Observation and Analysis of Photo Voltaic System by using PSO Technique to Reduce Harmonic Distortion

Mr. Himanshu Pramod Thakur[1]
(Student at SRK University Bhopal)

Mr. Santosh Negi[2]
(Professor at SRK University Bhopal)

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Abstract— Photovoltaic solar energy is one within the entire foremost wide used renewable energy. Thus the most and thus the foremost important key half in physical phenomenon generation systems area unit that the DC-AC device. And these application structure electrical converter area unit typically used. These can give associate degree AC voltage from separate DC sources, that is, from the physical phenomenon generators. Structure inverters have lower output harmonic content mono level inverters. There is a unit many ways so as to eliminate harmonic distortion. However these ways solely take away low-order harmonics expeditiously. Structure inverters area unit wide employed in solar power generation systems contains numerous electrical phenomenon generators. These converters deliver distorted output waveforms. During this paper, how is planned to attenuate and reduce the output harmonics of invertors. The Particle Swarm optimization algorithmic program won't to minimize the whole Harmonic Distortion that subject to restrictions on the harmonic content allowed. Particle swarm optimization (PSO) is additional allowable to cut back the steady state oscillations gift within the current and voltage wave at the output of inverters. A changed soft computing technique referred to as particle swarm optimization algorithmic program (PSO) is employed to ameliorate the change of the electrical converter. During this paper PV system is analyzed while not exploitation PSO in addition as exploitation PSO.

Keywords: Photovoltaic (PV), Particle Swarm Optimization (PSO), Maximum PowerPoint Tracking (MPPT), Solar Panel (SP).

I. INTRODUCTION

Solar electrical phenomenon (PV) is envisioned to be a preferred supply of renewable energy thanks to many vital benefits, like maintenance free and atmosphere friendly and particularly low operational value. Except the high value of modules, PV power generation systems, above all the grid-connected type; are commercial in several countries attributable to its potential long-run advantages. The worldwide energy Consumption is increasing everyday thanks to enhanced population and advanced technologies. Thanks to heating considerations there's a powerful ought to decision forth clean energy sources and execute energy economical solutions to fulfill future energy demand and every one countries specializing in star comes to extend the generation capability. A system is nothing however the PV system that is created from star modules. Variety of cells combines to make a module and these modules square measure connected to make the PV system. The output of system i.e. DC voltage of the solar array is then reborn to fascinating AC voltage for feeding a lot of power to the grid. And also the grid connected PV system is usually subjected to some complexities. Most Power following algorithms were developed to get continuous constant power. To optimize the use of enormous arrays of PV modules, Maximum power point tracking (MPPT) is mostly used in concern with the facility convertor. The most motive Of MPPT is to assure that the system will continually harvest the most power generated by the PV arrays. However, thanks to the dynamic condition, particularly temperature and star insolation, the P–V characteristic function exhibits a maximum power point (MPP) that varies nonlinearly with this Condition. Particle Swarm optimization rule (PSO) could be a flock behavior primarily based methodology and is comparably easier to develop. The planned work concentrates on coming up with PSO primarily based controller to boost the change performance of electrical converter.

II. PV SYSTEM MODELING

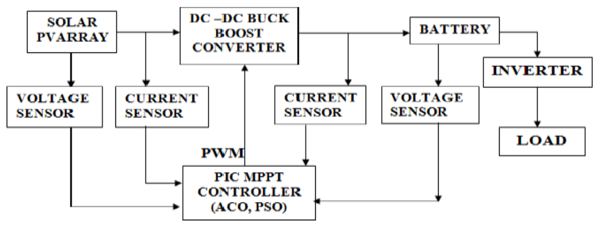

Fig. 1: System Design

Above shows the basic system design of photovoltaic system with peak or maximum power tracker, then DC-DC converter connected in series which fed dc supply to battery and then battery fed to inverter which convert DC-AC and supply to load. It also consist the PSO/MPPT controller, voltage and current sensors. The Peak Power tracker is a controlled DC/DC boost converter used by a photovoltaic power system. By changing the boost converter duty cycle (D), the load impedance as seen by the source is changed and adapted at the peak power point of the source in order to transfer the maximum power. Output power from the solar panel is maximized by controlling the conversion ratio of the DC/DC converter to keep the solar panel operating at its MPP.

