ANALYSIS OF DIFFERENT MPPT TECHNIQUES TO EXTRACT ITS OPTIMUM OF SOLAR ENERGY

[1]Ahrarul Haque, [2]Dr. Neel Kamal
[1]M.Tech final year, [2]Asso. Professor
[1]Power System and Control, SET
[1]Noida International University, Gautam Budh Nagar, UP, India

Abstract: Due to surging oil prices and environmental concern the interest in solar energy has risen. It is renewable, inexhaustible, and non-polluting. In many remote or underdeveloped areas, direct access to an electric grid is impossible and a photovoltaic inverter system would make life much simpler and more convenient. Solar radiant energy accounts for most of the usable renewable energy on earth. Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. The main encumbrance for the reach of Photovoltaic systems is their low efficiency and high capital cost. Here we intend to examine a schematic to draw out maximum obtainable solar power from a PV module for use in a DC application. The concept of Maximum Power Point Tracking is to be implemented which results in appreciable increase in the efficiency of the Photovoltaic System. Different schemes of MPPT algorithms such as Perturb and Observe, Incremental Conductance, Fractional Open Circuit Voltage, Fractional Short Circuit Current, Fuzzy Logic Control, Neural Network are to be studied and implemented. The MPPT algorithm thus proposed will identify the suitable duty ratio to obtain maximum power output. The benefit of this project is to give access to an everlasting and pollution free source of energy with improved efficiency.

Index Terms- Photovoltaic Cell, MPPT, Perturb and Observe, MPPT Algorithm.

1. INTRODUCTION

The world demand for electric energy is constantly increasing, and conventional energy resources are diminishing and are even threatened to be depleted. Moreover; their prices are rising. For these reasons, the need for alternative energy sources has become indispensable, and solar energy in particular has proved to be a very promising alternative because of its availability and pollution-free nature. Renewable sources like wind energy and solar energy are the prime energy sources which are being utilized in this regard. The continuous use of fossil fuels has caused the fossil fuel deposit to be reduced and has drastically affected the environment depleting the biosphere and cumulatively adding to global warming. Solar energy is abundantly available that has made it possible to harvest it and utilize it properly. Solar energy can be a standalone generating unit or can be a grid connected generating unit depending on the availability of a grid nearby. Thus it can be used to power rural areas where the availability of grids is very low. Another advantage of using solar energy is the portable operation whenever wherever necessary. In order to tackle the present energy crisis one has to develop an efficient manner in which power has to be extracted from the incoming solar radiation. But due to high production cost and the low efficiency of these systems they can hardly compete in the competitive markets as a prime power generation source.

Thus a new technology is introduced for the power control mechanisms called the Maximum Power Point Tracking (MPPT) techniques and the MPPT algorithms has led to the increase in the efficiency of operation of the solar modules and thus is effective in the field of utilization of renewable sources of energy. Unfortunately, PV generation systems have two major problems: the conversion efficiency in electric power generation is low (in general less than 17%, especially under low irradiation conditions), and the amount of electric power generated by solar arrays changes continuously with weather conditions. Moreover, the solar cell V-I characteristic is nonlinear and changes with irradiation and temperature. In general, there is a point on the V-I or V-P curve only, called the Maximum Power Point (MPP), at which the entire PV system (array, inverter, etc.) operates with maximum efficiency and produces its maximum output power. The location of the MPP is not known, but can be located, either through calculation models or by search algorithms. Maximum Power Point Tracking (MPPT) techniques are used to maintain the PV array's operating point at its MPP.

Many MPPT techniques have been proposed in the literature:

1. Perturb and Observe (P&O) Method,
2. Incremental Conductance (IC) Method,
3. Constant Voltage (CV) Method,
4. Short-Current (SC) Pulse Method,
5. Fuzzy Logic method,

etc;

The P&O and IC techniques, as well as variants thereof, are the most widely used. The MPPT techniques are evaluated considering different types of insolation and solar irradiance variations and calculating the energy supplied by a complete PV array.
Therefore, the aim of this work is to compare several widely adopted MPPT algorithms between them in order to understand which technique has the best performance. The evaluation of the algorithms' performance is based on the power measurement valuating the total energy produced by the panel during the same test cycle. In this work, respect to the MPPT algorithm compared by simulations, the methods that need temperature or irradiance measurements are not considered for sake of simplicity. Indeed, as described in [1], these techniques do not have very high performance and they are too expensive. In the simulations, the considered MPPT techniques have been implemented strictly following the description indicated in the references: no MPPT algorithm is preferred and no MPPT techniques have been realized with more attention respect to the others. In this work, the attention has been focused on experimental comparisons between some of these techniques, considering several irradiation conditions.

