COMPARISON BETWEEN PSO AND P&O MPPT ALGORITHMS FOR BOOSTCONVERTER

Dr.E.Latha Mercy
Department of Electrical and Electronics Engineering
Government College of Technology
Coimbatore,India.
mercy@gct.ac.in

P.Karthika
Department of Electrical and Electronics Engineering
Government college of Technology
Coimbatore,India
karthikadevi2728@gmail.com

P.Narasimman
Assistant Professor
Department of Electrical and Electronics Engineering
Kings college of Engineering
Thanjavur
Simman837@gmail.com

Ronald S.Ebenezer
Department of Electrical and Electronics Engineering
PSG Tech
Coimbatore
ronaldsebenezer7@gmail.com

***Abstract*— As the output characteristics of Photo Voltaic (PV) system depends on the ambient temperature, solar radiation and load impedance, its maximum power point (MPP) is not constant.**

Under each condition PV module can produces its maximum power. Therefore, a Maximum Power Point Tracking (MPPT) method is needed to uphold the PV panel operating at its MPP. This thesis presents a comparative study between Perturb and Observe (P&O) as conventional method and the non-conventional Particle Swarm Optimization (PSO) method.

To evaluate the study, the proposed PSO MPPT is implemented on a DC-DC boost converter and has been compared with P&O by using the MATLAB tool Simulink. The simulation result shows that the proposed non-conventional algorithm is simple and attain more power than the P&O algorithm.

Keywords—pvmodule,mppt,pso and p&o,matlab simulink

I. INTRODUCTION

The growing use of renewable energy sources (RESs) and Energy storage systems (ESS), due to global environmental concern, brings new challenges to the energy conversion technology. Because some devices that store or produce electrical energy (e.g., batteries, ultra-capacitors, fuel cells and solar photovoltaic) is often realized using multiple low voltage cells, which are usually connected in series to produce sufficient voltages for the intended application. Unfortunately, series connection of cells degrades the system performance, adds complexity to the system, and possible temperature rise due to fabrication variation and different operating conditions between cells. In batteries, this may be related to the state of charge of a cell. In solar arrays, it may be due to a change in solar irradiance or partial shading of the array.

The boost and buck-boost converters are the simplest non-isolation topologies that produce an output voltage that is greater in magnitude than the source voltage. However, the conventional boost and buck-boost converters must operate at extreme duty ratio to achieve high voltage gain (in particular ten times). This is an undesirable operating point.

concern related to the efficiency of high step-up converters is power device rating.

Two weaknesses exist within PV systems. Firstly, conversion effectiveness is very low (9%-20%) when subjected to low sun energy. Secondly, the current of the PV, and the production of energy, are dependent on weather patterns, leading to constant changes in temperature and solar energy. Moreover, the features of the PV battery are non-linear, i.e. they vary in temperature and irradiance. The PV output feature generally contains a point at which the PV module yields its highest output power and energy, i.e. MPP. At the same time, the actual point is unidentified, and may be arrived at through module computation or through search algorithms, including the MPPT technique. According to, PV panels present a number of local maximum output power points on the I-V or P-V curves of the PV panels, if allowed to function under non-uniform solar irradiation as a result of covering some of the modules. Conversely, a number of researchers advocate 4 MPPT algorithms, due to the existence of only a single unique maximum point across the P-V curve. In addition, no suboptimal local maximum exists along the output curves features of the PV panels. At the same time, it is not possible to correctly track MPP during a rapid change of weather conditions, and it is not possible to operate the system at MPP under PSC, due to a lack of differentiation between the local MPP and Global Peak (GP) this is because of the assumption that most MPPT controllers operate such that there is only one point that the PV module can produce its maximum power within the P–V characteristic. However, when partial shading conditions (PSC) occur the P–V characteristic becomes more complex and exhibits multiple peaks, which in turn affects the performance of the controller and causes a reduction in the whole output power of the system as a result. In view of these drawbacks, the following factors have been taken into consideration when developing the proposed MPPT algorithm: The dynamic response speed of the system: since a fast dynamic respond can increase the system output power. Steady-State Power oscillation: as reducing the power oscillation around the MPP can considerably reduce power loses. Tracking direction: in case of rapidly changing weather conditions most of the MPPT algorithm can be confused and track in a wrong direction. PSC: the efficiency of MPPT controllers is reduced under these conditions. The assumption made by the majority of MPPT controllers is that on the P-V characteristic there is only one point at which the PV module can produce its maximum power. However, when PSC occurs, the module will have several MPPs, which will impact on the performance of the controller, causing a reduction in the complete output power of the system.