A.PV Cell

As shown in Fig.no.2 When light shines on a photovoltaic (PV) cell, it may be reflected, absorbed, or pass right through it.

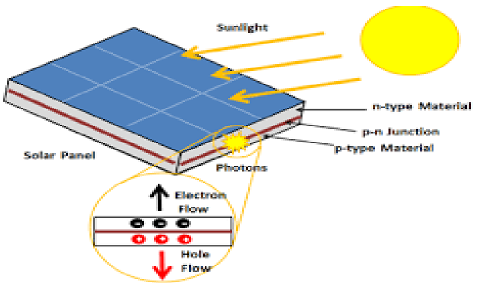

Fig. 2: PV Cell Structure

The PV cell is made up of different semiconducting material this material combines some properties like metals and some properties like insulating material. That makes it peerless capability of conversion light energy into electrical energy. When light is absorbed by a semiconducting material, light photon is transfer their energy in to electrons, allow the electrons to flow in the material as electrical current. This current flows out of the semiconductor to metal contacts and then makes its way out to power your home and the rest of the electric grid.

B. Solar Cell Model

The simplest PV cell model can be represented by a current source placed with an anti-parallel diode. On the other hand, in most cases it is required the use of a model that describes the non-linear behavior of a PV cell. It is done by introducing both series and shunt resistances as shown in Figure.3.

$$I = I_{ph} - I_r\left[e^{q\times\left(\frac{V+I\times R_S}{\eta\times k\times T}\right)-1}\right] - \frac{(V+I\times R_S)}{R_P} \;\ldots\ldots (1)$$

The output current of the PV cell is given by (1).

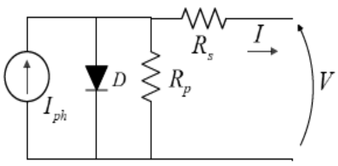

Fig. 3: PV Cell Model

Where:

V, I – Output voltage and current of the PV cell;

Ir – Reverse saturation current of the PV cell;

Iph – Photocurrent;

Rs, Rp – Series and shunt resistances;

η – Ideality factor of the p-n junction;

q – Electron charge, 1.6x10-19 C;

k – Boltzmann constant, 1.38x10-23 J/K;

T – Environment temperature, K.

Iph – Photocurrent;

Above solution of the equations that represents the mathematical PV model results in the non-linear characteristic curve V×I of the photovoltaic cell, as shown in Figure 3. The maximum power point represents the operation point at which the PV system operates at maximum power.

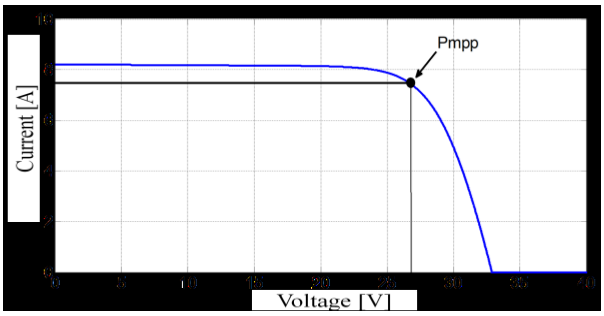

Fig. 3. Characteristic curve (VxI) of PV arrangement, without partial shading.

The parameters, such as solar temperature and radiation, presented in that mathematic model, are considered as inputs of the PV system, and are responsible for shaping the characteristic curve (VxI). Figure 4 shows the relationship between the PV voltage and current for different values of solar radiation. Figure 5 also shows the behavior of the characteristic curve (VxI) considering different values of temperature.

