# Improving Tracking Efficiency of Photovoltaic System by Using Ant Colony and Particle Swarm Optimization Algorithms

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*Abstract* — **there are some changes in temperature and irradiation when operating under partial-shading conditions and the power–voltage characteristics of photovoltaic panel (PV) have a non-linear output. So, the MPPT system is needed to sample the output of the cells and it will apply the proper resistance (load) to obtain maximum power for any given environmental conditions. A novel method is implemented to track the global MPP, which is based on Ant Colony Optimization (ACO) combined with Particle Swarm Optimization (PSO) that controlling a DC-DC converter connected at the output of PV array, such that it maintains a constant input-power load. This model indicates the DC-DC converter is an interleaved boost converter topology which will increase the efficiency and reduce the ripple factor which is easily control and greater stability can be achieved. By using this model we get very low conduction and switching losses then switching frequency is improved and size of the system also reduced. The proposed method has the advantage that it can be applied in either standalone or grid-connected PV systems comprising PV arrays with unknown electrical characteristics and does not require knowledge about the PV modules configuration.**

*Keywords*— **Photovoltaic system, DC-DC converter, MPPT controller, Induction motor.**

## I. INTRODUCTION

Nowadays fossil fuels play a vital role in the generation of huge power, which emit tons of carbon dioxide and other contaminants pollution. More importantly, fossil fuel will eventually run out. In order to make less harm to our environment, there is a need of clean renewable energy. Among various renewable energy sources like solar, wind, hydro power and geothermal, solar energy is the cleanest and inexhaustible of all known energy sources.

To utilize the solar energy, photovoltaic system attracts more attention. Because, they provide excellent opportunity to generate electricity. But the current–voltage (–) and power–voltage (–) relations of the PV arrays possess nonlinear characteristics that are affected by factors Such as irradiance intensity, temperature, and device degradation. To avoid these problems there is a unique operating point known as the maximum power point (MPP) on the PV array characteristics. In photovoltaic generating systems, DC-DC converters are widely used as an interface between the Photovoltaic panel and the load, and it allow the follow-up of the Maximum Power Point (MPP). The main application and benefits of Maximum Power Point Tracking (MPPT) in solar power system is to increase the efficiency and power of solar cells. In proposed system DC-DC converter is a boost Converter with an interleaved topology to reduce the ripple current, improve reliability and increase efficiency.

For MPPT systems, the control objective is to maximize the power output and improve the solar energy harvest. To optimize the utilization of large arrays of PV modules, maximum power point tracker (MPPT) is normally employed in conjunction with the power converter (dc–dc converter and/or inverter). The objective of MPPT is to ensure that, in varying environmental condition also the system can always harvest the maximum power generated by the PV panel. Therefore MPPT techniques are needed to maintain the PV array's operating at its MPPT. 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 only ensures the ability to find the global maximum power point (MPP), but also gives a lower system cost and simpler control scheme. 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. This maximum output power would run three phase induction motor with the help of voltage source inverter. The rest of the paper consist the following sections. Section II discuss about DC-DC converter interfacing with PV module. Section III describes about the MPPT techniques used in DC-DC converter. The simulation results are discussed in section IV. Section V Consists conclusion of the paper.

## II. DC-DC CONVERTER AS AN INTERFACING MEDIUM

Solar or photovoltaic (PV) cells convert light energy into useful power. These cells are produced from light-absorbing materials. When the cell is illuminated, optically generated carriers produce an electric current to a load. The equivalent circuit of a PV cell is shown in figure 1.

The current source $I_L$ represents the cell photocurrent. $R_{sh}$ ,$R_s$ are the intrinsic shunt, series resistances of the cell, respectively. Generally the value of $R_{sh}$ is very large and that of $R_s$ is very low value, hence they may be neglected to simplify the analysis. More number of PV cells is connected in larger units called PV modules which are further interconnected in a parallel-series configuration to form PV arrays.

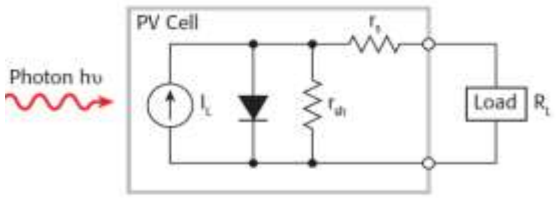


Fig 1. Equivalent circuit of a PV cell

DC-DC converters are used in applications where an average output voltage is higher or lower than the input voltage. 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 input capacitor.

