Case Study Of Maximum Power Point Tracking Techniques For Photovoltaic Systems

[1]K. Kranthi Kumar, [2]Avula Shiva Kumar

[1]M.Tech (Control Systems), [2]M.Tech (Electrical Power Engineering),

[1,2]Assistant Professor, Department of Electrical and Electronics Engineering, Kommuri Pratap Reddy Institute of Technology, Ghanpur(V), Telangana, India.

***Abstract*—This paper presents a comparative study among maximum power point tracking methods for photovoltaic systems. In special, an extensive bibliography and a classification of many maximum power point tracking methods is presented. Computational simulations with fast changes in the solar irradiance have been done and the best maximum power point tracking technique is chosen. Experimental results corresponding to the operation of a photovoltaic converter controlled by a digital signal processor are also presented.**

Keywords - Energy conversion, Photovoltaic power systems, solar energy, tracking.

I. INTRODUCTION

Nowadays, the requirement in generating electric energy has lead to an intensive research of alternative ways of generation. One of the possible ways of electric energy generation is the Photovoltaic (PV) energy. PV energy has great potential to supply energy, since it can be considered a clean and pollution free source while the PV panels are generating energy. The main drawbacks are associated with the impact on the environment because of the high energy used during the panel's fabrication process and the lifetime of the panels that is between 20 and 30 years. Other drawbacks are the initial installation cost and the energy conversion efficiency.

To overcome some of these problems, it is important to operate the photovoltaic system near the Maximum Power Point (MPP) to increase the efficiency of photovoltaic arrays. If Maximum Power Point Tracking (MPPT) techniques are used in PV systems, it can be generated more power with the same number of modules. These techniques allow the module generate its maximum power, having a high level of utilization of its generation capability. However, to improve the energy captation it is necessary to have a converter between the PV panels and the load or grid. This converter will have a limited and variable efficiency in according to the load conditions and the solar irradiance. Therefore the global efficiency (including PV array and converter efficiencies) is a better parameter for the whole system, but it would be necessary to compare the losses produced by the converter switches. The purpose of this paper is to compare the algorithms of maximum power point tracking and the converter efficiencies are not considered Various methods of MPPT have been considered in PV systems. The methods may be classified as: off-line techniques [1][2][3]. The off-line techniques require a PV array model and the measurement of temperature and solar irradiance. The on-line techniques do not require the measurement of temperature and solar irradiance. In addition, they do not need the PV array model. Among the most desirable features in MPPT techniques are the following [6][7]:

-Stability
-Fast dynamic response
-Small steady state error
-Robustness to disturbances-
- Efficiency in a large power range.

The on-line techniques have been shown as more efficient than the off-line techniques in terms of desirable features in MPPT methods. The on-line techniques may be classified as:
Constant Voltage (CV), Perturbation and Observation (PO), and Incremental Conductance (IncCond). Some variations of these methods have been also presented in literature. In [8], it was shown that the MPP voltage of a PV array is close to a fixed percentage of the array's open circuit voltage. In the MPPT technique, the converter is disconnected and the open circuit voltage is measured at regular sampling rates [9] [10]. The energy wasted by the sampling of the open circuit voltage is considered negligible in [11]. This method was defined as Constant Voltage (CV) technique in [9] and it has been used in some PV systems [10]. The PO method is often used in many PV systems PO techniques operate by perturbing the reference value with specific sampling rates. These techniques present slow dynamic response and steady state error. A choice of high values of perturbation provides a fast tracking for the MPP voltage, but it has large oscillations. If the perturbation has a low value, the MPPT will be slower, but it will have small oscillations around the MPP. In addition, with fast