2. A Photo Voltaic Cell:

The basic operation of a semiconductor photovoltaic cell involves two steps. The first is the absorption of light which leads to the generation of electron-hole pairs within the photovoltaic material, while the second is the separation of these electron-hole pairs giving rise to an electrical current which flows in an external circuit. Also, the built-in potential barrier of the PN-junction separates these electron-hole pairs created by light producing an external potential of about 0.5 volts from the photovoltaic cell. Photovoltaic (PV) cells require only daylight and not direct sunlight in order to generate electricity which means that they can also generate electricity even on cloudy days, but standard types of photovoltaic cells have very low conversion efficiency. The higher photovoltaic cells conversion efficiency, the more electricity it generates for a given area of exposure to the sunlight and for standard silicon PV cells this is about 8% increasing to 25% for the more expensive types of photovoltaic cell. This conversion efficiency can be increased to about 40% with the use of concentrating mirrors and lenses. This is because most of the sunlight that arrives at the cells surface passes right through it with little or no effect to the power output.
Also excess photon energy that is not converted into electricity is wasted as heat. The heating effect of the silicon cell results in the maximum efficiency of a silicon PV solar cell in hot sunlight being very low. Then one of the primary factors in selecting a given semiconductor material for use as a photovoltaic material is its maximum conversion efficiency and power output. The average power output from a standard silicon photovoltaic cell is also dependent on the application, the suns irradiance on the photovoltaic cell and the size of the actual cell.

2.1. Model of a PV Cell:

The modeling of a photovoltaic cell is based on assessing the performance of photovoltaic cells through I-V characterization. This series includes an overview of PV cells, and describes the theory behind I-V characterization2.

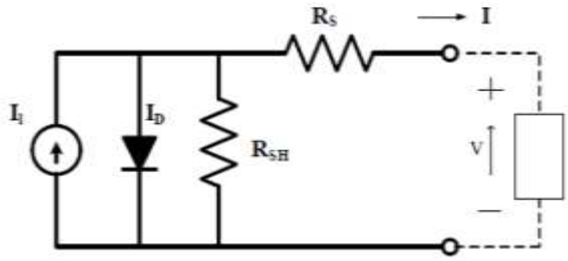

Fig. 2.1: Equivalent Circuit of a PV Cell
[source:pveducation.org/pvcdrom]

2.2. I-V Characteristics of a PV Cell:

PV cells can be modeled as a current source in parallel with a diode. When there is no light present to generate any current, the PV cell behaves like a diode. As the intensity of incident light increases, current is generated by the PV cell.

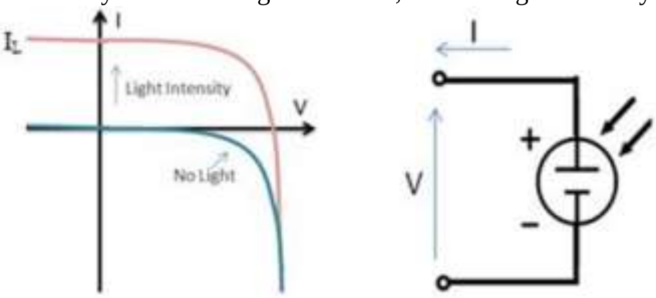

Fig. 2.2: I-V Curve of a PV Cell
[source:pveducation.org/pvcdrom/characterisation/double-diode-model]

3. The MPPT Techniques:

Due to many technical reasons, only 30 to 40 percent of the solar radiations are converted into electrical energy through a solar panel. Maximum power point tracking techniques are used to enhance the performance of the solar panel. MPPT block is connected to the DC-DC converter of the system, this converter is used as the interface between the solar panel and load. MPPT is used to match the load impedance to the optimal impedance of the
PV module. This also helps to reduce losses of the PV system. Fluctuating climatic conditions causes oscillation around maximum power point of PV array which affects the performance characteristics (P-V, I-V curves) of PV array causing the reduction in the overall efficiency. MPPT detects the PV array voltage and current, it tracks the maximum power point by adjusting its voltage under varying irradiance. Triggering of DCDC converter is controlled by the MPPT through switching devices. To match the MPP of PV array under different atmospheric conditions a suitable converter must be chosen. MPPT is used to haul out the maximum power of the PV cell and transfer this power to the load.

