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MPPT BASED ON CUSTOMIZED PARTICLE SWARM OPTIMIZATION

C. Deepak Chandran
PG Scholar,
Electrical and Electronics Engineering,
Government College of Engineering,
Salem, Tamilnadu, India.

Dr. J.S. Christy Mano Raj,
Assistant Professor,
Electrical and Electronics Engineering,
Government College of engineering,
Salem, Tamilnadu, India

ABSTRACT

This paper concerns the design and implementation of Particle swarm optimisation (PSO) technique and it has been highly achieved in various applications. More than hundreds of papers have reported successful applications of PSO so far. In fact, there are so many of them found that there is difficult for PSO practitioners and researchers to have a clear updated vision in the area of PSO applications. PSO, in its present form, has been in existence with formative research in related domains (such as social modelling, computer graphics, simulation and animation of natural swarms or flocks). A short time compared with some of the other natural computing techniques such as artificial neural networks and evolutionary computation. However, in that short period, PSO comes with some more ideas amongst researchers and has been shown to offer good performance in a variety of application fields, with potential for demonstration , hybridisation and specialisation, and of some interesting emergent behaviour. In this paper, PSO method is being implemented and applied to various mathematical functional optimization and engineering problems. The proposed approach employs PSO algorithm to find the maximum (or) minimum peak from the obtained multi-peaks using MATLAB.

Index Terms— *MPPT , PSO , Particles , velocity , local peak , global peak , Inertia weight , lbest , gbest.*

I. INTRODUCTION

Solar photovoltaic (PV) energy investment is rapidly increasing across the world due to its long term economic prospects and more crucially, concerns over the environment. In addition to the PV panels ,The solar PV system also consists of few power electronic converters which is used to connects its output to the grid. The power electronics converters used are, (a) the DC-DC converter to boost the PV output DC, and the (b)DC-AC inverter for AC conversion. Generally, the Maximum Power Point Tracking (MPPT) algorithm is incorporated with the DC-DC converter to raise the level of the solar PV array output voltage, and to achieve the maximum energy extraction. Also, The photovoltaic (PV) cell directly converts solar energy into electricity. A unique point on the I-V or P-V curve of a PV cell, called the Maximum Power Point , the PV system is active with the maximum efficiency and produces the maximum output power. Hence, it is essential to include a MPPT module in the PV system so that the PV arrays are able to deliver the maximum available power.

II. OBJECTIVE OF THIS PAPER

This method proposed an improved maximum power point tracking (MPPT) method for the photovoltaic (PV) system using a particle swarm optimization (PSO) Algorithm. In addition to this method, reduction in the steady state oscillation once the maximum power point is located. The proposed method has the ability to track maximum power point at the particular environmental condition such as partial shading condition. This Algorithm is simple and can be computed very rapidly; thus its implementation using a low cost microcontroller is possible. To evaluate this method , MATLAB simulation carried out.

III. MAXIMUM POWER POINT TRACKING (MPPT)

MPPT is a technique that is used to charge controllers use for wind turbines and PV solar systems to maximize the power output. PV solar systems is said to be exist in several different configurations. The most basic version sends power directly from collector panels to the DC-AC inverter, and from there directly to the electrical grid. A second version called a hybrid inverter that might split the power at the inverter, where a percentage of the power goes to the grid and the remainder goes to a battery bank. The third version is not connected at all to the grid but employs a dedicated PV inverter that features the MPPT. Power flows directly to a battery bank in this configuration. A variation on these configurations is micro inverters are deployed instead of only one single inverter, one for each PV panel. New MPPT contains specialty inverters now exists with three functions: (a)grid-connecting wind power , (b) PV solar power, and (c) branching off power for battery charging.

i. Solar inverters convert the DC power to AC power and may incorporate MPPT: such inverters sample the output power (I-V curve) from the solar modules and apply the proper resistance (load) so as to obtain maximum power.

ii. MPP(Maximum power point) is the product of the MPP voltage (Vmpp) and MPP current (Impp).

IV PARTIAL SHADING

The MPP tracking becomes more complicated when the entire PV array does not receive uniform irradiance. This condition is known as partial shading. Basically, it is caused by the clouds that strike on certain spots of the solar array, while other parts are left uniformly irradiated. Another source of partial shading-like characteristics is exhibited by module irregularities; a common example would be the presence of cracks on one or more modules of the PV array.

Fig. 1 shows a PV array in a typical series-parallel configuration. In this example, the modules are connected in strings with three modules per string. When one of the modules in the string experiences less illumination due to shading, its voltage drops; thus it behaves as a load instead of a generator. A hot spot ensued and typically a bypass diode is connected in parallel with each PV module to protect the shaded module from being damaged. Additionally, a blocking diode is connected at the end of each string (combination of series modules in one current path) to provide the protection against reverse current caused by the voltage mismatch between the parallel-connected strings.

