

LITERATURE SURVEY ON MPPT SCHEMES FOR STAND ALONE AND GRID CONNECTED PHOTOVOLTAIC SYSTEM

A. SharanMonika, and S.Stephy Sharon

Final year ME-PED, EEE, Saranathan College of Engineering, Panchapur, Tiruchirapalli
sharanm7@gmail.com, stephysharon92@gmail.com

Abstract—Solar energy which is trapped by Photo-voltaic (PV) array has witnessed a tremendous growth in the past decade. Along with this the need for energy efficient and reliable system has boosted the researchers to develop Maximum Power Point Tracking (MPPT) schemes for PV systems. The Energy Utilization Efficiency of a PV standalone system can be significantly improved by using MPPT controllers. But the problem arises with selecting the proper MPPT as each MPPT has its own merits and demerits. This paper presents a comprehensive review of major MPPT techniques used for standalone and grid connected systems.

Key Words —Maximum Power Point Tracking (MPPT), Perturb and Observe (PO), Incremental Conductance (INC), standalone PV systems.

1. INTRODUCTION

The main concern in the power sector is the day-to-day increasing power demand and the unavailability of enough resources to meet the power demand using the conventional energy sources. Demand has increased for renewable sources of energy to be utilized along with conventional systems to meet the energy demand. 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 and wherever necessary. In order to tackle the present energy crisis one has to develop an efficient method in which maximum power has to be extracted from the incoming solar radiation. The power conversion mechanisms have been greatly reduced in size in the past few years. The development in power electronics and renewable energy systems has helped engineers to come up with very small but powerful systems to withstand the high power demand. But the

disadvantage of these systems is the increased power density. The use of power optimization mechanisms called the Maximum Power Point Tracking (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.

In this paper a comprehensive review of major MPPT techniques used in the PV standalone system are presented. Section II explains the principle of standalone and grid connected PV system. Section III gives a brief explanation of Maximum power point tracking. Section IV gives a detailed review on various MPPT techniques used in the literature. Simulation of a PV standalone system with both the MPPT schemes and the results of simulation are presented in section V.

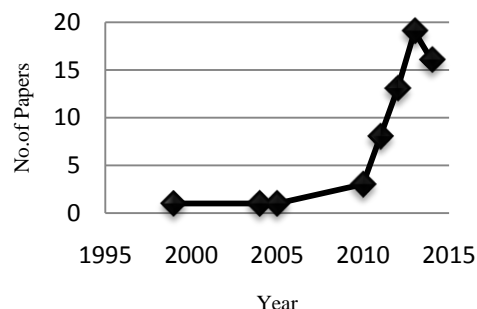


Fig.1. Graph on the Number of papers on Standalone PV systems versus Year of publication

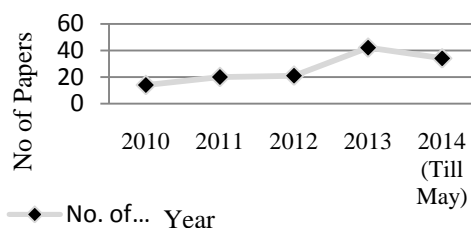


Fig.2. Graph on the Number of papers on grid connected PV systems versus year of publication

2. STANDALONE AND GRID CONNECTED PV SYSTEMS

A system feeding a load or connected to a load and which is not connected to the grid is called a Standalone or Isolated system. When a system is connected to the grid or if it feeds the grid then the

system is said to be grid connected. Standalone system requires a battery in some cases but with grid connected system battery is not needed as the deficit power could be obtained from the grid itself. Both standalone and grid connected photovoltaic systems use Maximum Power Point Tracking to obtain the maximum possible output power from the PV array. The basic schematic of PV standalone and grid connected system is shown in Fig.3

