optimization Algorithm Flow Chart

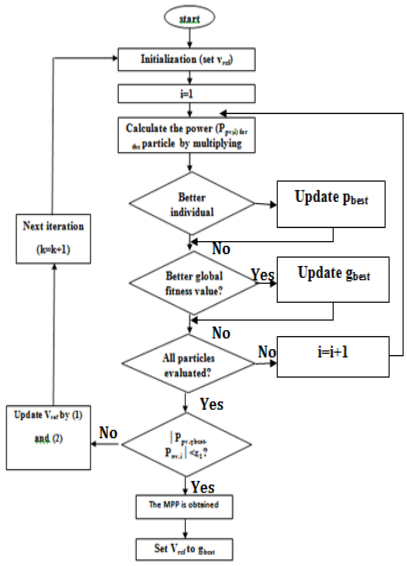

Figure 5. Particle Swarm Optimization Algorithm Flow Chart

While facing the multipeak values the weight becomes low, particle movement becomes slow, and the local optimum trap might be unavoidable. Based on the objective function the weighting is always decided.

4. Results and Analysis

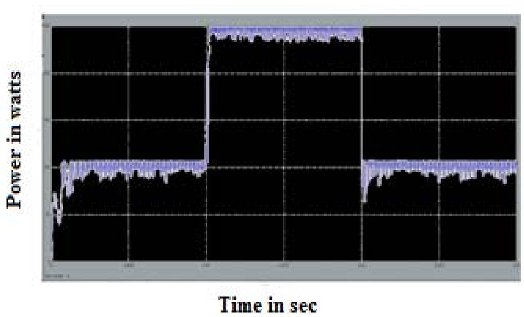

Figure 6. Output Power of Ordinary Boost Converter

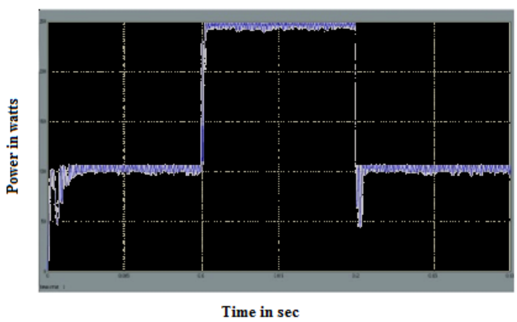

Figure 7. Output Power of Interleaved Boost Converter

The result analysis shows the tracking time and average output power for both the conventional boost converter and interleaved boost converter. The tracking time and average output power of the interleaved boost converter is 246.4W and tracking time for 1KW/m2 to 0.4KW/m2 is 0.5ms/10cycle. The tracking time and average output power of the conventional boost converter is 244W and tracking time for 1KW/m2 to 0.4KW/m2 is 1ms/20cycle.

By comparing these two topologies, interleaved boost converter make the system more efficient and faster.

5. Conclusion

Under rapidly changing environmental conditions fast MPPT is required, while under steady environmental conditions very accurate and efficient MPPT without Oscillations are required. The developed MPPT algorithm is programmed in a microcontroller based MPPT controller and tested on PV system. Simulation results shows that the proposed MPPT gives an average tracking efficiency of 89.2%.An advantage of the proposed MPPT controller is that it is cost effective and simple because it does not require current measurements during MPP tracking.

References

[1] Ali Bidram, Ali Davoudi, Robert S Balog. Control and Circuit Techniques to Mitigate Partial Shading Effects in Photovoltaic Arrays. *IEEE Journal of Photovoltaics.* 2012; 2(4): 532-546.
[2] Azadeh Safari, Saad Mekhilef. Simulation and Hardware Implementation of Incremental Conductance MPPT with Direct Control Method Using Cuk Converter. *IEEE Transactions on Industrial Electronics.* 2011; 58(4): 1154-1161.
[3] Bader N Alajmi, Khaled H Ahmed, Stephen J Finney, Barry W Williams. A Maximum Power Point Tracking Technique for Partially Shaded Photovoltaic Systems in Microgrids. *IEEE Transactions on Industrial Electronics.* 2013; 60(4): 1596-1606.
[4] Dezso Sera, Laszlo Mathe, Tamas Kerekes, Sergiu Viorel Spataru, Remus Teodorescu. On the Perturb-and-Observe and Incremental Conductance MPPT Methods for PV Systems. *IEEE Journal of Photovoltaics.* 2013; 3(3): 1070-1077.
[5] Dzung Nguyen, Brad Lehman. An Adaptive Solar Photovoltaic Array Using Model-Based Reconfiguration Algorithm. *IEEE Transactions on Industrial Electronics.* 2008; 55(7): 2644-2654.
[6] Eftichios Koutroulis, Frede Blaabjerg. A New Technique for Tracking the Global Maximum Power Point of PV Arrays Operating Under Partial-Shading Conditions. *IEEE Journal of Photovoltaics.* 2012; 2(2): 184-189.
[7] Kashif Ishaque, Zainal Salam, Muhammad Amjad, Saad Mekhilef. An Improved Particle Swarm Optimization (PSO)–Based MPPT for PV With Reduced Steady-State Oscillation. *IEEE Transactions on Power Electronics.* 2012; 27(8): 3627-3638.
[8] Liang-Rui Chen, Chih-Hui Tsai, Yuan-Li Lin, Yen-Shin Lai. A Biological Swarm Chasing Algorithm for Tracking the PV Maximum Power Point. *IEEE Transactions on Energy Conversion.* 2010; 25(2): 484-493.
[9] Soren Baekhoj Kjaesr. Evaluation of the "Hill Climbing" and the"Incremental Conductance" Maximum Power Point Trackers for Photovoltaic Power Systems. *IEEE Transactions on Energy Conversion.* 2012; 27(4): 922-929.
[10] Weidong Xiao, Nathan Ozog, William G Dunford. Topology Study of Photovoltaic Interface for Maximum Power Point Tracking. *IEEE Transactions on Industrial Electronics.* 2007; 54(3): 1696-1703.
[11] Aryuanto Soetedjo. Modeling of Maximum Power Point Tracking Controller for Solar Power System. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2012; 10(3): 419-430.