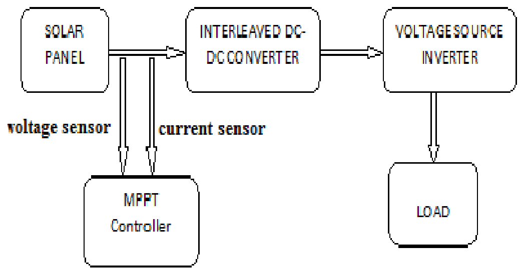


Fig 2. Block diagram of dc-dc converter interfacing with load

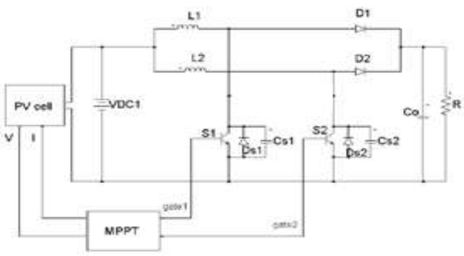


Fig 3.Schematic diagram of proposed system

But the ripple content is high due to the usage of power electronic switches and inductor. In proposed system DC-DC converter is a boost converter with an interleaved topology to reduce the ripple current, improve reliability and increase efficiency.

## III. MPPT TECHNIQUES USED FOR TRACKING MAXIMUM POWER POINT

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.

In proposed system, to overcome the above difficulties, 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. 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.

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

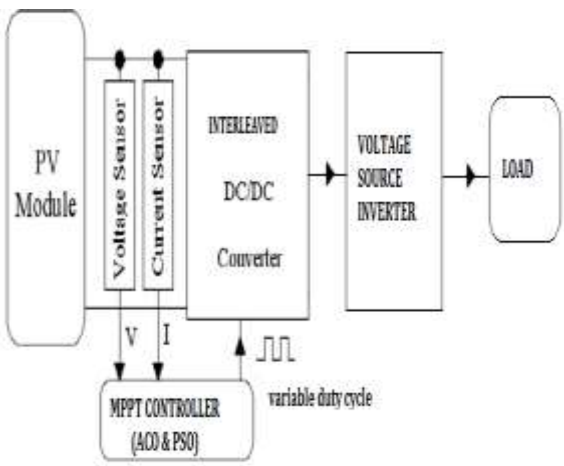


Fig 4. ACO & PSO controller for interfacing PV panel and DC-DC converter.

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

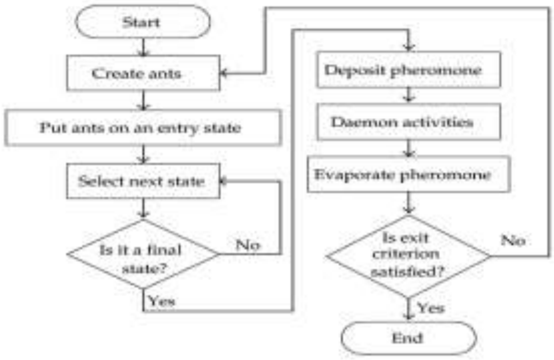


Fig 5: Ant colony optimization algorithm flow chart

The PSO is a theory inspired by the foraging behaviour of birds and applied this phenomenon to resolve problems related to search and optimization. PSO simulates the behaviors of bird flocking. Like, a group of birds are randomly searching food in an area. 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 how far the food in each iteration. The effective 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 fitness function to be optimized, and have velocities which direct the flying of the particles. The particles fly through the problem space by following the current optimum particles.Two memory values influence the movement of the particles: $P_{best}$ and $G_{best}$. After finding the two best values, the particle updates its velocity and positions. $P_{best}$ is the individual optimum of particle i ; and $G_{best}$ 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.

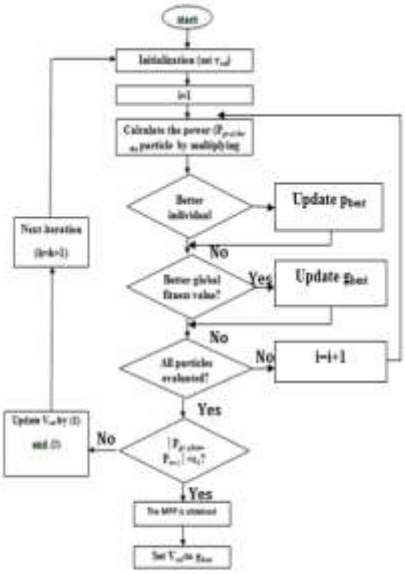


Fig 6. Particle Swarm optimization Algorithm flow chart

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 because the movement step sizes are too large. However, if the weight is low, particle movement becomes slow, and the local optimum trap might be unavoidable when facing multipeak values. Thus, weighting is typically based on the objective function.

## IV. SIMULATION RESULTS

The solar irradiation is given as an input for PV array and the respective voltage and current obtained from the PV array is given to the converter topology. The power and voltage graph of PV panel is obtained by considering the measured voltage, current value of PV panel and converter output power.

