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Maximum Power Point Tracking For Photovoltaic Systems Under Partial Shading

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Abstract— *Partial shading in photovoltaic (PV) arrays renders conventional maximum power point tracking(MPPT)techniques ineffective. The reduced efficiency of shaded PV arrays is a significant obstacle in the rapid growth of the solar power systems. Thus, addressing the output power mismatch and partial shading effects is of paramount value.Under partially shaded conditions, I-U characteristic of PV array exhibits multiple stairs, and P-U characteristic of PV array shows multiple peaks.In such a condition, the global search abilityof ant colony optimization (ACO) and local search capabilityof P&O method are integrated to yield faster andefficient convergence. The satisfactory steady-state and dynamic Performances of this new hybrid technique under variable Irradiance and temperature levels show the superiority over the state of the other control methods*

Keywords— Ant-colony optimization (ACO), maximum power point (MPP) tracking (MPPT), photovoltaic (PV) systems, perturb and observe (P&O).

I. INTRODUCTION

Among the various renewable energy sources available, photovoltaic (PV) or solar energy has several advantages as follows: it is omnipresent, eco-friendly, and absence of rotation of parts added with various favourable government policies. As a result, the total installed PV capacity in various countries has increased from 0.3 to 35 GW during the period1997–2010 [1].In the new trend of integrated PV systems, it is difficult toavoid partial shading of array due to obstructions (e.g. building, tree) . In a series connected solar photovoltaic modules, performance gets adversely affected if all its cells are not equally illuminated. All the cells in a series array are forced to carry the same current even though a few cells under shading produce less photon current. The shaded cells may get reverse biased, acting as loads, draining power from fully illuminated cells. If the system is not appropriately protected, hot-spot problem (premature failure problem) can emerge and in several cases, the system can be irreversibly damaged. To protect the system from such premature failure, modules are generally connected with “bypass diodes” in parallel with the cell.Under uniforminsolation, the characteristic curve of a PV array presents asingle power maximum [2]–[4] which can be tracked using one of several well-known maximum power point tracking (MPPT)Techniques (e.g., hill-climbing, perturb & observe (P&O) incremental conductance ripple correlationamount of light reaching the cell(s) of a module.

All the above mentioned topologies are not much accurate and needs additional hardware requirement.Therefore it is better to move towards a control algorithm which is mainly based on optimisation technique.

This paper suggests a novel MPPT scheme which suitably integrates the salient features of ant-colony optimization (ACO) and traditional P&O method. In the initial stages of scanning, the foraging ants in the ACO method perform global search and after a finite number of ant movements, the best solutionachieved is used to start the P&O method.

II. PARTIAL SHADING EFFECTS IN PV CURVES

Partial shading is a frequent phenomenon that occurs when somecells within a module or array are shaded by buildings, birds, passing clouds and birds. Since the short-circuit current of a PV cell is proportional to the insolation level, the partial shading effect is a reduction of then photocurrent for the shaded PV cells while the unshaded cells continue to operate at a higher photocurrent. Since the string current must be equal through all the

series-connected cells, the result is that the shaded cells operate in the reverse bias region to conduct the larger current of the unshaded cells. Fig. 1 illustrates how the string current flows through all the series-connected cells including shaded and unshaded. The bias voltage *V*bias is the reverses voltage at which the shaded cells must operate to support the common string current.The shaded cells consume power due to the reverse voltagepolarity.