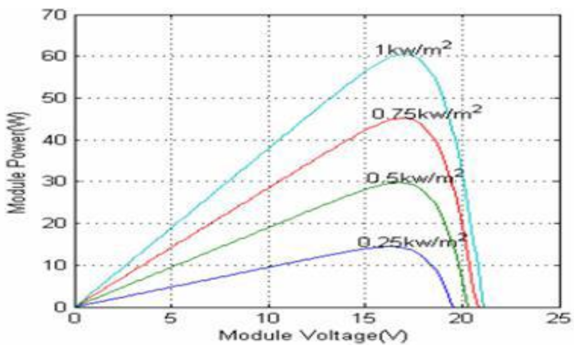

Fig.4. PV Curves at Various Irradiation Levels and Constant Temperature

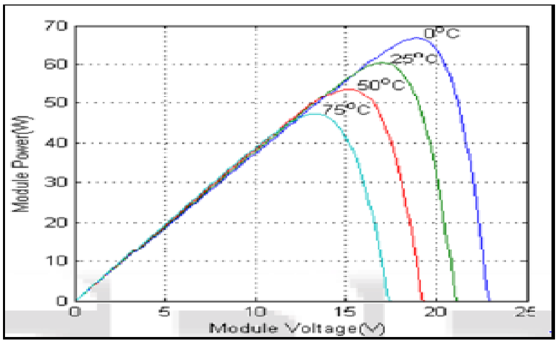

Fig.5.PV Curves at Various Temperatures and Constant Irradiation.

We can clearly be observed in the Figure 4 the PV voltage at MPP is slightly changed for solar radiation changes, while the PV current varies significantly. On the second side, from Figure 5, it can be noted that variations in the temperature affect the PV voltage at MPP significantly, while the PV current remains almost constant. Therefore, when these variations are uniform, the characteristic curve VxI will have only one point of maximum power, which can change along to both solar radiation and temperature conditions. Hence, it is necessary the use of specific techniques for tracking the PV array at maximum power point.

III. MAXIMUM POWER POINT TRACKING (MPPT) IN A PHOTOVOLTAIC SYSTEM

Solar energy is the most preferred alternative energy source because of its advantages such as cleanliness, fidelity and because it is free. We use a technique that ensures the conversion of the maximum power of the solar panel to the load by searching for the MPP. This search is done by the use of a DC-DC converter between the solar panel and the load.

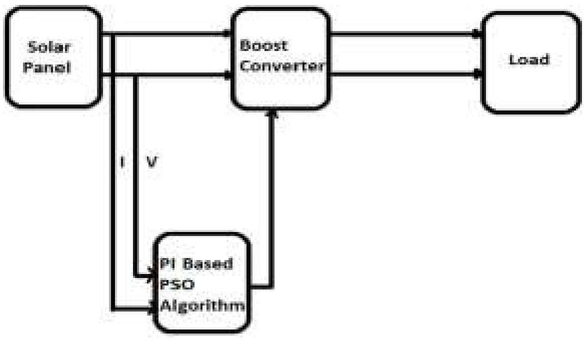

Fig. 6: Block Diagram of the MPP Search Algorithm

Every type of PV module has it's possess specific characteristic. Here, there is a one point on the V-I or V-P curve which is called as Maximum Power Point, on this point complete PV system is operates on maximum potency and produces its maximum available output power. This point can be located a PV system with MPPT controller has been shown in block diagram of Figure 6. Maximum Power Point Tracker, repeatedly referred to as MPPT, which is electronic system and it operates the PV modules system in a way that which makes the PV modules to generate all the power they have capacity of MPPT is not a system like mechanical tracking that which "physically moves" the modules to make them point more directly at the sun. MPPT is a fully an electronic system and this system varies the electrical operating point of the modules that thanks to that modules it is capable to deliver maximum power.

IV. PARTICLE SWARM OPTIMIZATION

The particle swarm optimization (PSO) algorithm is based on the notion of a swarm of particles working together to carry to complete the goal. Now a days, a number of heuristic optimization techniques such as genetic algorithms (GA), ant colony algorithm (ACO), PSO and recently biogeography-based optimization (BBO), are developed to disentangle a variety of intricate engineering problems that are difficult to be solved using conventional optimization methods. PSO is developed by Kennedy and Eberhart. It was found to be likely in solving non-linear problems with polymerism optima. In PSO, a number of particles form a "swarm" that evolve or fly throughout the feasible extreme space to search for such productive regions in which optimal solution may exist. The particles do not necessarily have complete knowledge about the overall goal, but they have cognition on how close they are to achieving it. This is called the error. The lowest error obtained by a particle is called the local best error. The lowest error of the local best errors of all particles in the swarm is named the global best error and it is known by every particle. The particles move towards the global best error and towards their own local best error. If on their way they obtain a lower error then all the errors are updated accordingly. Every particle has a different set of values for the parameters of a system. In essence, each particle represents the same system but with different parameters. Each particle is fed to the system and a response is produced. This response is compared with a desired response and the error is then calculated. Because the parameters of each particle are updated taking into consideration the results of the other particles, it leads to an emergent behavior explained as social intelligence, or in this specific case, swarm intelligence. Once again the particles are fed to the system and a different response is produced. This iterative process continues until one particle is found that meets an acceptable error. The flowchart for this algorithm is shown on Figure 7. As the number of particles increases, the iterations decrease.

