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COMPARATIVE ANALYSIS OF AN IMPROVED PSO BASED MPPT ALGORITHM USING DC-DC CONVERTER FOR PHOTOVOLTAIC SYSTEM

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ABSTRACT

Many Different approaches have been proposed for Maximum Power Point Tracking (MPPT). It is plays an essential role in operations of any Photo-Voltaic (PV) cell design. By using PSO can achieve reduction in steady state oscillations when it reached maximum power points, this can track MPP for different environmental conditions like Partial shading conditions, temperatures fluctuations of insulations, Faces many challenges because of various factors like uncertainty resulting higher degree of fluctuation in current and voltage of PV cell. This paper presents a novel approach of different analysis of modified PSO algorithms with simple design and computations. Peak power to be extracted from the PV cells using PSO based MPPT. The outcomes of the model are analyzed and compared with tracking speed, accuracy and faster time response and fast convergence easy implementations, better analysis of current-voltage- power for given state of PV cells compared with traditional PSO systems.

KEYWORDS: Photo-Voltaic, Solar Energy, MPPT, PSO, Tracking speed, time response, DC-DC converter, partial shading, MPPT.

1. INTRODUCTION

Highest Usage of power in a controller design refers to Maximum Power Point Tracking (MPPT).[1,2] it correlated with Photo-Voltaic (PV) module system subjected to specific set of

environmental and operating conditions. PSO because of its simple and quick solving most commonly used algorithms. In this mechanism, the contribution of both current and voltage is highly essential in order to generate highest power that is also represented as peak point of power.[3,4] Power in PV cells as solar radiation fluctuates very often and is highly dependent on various external parameters e.g. temperature of solar cell.[5] The core role of MPPT approach is to make the PV cell work under the significant scale of Voltage that corresponds to the highest degree of power point.[6] The MPPT is to optimize and improve the use of photovoltaic systems to maximize the array efficiency. Many MPPT methods have been developed in order to achieve the Maximum power the conventional methods includes perturb & observe, Incremental conductance, hill climbing is based on duty cycle of the power converter. HC operates on control structure which eliminates the need of proportional integral. It updates the operating point instead of perturbing the voltage and current P&O depends on tracking speed and oscillation. Main drawback is rapid fluctuations of insulations, its losing the tracking of MPP.[7,8]

IC based on incrementally comparing the ratio of derivative of conductance, here also facing the same problems of P&O. Nonconventional nature inspired EA algorithms took place important role because of its ability to manage global peak PV curve and nonlinear objective functions very effective to achieve MPP problem fast convergence. The developed algorithm provides the maximum power extraction from a photovoltaic (PV) panel and simplified implementation with a benefit of high convergence velocity.[9][10] A n alternative approach has been proposed to employ evolutionary algorithm is effective to deal with MPPT problems. Among Anti colony system, flashing firefly algorithms cuckoo search algorithm, PSO is the very effective highly potential easy implementation, fast computational capability, it should locate MPP for any PV curve regardless of environmental conditions. Many researchers have been developed this technique to improve the MPP.[11-20] It measures the characteristics and respective operating point of PV system. This method is fail to track the true MPP under module irregularities and partial shading conditions.[7] This process can also act as a source of origination of energy supply for DC loads. It has been found that climatic condition and highly discharged battery state are the adverse condition that negatively affects MPPT. An efficient design of the controller can be achieved using MPPT that are characterized by following: i) controller system for MPPT assists in rectifying the fluctuation occurred in voltage and current occurring in solar cells especially, ii) it can perform extraction of the highest level of power in order to ensure better operation of voltage required