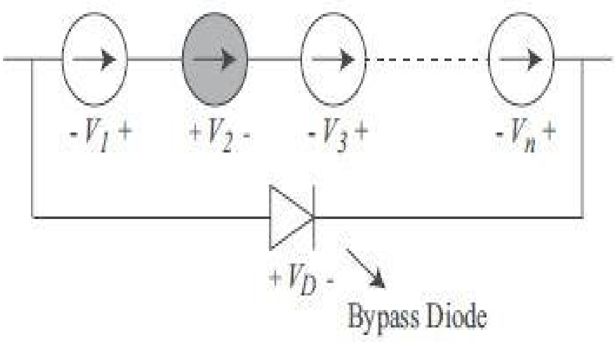


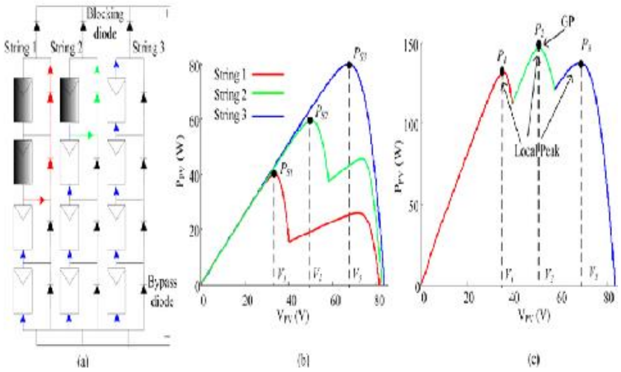
Fig.1. string current flows through all the series cells

Therefore, the maximum extractable power from the shaded PV array decreases. The high bias voltage may also lead to an avalanche break down. This, in turn, may cause the thermal break down of the cell, creating a so-called hot spot. If untreated, excessive heating can result in cell burn out and

Create an open circuit in the shaded string. This hot spot can be avoided by using the bypass diodes. These diodes are connected parallel to the cells to limit the reverse voltage and, hence, the power loss in the shaded cells. For example, in a module with 36 series cells, one diode may be connected across each set of 18 series cells. If the reverse voltage across the shaded cell increases, the bypass diode restricts the reverse voltage to less than the breakdown voltage of the PV cells. For example, the bypass diode that is connected across the panels begins to conduct when

$V_2 - \sum_{i=1}^{n} V_i > V_D$;i≠2

is satisfied, where $V_D$is the forward voltage drop of the diode. Since the bypass diodes provide an alternate current path, cells of a module no longer carry the same current when partially shaded. Therefore, the power–voltage curve develops multiple maxima, shown in Fig. 2. Conventional MPPT algorithms may not be capable of distinguishing between the local and global maximum.



.Fig .2. P-V curves under partial shading

III. ANT COLONY OPTIMIZATION

The first ant colony optimization algorithm is known as Ant System and was proposed in the early nineties. Since then, several other ACO algorithms have been proposed.ant colony algorithms are typically use to solve minimum cost problems.we may usually have *n* nodes and*A* undirected arcs.There are two working modes for the ants: either forwards or backwards.Pheromones are only deposited in backward mode. Its main characteristic is that, at each iteration, thepheromone values are updated by *all* the *m* ants that have builta solution in the iteration itself.

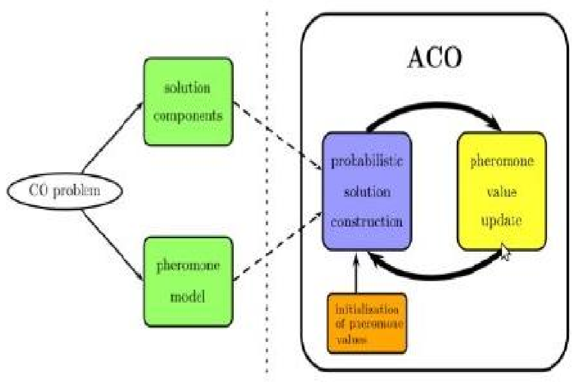


Fig.3. ACO Logical diagram

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The ants memory allows them to retrace the path it has followed while searching for the destination node Before moving backward on their memorized path, they eliminate any loops from it. While moving backwards, the ants leavepheromones on the arcs they traversedThe pheromone *τi j*, associatedwith the edge joining cities *i* and *j*, is updated as follows:

$$\tau_i \leftarrow (1-\rho).\tau_i + \sum_{k=1}^{m} \tau_i^k$$

Where $\rho$is the evaporation rate, *m* is the number of ants, and $\Delta\tau_i^k$is the quantity of pheromone laid on edge (τ_i^k)by ant *k*

$$\Delta\tau_i^k = \begin{cases} \frac{Q}{L_K} i\imath\ a \quad k\,u \quad e \quad (i,j) i\imath\ it\ t\iota \\ 0\ o\ he\imath \end{cases}$$

Where *Q* is a constant and *L k* is the length of the tour constructed by ant *k*.