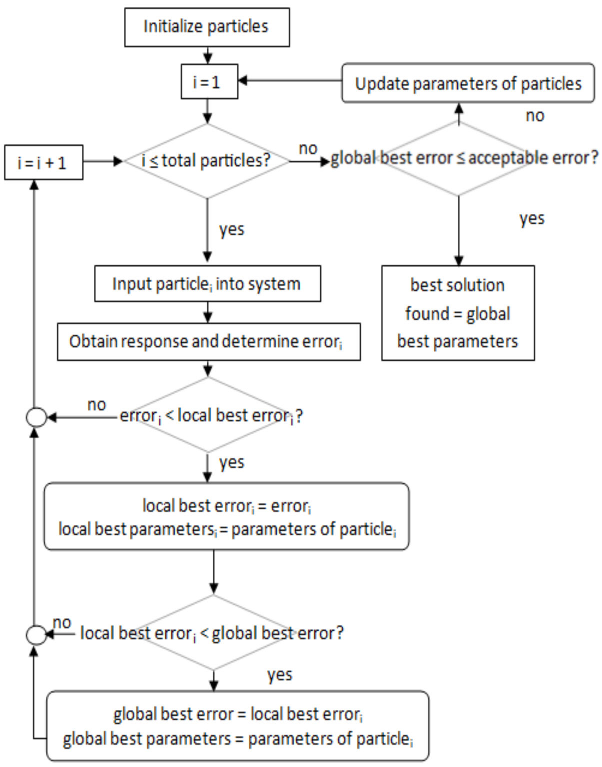

Figure 7. Flowchart for PSO algorithm

The motility of particles affected by two variables, the Pbest is used to accumulation the best position of each particle has an individually the best position and the Gbest is found by compare the personal positions of the particle swarm and store it as best position of the swarm. The particle swarm uses this process to move towards the best position and continuously it revises its direction and velocity by this way each particle quickly converges to an optimal or close to a global optimum. The standard PSO method can be defined by the following equations;

$$V_{i(k+1)} = wV_{i(K+1)} + C_1r_1\left(P_{best} - X_i(K)\right) + C_2r_2 \times \left(G_{best} - X_i(k)\right) \ldots\ldots\ldots\ldots (2)$$

$$X_{i(k+1)} = X_i(k) + V_{i(k+1)} \ldots\ldots\ldots\ldots (3)$$

i=1,2,_ _ _ _ _,N

Where Xi and Vi are the velocity and position of particle i, k represents the iteration number; w is the inertia weight; r1, r2 are random variables and their values are uniformly distributed between [0,1]; c1, c2 represents the cognitive and social coefficient respectively. Pbest, i is the personal grossly position of particle i, and Gbest is the swarm grossly position of all the particles.

$$P_{besti} = X_{ik} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

f(xik)>f(pbesti) ………………… (5)

Where, 'f' represents the objective function that should be maximized.

A. Algorithm for PSO Implementation

Step 1: Generation of initial condition of every agent Initial looking out points and velocities of every agent square measure sometimes generated arbitrarily inside the allowable vary. This looking out purpose is ready to Pbest for every agent. the simplest evaluated worth of Pbest is ready to Gbest and also the agent variety with the simplest worth is keep.

Step 2: analysis of looking out purpose of every agent. The target operates worth is calculated for every agent. If the worth is better than this Pbest of the agent, the Pbest worth is replaced by this worth. If the simplest worth of Pbest is better than this Gbest, Gbest is replaced by the simplest worth and also the agent variety with the simplest worth is keep.

Step 3: Modification of every looking out purpose. this looking out purpose of every agent is modified.

Step 4: Checking the exit condition like most variety of iteration.