Maximum Power Point Tracking

MPPT is employed to ensure that the highest power is obtained from the PV modules under all environmental conditions (in particular, solar insulations and temperature). This is achieved by matching the functioning voltage and current of coordination power converters. To link a standalone DC-DC structure (as designated within the figexpanded through inclusion of extra electronic devices, together with inverter and grid units.

Despite PV systems containing a number of major advantages, they also have a number of specific disadvantages, i.e. high cost; limited capacity in comparison to other low and zero carbon energy sources; low conversion efficiency; and (as they generally rely on atmospheric conditions) a dependence on weather conditions.Consequently, MPPT is capable of only generating electric current for a short period each day, conditional on both energy from the sun and the prevailing temperature. In addition, is an inductor capacitance (LC) electrical circuit, which is regulated in an electronic manner. A pulse width modulator (PWM) controls the duty cycle (D) of the electronics switch, which takes the following form:

differences in climatic setting cause PV systems to have non-linear features, while a PV unit has a position within each climatic condition at which it is capable of generating its highest output current, as well as power, i.e. MPP. It is thus necessary to regulate the PV unit to manage it at MPP. As established by the references, MPPT is capable of raising the generation of electric current to 25% . This illustrates the I-V plus P-V output features of a standard PV module at STC .

DC-DC BOOST CONVERTER:

A.General Structure of DC-DC Boost Converters

Depending on the configuration, the input side can be current fed or voltage fed. The input voltage can be a battery, fuel cell or solar photovoltaic

B. Isolated DC-DC Boost Converters

The high-frequency transformer based system is an attractive solution for providing galvanic isolation and impedance matching between the source and load. As an example, isolation is usually required by regulatory agencies in off-line power supply applications. Classical converters with galvanic isolation such as flyback, current-fed push-pull converters can easily achieve high voltage gain by adjusting the turns ratio. However from an efficiency standpoint, the high-frequency transformer implies additional cost, losses and inhibits developing a compact converter. Thus, the volume weight and losses are the main limitations of isolated converters in embedded applications. Isolated boost converters are either current-fed or voltage-fed. Some typical examples of isolated DC-DC converters topologies include flyback, forward, full bridge, half bridge, push-pull converters or their variations.

C. Non-isolated DC- DC Boost Converter

Rather than the isolated converters, non-isolated DC-DC converters can be used to improve the efficiency. Consequently, the volume, weight and losses associated with the high-frequency transformer are reduced. Furthermore, in the high power application where weight size is the main concern, the transformer-less structure is the most attractive. It is becoming a more suitable solution to employ non-isolated converters to reduce the system cost and improve the efficiency. Since the passive components size and weight of non-isolated converters vary inversely with frequency, the components then operate at converter switching frequency in tens of kilohertz (KHz) range or higher. This high frequency leads to dramatic reduction in converter size and weight. In summary, for applications that require isolation between source and load based on safety measures, the isolated topologies are the right choices. However, in high power applications where volume weight is the main concern, the non-isolated topologies are the best option. The basic non-isolated DC-DC step-up topologies that produce an output voltage higher in magnitude than the input voltage are the boost and buck-boost converters.

D.Limitations of Conventional Converters in High step-up Applications

The boost and buck-boost converters are the simplest PWM controlled topologies for voltage step-up. However, these converters typically operate under extreme duty ratio to achieve high voltage gain. As a consequence, significant voltage and current stresses are incurred by the power converter devices and poor dynamic characteristics can result in the controlled output response. Besides, the power device rating is proportional to the output voltage and a high rated power device potentially increases the conduction losses which also degrade the efficiency. Furthermore, the output diodes often sustain short, but high amplitude, current pulses due to the narrow turn off time; which induces reverse recovery losses.

