DISTRIBUTED PV POWER GENERATION USING PSO-BASED MPPT TECHNIQUE

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ABSTRACT:- **Photovoltaic (PV) system is the main factor in distributed power generation. PV systems are gaining much interest because of their increased efficiency and importance. Solar energy fluctuates with the intensity of the radiated light. As a result the output power of the panel varies. This varying supply can neither be connected to grid nor used for load. Hence to obtain a maximum power, maximum power point technology (MPPT) is proposed. Conventional techniques proved to be less efficient in finding the optimal solution. Hence soft computing technique called Particle Swarm optimization algorithm (PSO) is proposed to find the maximum power even under different environmental conditions. The proposed MPPT control algorithm is developed in MATLAB, which optimizes the panel voltage. Simulation results show that the proposed algorithm is more efficient.**

Index Terms— **Maximum Power Point Tracker(MPPT), MATLAB, Photovoltaic Systems, Particle Swarm Optimization(PSO),Partial Shading Condition(PSC).**

I. INTRODUCTION

Due to Global warming concerns, there is a strong requirement to deploy clean energy sources and implement energy efficient solutions to meet future energy demand. Energy engineers all over the world are focusing on solar projects to make excess generation capacity. A solar system is made up of solar modules. Number of cells combines to form a module and these modules are in turn connected to form the PV system. The output DC voltage of the panel is then converted to desirable AC voltage for feeding excess power to the grid. Since the PV arrays exhibit a nonlinear power–voltage (P–V) characteristic curve which varies with insolation and temperature, how to achieve maximum power point tracking (MPPT) is a very important technology. Soft computing based algorithms are recently developed to obtain the global optimal solution under varying environmental conditions. The PSO method is a simple and effective metaheuristic approach for obtaining optimal solution. It requires assignment of random weights and velocity vector. The proposed Particle Swarm Optimization algorithm (PSO) is a swarm behavior based technique and is relatively easier to develop. The essential issue of MPPT control is an optimization problem which can be achieved by using evolutionary algorithm. PSOalgorithm owns the characteristics of parallel processing, good robustness, and high probability of finding global optimal solution. Because of its good performance in multiple-peak function optimization, PSO is very suited for MPPT control of PV system under PSC .

II. PARTICLE SWARM OPTIMIZATION ALGORITHM

Particle swarm optimization was first developed by Kenney and Eberhart. PSO is used to solve power system optimization problems. It provides optimal solution to problems like Economic load dispatch, Unit commitment, optimal reactive power dispatch etc., PSO is based on swarm intelligence to solve constrained optimization problems. PSO is a computational intelligence-based technique that is not largely affected by the size and nonlinearity of the problem, and can converge to the optimal solution in many problems where most analytical methods fail to converge. It can, therefore, be effectively applied to different optimization problems in power systems. The initial set of solution is called population and each member in the population is called as swarms. The standard PSO method can be defined using the following equations :

$$vi(k + 1) = wvi(k) + c1r1 \cdot (p\text{best},i - xi(k)) + c2r2 \cdot (g\text{best} - xi(k)) \quad \text{-- (2.1)}$$

$$xi(k + 1) = xi(k) + vi(k + 1) \quad \text{-- (2.2)}$$

$$i = 1, 2, \ldots, N$$

PSO uses a initial solutions called swarms which are generated at random.

$X=[X1, X2, X3 \ldots Xn]$ -- (2.3)

These particles move in the search space to find a good optimal solution. Particles find their search direction by using social and cognitive information. The best position that a particle has found is called pbest and the best position that any particle found is called gbest. The new position of a particle is found by the equation

$X(t+1)=X(t)+V(t+1)$ -- (2.4)

III. APPLICATION OF PSO TO MPPT

Step 1 (Parameter Selection): In the proposed system, the particle position is defined as the duty cycle value, d of the dc–dc converter, and the fitness value evaluation function is chosen as the generated power Ppv of the whole PGS. From the algorithm point of view, a larger number of particles result in more accurate MPP tracking even under complicated shading patterns. However, a larger number of particles also lead to longer computation time. Therefore, a tradeoff should be made to ensure good tracking speed and accuracy.

According to the literature, there exist at most m MPPs in the P–V curve for PV modules consist of m series connected PV cells. Consequently, the particle number N is chosen as the number of the series connected cells in the PGS.

Step 2 (PSO Initialization): In PSO initialization phase, particles can be placed on fixed position or be placed in the space randomly. Basically, if there is information available regarding the location of the GMPP

in the search space, it makes more sense to initialize the particles around it. The peaks on the P–V curve occur nearly at multiples of 80% of the module open voltage Voc module , and the minimum displacement between successive peaks is also nearly 80% of Voc module . Therefore, the particles are initialized on fixed positions which cover the search space $[Dmin, Dmax]$ with equal distances in this paper. Dmax and Dmin are the maximum and minimum duty cycle of the utilized dc-dc converter, respectively.