The PSO Algorithm having following advantages

i) The calculation in PSO is incredibly straightforward. Compared with the opposite developing calculations, it occupies the larger optimization ability and it is completed simply.

ii) PSO adopts the important variety code, and it's determined directly by the answer. The quantity of the dimension is adequate to the constant of the answer.

iii) PSO relies on the intelligence. It is applied into each research project and engineering use.

iv) PSO has no overlapping and mutation calculation. The search is administrated by the speed of the particle. Throughout the event of many generations, solely the foremost mortal particle will transmit data onto the opposite particles, and therefore the speed of the researching is incredibly quick.

VI. POWER ELECTRONIC CIRCUITRY AND OPERATING PRINCIPLE

In this power circuit it consist Buck-Boost converter (step up-step down converter) which converts a dc voltage to a different required voltage level. Converter switches can be implemented using power MOSFET, BJT, GTO thyristor and IGBT In order to perform power conversion with the highest probable efficiency. It is a class of switching mode power supply (SMPS) containing minimum two semi-conductors switches and at least minimum one energy storage element. Filters made of capacitors which are added to the output of the converter to reduce output voltage ripple content. A boost converter (step-up converter) is DC voltage converter in which DC voltage greater than its input DC voltage and buck converter convert DC voltage less than its input DC voltage. The boost convertor has constant elements because the buck convertor, however this convertor produces AN output voltage bigger than the supply. "Boost" converters begin their voltage conversion with a current flowing through the inductance (switch is closed).The current then wants to slow really fast and the way it can do this is by increasing its voltage at the end that which connects to the diode, and switch. If the voltage is high enough it opens the diode, and one through the diode, the present cannot flow back. It is the very basic concept of boost converter. The main principle that drives the voltage boost converter is the property of an inductor to oppose to changes in current. When inductor is being charged it acts as a connected load and absorbs energy (like a resistor); when it is being discharged it acts as energy source (like a battery). The voltage it generates during the discharge phase is related to the rate of change of current.

VII. SIMULATION

The algorithm and simulation circuits are developed in MATLAB software. The output efficiency is checked by using different number of iterations and swarms. PSO traps the global optimal value when radiation level is different due to different atmospheric conditions. It contains of PV array and Inverter, DC/DC boost converter. Inverter fed PSO based control algorithm via PI controller and a RL load. Implementation of MPPT based photovoltaic converter with using PSO and without using PSO is carried out in MATLAB software. Below figure number 8 shows the circuit of Simulation for Implementation of PV based converter system without PSO and figure number 9 shows the circuit of Simulation for Implementation of PV based converter system with using PSO. The DC/DC boost converter consists of MOSFET switch, an inductor L of 0.1mH, Capacitor connected across PV array to reduce fluctuations in generated PV voltage. The switch was controlled by a Pulse breadth modulation (PWM) technique with change frequency of twenty kilocycles per second. PV array generates PV voltage which acts as a controlled voltage source for boost converter. Below shows the complete circuitry of PV system with and without using PSO in MATLAB and due to these we completely understand the difference in results of these systems which shown in below.

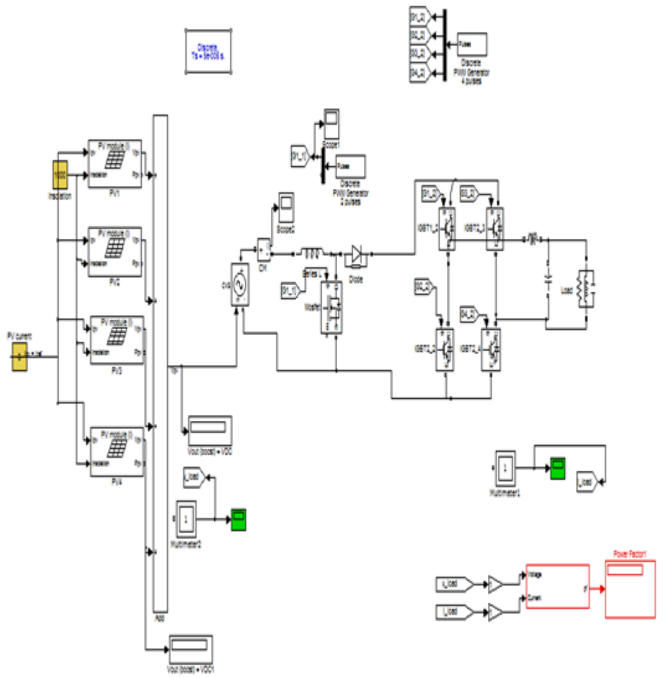

Fig.8. Simulation circuit of PV based converter system without PSO.