During the switch turn on instant, the diode DO is reversed biased, and the input source charges the inductor L. When the switch turns off, the load receives energy from the input as well as the inductor. The capacitor CO removes the switching harmonics from the applied input signal. Noticeably, the energy transfer in a step-up (boost) converter is between a voltage and current source. Since in a steady state, the capacitor or inductor can be represented by their instantaneous voltage or currents as an equivalent voltage and

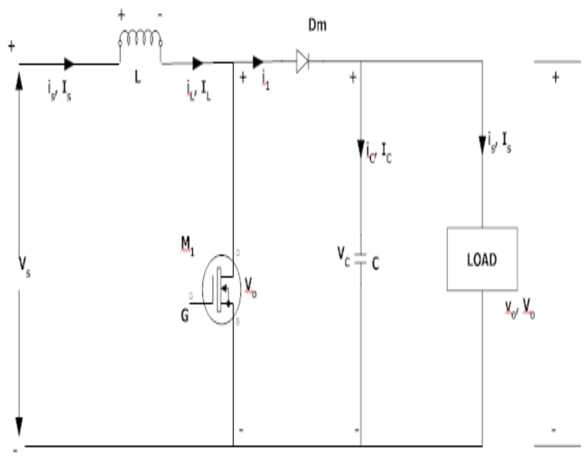

FIG 3.1.GENERAL STRUCTURE OF BOOST CONVERTER

The function of boost converter can be divided into two modes, Mode 1 and Mode 2. Mode 1 begins when transistor M1 is switched on at time t=0. The input current rises and flows through inductor L and transistor M1.

Mode 2 begins when transistor M1 is switched off at time t=t1. The input current now flows through L, C, load, and diode Dm. The inductor current falls until the next cycle. The energy stored in inductor L flows through the load.

4.1.1. Perturb and Observe algorithm

This technique is founded on an exploration of the affiliation between PV component output power and its output voltage wherein the PV module operating point is on the left of the P-V arc (dp is positive), indicating that once the output current of the PV component raises, the PV unit current perturbation will persist within the same course in the direction of the MPP. If the functioning point of the component was on the P-V arc right side, subsequently the regulator would shift the PV unit functioning point back, looking for the factual MPP. This can be attained through overturning the perturbation course.

There are two commonly used techniques when using the P&O method: (1) the reference voltage; and (2) the converter duty ratio. In the reference voltage, the PV module output voltage is adjusted by a PI controller operating the PV module at its MPP under standard test conditions. In the converter duty ratio, the duty ratio of the DC-DC converter is perturbed to extract the maximum output power from the PV module. This method is founded on the association between the PV component output energy and the duty proportion of the DC-DC converter; whereas MPP is attained by amending the switching disposition of the adapter (duty proportion) until dp/dd is equivalent to zero. The downsides of P&O techniques are that they generate osculation near the MPP within the stable state. A constant fluctuation in P&O techniques within the stable state leads to a decreasein the PV component output energy. Additionally, it is not capable to run the compone nt at its utmost output energy during swiftly changing weather circumstances .

Digital circuits can implement P&O MPPT algorithms without difficulty. As discussed in The output power of PV panels is computed based solely on the terminal voltage and current of a PV panel. A comparison is then undertaken between this result, and that preceding, in order to establish the orientation of the subsequent perturbation. This process is facilitated by digital circuits. The primary advantage of the use of P&O algorithms is their capacity for acting to slow fluctuations, not only in solar irradiation and temperature, but also in the properties of the PV panels. On the other hand, P&O algorithms fail to respond with sufficient rapidity when searching for the most effective operating point to generate maximum output power.

The speed of the process is also limited by the average voltage, power or current in the majority of implementations being used by perturbation methods to supply data relating to derivatives. A number of different studies have demonstrated that the MPP is tracked by standard P&O systems at a couple of tens of milliseconds or more. Once the MPP is tracked, the PV panel operating point will still suffer perturbations, due to the ongoing use of perturbations in MPPT. Under stable conditions, PV power is lost, due to the rising P&O system fluctuations around the MPP. P&O algorithms have an additional limitation. Furthermore, atmospheric conditions undergoing rapid changes may trigger a temporary deviation of the operating point from the MPP.

The assumption underpinning P&O algorithms is that perturbation is the cause of fluctuations in output power. Since they cannot rely on measured values to detect unexpected fluctuations in atmospheric conditions, any deviation from the MPP can occur if the direction of the perturbation responsible for increasing output power is maintained, i.e. it is impossible to prevent tracking in the incorrect direction. However, faster tracking cycles can help to diminish duration and power loss.