IV. FORMULATION OF THE ACO PROBLEM

The MPPT is formulated as an optimization problem as follows

:Maximize $P_p\ (d)\quad : \quad D_m \ < D < D_m$

In the above, *P*pv stands for PV output power, *d* is the duty ratio of the boost converter,d_m andd_m are the maximum and minimum values of the duty ratio taken as 10% and 90%, respectively, in this work.

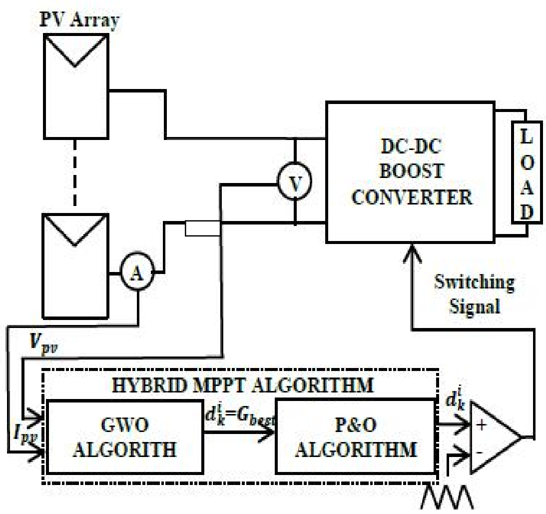

Fig 4. Block diagram.

[redacted]

Apart from conventional ant colony optimization here duty ratio is taken instead of ants and power is taken instead of pheromone content.

The step of ACO-based MPPT is as follows:

Step 1: Initialize the position of the ants on fixed positions with equal space to lie between 10% and 90% of then duty ratio.

Step 2: This step demands ant population size and step of ant movement.

Step 3: It may be noted that this way of initialization of ant position guarantees convergence to GMPP. This step is a major deviation from the traditional ACO method where the ants are properly arranged in the solution space.

Step 4: To maximize the PV array output power 'P' at each ant position, activate the converter and evaluate output power:$P_p \ = v_p \ * i_p$.

Step 5: After initial power calculation determine the maximum power and duty ratio corresponding to the maximum power.Adust the all other duty ratios towards the direction of duty ratio corresponding to maximum power.

Step 6: Adjustment of the position of all other ants are as follows: If the current duty ratio is less than the d_m add a step size which is propotional to the average of difference between them. In the same way if the current duty ratio is more than d_m reduce the step size which is propotional to the average of difference between them.

Step 7: In each such iterations check whether Global maximum power is varying if so update d_m and continue the procedure until all the wolves converge towards the MPP.

Step 8: After locating the MPP begin the P&O loop for tracking the maximum power (GP). Choose a small step size to obtain reduced oscillations in PV output power and higher tracking efficiency.

In each new iteration the power maximum obtained inthe previous iteration is compared with the current iterations maximum power. Ifpower maximum in both cases is differed by more than certain value then d_m needed to beupdated. Similarly the ant colony optimization algorithm finally converges when all the ants moves towards the duty ratio corresponding to the global maximum.