 DOI : 10.18231/2454-9150.2017.0036

ISSN : 2454-9150 Vol-03, Issue-08, Nov 2017

changes of irradiance and temperature, the PO technique can track a wrong point. In, it was proposed an implementation of a PO method that instantaneous values of current and voltage are used to determine the direction of the next perturbation. This solution reduces the problems related to the PO techniques. A popular variation of the PO method is based on the relationship of the PV array output power and the switching duty cycle. This method is defined as the Hill Climbing (HC) technique in . When it happens a fast variation in the environment conditions, it can be tracked a wrong voltage point instead of a point that means the MPP, creating an error in the algorithm. In other words, the algorithm will try to lead the array voltage to the MPP voltage of the curve corresponding to the previous solar irradiance. This problem can be also caused by a wrong choice of the sampling rate. A solution can be the best adjustment of the sampling rate and the best adjustment of the perturbation (increment or decrement) in relation to the sampling rate , both in accordance with the dynamics of the converter. A Modified Adaptive Hill Climbing (MAHC) technique has automatic parameter tuning to satisfy the requirements of fast dynamic response and small steady state error. The Incremental Conductance (IncCond) technique is widely used in PV systems. The voltage of the MPP is tracked to satisfy dP/dV=0 . The parasitic capacitance method uses the capacitances of the PV array to improve the IncCond technique. A method which improves the IncCond technique by inserting a test signal in control input was proposed in. In it was proposed a technique that determines the MPP of a PV array for any temperature and solar irradiance using a tolerable power error. At each sample, the difference between the reference value and operating power of the PV array is calculated and compared with the assumed MPP error. A MPPT control scheme for PV array based on a principle of power equilibrium at dc link is proposed in. The proposed scheme does not need detection or calculation of the power. A two-mode MPPT control method combining the CV and IncCond techniques was proposed to improve efficiency of the PV power generation systems at different irradiance conditions. A method of locating the MPP based on injecting a small sinusoidal perturbation into the switching frequency and comparing the ac component and the average of the array terminal voltage was proposed in. A MPPT method in combination with one-cycle control for PV power generation was proposed in. it was used an algorithm with two stages of operation. In the first stage, variable large steps allow fast tracking when the PV voltage is far from the MPP voltage. Around the MPP voltage, any technique using fixed step can be used to track the MPP. Due to the vast number of MPPT techniques with sometimes contradictory performance claims, their comprehensive study still seems to be appropriate. The algorithms have been verified on a PV system modeled in Matlab. Many simulations results are presented and the characteristics determined in this study are summarized in comparative tables.

II. CONSTANT VOLTAGE

The MPP voltage (*VMPP*) of a PV array is close to a fixed percentage of the PV array's open circuit voltage (*VOC*). The relation *VMPP* =*VOC* is usually around 76% [8]. Initially, *VOC* is measured by setting the PV array current to be zero. In this way, the *VMPP* is adjusted for 76% of *VOC*. This value of *VMPP* is kept for a period of time until another sample occurs. The MPPT technique samples *VOC* at regular.

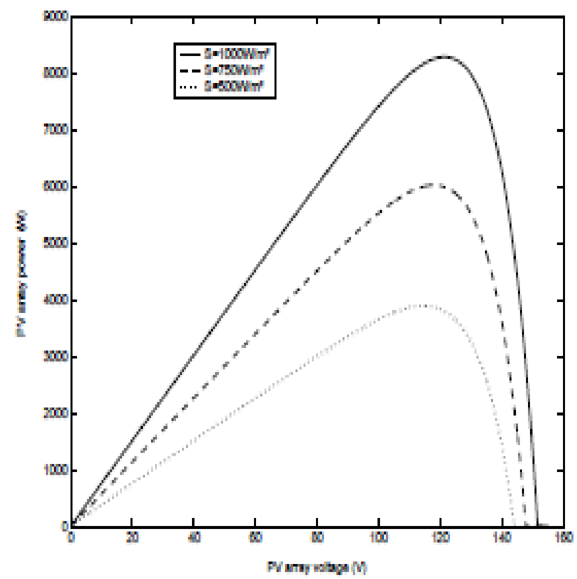


Fig. 2. Characteristic diagram of the PV array.