for efficient DC-DC controller system, iii) it permits the user to make use of PV cells associated with maximum output voltage as compared to the voltage required for operating the battery unit, iv) it is also claimed to minimize the complexity associated with the system that normally surfaces during higher peak loads. v) it also allows to be used for multiple number of sources of energy as efficient controlling of DC-DC converter can be carried out more efficiently, vi) the applicability of the MPPT controller system is more towards renewable resources.[8]-[10] An effective design of MPPT controller system has many clauses to be checked for as i) computing the normal voltage of battery that is required for charging the controller and likewise perform selection of such voltage, ii) selection of appropriate current for charging, iii) ensure that the highest charging current is under the limits of standards imposed on operating PV cells, etc. Existing system shows that there are various forms of classification of controller design strategy e.g. i) incremental conductance, ii) perturb and observe, iii) constant voltage, iv) current sweep. At present, there are various research work being carried out towards developing MPPT for designing an efficient controller system.[11] In spite of associated benefits of existing approaches, there are non-availability of any form of benchmarked models to ensure the best performance of MPPT.

To maximize the array efficiency of the photovoltaic system improvement in optimization for MPPT is required it allow MPP tracing over time maximum power can attain.[12] for conventional MPPT many methods have been mentioned among Incremental conductance, hill climbing and most popular algorithm is perturb and observe, here duty cycle is important, it is an iterative technique for MPPT; PV character will measure the operating point to meet the change in direction. More able to measure multi peaks PV curve in non-conventional algorithms are biological inspired consists of fast convergence and guaranteed convergence to achieve global peak., the new optimization techniques are implemented to evaluate the non-differentiable and non-continues optimization problems. Most of the meta-heuristic methods have been acquired by inspecting and studying the behavior of the mammals live in nature.

Exploration and exploitation capabilities are two major features meta-heuristic algorithms powerful to search the global optimum. The exploration phase helps to search for the feasible space for new results and finding the global optimum. In the exploitation phase algorithm searches the neighborhood of the highest quality solution. It is important to balance of these two phases efficient algorithm provides a good exploration phase in the inception of the

process and good exploitation ability in the final stages. particle swarm optimization (PSO), is a well-known meta heuristic, highly potential, simplest structure, fastest computations, say implementation and it is based on principles such as population, the intelligent particles, and motion. This algorithm implements the social behavior of animals such as fish and bird flocks. PSO has two main problems: 1) cannot find new solutions, because of some particles walk into a local minimum trap and 2) the best solution is converged in the very first steps of the optimization procedure. while finding MPP the velocity becomes very low or zero researchers not observed duty cycle conjunctions with PSO, by maintaining the constant duty cycle with this steady state oscillations can be minimized it very common problem in traditional MPPT which in turn can improve the sufficiency. An alternative optimization technique applied to the MPPT controller of PV systems is PSO.[32]-[37]

2. Particle Swarm Optimization (PSO)

P article swarm optimization is conventional, simple, intelligence optimization and effective meta heuristic approach. The PSO method is originated from simulating the social attribute of the population of birds, fish schooling, and this concept appeared to reduce search and optimization problems that related to the conventional ones. The researchers presented their optimization method in 1995 (Eberhart & Kennedy, 1995).

In order to overcome with these difficulties involves many researchers from all over the world and many types of PSO had been introduced. Among that researches are adaptive acceleration coefficients, PSO with asymmetric time-varying acceleration coefficients teaching-learning-based optimization self-organizing hierarchical PSO with time-varying acceleration coefficients combination of PSO, convergence and divergence operators for problems, a mathematical model of diverse particles groups called autonomous, groups time-varying accelerator coefficient.

The particles randomly scatter in the initialization step in original PSO. With improving the initialization, the final results of PSO would be more exact.it is having ability to track the MPP in extreme environmental conditions like temperature variations partial shading conditions.

The modules arrays which are connected in the form of series and parallel configuration for the generation of desired voltage values form this voltage output current can be generated. These parameters depends upon solar radiations proportional to irradiances conditions so

there is an opportunities to implement different maximum power points instead of single MPP because of this reduction in output power this might not found true operating point for the MPP this is called partial shading conditions. This can observed shown fig.