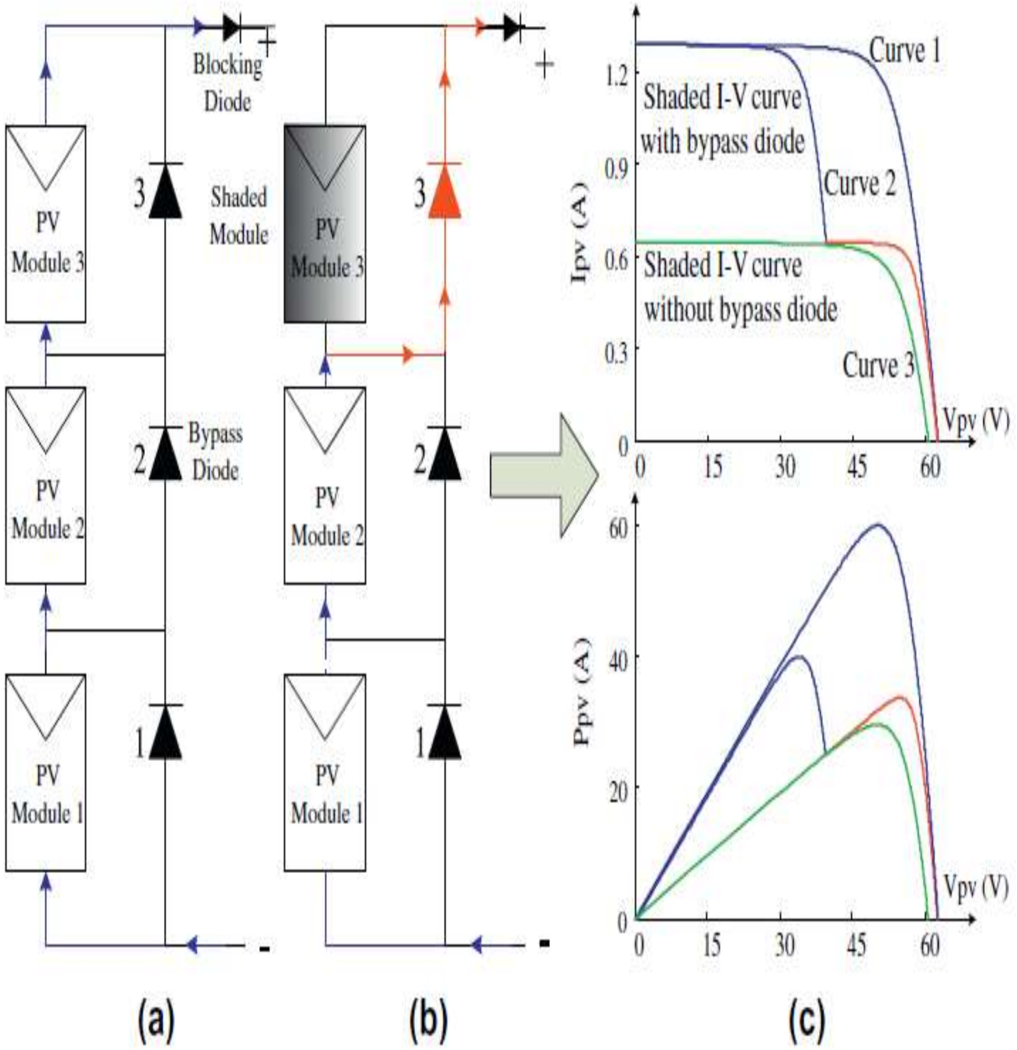

Fig 1 Operation of PV arrays (a) under uniform insolation, (b) under partial shading, (c) the resulting I-V and P-V curve for (a) and (b).

In normal condition, i.e., when the solar insolation on the entire PV array is uniform, as shown in Fig 1(a), the P–V curve exhibits the typical unique MPP (curve 1 of Fig. 1(c)). During partial shading, as the third PV module being less illuminated (shown by shaded block in Fig. 1(b)), the difference in insolation between two modules activates the bypass diode of module3. As a result, two stairs current waveform is created on the I–V curve. Consequently, the corresponding P–V curve is characterized by several local peaks and one global peak (GP), as depicted by curve2. Furthermore, if the bypass diode is removed, the PV array exhibits only a single peak (curve3); but this is achieved at the expense of a significant reduction in power. Therefore, in general, the bypass diode is always installed to improve the power throughput of the PV array, despite the complication that arises during partial shading.