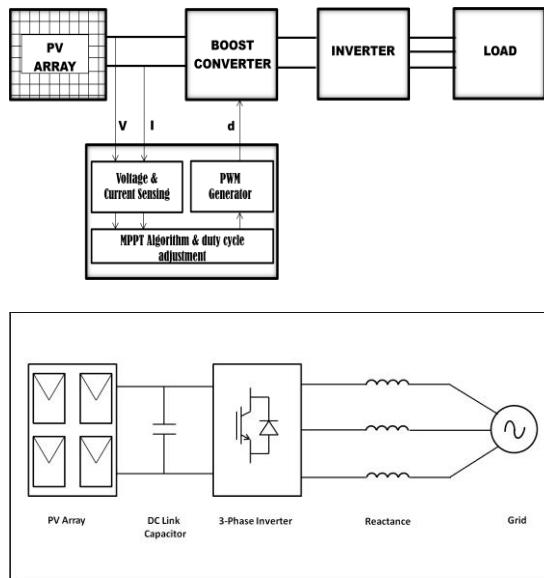


Fig.3. Block schematic of a PV standalone system and grid connected system

3. MAXIMUM POWER POINT TRACKING

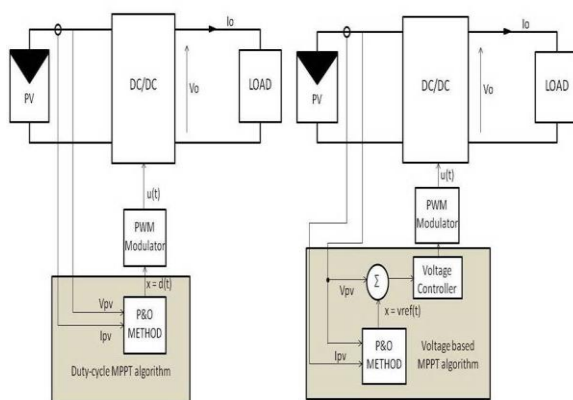


Fig. 4 Block schematic of a PV standalone system and grid connected systems

Maximum Power point tracking is a technique used to obtain the maximum possible power output from the PV source. MPPT can be used in both in standalone and grid connected systems. MPPT algorithm can be implemented using two different configurations- Duty cycle MPPT algorithm and Voltage based MPPT algorithm as shown in Fig.4

4. REVIEW OF MPPT TECHNIQUES

From the literature survey done it is observed from Fig.1 and Fig.2 that the research in PV system is greatly increasing in the past decade. Maximum Power Point Tracking of a PV array has become an essential part of any PV system. Various MPP tracking methods have been discussed, developed and implemented in the literature. The following different MPPT techniques were observed in the standalone PV and grid connected system as shown in Fig.3

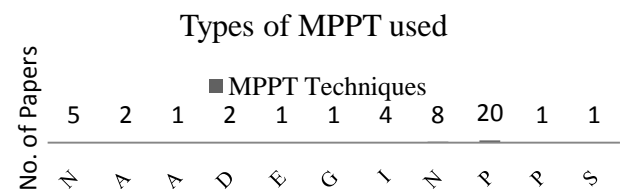
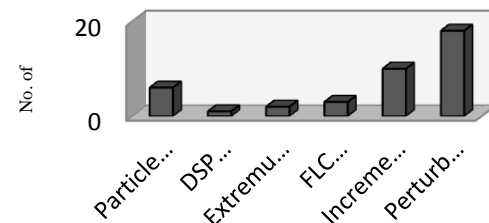


Fig.5. Graph on the Number of papers versus MPPT methods used in standalone and grid connected systems

Perturb and Observe(PO) algorithm- It is the most popular algorithm belonging to the class of the direct MPPT techniques. It is characterized by the injection of a small perturbation into the system and the resulting effects are used to drive the operating point toward the MPP. The PV operating point is perturbed periodically by changing the voltage at PV source terminals, and after each perturbation, the control algorithm compares the values of the power fed by the PV source before and after the perturbation. If after the perturbation the PV power has increased, this means that the operating point has been moved toward the MPP; consequently, the subsequent perturbation imposed to the voltage will have the same sign as the previous one as shown in Table I. If after a voltage perturbation the power drawn from the PV array decreases, this means that the operating point has been moved away from the MPP as shown in Fig.6.

Table 1. P&O APPROACH

Perturbation	Change in Power	Next Perturbation
Positive	Positive	Positive
Positive	Negative	Negative
Negative	Positive	Negative
Negative	Negative	Positive

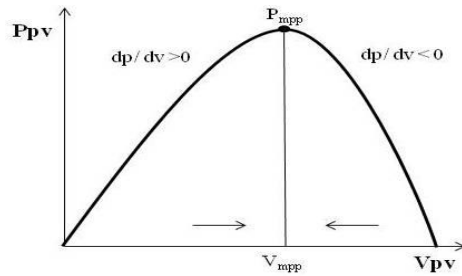


Fig.6. PV Curve

In recent times this method has been widely used to achieve the maximum amount of power from a solar panel. Huang *et al* proposed a modular self controlled photovoltaic (PV) charger with P&O MPPT. Usually in battery charging applications the P&O responds in a slower manner. Here the author has given a new idea of a fast MPPT method by narrowing the charging period [6].

Mohammed *et al* gives a complete assessment of P&O algorithm implementation techniques. A detailed assessment on the reference voltage perturbation and direct duty ratio perturbation is simulated, implemented, and analyzed and concludes with the advantage and disadvantages of both methods. The paper also describes the advantages of P&O that it is a simple algorithm and it is easy to implement. [2]Kun Ding *et al* proposed a complete MATLAB / Simulink based PV module with the P&O technique and have analyzed the results for both the conditions of uniform and non-uniform irradiance [3].