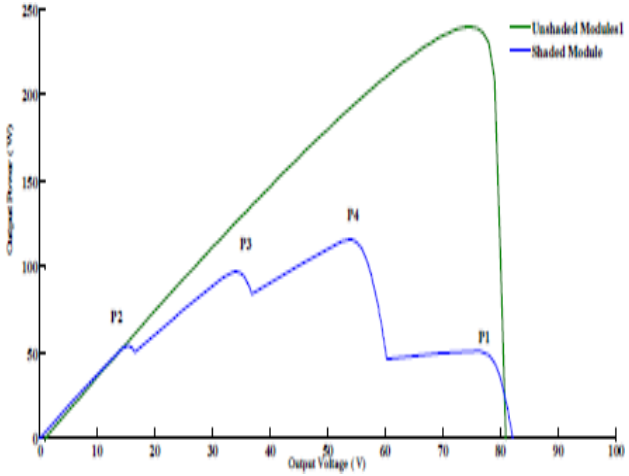

Fig 1. V-P curve of the PV array under PSC.

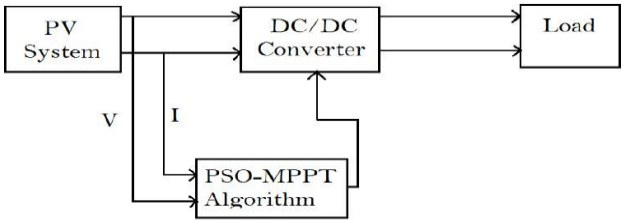

Fig. 2. A PSO based MPPT Algorithm.

System is developed using matlab Simulink consists of PV module and converter which is chosen as a power interface. Output voltage and current form the Pv module fed in to the MPP algorithm, output of the PWM signal are used to drive the switch of the converter to achieve the MPPT form the PV module.

The population is defined as the following set: S={X1, X2,…XN} S= X1,X2,…XN
Where N is the number of the particle (candidate solution).
The position vector for each particle is defined as follows: Xi=(Xi1,Xi2,…,Xin) Tϵ A, i=1,2,…,N Xi=Xi1,Xi2,…,Xin
Tϵ A,i=1,2,…,N

It is assumed that objective function f(x) is available for all particles of A so that each particle has a unique function value fi=f(xi) Also, all particles of the search space are frequently moving. These movements can be defined with the help of velocity definition in the

following

Vi=(vi1,vi2,…,vin)T ,i=1,2,…,N vi=vi1,vi2,…,vinT, i=1,2,…,N

Where T represents the number of repetitions. The position of the particle and its velocity are indicated as Xi(t) and Vi(t) respectively.

The PSO memorizes the positions of particles as P={P1,P2,…,PN} P= P1,P2,…,PN.

P explains the best position that every particle has ever met.

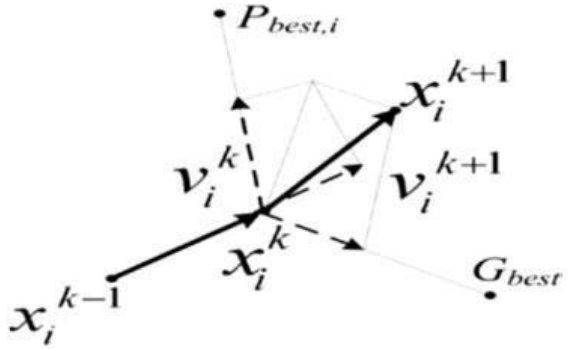

Fig 3. Movement of particles in the optimization process.

$(K+1)=w.(K)+c1r1.(Pbest-xi(K))+c2r2.(Gbest-xi(K))$

$(K+1)=(K)+Vi(K+1)$

The location and the velocity of the particle is updated in every iteration till reached the required value from the fitness function which is the maximum power of the PV module.