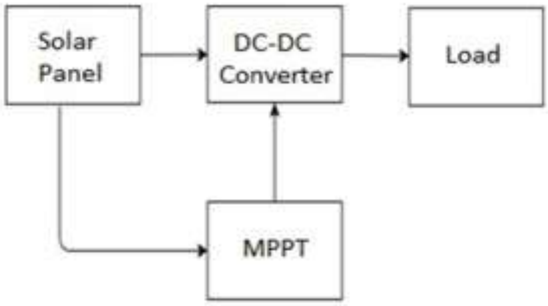

Fig 3.1: Block Diagram of a MPPT
[source: pveducation.org/pvcdrom]

DIFFERENT MPPT TECHNIQUES USED:

3.1. Perturb and Observe (P&O) Method

The principle is based on perturbing the voltage and the current of the PV regularly, and then, in comparing the new power measure with the previous to decide the next variation. Three Perturb and Observe (P&O) Methods are well known:
P&Oa with a fixed perturbing value.
P&Ob with a variable perturbing value.
P&Oc or Three-Point Weighted Method, where the direction of the perturbing value is defined by three points[2].

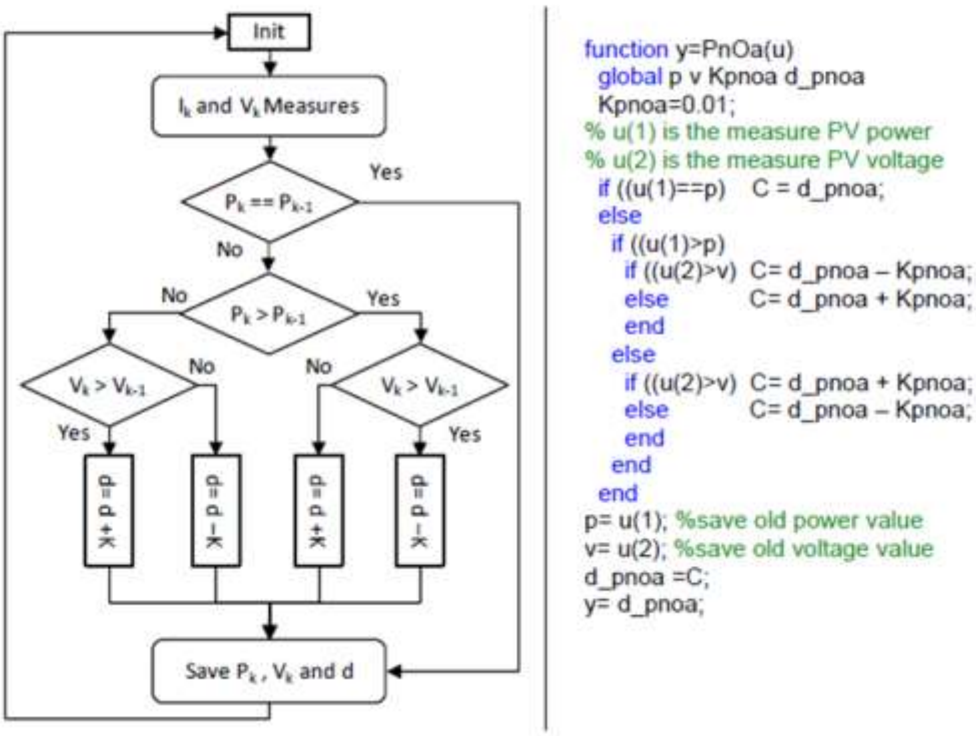

Fig.3.4. P&Oa algorithm and the code of Matlab embedded function

The P&Oa method requires the PV voltage and current measurements. The Matlab embedded function is evaluated with a 1 kHz frequency. The P&Ob method is similar to the P&Oa except than the constant coefficient Kpnoa is replaced by a variable coefficient Kpnob:

Kpnob=0.02.│ΔP│

The P&Oc or Three-Point Weighted Method is equivalent to a 2nd Order gradient approximation of the Power derivative. So it means the MPPT convergence will be better and more robust.