T.Esram and Patrick served with a convenient reference with the comparison on different MPPT techniques and it is mentioned that P&O technique is the most used MPPT control technique due to its simplicity and ease to implement. It is also given that the main drawback in P&O is the efficiency of the MPPT decreases under rapidly changing irradiance. [4]

Incremental Conductance MPPT-The basic idea of the Incremental Conductance algorithm is that, at the MPP, the derivative of the power with respect to the voltage or current becomes zero because the MPP is the maximum point of the power curve as shown in fig.6. Here the output characteristics of power and voltage are analyzed. We note that in the left side of the MPP the power increases with voltage, i.e. $dP / dV > 0$ and it decreases with voltage at the right side of the MPP, i.e. $dP / dV < 0$. The algorithm of INC starts its cycle by obtaining the present values of $I(k)$ and $V(k)$, then using the corresponding values stored at the end of the preceding cycle, $I(k-1)$ and $V(k-1)$, the incremental change is approximated as: $dI \approx I(k) - I(k-1)$, and $dV \approx V(k) - V(k-1)$. The main check is carried out by comparing dI / dV against $-I/V$, and according to the result of this check, the duty ratio will

be adjusted in order to move the array terminal voltage towards the MPP voltage.

Qianget *al* have proposed a modified variable step size Incremental conductance method. The INC method usually works under fixed iteration step size. In some of the literature variable step size INC is used. However the dynamics of MPPT is affected greatly due to when the irradiance changes quickly. In order to overcome this limitation this modified variable step size INC was proposed. [5]Mohammed *et al* compares INC with other hill climbing methods such as Perturb and observe (PO) and Constant Voltage MPPT method and concludes that INC is less confused by noise and it has got higher energy utilization efficiency. The limitation of INC is also mentioned that implementing it with analog circuits becomes complex and costly. [6]Kok and Saad proposed a modified IncCond algorithm based on multifaceted duty cycle control method which utilizes the PV curve under partial shaded conditions effectively and the tracking speed is also increased than the conventional INC method [7].

Particle Swarm Optimization-In case of shaded PV system the PV curve possess multiple peaks and convergence to MPP becomes essential. In order to overcome this many biologically inspired optimization methods were implemented. One such optimization method is called Particle Swarm Optimization where the individual module voltage is determined. Mohammed *et al* have used this algorithm for switching power converters which used multi-junction solar cells. Thus only a single PSO based controller has been used thereby reducing the cost and complexity. [2]K. L. Lianet *al* proposed a hybrid model of Perturb & Observe (PO) and PSO method. The PO method was used to initially identify the nearest local maximum then the PSO method is followed. The advantage of this hybrid method is the search space is reduced with very fast MPP tracking [8].

Fuzzy Logic based MPPT method-This method comes under the Artificial Neural Network (ANN) type of MPPT as classified by Bidyadhar and Brassware. [13] Ahmad and Rached have proposed a new DSP controlled dual-MPPT scheme based on fuzzy logic control (FLC). The first MPPT controller is an astronomical two-axis sun tracker that keeps maximum radiation on the panel throughout the day. The second controller implements a new fuzzy-based MPPT technique to adaptively change the P&O perturbation step size depending on the PV system operating point and the current step size. The proposed control scheme achieves stable operation in the entire region of the PV panel and eliminates therefore the resulting oscillations around the maximum power operating point [14].

Extremum Seeking control MPPT method- In order to deal with the varying shading conditions Peng *et al* proposed a sequential Extremum Seeking Control(ESC).This method deals with segmental search of MPP with consistent definition of searching range in order to achieve better computational efficiency. In this method the accumulative variation of in determining the initial search voltage is avoided [10].

Xiao *et al* classifies the MPPT methods as static and dynamic where the Extremum Seeking Control comes under dynamic category of MPPT and these are the methods which improve the transient performance. They have also brought some stability and performance issues of the normal ESC MPPT methods. In order to overcome such limitations they have proposed an Adaptive Extremum Seeking Control (AESC) which has some modifications in the previous ESC method [12].

DSP based MPPT method-In the research of MummadiVeerachary a voltage-based power tracking for nonlinear PV sources using coupled inductor SEPIC converter was proposed and demonstrated. Here a DSP based MPPT with a separate mathematical algorithm is explained.The main advantage of this method is the reduced ripple in the array current and the converter efficiency has improved. [11]

5. CONCLUSION

The review and analysis of various MPPT technique used in the literature for both standalone and grid connected systems has been discussed. The advantages and disadvantages for each MPPT method can be understood from the survey. From this paper appropriate MPPT method can be selected and implemented as per the requirement.

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