$Pbest$: Personal best position for the particle itself

: Global best position among all particles

: The location of particle

vi: The velocity of the particle

$r1$, 2: Random numbers between [0,1] K: number of iterations

$c1$,2: Cognitive and social coefficient respectively W: inertia weight

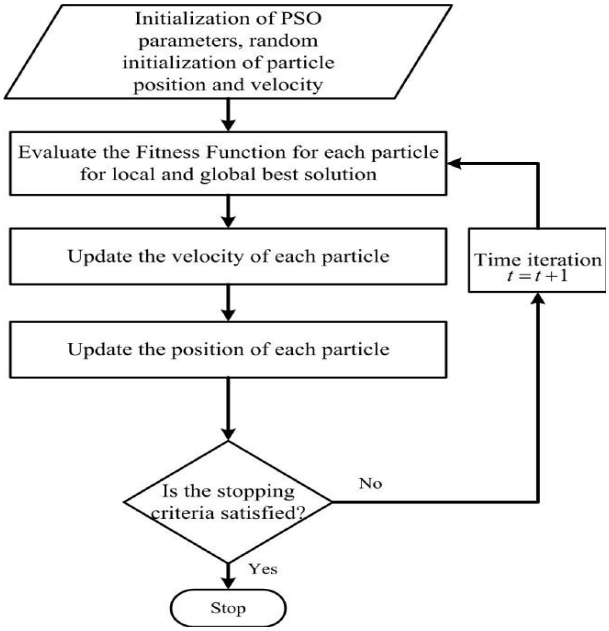

Fig 4. Flow chart of conventional PSO.

The flow chart of MPPT based Basic PSO algorithms is shown above as follows;

1) Initialization of PSO parameters like swarm size, initial velocity, position iteration counter.
2) Fitness evaluation evaluate the fitness value of the each particle
3) Updating and evaluating best position of the particles (P best)
4) Evaluating and updating global best position (G best)
5) Updating Position and velocity of each particle
6) Checking the convergence determination criteria.
7) Initialization, fitness value is not constant as it changes with weather conditions and load impedance, PSO must be reinitialized to search new MPP.

Table I: PSO Parameters.

Parameters	Value
Population size	5
Dimension number	1
W	0.4
C1	0.8
C2	1.2
r1	0.5
r2	0.7

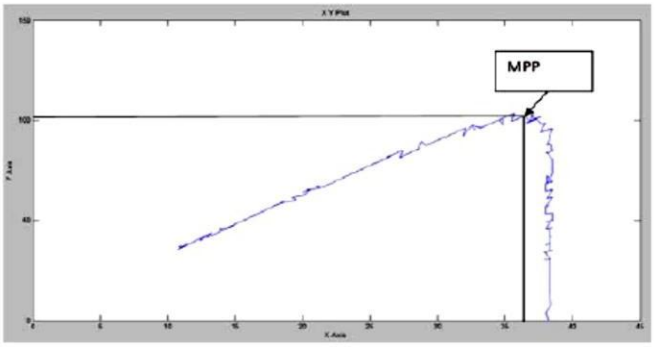

Fig 5. P-V characteristics.

So now comparing PSO based MPPT and modified PSO experimental studies.

Above system under solar radiation conditions and temperature, load the identify MPP extracted from 102.5w and 36.6V.[33]

Tracking speed of PSO which takes around 10.4s for global convergence. Oscillations in the Photovoltaic power identified with PSO, duty cycle is oscillates around the MPP. but power dimination is less compared to P&O methods at steady state this leads to get better MPPT performance.

From above methods achieved with 96.15% of tracking efficiency with voltage of 35.2V, current of 2.80A with tracking speed of 10.4 sec.

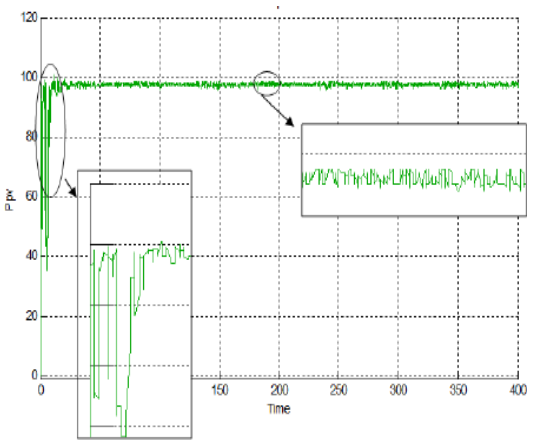

Fig 6. Tracking curve.