Step 3 (Fitness Evaluation): The goal of the proposed MPPT algorithm is to maximize the generated power Ppv. After the digital controller output, the PWM command according to the position of particle i (which represents the duty cycle command), the PV voltage Vpv and current Ipv can be measured and filtered using digital finite impulse response filters. These values can then be utilized to calculate the fitness value Ppv of particle i . It should be noted that in order to acquire correct samples, the time interval between successive particle evaluations has to be greater than the power converter's settling time.

Step 4 (Update Individual and Global Best Data): If the fitness value of particle, i is better than the best fitness value in history $Pbest,i$; set current value as the new $Pbest,i$. Then, choose the particle with the best fitness value of all the particles as the $Gbest,i$. This step is similar to step 3 of the standard PSO method.

Step 5 (Update Velocity and Position of Each Particle): After all the particles are evaluated, the velocity and position of eac1h particle in the swarm should be updated. In this paper, the parameters w, $c1$, and $c2$ are set as variables to speed up the convergence. Therefore,

$vi(k + 1) = w(k)vi(k) + c1\,(k)r1\,(p\text{best},i - xi(k)) + c2\,(k)r2\,(g\text{best} - xi(k))$ -- (3.1)

The first term $w(k)vi(k)$ is utilized to keep the particle moving in the same direction it was originally

heading; therefore, it controls the convergence behavior of PSO. To accelerate convergence, the inertia

weight shall be selected such that the effect of $vi(k)$ fades during the execution of the algorithm. Thus, a decreasing value of w with time is preferable. A very common choice is to initially set the inertia weight

to a larger value for better exploration and gradually reduce it to get refined solutions. In this paper, a linearly decreasing scheme for w is used, as shown in (3.1) .

$w(k) = w\text{max} - k\ k\text{MAX}\,(w\text{max} - w\text{min})$ -- (3.2)

In (3.1), $w$min and $w$max are the lower and upper bounds of w, and kMAX is the maximum allowed number of iterations. Similarly, the cognitive and social parameters can be modified. The values of $c1$ and $c2$ can affect the search ability of PSO by biasing the direction of a particle. Choosing $c1 > c2$ would bias sampling toward the direction of $Pbest,i$, while in the opposite case, $c1 < c2$, sampling toward the direction of $Gbest,i$ would be favored. In this paper, these two parameters are defined as linearly decreasing and linearly increasing functions, respectively.

$c1\ (k) = c1{,}\max\ -\ k\ k\mathrm{MAX}\ (c1{,}\max\ -\ c1{,}\min)$ --(3.3)

$c2\ (k) = c2{,}\min\ +\ k\ k\mathrm{MAX}\ (c2{,}\max\ -\ c2{,}\min)$. --(3.4)

In (3.3) and (3.4), $c1\min$, $c1\max$ and $c2\ \min$, $c2\max$ are the lower and upper bounds of $c1$ and $c2$, respectively.

It should be noted that due to the stochastic nature of PSO, the calculated new position $x1\ (k + 1)$ may become very far away from the previously outputted position $xN\ (k)$. Since $x(k)$ represents the duty cycle command of the utilized DC-DC converter, this sudden duty cycle change will be in very large voltage stress on the power switch. One method to deal with this condition is to sort the obtained particle positions based on the last outputted duty cycle command in advance, and output the nearest particle first. This will reduce the voltage stress significantly.

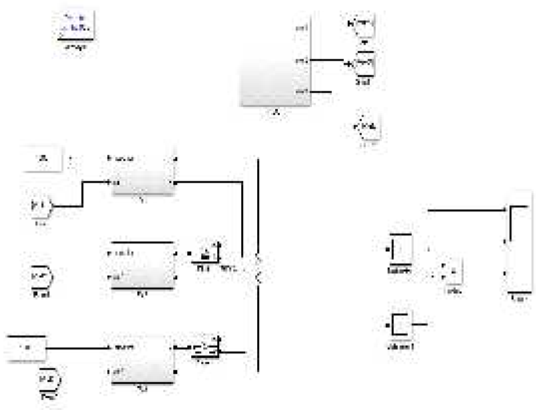
Step 6 (Convergence Determination): Two convergence criteria were utilized here. If the velocities of all particles become smaller than a threshold, or if the maximum number of iterations are reached, the proposed MPPT algorithm will stop and the obtained *Gbest* solution will be the output.