V. INTRODUCTION TO THE PARTICLE SWARM OPTIMIZATION AND ITS MPPT BASED APPLICATIONS

This algorithm searches the space of an objective function by adjusting the trajectories of individual agents, called particles, as these trajectories form piecewise paths in a quasi-stochastic manner. The movement of a swarming particle consists of two major components: a stochastic component and a deterministic component. Each particle is attracted toward the position of the current global best g^* and its own best location xi^* in history, while at the same time it has a tendency to move randomly. And also PSO uses the real-number randomness and the global communication among the swarm particles.

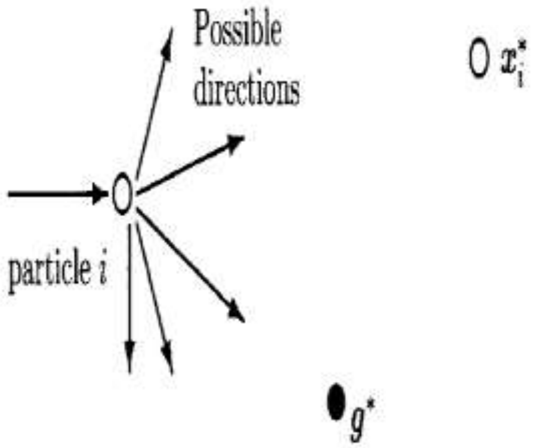

Figure 2 : Schematic representation of motion of the particle in PSO, moving towards the global best g^* and the current best xi^* for each particle i

When a particle finds a location that is better than any previously found locations, then updates it as the new current best for particle i. There is a current best for all n particles at any time t during iterations. The aim is to find the global best among all the current best solutions until the objective no longer improves or after a certain number of iterations. The movement of particles is schematically represented in Figure 2, where xi^* is the current best for particle i, and $g^* \cong \min\{f(xj)\}$ for $(i = 1,2, \ldots,n)$ is the current global best.

VI. PSO ALGORITHM:

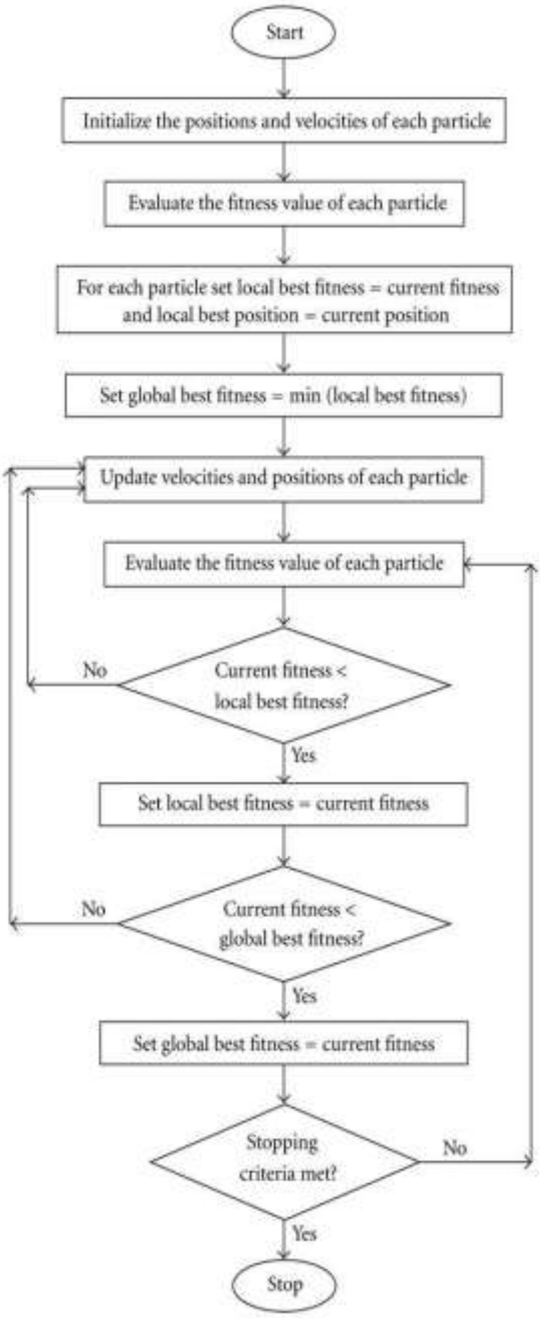

Figure 3 Flow chart of PSO Algorithm.

The essential steps of the particle swarm optimization can be summarized as flow chart shown in Figure 3.