In the above results shows the PSO algorithm capable to converge maximum power point faster than the P&O methods, in this results shows at steady zero fluctuations saves much power loss.

One of important problems used observe is large variation in duty cycle is not possible to trace the MPP accurately in order overcome this drawback Novel approach for MPPT for PV system is Lagrange Interpolation (LI) PSO determine the optimum value of the duty cycle according to the operating point.[32] By providing the initial swarm with best position, this can improve PSO efficiency and faster convergence with zero steady state oscillations. Without adding extra complexity can enhance possible tracking speed this method improvement over the conventional PSO method.

Traditional MPPT algorithm based on particle swarm optimization (PSO) is usually fall into premature convergence and may work slower in the later iterations, the MPPT method based on improved PSO with natural selection was proposed to overcome this problems. By replacing and eliminating the particles with lower fitness during the iterative process and hence the swarm could track better and faster for the maximum point, with less chances of premature convergence.

Improved PSO by Natural Selection Conventional PSO may cause premature convergence slower work in later iterations during the search and it can easy fall local extreme point of power peak because of this it effect the performance of the MPPT. By using natural selection process it can replace the speed, place of the particle fitness in each iteration. In the PSO algorithm, each particle i of N dimensional search space have a function to be optimized by a determined adaptation value (fitness value) and the velocity vector direction and distance. In all particles the best position found by itself (Personal best) and the best position found by currently groups (Global optimal solution). w is the inertia weight factor, C1 and C2 care positive learning factors, r1 and r2 are random numbers uniformly distributed between 0 and 1, d is the spatial dimensions, P i j is the P best, and P g j, is the global optimal solution.

By implementing this new methods can improving post optimization and better local minima, by iterative process particle population makes evaluation and replacement continuously in the process of MPPT in such a improving the premature convergence in search speed and accuracy. Analysis done on standard test of temperature of 250C, standard light intensity is 1000w/m2, short circuit current is 7A; open circuit's voltage is 0.6V with 10PV module in series.[38] duty ratio must perform the searching of the P-V curve and will quickly do the tracking of new MPP.

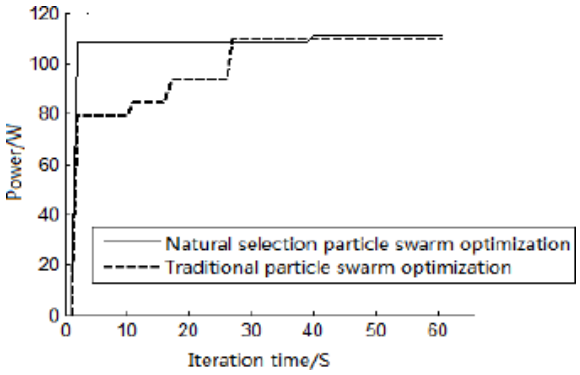

Fig 7. Effect of MPPT.

In improved PSO solved faster & power is more stable which proving that better optimization speed stability with general uniform conditions with good universality in MPPT of the PV array in complex lighting and can avoid premature convergence which prove that photovoltaic array has better optimization speed and solution stability in the improved MPPT algorithms.