Step 7 (Reinitialization): Typically PSO method is used to solve problems that the optimal solution is time invariant. However, in this application, the fitness value (global maximum available power) often changes with environments as well as loading conditions. In such cases, the particles must be reinitialized to search for the new GMPP again. In this paper, the following constraint is utilized to detect the insolation change and shading pattern changes. The proposed PSO algorithm will reinitialize the particles whenever the following condition is satisfied:

$|P_{pv,new} - P_{pv,last}\ |\ /\ P_{pv,last} \geq \Delta P(\%)$ --(3.5)

IV. SYSTEM CONFIGURATION

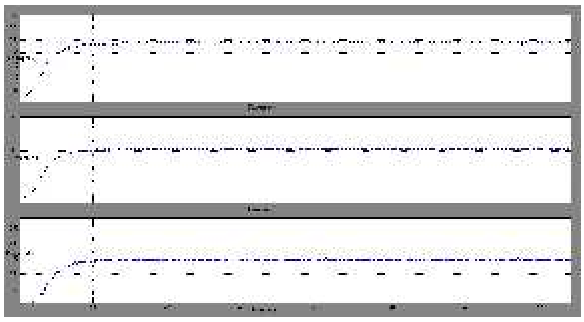
The figure below shows the simulink model for PSO-based MPPT in a Photovoltaic system. There are three solar panels,each having the maximum capability of providing the power of 175W. The PV system consists of three panels connected in parallel.



There are different conditions that illustrates the effectiveness of PSO based PV.

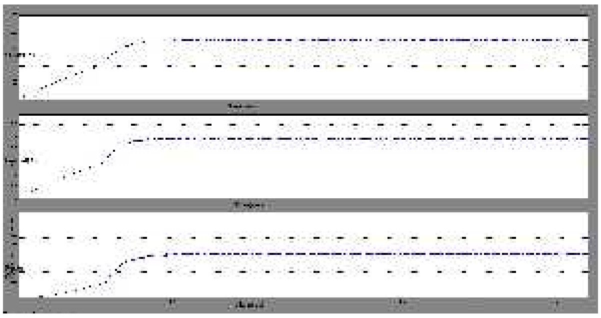
(a) PV BEFORE RUNNING PSO ALGORITHM

The figure shows the voltage, current and power curves before running PSO algorithm. The value of the PV voltage *Vpv*(t) is assumed to be known because it is fixed by the DC-DC converter controller according to the imposed reference. The figure shows the voltage, current and power curves without using particle swarm optimization algorithm. The maximum capacity of power to be produced by the solar panel is 525W. But the power obtained to be below 200W.



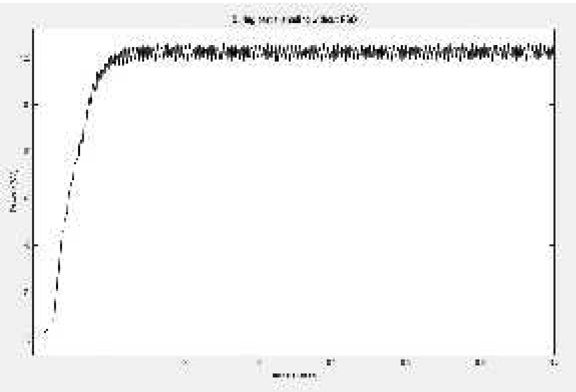
(b)PV AFTER RUNNING PSO ALGORITHM

On running PSO algorithm, an optimized voltage value will be obtained which is utilized to obtain the maximum power from the panel. Here the figure above shows the voltage, current and power curves after PSO algorithm. From the graph it is evident that the power obtained is 525W. The value is far better than the condition when PSO was not applied.



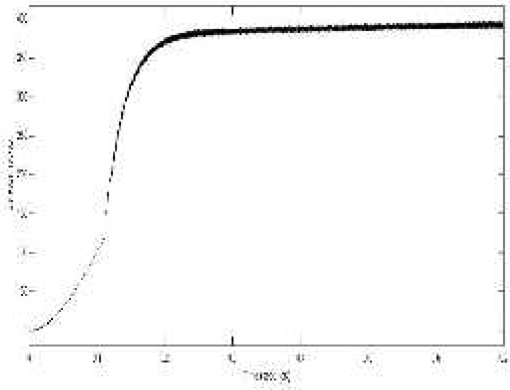
(c)DURING PARTIAL SHADING CONDITION WITHOUT RUNNING PSO

The partial shading condition is achieved by lowering the irradiance level of one of the panels to half or less than half of its value. The figure shows the power obtained without running PSO algorithm.



(d)DURING PARTIAL SHADING CONDITION AFTER RUNNING PSO

The figure below shows that the power curve has risen after running PSO algorithm under partial shading condition.



The various conditions on PSO algorithm under different environmental conditions shows the effectiveness of the algorithm.

V. CONCLUSION

The main purpose of this paper is to develop an accurate MPPT algorithm for centralized-type Photovoltaic Generation System operating even under Partial Shading Condition. PSO is to meet the practical consideration of PGS operating under PSC. PSO can applied to many practical purposes for its efficient working.

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