Let *xi* and *vi* be the position vector and velocity for particle *i*, respectively. The new velocity vector is determined by the following formula.

$$\boldsymbol{v_i^{t+1} = v_i^t + \alpha\epsilon_1 * (g * -x_i^t) + \beta\epsilon_2 * (x_i^* - x_i^t)} \qquad \textbf{(1)}$$

where ϵ_1 and ϵ_2 are two random vectors, and each entry taking the values between 0 and 1. The product of two matrices $u * v$ is definedas the entry wise product, that is $[u * v]ij = \boldsymbol{u_{ij}v_{ij}}$. The parameters a and ß are the learning parameters or acceleration constants, which can typically be taken as, say, $\alpha \cong \beta \cong 2$.

The initial locations of all particles should distribute relatively uniformly so that they can sample over most regions, which is especially important for multimodal problems. The initial velocity of a particle can be taken as zero, that is, $v_i^{t=0} = 0$. The new position can then be updated by ,

$$\boldsymbol{x_i^{t+1} = v_i^{t+1} + x_i^t} \qquad \textbf{(2)}$$

Although *vi* can be any values, it is usually bounded in some range [0,*vmax*].

VII. SWARM TOPOLOGIES

Two general classifications of neighbourhoods are being discussed in swarm topologies

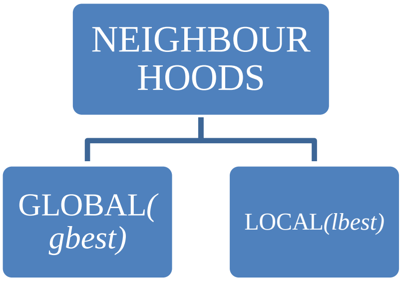

Figure 4. Classification of neighbourhoods in Swarm Topology.

The hierarchy shown in figure 4 shows the general classification of neighbourhoods under swarm topologies.

The comparison between these topologies are discussed as follows:

1. *Global best(gbest)* is of the form of fully connected network.
2. *Local best(lbest)* can be examined according to the topologies structure.

The following figures clearly shows the difference between the *global best* and the *local best.*

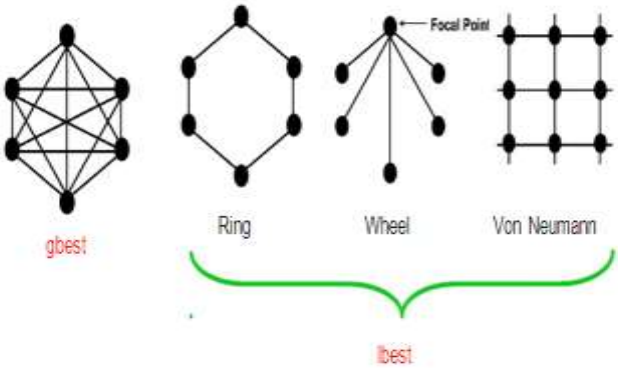

Figure 5 Comparison of *Global* and *local* best.

Also second difference is that,

1. *Gbest* converges fast but may be trapped in a local optima.
2. *Lbest* is slower in convergence but has more chance to find the optimal solution.

VIII. ADVANTAGES OF THE PROPOSED PSO METHOD

The proposed method offers several advantages compared to other MPPT techniques.

1) The difference between the previous duty cycle *di* (*k*) and the local best particles *Pbesti* , and the difference between the previous duty cycle *di* (*k*) and the global

best particle *G*best . Thus, the power converter tracks the two best *P*best*i* and *G*best at the same time. As a result, the tracking spaces are searched to obtain an optimal solution with a faster speed.

2) Once the particle reaches MPP, the velocity of particles is practically zero. Hence, at steady state no oscillations will be seen. These steady-state oscillation (normally present in HC) are very critical because it is one of the major reasons for the reduced MPPT efficiency.

3) In the case of rapid fluctuations in the environmental conditions, the HC method can lose the direction of new MPP and tracking could be driven into a wrong direction. This is one of the major problems of the HC method. However, the proposed method works on three duty cycles. Since the operating power information is obtained from all three duty cycles, it never loses the direction of MPP in rapid fluctuations.

4) In the condition of partial shading, the $P-V$ characteristic curve is characterized by multiple peaks. As a result, the HC method is most likely to trap at local maxima. On the other hand, the PSO method works based on a searching scheme. Hence, it can still track the global peak correctly.