3. Modified particle swarm optimization algorithm to enhance MPPT in the PV array

In this method for the algorithm, the duty cycle is partitioned into two parts. The previous duty ratio Similarly, in providing new PV curve for MPP by using search optimization, two duty cycles d1 and d3 in the positive and negative direction to K2 constant value perturbation. The following Figure provides an estimation model for K1 where it can be observed that the maximum power of array and respective power (pMPP), duty ratio, the relationship among Pb, Gb to DC/DC converter having with respect to duty ratio. The response optimized can be minimized to 0.1, step 0.1. However, there exist two expressions are considered, which brings the relationship between dbest and pMPP. Also, there exists a linear relationship between array power and duty. pMPP d.

$$d_{new} = d_{old} - \frac{1}{K_1}\left(P_{old,MPP} - P_{MPP}\right)$$

d old is the previous ratio for Gb

$$\text{The slope } (K_1) = \frac{\Delta_{pMMP}}{\Delta d}$$

For the linear relation changes as per change in operating power and its value is almost equal to the new optimal duty cycle. Hence, the initialization of

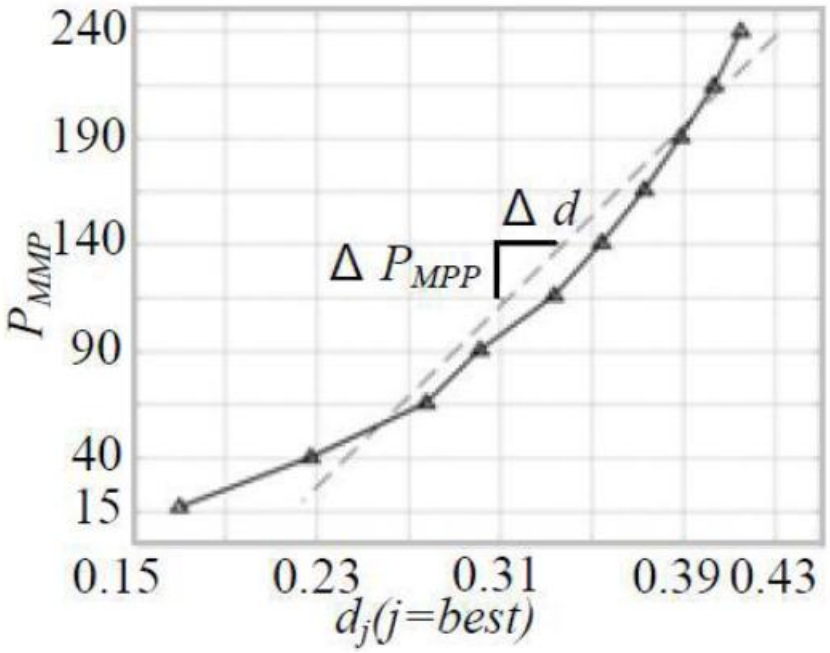

Fig 8. Relation among Gb, duty cycle and pMPP.

From the above analysis, it has been found that, the reduction in solar radiation (from wavelength=0,λ=0.1) always leads to load line in PV array I-V gives maximum MPP voltage (VMPP) to the right of plot curve. The increment in sunshine brings load line to the right. The difference between VMPP and output voltage will become small, and it leads to a small variation in power. Hence, the same value of d old & K1 is not to be deleted. Thus, the PSO algorithm needs to have more iteration to track MPP. To neutralize such type of problems, a simple assumption is made with two different values of K1.

$$\text{i.e., } K_1 = \begin{cases} K_1 \ \ if \ \ \Delta P > 0 \\ \dfrac{K_1}{2} \ \ if \ \ \Delta P < 0 \end{cases}$$

In this equation, old $\Delta P = P$

The value of P>0 & P<0 indicates the decrement and increment in sunshine radiation. In order to get the duty ratio of new perturbation for d1 and d3 respectively. The following formula of data ratio updates position, and negative direction.

$$(d_i)_{new} = \left[(d_1 - K_2), d_2, (d_3 + K_3)\right] \text{ Where } K_2 \geq 0.05$$

The selection mechanism of this 0.05 helps to manage low power fluctuation but, during the partial shade, the working voltage may increases up to 85%, this helps PSO algorithm to track global peak more.

The significance of proposed PSO is that it yields faster search and tracks the MPP optimal solution. After acquiring the MPP by particles, the velocity almost becomes zero. Hence, no oscillations will be observed in steady state. The steady state oscillation is necessary as it is helpful in getting the efficiency of MPPT. Another significant feature of modified PSO is that it exhibits 3-duty cycles, and hence, it does not lose direction in short term fluctuations. This PSO effectively able to track the global peak.