4.1.2. Incremental Conductance

IncCond was built by a Saga University student, and has been applied to prevail over the P&O technique drawback under fast altering ecological circumstances. The technique is attained by computing the symbol of dp/dv employing the PV component incremental and its straight conductance (dI/dV and I/V) . Just two feelers (the current and voltage sensors) are needed within the IncCond system to determine the PV unit output energy and voltage, presuming the existence of simply one point on the P-V distinctive, wherein the PV component can generate its MPP.

The relationship between the output voltage and power are expressed as follows;

dP/dV =0 at MPP

dP/dV >0 on the left side of MPP

dP/dV <0 on the right side of MPP

The slope (dp/dv) of P-V characteristic can be calculated using the PV module output voltage and current, as follows:

dP/dV=(dI)/dV=I×dV/dV=I×dV/(dV)+V×dI/(dV)=I+VdV/dI

Hence, the operating point of the module at its MPP can be calculated based on equation, as follows:

dI/ dV= I/V at MPP

dI/ dV > I/V on the left side of MPP

dI/dV < I/V on the right side of MPP

These equations reveal that the PV unit functions at its MPP once the IncCond I/dV is equivalent to its straight conductance I/V. Nevertheless, if the PV component IncCond dI/dV is above its conductance I/V, then the regulator will augment the PV unit voltage through regulating the duty proportion of a DC–DC adapter. If this was not the situation, the perturbation could be in the conflicting course, or would amplify the duty proportion of the converter so as to decrease the current and change the functioning position back to the MPP.

Therefore, regardless of the pace of change in atmospheric conditions, the operating point is, in theory, moved by the IncCond algorithms towards the MPP. Nonetheless, these algorithms are not without limitations, including a lack of cost-efficiency due to the complex nature of the control circuit and the necessity of rapid computation for the IncCond di/dv. An estimation of di/dv is typically achieved based on the relationship di/dv = I(k) – I(k-1)/V(k) – V(k-1)

Under circumstances of rapidly changing atmospheric conditions, a slow computation speed will result in an invalid di/dv estimation. Hence, it is not possible to guarantee the advantage displayed by IncCond algorithms regarding the movement of the operating point towards the MPP, regardless of the pace of change of atmospheric conditions. This leads to an issue comparable to the P&O algorithm deviation from MPP under rapidly changing atmospheric conditions.

Particle Swarm Optimisation

A further optimisation technique capable of being applied in a multivariable function optimisation with many local optimal points is the PSO algorithm, as outlined by Kennedy and Eberhart in 1995. The principle of the PSO algorithm has been inspired by the social behaviour observed in natural phenomena, e.g. bird flocking and fish schooling. The differences between PSO and alternative global optimisation methods consist of PSO's easy implementation and rapid convergence. As a result, PSO has received increased attention from researchers studying its use with MPPT in PV systems. Following the flocking analogy noted above, PSO models several cooperative 'birds', in the form of particles, acting together in a 'flock', otherwise known as a swarm. Each particle moving in the swarm has a fitness value mapped by an objective function and an individual velocity, which the particle uses to decide the direction and distance of its movement. Each particle exchanges the information it obtains during its respective search process.

The position of a particle is influenced by two variables: (1) the most effective solution is identified by the particle itself (*p*best), which is stored for use as an individual best position; and (2) the best particle in a neighbourhood (*g*best), which is stored as the best position of the swarm. The particle swarm employs this method to move towards the best position and continuously revises its direction and velocity. In this manner, each particle ultimately moves to an optimal point, or close to a global optimum . The standard PSO method can be defined by means of the following equations:

$(k+1)=(k)+c1r1.(Pbest-xi(k))+c2r2.(gbest-xi(k))$ (6-1)

$(k+1)=(k)+vi(k+1)$ (6-2)

i=1, 2…, N

Where xi and vi are the velocity and position of particle i, respectively; k represents the iteration number; w is the inertia weight; r1 and r2 are random variables, whose values are uniformly distributed in the range (0,1); and c1 and c2 represent the cognitive and social coefficients, respectively. *P*best,i forms the individual best position of particle i, and *g*best,i is the best position of all particles in the swarm. If condition of the initialisation has been satisfied.

where *f* represents the objective function to be maximised.
The essential operating guideline for this strategy can be clarified as follows:
Stage 1 (PSO Initialisation): a random initialisation of the particles is considered by engaging a consistent allocation over the search area, or getting instigated on grid nodes within the search space with halfway points. The primary velocities are determined randomly.
Stage 2 (Fitness Evaluation): each particle's fitness value is examined by having the candidate solution supplied to the objective function.
Stage 3 (Update Individual and Global Best Data): pbest,i and gbest (individual and global best fitness values, in that order) plus the positions, are renewed via comparing the freshly computed fitness values with the preceding examples, as well as having the pbest,i and gbest replaced (in addition to their resultant positions), as required.
Stage 4 (Update Velocity and Position of Each Particle): each particle's position and velocity within the swarm is updated.
Stage 5: (Convergence Determination): checking of the convergence measure is done, and, when achieved, termination of the process may occur; else, the iteration number goes up by 1 and go to stage 2.