3.2. Incremental Conductance (IC) Method

The principle of the Incremental Conductance (IC) Method is based on the property of the MPP: the derivative of the power is null, as in (5). So, the IC method uses an iterative algorithm based on the evolution of the derivative of conductance G, as in (6). Where the conductance is the I/V ratio[3].

$$(dP)/dV = 0 \; for \; P = V.I$$
$$(dP)/dV = V\,(dI)/dV + I\,(dV)/dV = 0$$
$$Thus{:}\; (dI)/dV + (I)/V = 0$$
$$dG + G = 0$$

This method (ICa) has been improved, because when the voltage is constant, dG is not defined. So, a solution is to mix the CV method with the IC method. It is known as the Two-Method MPPT Control (or ICb). Fig. 7. shows the Two-Method MPPT Control algorithm and the code of the Matlab embedded function:

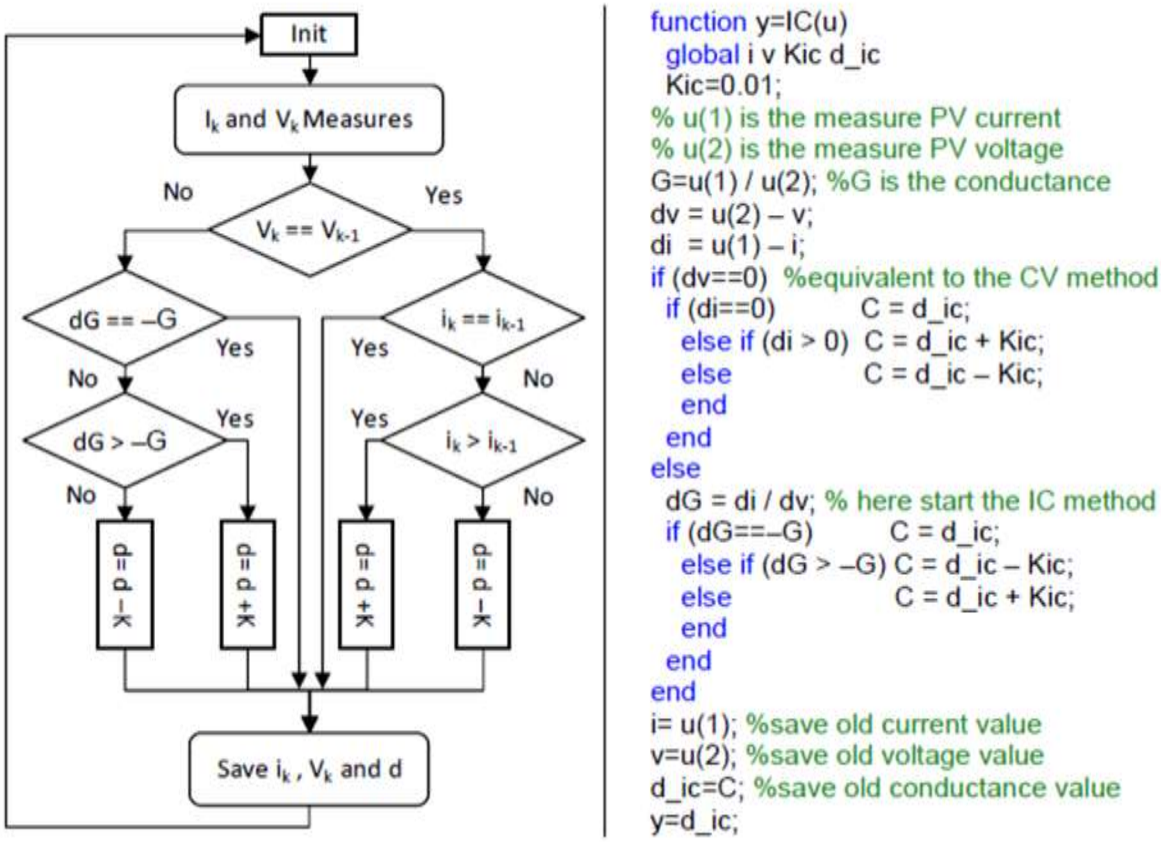

Fig.3.2. Two-Method MPPT Control algorithm and the code of Matlab embedded function

The Two-Method MPPT Control method requires the PV voltage and current measurements. The Matlab embedded function is evaluated with a 1 kHz frequency.