IX. SIMULATION RESULTS

The feasibility of the proposed MPPT based on Particle Swarm Optimization was verified in MATLAB using Simulink with the help of S-function (a commercially available software package dedicated for power electronic converter simulations) and proposed algorithm was simulated based on the following specifications:

Output Voltage: Vo = 40.4 Volts
Output Current: Io = 2.295 A
Output Power: P_o = 92.72 W
Switching Frequency: fs = 50 kHz
Amplitude: A = 1
Duty cycle: D = 50%
Load Resistor: R = 16 ohm
Simulation Stop time = 0.01s.

X. SIMULATED CIRCUIT

The Fig. 9 shows the proposed simulation circuit for MPPT based on PSO Algorithm. Here the value for output voltage, output current and output power are displayed simultaneously as shown in the Fig. 9. Also sub-function blocks for MPPT Controller and Cuk Converter are shown in the Fig. 10 and Fig. 11 respectively.

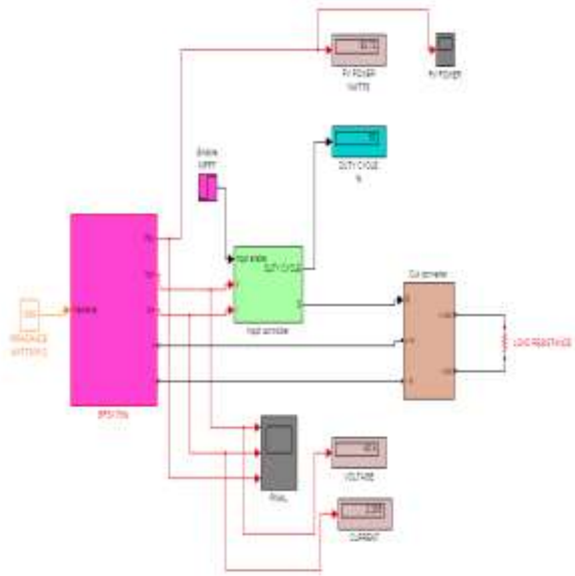

Fig. 9 Main Simulation of proposed converter.

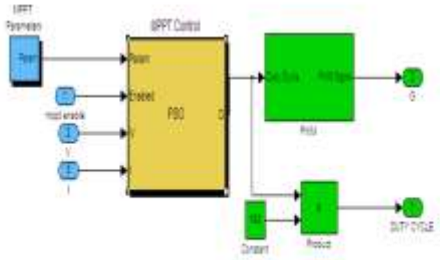

Fig. 10 Sub-Function Simulation block for MPPT Controller.

SIMULATED WAVEFORM

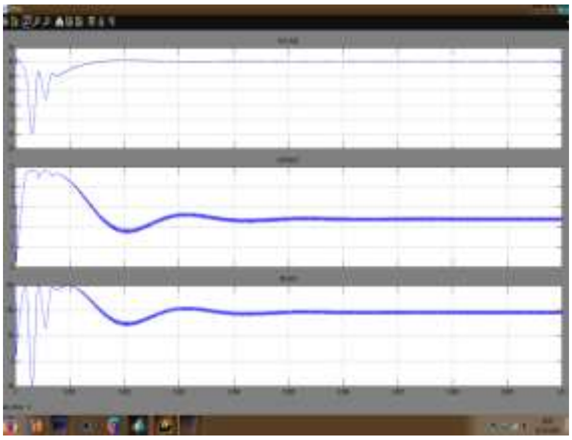

Fig 12: Simulation Waveform for Output Current and Voltage.

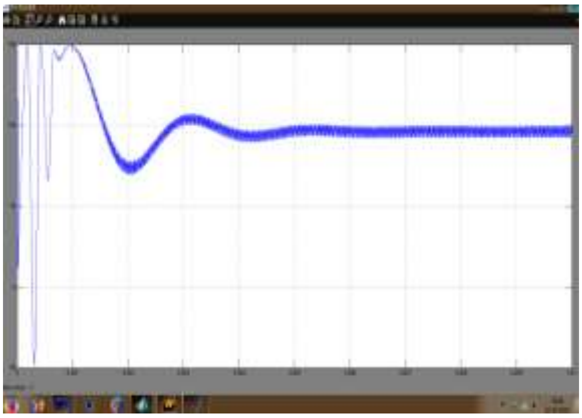

Fig. 13 Simulated Waveform for Output Power.

XI. CONCLUSION

In this paper, MPPT based on PSO method has been implemented successfully and verified using Matlab. This program can find the global optimal solution for the most of nonlinear functions. There are other variants of particle swarm optimization; in fact, there are about more than 20 different variants. PSO algorithms are often combined with other existing algorithms to produce new algorithms. In fact, it is still an active area of research with many new studies published each year. The future improvement should be concentrated more on the limitations and weaknesses of this project.

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