In this system model is simulated using MATLAB. In the optimization process, the fitness value is updated by PV array output power.

The performance analysis of the modified PSO is done with traditional PSO under partial shading condition aiming with accurate MPP tracking. Figure.9 represents the tracking result of traditional PSO, where it is observed that a large range of fluctuations exists in optimization. This misjudges the MPP and takes ~0.045sec for tracking the MPP.

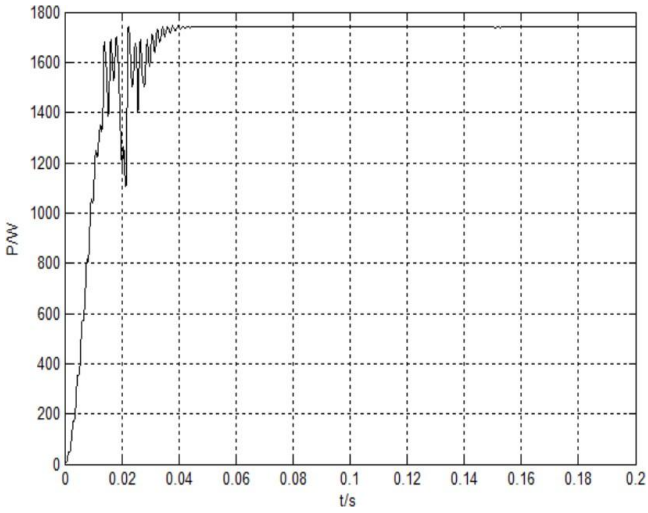

Fig 9. Tracking of MPP with PSO.

With the modified PSO by considering the search based optimization uses 3 duty cycles, it's not going to lose its direction in short term fluctuation. figure.10 shows power Vs time curve obtained from modified PSO is very smoother than traditional PSO and it takes only~0.038sec for tracking MPP, which is improved about 0.08sec. this is more stable and improves the performance of the MPP and also improved the dynamic response speed tracking accuracy in a steady state.

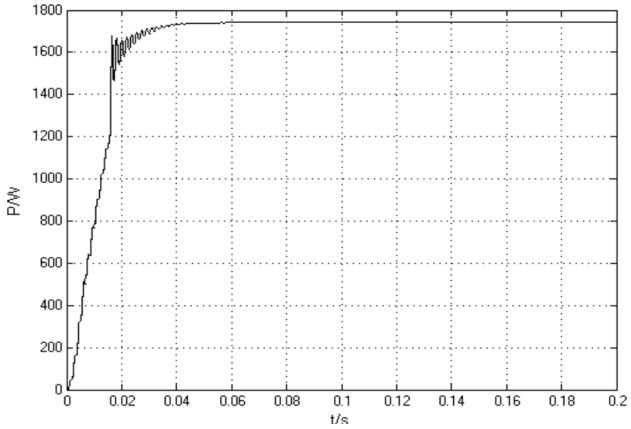

Fig. 10. Tracking MPP with modified PSO Table II comparison of PSO and Modified PSO.

Parameters	Traditional PSO	Modified PSO
Dynamic response	Poor	Good
Tracking speed	slow	fast
Steady state oscillations	large	Almost zero
Tracking in partial shading	Not possible	yes
Execution time	Very fast	fast
Time taken to track MPP	0.045sec	0.038sec

4. CONCLUSION

In this paper, a PSO with the capability of duty cycle is used to track the MPP of a system.it is very simple easy implementation technique for MPPT. In this comparison Different PSO methods used to improve the tracking speed, efficiency, convergence speed, and performance.by using modified PSO we can achieve superior dynamic response, faster speed and exhibits zero oscillations, can locate MPP any environmental variations, including partial shading conditions and zero fluctuation at steady state, can track good power easily for the PV system.

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