3.3. Constant Voltage (CV) Method

The principle of the Constant Voltage (CV) Method is simple: the PV is supplied using a constant voltage. Temperature and Solar Irradiance impacts are neglected. The reference voltage is obtained from the MPP of the P(i) characteristic directly. Here, the MPP voltage is about 16.3V for the studied PV[4].
The CV method requires the PV voltage measurement only. The Matlab embedded function is evaluated with a 1 kHz frequency. This Constant Voltage Method cannot be very effective regarding Solar Irradiance impact and certainly not regarding the temperature's influence. Thus, some enhancements of the CV methods exist.

3.4. Short-Current (SC) Pulse Method

The principle of the Short-Current Pulse (SC) Method is based on a simple relation: the MPP current is proportional to the Short-circuit current iSC, with some temperature and solar irradiance conditions. To simplify the iSC estimation, it is often considered as constant, even if the temperature varies between 0 and 60°C. The determination of the Short-circuit current iSC is in fact, done just before connecting the PV systems to the grid.

The SC method requires the PV current measurement only. The Matlab embedded function is evaluated with a 1 kHz frequency.

4. SIMULATION ANALYSIS:

The measurements have been performed several times in order to cut off deviations caused by interferences and/or environmental factors in this system. Inorder to realize a precise analysis of the performance of the different MPPT techniques, they are experimentally compared taking into account two different ir-radiation diagrams[5].

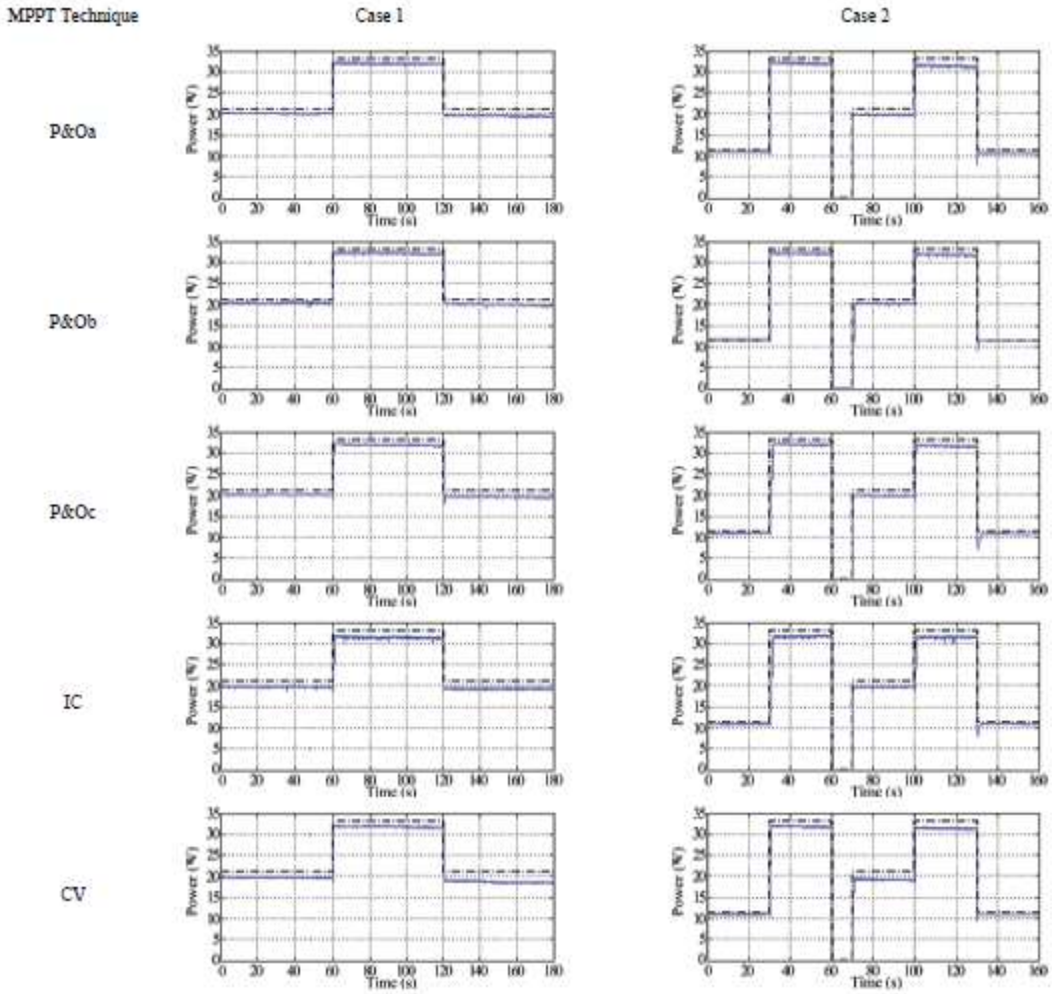

Figure 4. Power generated by the PV array in the Case 1 and Case 2 by different optimized MPPT methods (solid line) and ideal (dot-dashed line) MPPT method