SIMULATION OF PERTURB & OBSERVE MPPT CONTROLLER:

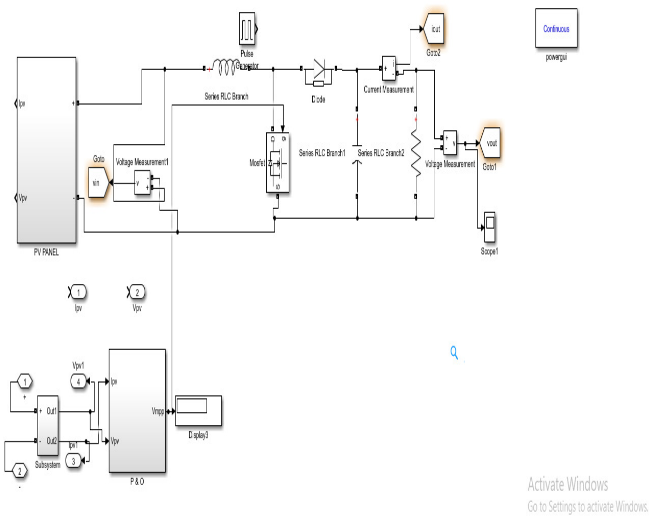

FIG 6.1 SIMULINK MODEL OF P&O MPPT CONTROLLER

OUTPUT VOLTAGE OF P&O CONTROLLER:

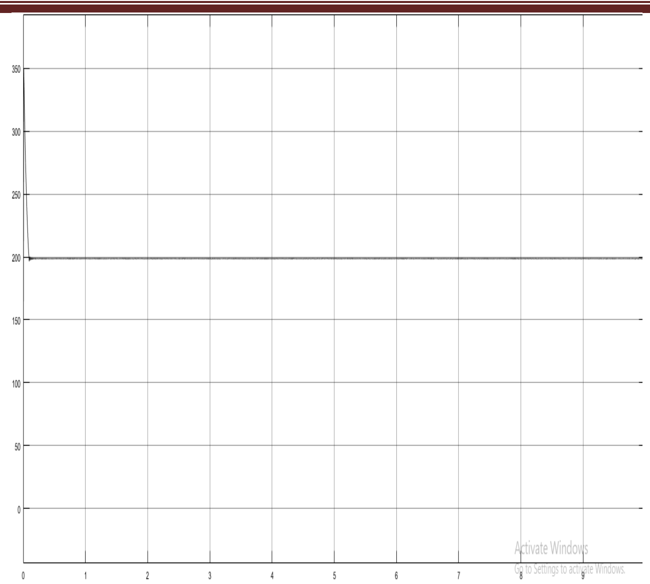

FIG 6.2 OUTPUT VOLTAGE OF P&O MPPT CONTROLLER

Simulation circuit and the output voltage for P&O MPPT controller for boost converter are shown.The output voltage is obtained to be 198.9 V.Duty cycle generated from P&O controller is given as gate pulse for MOSFET switch.

SIMULATION OF PARTICLE SWARM OPTIMISATION MPPT CONTROLLER:

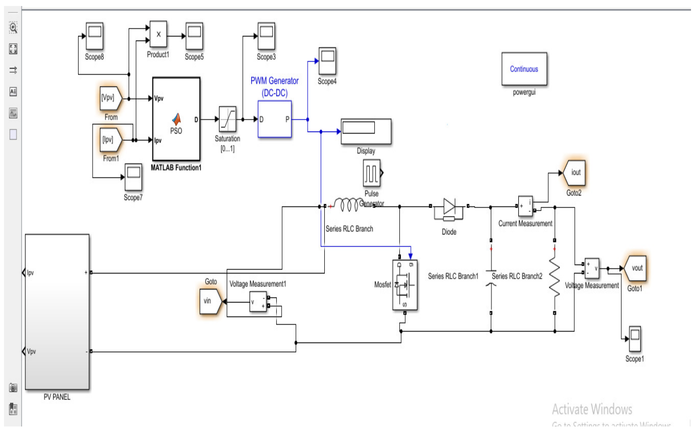

FIG 6.3.SIMULINK MODEL OF PSO MPPT CONTROLLER

GENERATING PULSE FROM PSO CONTROLLER:

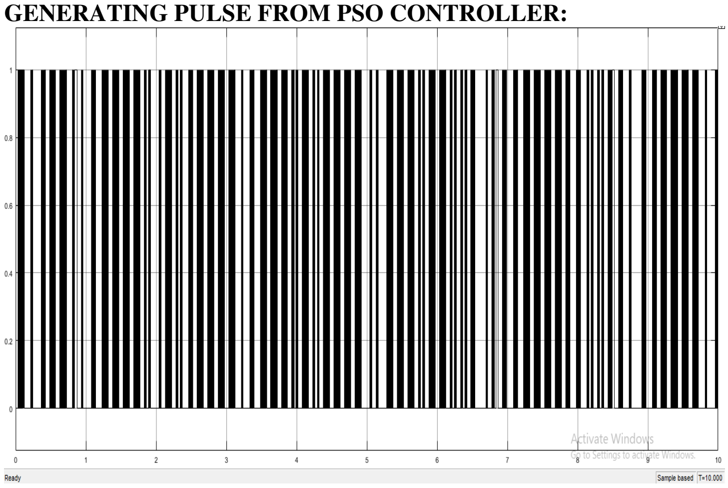

FIG 6.4 GATE PULSE FROM PSO MPPTCONTROLLER

Simulation circuit and the pulse generated from PSO MPPT

Parameters	Output Voltage	Output Current	Output Power
PID	**192v**	**3.16a**	691.2w
P&O	**198.9v**	**3.8a**	784w
PSO	**206.4v**	**4.1a**	840w

controller are shown.The generated pulses are given as gate pulse signal for the boost converter MOSFET switch.
Depends on the gate pulse,output voltage is generated.

OUTPUT VOLTAGE OF PSO CONTROLLER:

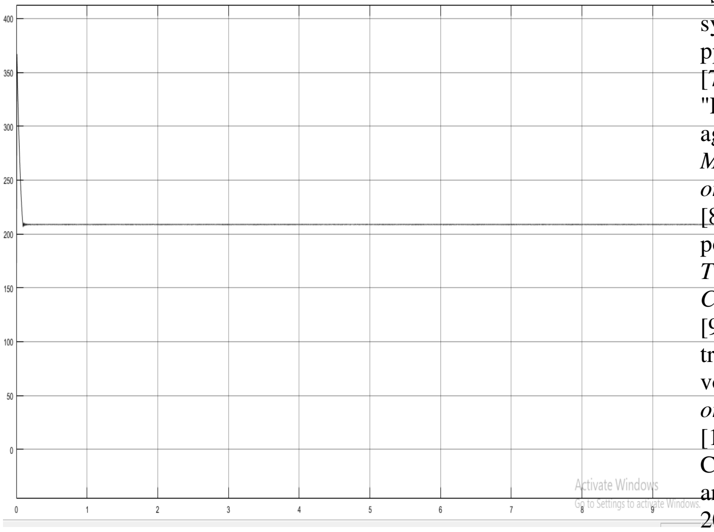

FIG 6.4.OUTPUT VOLTAGE OF PSO MPPT CONTROLLER

OUTPUT MEASUREMENTS:

TABLE 6.5 OUTPUT MEASUREMENTS ON COMPARISON OF VARIOUS MPPT

The output voltage obtained from the PSO controller is 206.4 V.From the above results the output voltage obtained from the PSO controller is higher than that of P&O MPPT controller.

Therefore, the proposed PSO MPPT is implemented on a DC-DC boost converter and has been compared with P&O by using the MATLAB/Simulink. The simulation result shows that the proposed PSO algorithm is simple and attain more power than the P&O algorithm.

REFERENCES

[1] S. R. Potnuru, D. Pattabiraman, S. I. Ganesan and N. Chilakapati, "Positioning of PV panels for reduction in line losses and mismatch losses in PV array," Renewable Energy, vol. 78, , 2015, pp. 264-275.