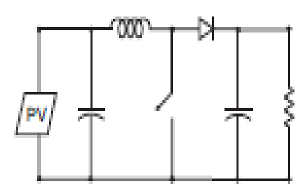


Fig. 1. Stand alone PV system using a boost converter

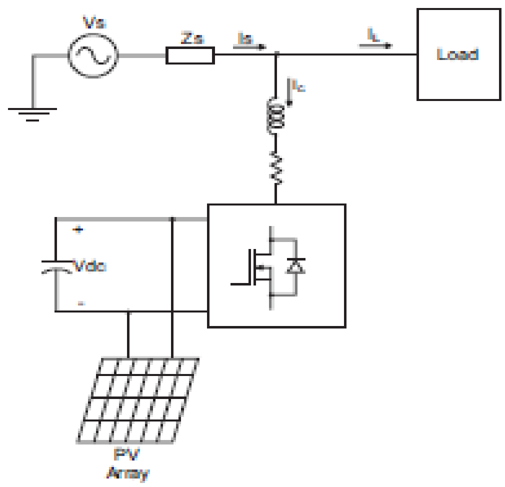
Fig. 1. Stand alone PV system using a boost converter. samples [10] and the energy wasted by the sampling of *VOC* is considered negligible in. However, this consideration should be evaluated. Another problem of this technique is that the MPP is not always located at 76% of the *VOC*, increasing the steady state error [9]. Two different sample rates are used to estimate the efficiency. Using a low constant sample rate, the reference for *VMPP* is changed more frequently allowing better tracking while the system is connected to the PV array. However, the energy wasted by the sampling of *VOC* will be more significant since the PV array current will go to zero many times.

DOI : 10.18231/2454-9150.2017.0036

ISSN : 2454-9150 Vol-03, Issue-08, Nov 2017

III. PERTURBATION AND OBSERVATION

The PO technique compares the power of the previous step with the power of the new step in such a way that



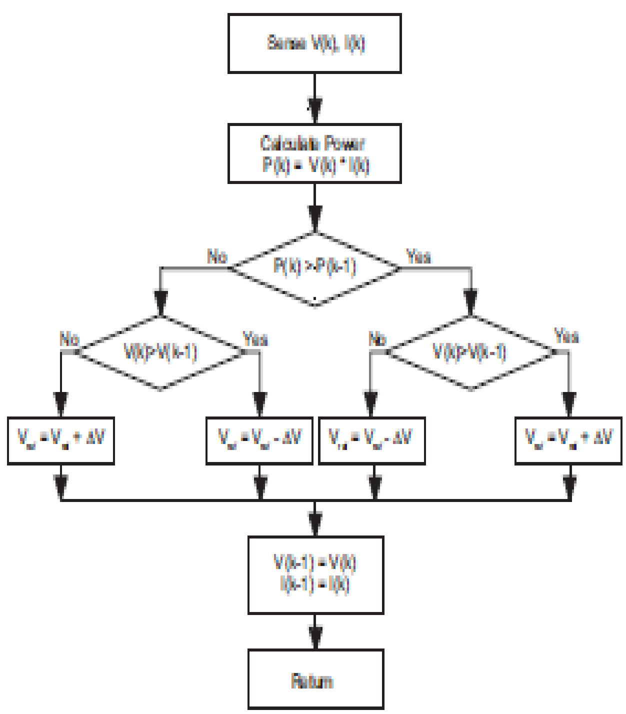


Fig. 2. The flowchart of the PO technique.

it can increase or decrease the voltage or current . This method changes the reference value by a constant factor of current or voltage. It moves the operating point toward the MPP by periodically increasing or decreasing the array voltage or current. The PO method works well when the irradiance does not vary quickly with time. However, with this method the power oscillates around the MPP in steady state operation and it is not good when there are fast variations of temperature and irradiance.

IV. HILL CLIMBING

The HC method is based on the relationship of the PV array power and switching duty cycle . The flowchart is shown in Fig. 1. Slope is a program variable with either 1 or -1, indicating the direction to increase the output power, while "a “represents the increment step of duty cycle, which is a constant number between 0 and 1, and D and P represent the duty cycle value for the switch in Fig. 3 and power level, respectively. With rapidly changing atmospheric conditions, the same problem of the PO can happen. The MAHC method includes automatic parameter tuning to have good dynamic.