The main function of MPPT controller is to give a proper duty cycle to the converter topology. Here, the MPPT controller block consist two algorithms; 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.

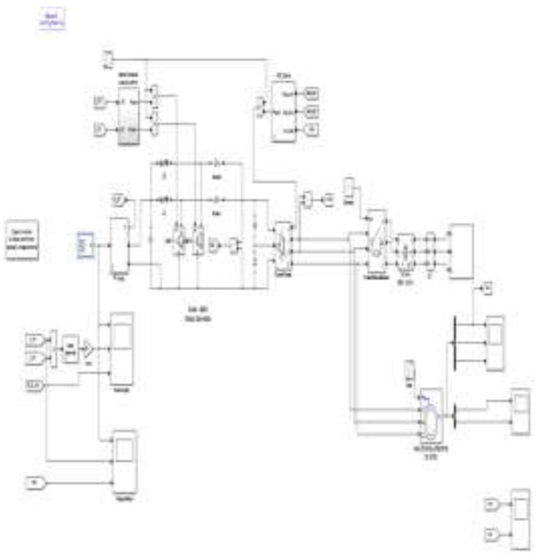

Fig 7. The overall MATLAB simulation diagram for proposed concepts.

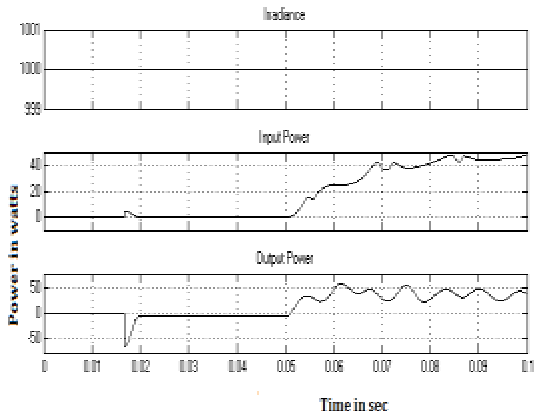


Fig 8. Power graph of PV panel

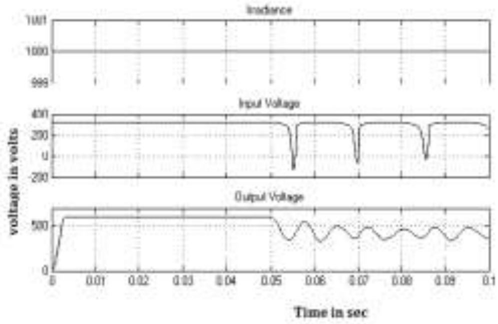


Fig 9. Voltage graph of PV panel

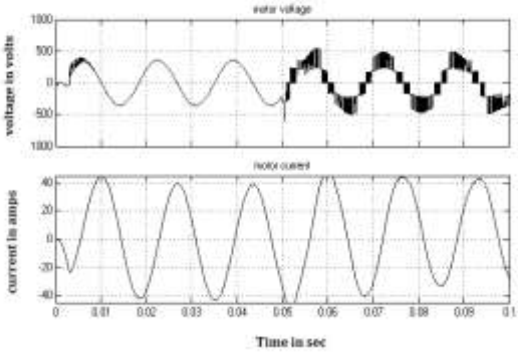


Fig 10. Output voltage and current of inverter

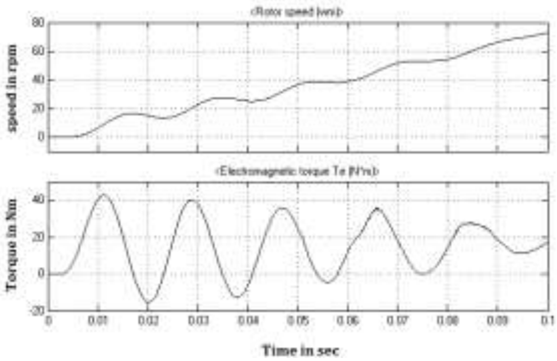


Fig 11. Motor speed and torque characteristics

From the above graph, it is observed that the maximum speed at motor is achieved.

## V. CONCLUSION

This paper proposes a novel MPPT technique to extract maximum obtainable solar power from the PV panel by increasing the performance of Maximum Power Point Tracking (MPPT) and to reduce the ripple current caused by the power electronic switches, based on Ant Colony Algorithm (ACO) combined with Particle Swarm Optimization (PSO) Algorithm along with interleaved boost converter topology. The proposed algorithms can track the global maximum power point effectively in shortest path with better tracking accuracy and lesser iterative steps as compared to the widely used (P&O) and Incremental Conductance (INC) algorithms. Also the tracking speed was superior to that of conventional method. Thereby, enhancing the power generation; the efficiency of photovoltaic systems is improved.

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