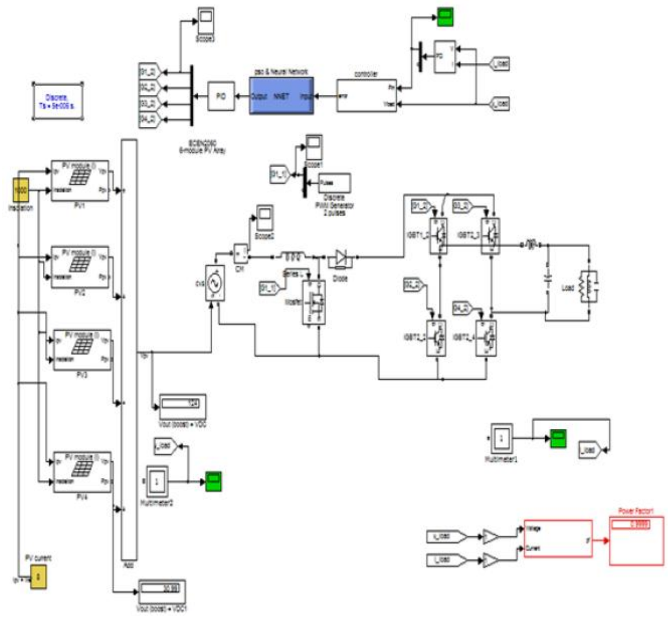

Fig.9. Simulation circuit of PV based converter system with using PSO.

VIII. RESULTS

When we simulate the above simulated circuit shown in figure 8 we get the result which is shown in below figures i.e. in figure 10 and figure 11 which shows the respective voltage and current waveform without using PSO. From this we get result that voltage and current waveform shows some peaks between some specified time intervals.

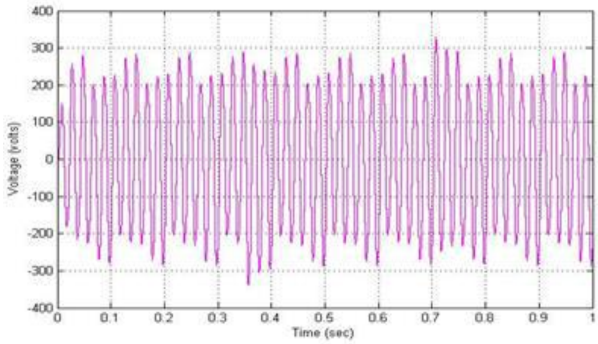

Fig.11. Voltage Waveform without using PSO

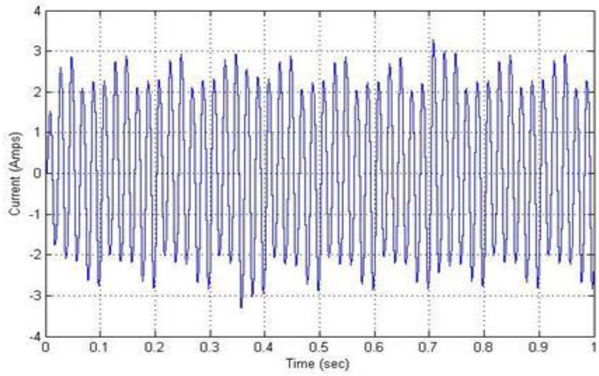

Fig.10. Current Waveform without using PSO

It means that the output power is varies which do not remain constant. Hence, they are responsible for complexities in the load fed by this model. And when we simulated the model shown in figure 9 the PV solar system with PSO method we obtained resultant voltage and current waveform which is shown in figure 11 and figure 12.