The first one is characterized by medium and medium-high irradiation levels and the second one with low, low-medium, medium-high irradiation levels. Every MPPT technique analysis starts when the initial steady state condition of each case is reached. A couple of samples of voltage and current is available every 10 ms and P&Oa, P&Ob, IC, CV, OV and SC algorithms can perform an iteration for each couple of values. The CV technique is optimized for a single radiance value; the performance of this technique is strongly related with the voltage set point. It provides satisfying results, but they are not as good as the ones provided by P&O and IC techniques.

5. CONCLUSION:

This work Analysis has presented a comparison among some of the more diffused Maximum Power Point Tracking techniques in relation to their energy performance. The results show that the best MPPT technique is the modified P&O (P&Ob).The logic turned out to be effective in both the situations here considered, providing always the highest efficiency. The IC technique has efficiency lower than the P&O techniques, but its response time is quite independent to the irradiation values and its efficiency increase with the irradiance level. This technique can be a good alternative to the P&O techniques in applications characterized by high, fast and continuous radiance variations. Furthermore, the fastest MPPT seems to be the P&Ob, due to variable perturbing value. As all the other MPPT algorithms have been tested using a coefficient K of about 0.01, the improvement of the variable perturbing value of the P&Ob is clearly discernible. Finally, among the compared MPPT Method, Perturb & Observe Method seems the most use. Indeed, the P&Ob is the fastest and stable, due to his variable perturbing value.

6. REFRENCES:

[1] 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 net-work,” IEEE Trans. Energy Conv., Vol. 21, pp. 793–803, 2006.

[2] B.R.Sanjeeva Reddy, P.BadariNarayana, et al., “MPPT Algorithm Implementation for Solar Photovoltaic module using Microcontroller”.

[3] K.H. Hussein, I. Muta, T. Hoshino and M. Osakada, “Maximum photovoltaic power tracking:an algorithm for rapidly changing atmospheric conditions,”IEEEploc.-Gener. Transmission and Distribution, Vol. 142, No. 1 , Jan. 1955.

[4] C.Thulasiyammal and S Sutha, “An Efficient Method of MPPT Tracking System of a Solar Powered Uninterruptible Power Supply Application,” 1st International Conference on Electrical Energy Systems, 2011.

[5] NoppadolKhaehintung and PhaophakSirisuk, “Application of Maximum Power Point Tracker with Self-organizing Fuzzy Logic Controller for Solar-powered Traffic Lights,” IEEE, 2007.

[6] C. S. Chin, P. Neelakantan, et al., “Fuzzy Logic Based MPPT for Photovoltaic Modules Influenced by Solar Irradiation and Cell Temperature,” UKSim 13th International Conference on Modelling and Simulation, 2011.

[7] PanomPetchjatuporn, PhaophakSirisuk, et al., “A Solar-powered Battery Charger with Neural Network Maximum Power Point Tracking Implemented on a Low-Cost PIC-microcontroller”.

[8] S. Yuvarajan and JulineShoeb, “A Fast and Accurate Maximum Power Point Tracker for PV Systems,” IEEE, 2008.

[9] Prof.Dr.IlhamiColak, Dr.ErsanKabalci and Prof.Dr.GungorBal, “Parallel DC-AC Conversion System Based on Separate Solar Farms with MPPT Control,” 8th International Conference on Power Electronics - ECCE Asia, The ShillaJeju, Korea, May 30-June 3, 2011.

[10] S. G. Tesfahunegn, O. Ulleberg, et al., “A simplified battery charge controller for safety and increased utilization in standalone PV applications,” IEEE, 2011.

[11] Yuncong Jiang, Ahmed Hassan, EmadAbdelkarem and Mohamed Orabi, “Load Current Based Analog MPPT Controller for PV Solar Systems,” IEEE, 2012.

[12] ArashShafiei, AhmadrezaMomeni and Sheldon S. Williamson, “A Novel Photovoltaic Maximum Power Point Tracker for Battery Charging Applications,” IEEE, 2012.