V. CONCLUSION

Researchers continue to make an effort to control the photovoltaic array near to the maximum power point. This paper has classified the maximum power point tracking techniques in terms of the way that the reference variable is changed. Principles of operation and main features have been discussed for a better understanding of each possibility. Tables summarize the simulation results and the IncCond technique has presented the best results for the different situations tested in this paper. A comparative study on losses in the converter is under study to complete this scenario that is expected to aid the engineers in the preliminary stages of maximum power point tracking techniques selection and analysis.

REFERENCES

[1] B. K. Bose et al, Microcomputer control of a residential photovoltaic power conditioning system, *IEEE Trans. on Industry Applications*, vol. 21, no. 5, pp. 1182-1191, September 1985.

[2] J. Appelbaum, The operation of loads powered by separate sources or by a common source of solar cells, *IEEE Trans. on Energy Conversion*, vol. 4, no. 3, pp. 351-357, September 1989.

[3] J. Appelbaum and M. S. Sarma, The operation of permanent magnet DC motors powered by a common source of solar cells, *IEEE Trans. on Energy Conversion*, vol. 4, no. 4, pp. 635-642, December 1989.

[4] O. Wasynczuk, Dynamic behavior of a class of photovoltaic power systems, *IEEE Trans. on Power Apparatus and Systems*, vol. 102, no. 9, pp. 3031-3037, September 1983.

[5] F. Harashima et al, Microprocessor-controlled SIT inverter for solar energy system, *IEEE Trans. on Industrial Electronics*, vol. 34, no. 1, pp. 50-55, February 1987.

[6] W. Xiao and W. G. Dunford, A modified adaptive hill climbing MPPT method for photovoltaic power systems, *IEEE Power Electronics Specialists Conference*, pp. 1957- 1963, 2004.

 DOI : 10.18231/2454-9150.2017.0036

ISSN : 2454-9150 Vol-03, Issue-08, Nov 2017

[7] Y. C. Kuo, T. J. Liang, and J. F. Chen, Novel maximum power-point-tracking controller for photovoltaic energy conversion system, *IEEE Trans. on Industrial Electronics*, vol. 48, no. 3, pp. 594-601, June 2001.

[8] J. J. Schoeman and J. D. van Wyk, A simplified maximal power controller for terrestrial photovoltaic panel arrays, *IEEE Power Electronics Specialists Conference*, pp. 361- 367, 1982.

[9] D. P. Hohm and M. E. Ropp, Comparative study of maximum power point tracking algorithms using an experimental, programmable, maximum power point tracking test bed, *IEEE Photovoltaic Specialists Conference*, pp. 1699-1702, 2000.

[10] A. S. Kislovski, Power tracking methods in photovoltaic applications, *IEEE Power Conversion Proceedings*, pp. 513-528, 1993.

AUTHOR DETAILS :

K. KRANTHI KUMAR Received the B. Tech (Electrical and Electronics Engineering) degree from the Jawaharlal Nehru Technological University, Hyderabad at Princeton College of Engineering& Technology, Hyderabad. And M. Tech (Control Systems) from Jawaharlal Nehru Technological University, Hyderabad at St. Mary's College of Engineering & Technology Hyderabad. Currently he is an Assistant Professor in the Department of Electrical and Electronics Engineering at the Kommuri Pratap Reddy Institute of Technology, Ghanpur(V), Ghatkesar(M),Medchal Dist. His area of interest in the field of Power Systems, Renewable Energy Sources – Wind & Solar,Electrical Circuits and Control Systems.

AVULA SHIVA KUMAR Received the B. Tech (Electrical and Electronics Engineering) degree from the Jawaharlal Nehru Technological University, Hyderabad in 2012 At Aware Madhavanji college of Enginnering Bhagavathipuram and M. Tech (Electrical Power Engineering) from Jawaharlal Nehru Technological University, Hyderabad. at B.I.E.T. Currently he is an Assistant Professor in the Department of Electrical and Electronics Engineering at the Kommuri Pratap Reddy Institute of Technology, Ghanpur, Ghatkesar, and R. R. District. His area of interest in the field of power systems Renewable Sources - Wind, Solar PV, Bio-mass, Municipal Solid Waste, Wind / Solar PV / Bio - Mass/MSW/Fuel Cells and Electrical Machines.

 DOI : 10.18231/2454-9150.2017.0036