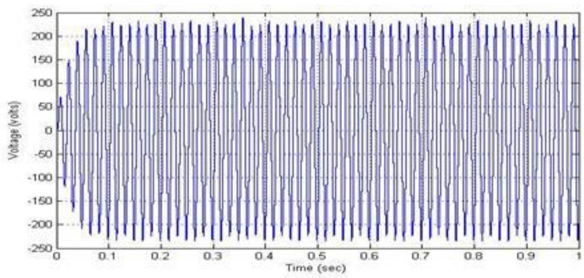

Fig.11. Voltage Waveform using PSO

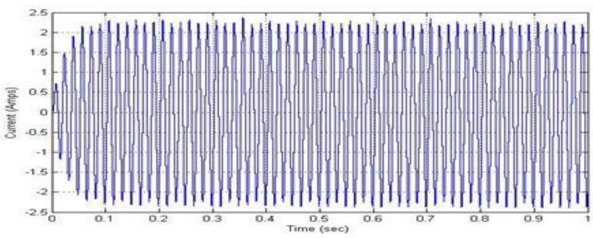

Fig.12. Current Waveform using PSO

Along with this waveform analysis FFT analysis is also done. From this resulting waveform we conclude that is steady state value for both voltage and current ultimately output power remains constant over the specified time interval. From figure 13 results obtained are such that we get the Total Harmonic Distortions are 4.50% for PV system without using PSO while from figure 14, it is clearly observed that Total Harmonic Distortions is 0.70 % only.

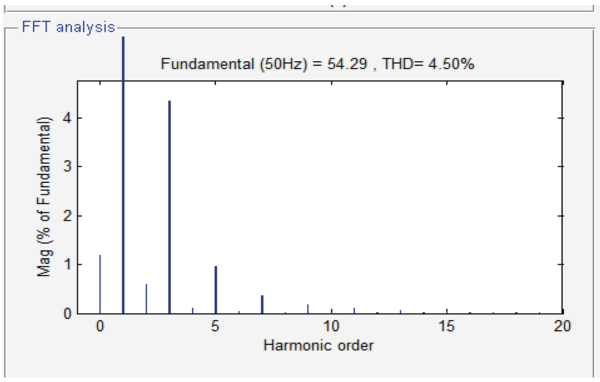

Fig. 13: FFT Analysis without using PSO in PV system

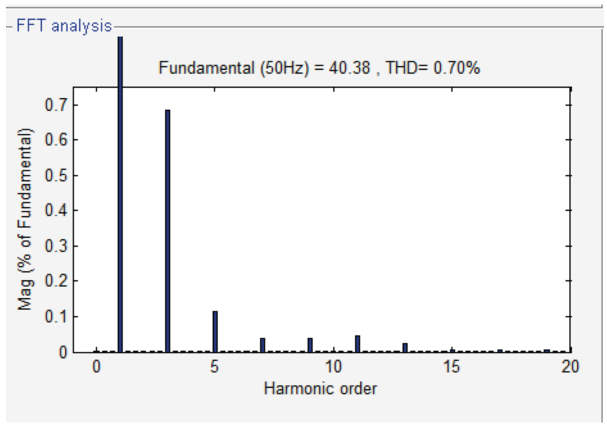

Fig. 14: FFT Analysis using PSO in PV system

IX. CONCLUSION

The proposed MPPT-PSO technique reaches best use of the available energy provided by the presented PV system. It was possible the recovering of the global maximum power from the PV array considering partial shading conditions. In addition, it was look a minimum power change around the power drained from the PV array at the MPP in steady state. The results can be obtained and compared with operation which confirms the effectiveness of peak power tracking technique. The primary design of the peak power tracker is to read the current and voltage levels at the solar panel simulator output, process these values using the PSO algorithm, and then adjust the voltage in order to obtain maximum power from system. If Comparison of Solar PV panel output with and without optimization is carried out then the results show that particle swarm optimization technique given good and satisfactory results. This system is not only able to track MPP for rabid environmental conditions but also it reduces steady state oscillations at

Maximum Power Point which results in stability of the system. Hence PSO technique can be employed for Solar PV panels. And in real conditions, it is not easy to disregard the effect of partial shading in PV arrangements, which can cause significant effect on the PV array power extraction. Thus, the MPPT-PSO technique proposed in this work proved to be thriving and efficient in relation to the extracting of the maximum power in PV arrays submitted to partial shading conditions.

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