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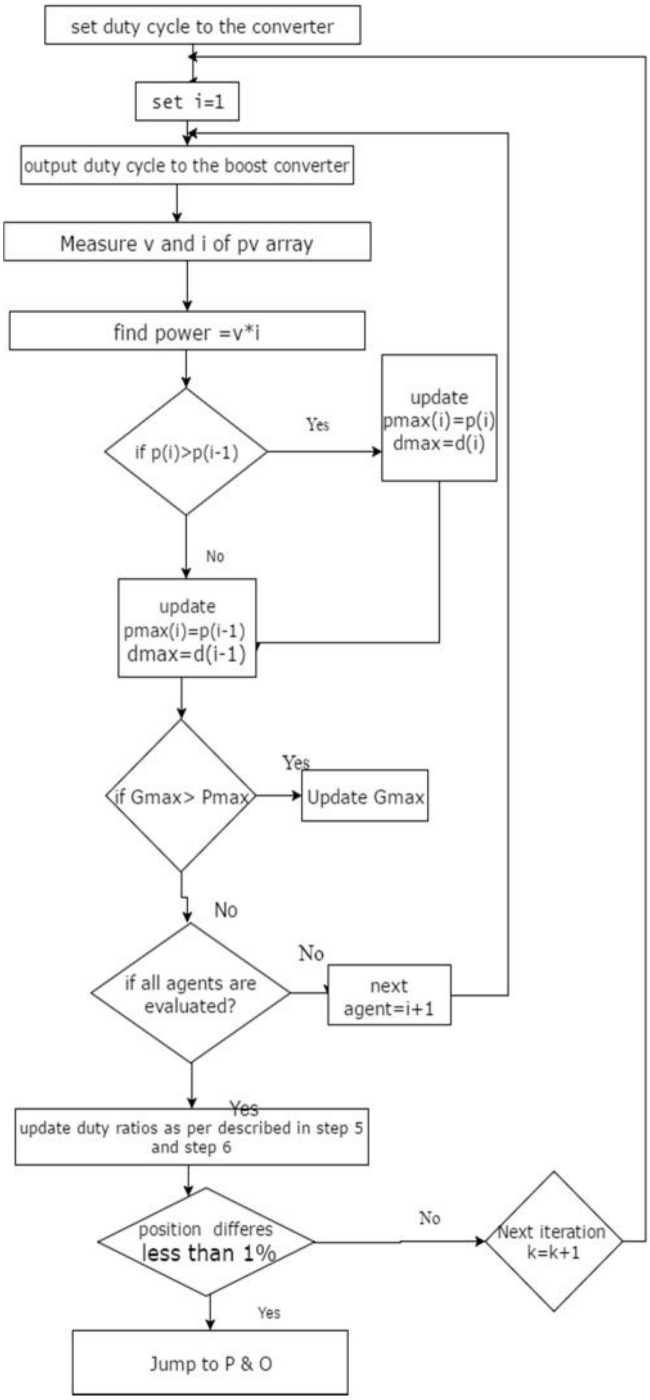
V.FLOW CHART OF ACO