[2] T. L. Kottas, Y. S. Boutalis and A. D. Karlis, "New maximum power point tracker for PV arrays using fuzzy controller in close cooperation with fuzzy cognitive networks," *IEEE Trans. Energy Convers.,* vol. 21, 2006, pp. 793-803.

[3] Senjyu, T. Uezato and K. (1994Maximum power point tracker using fuzzy control for photovoltaic arrays", *Proceedings of the IEEE International Conference on Industrial Technology*, 5-9 Dec, pp. 143-147.

[3] Z. Liang, R. Guo, J. Li and A. Q. Huang, "A high-efficiency PV module integrated dc/dc converter for PV energy harvest in freedom systems", IEEE *Trans. Power Electron*., vol. 26, no. 3, 2011,pp.897 -909.

[4] R. Kadri, J. Gaubert and G. Champenois, "An improved maximum power point tracking for photovoltaic grid-connected inverter based on voltage-oriented control," *IEEE Trans. Ind. Electron.,* vol. 58, 2011,pp. 66-75.

[5] M. Miyatake, F. Toriumi, T. Endo and N. Fujii, "A novel maximum power point tracker controlling several converters connected to photovoltaic arrays with particle swarm optimization technique," in *Power Electronics and Applications, 2007 European Conference on,* 2007, pp. 1-

[6] B. N. Alajmi, K. H. Ahmed, G. P. Adam and B. W. Williams, "Single-phase single-stage transformer less grid-connected PV system," *IEEE Transactions on Power Electronics,* vol. 28, 2013, pp. 2664-2676.

[7] V. Phimmasone, Y. Kondo, T. Kamejima and M. Miyatake, "Evaluation of extracted energy from PV with PSO-based MPPT against various types of solar irradiation changes," in *Electrical Machines and Systems (ICEMS), 2010 International Conference on,* 2010, pp. 487-492. 156

[8] J. Ahmad, "A fractional open circuit voltage based maximum power point tracker for photovoltaic arrays," in *Software Technology and Engineering (ICSTE), 2010 2nd International Conference on,* 2010, pp. V1-247-V1-250.

[9] S. Hadji, J. Gaubert and F. Krim, "Maximum power point tracking (MPPT) for photovoltaic systems using open circuit voltage and short circuit current," in *3rd International Conference on Systems and Control,* 2013, pp. 87-92.

[10] S. R. Potnuru, D. Pattabiraman, S. I. Ganesan and N. Chilakapati, "Positioning of PV panels for reduction in line losses and mismatch losses in PV array," Renewable Energy, vol. 78, , 2015, pp. 264-275.

[11] T. L. Kottas, Y. S. Boutalis and A. D. Karlis, "New maximum power point tracker for PV arrays using fuzzy controller in close cooperation with fuzzy cognitive networks," *IEEE Trans. Energy Convers.,* vol. 21, 2006, pp. 793-803.

[12] Senjyu, T. Uezato and K. (1994Maximum power point tracker using fuzzy control for photovoltaic arrays", *Proceedings of the IEEE International Conference on Industrial Technology*, 5-9 Dec, pp. 143-147.

[13] C. Won, D. Kim, S. Kim, W. Kim and H. Kim, "A new maximum power point tracker of photovoltaic arrays using fuzzy controller," *in Power Electronics Specialists Conference, PESC'94 Record., 25th Annual IEEE,* 1994, pp. 396-403.

[14] N. Khaehintung, P. Sirisuk and W. Kurutach, "A novel ANFIS controller for maximum power point tracking in photovoltaic systems," *in Power Electronics and Drive Systems, 2003. PEDS 2003. the Fifth International Conference on,* 2003, pp. 833-836.

[15] M. Abdulaziz, S. Aldobhani and R. John, "Maximum power point tracking of PV system using ANFIS prediction and fuzzy logic tracking," 2008.

[16] Mashaly, H.M.; Sharaf, A.M.; Mansour, M.M.; El-Sattar, A.A. "Fuzzy logic controller for photovoltaic-utility interfacing scheme ", Electro technical *Conference, 1994. Proceedings., 7th Mediterranean,* On page(s): 715 - 718 vol.2N.Femia, G. Petrone, G.

[17] T. Wu, C. Chang and Y. Chen, "A fuzzy-logic-controlled single-stage converter for PV-powered lighting system applications," *IEEE Trans. Ind. Electron.,* vol. 47, 2000,pp. 287-296.