VI.SIMULATION PARAMETERS

Inductor	12mH
Capacitor	5µF
Resistor	100Ω

Table 1

VII.SIMULATION DIAGRAMS

PARTIAL SHADING SIMULATION

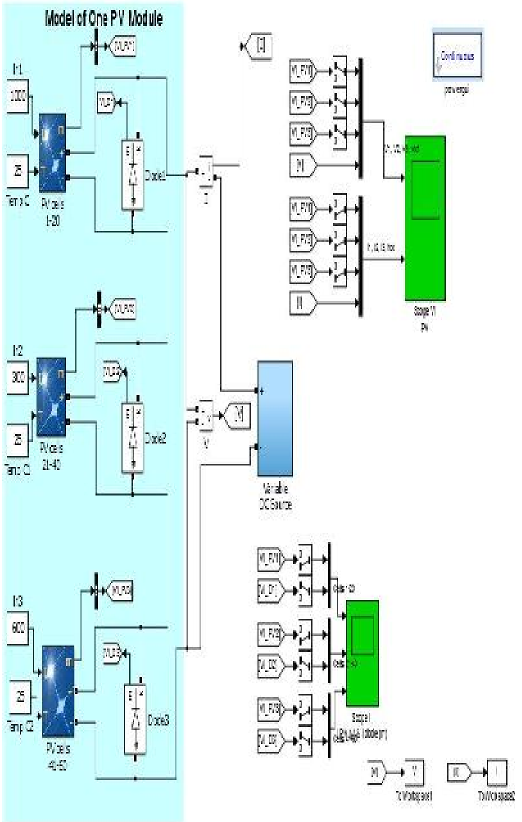


Fig 5.Simulation of partial shading

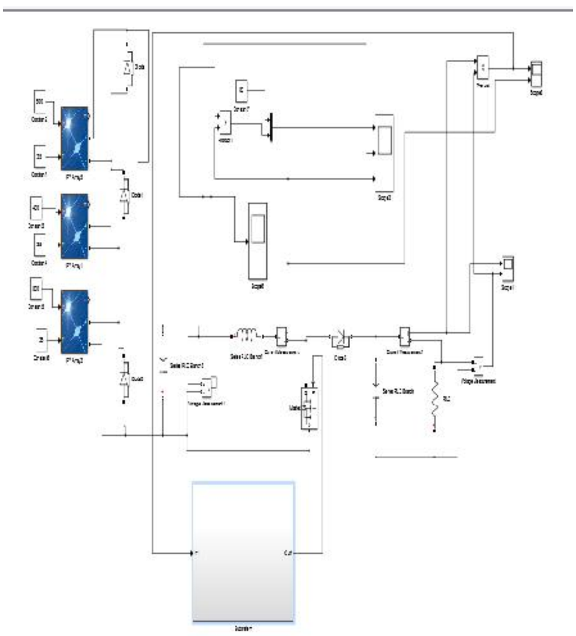


Fig 6. Simulation of ACO algorithm

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VIII.SIMULATION RESULTS

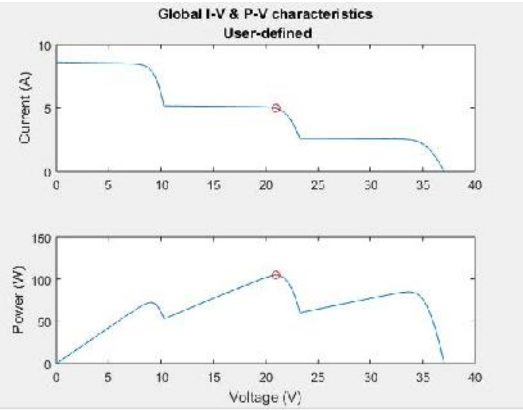

Fig 7.Current voltage curve under and pv curve under partial shading

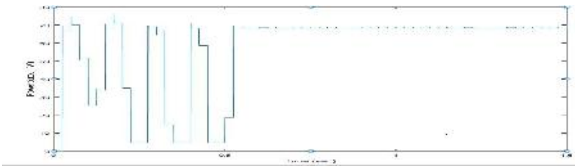

Fig 8 .Output power during ACO for intensityof(1000w/m^2,800w/m^2,900w/m^2)

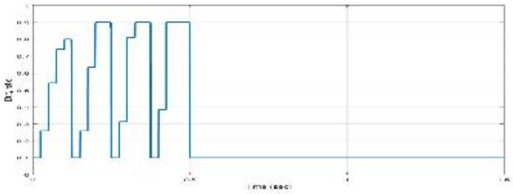

Fig 9. Duty ratio waveform

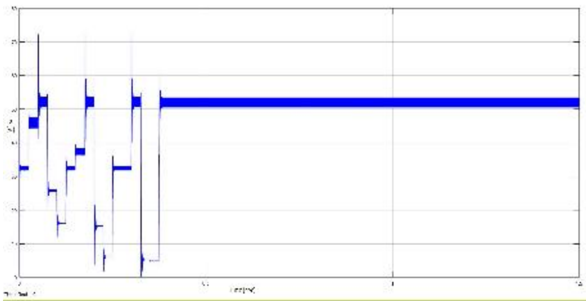

Fig Fig .10.Output power during ACO for intensity of(1000w/m^2,800w/m^2,600w/m^2)

SIMULATION RESULT ANALYSIS

From the simulation results obtained it is clear that the convergence is fast .Compared to PSO and other optimisational algorithms ACO does not require complex computations for determining the global maximum power point.In initialization step we are dividing the entire voltage range into equal intervals algorithm inspects the entire voltage range.

After testing simulation for different value of irradiations, it was verified that the proposed ant colony optimization technique works better for all irradiation conditions.A maximum output power of 50w is obtained in Fig .10. Output power during ACO for intensity of(1000w/m^2,800w/m^2,900w/m^2).In second case maximum output power of 70w is obtained in Fig .8. Output power during ACO for intensity of(1000w/m^2,800w/m^2,600w/m^2)

CONCLUSION

This paper proposes a new hybrid MPPT algorithm for the boost converter used in photovoltaic application under PSC. The algorithm is a combination of an intelligent ACO inspired and a conventional P&O. In the first stage, ACO is utilized to reach the vicinity of the GP. When the convergence criteria is met, the algorithm proceeds with P&O. Since the vicinity of the GP has been reached by the ACO, the P&O is able to find the GP with ease. Using a Simulink model developed in MATLAB/SIMULINK software, a study was carried out to investigate the effect of partial shading on the P-V, I-V curves of series connected photovoltaic modules. The MPPT strategy based on ACO and Perturb & Observe method was also implemented in a boost converter and the effectiveness of the proposed power tracking control strategies was evaluated and the waveforms were also evaluated.

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