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COMPARATIVE ANALYSIS ON PERFORMANCE OF POWER CONVERTERSFOR MPPT USING PAO TECHNIQUE

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ABSTRACT

This research work is mainly spotlight to identify a suitable power converter for tracking the Maximum Power Point, an analysis of MPPT based power converters has been carried out in this work. A PV system is a non-linear power source due to the variations in the climatic conditions, hence tracking the maximum power point is difficult. It mainly explains about the PAO algorithm based MPPT method to track the maximum power. It also discuss about different types of conventional power converters such as SEPIC, ZETA and B3 based on MPPT with PAO technique. The simulation results of various converters with PAO technique are compared and the result proves the need of a suitable power converter to be identified for tracking the MPP

KEYWORDS: Maximum Power point Tracking (MPPT),PV System, performance analysis, Power conversion, PAO Method (Perturb And Observation), Tracking of MPP.

I. INTRODUCTION

To identify a suitable power converter for tracking the MPP, an analysis of MPPT based power converters has been carried out in this chapter. Nowadays the PV systems are in advance of improved significance as a renewable resource due to its advantages like no fuel cost, less maintenance and absence of noise and moving parts etc. Still, there are some basic difficulties to use the photovoltaic systems such as the cost of installation is high, the energy conversion and tracking efficiency is low owing to its conversion stages [11].A PV system is a non-linear power source due to the variations in the climatic conditions, hence tracking the maximum power point is difficult, and it leads to a property of nonlinear. The output current and voltage of a PV system is mainly depending on the maximum power operating point [12].

This paper mainly discuss about the characteristics and mathematical analysis of solar PV system [8]. It mainly explains about the PAO algorithm based MPPT method to track the maximum power. It also discuss about different types of conventional power converters such as SEPIC, ZETA and B3 based on MPPT with PAO technique. Finally a requirement of suitable converter is identified in order to harvest the maximum power from the solar panel [13].The simulation results of various converters with PAO technique are compared and the result proves the requirement of a suitable converter to be identified for tracking the MPP and also suitable for PV powered backup systems.

II. CHARACTERISTICS OF SOLAR PV SYSTEM

A solar PV module consists of number of solar cells and each cell is fabricated in a thin layer of semiconductor material. The electron of semiconductor material can be placed in either the conduction band or in valence band. The electrons obtain adequate energy in order to move from the valence band to the conduction band, when the semiconductor is knockout by sunlight and they move freely hence forming electricity [4]. Most of the solar cells are fixed in order to decrease the energy which is required for the electron to travel from conduction band to valence band.

The efficiency of a solar cell is determined by the volume of energy received from the sunlight and this energy is called as photon. The nature of the photon is it can be reproduced, enthralled or it can pass through a semiconductor material. Since the photons donate electrical energy when they are passing through the semiconductor material and they must be reduced. Hence an anti-reflective coating is normally applied on the surface of solar cell.The output and efficiency of a solar cell is disturbed by some of the following peripheral factors such as the ambient climate conditions like temperature, lighting, and sheltering, etc. The main purpose is to plan a system which can harvest maximum amount of power from the sunlight [10].Irradiance is one of the important characteristic of solar PV and it is related to the amount of sun energy which is observed by the ground and it can be measured as 1000 W/m. The I-V characteristic of a solar cell is shown in the Figure 1.

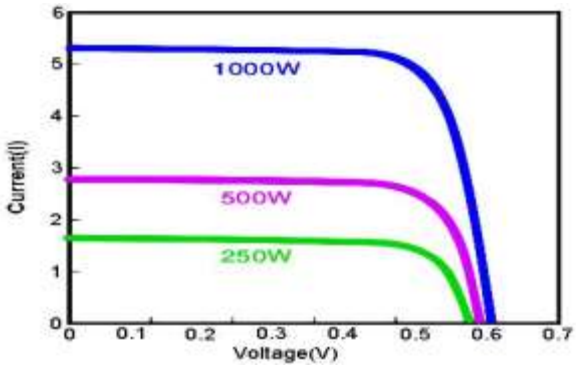

Figure 1. I-V Characteristic of a Solar Cell at Various Irradiation Level

In a solar PV array, it is more important that the impedance of load and source impedance are properly matched. When the solar cells are coordinated by their I-V characteristics, then they can be arranged into separate arrays and each array is ready to work at a point of its maximum energy transfer. The PV Characteristics of a solar panel and to select the position of MPP is shown in Figure .2. It is observed that the maximum power point for the proposed system is obtained, where the maximum value of solar PV voltage and PV current are intersecting (I_{max}= 4.1A and V_{max}= 35 V).

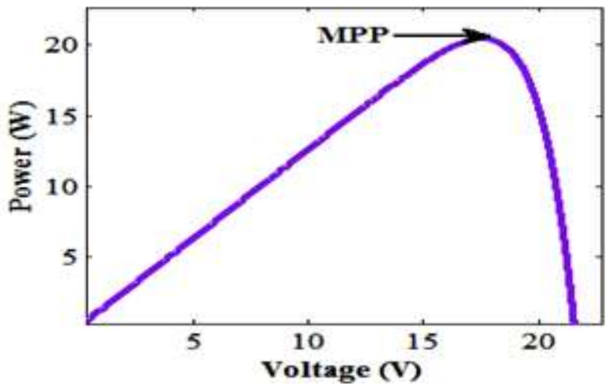

Figure 2. PV Characteristics of a Solar Panel

III. METHODS OF MPPT FOR PV ARRAY

The efficiency of the solar panel is mainly determined by the efficiency of energy conversion and also the other conditions which influence the efficiency are such as weather, the level of irradiation and temperature. The operating point of the system will be at the intersection of the I–V curves of the load and the solar panel, when a PV array is directly connected to a load [5,10].

The MPPT is implemented in order to acquire the maximum power from a PV array and the position of the MPP is not known well in advance. So it can be calculated using a PV array model, amount of irradiance and array temperature and the MPPT must constantly hunt for the MPP of the solar PV array. The Figure 3 indicates the general system block diagram which consists of solar panel, MPPT circuit, DC-DC converter and also the load. The solar panel voltage and current are taken as inputs to the MPPT circuit where it compares with a reference voltage. The duty cycle is the output of MPPT circuit and it is fed to the DC-DC converter in order to vary the converter voltage.

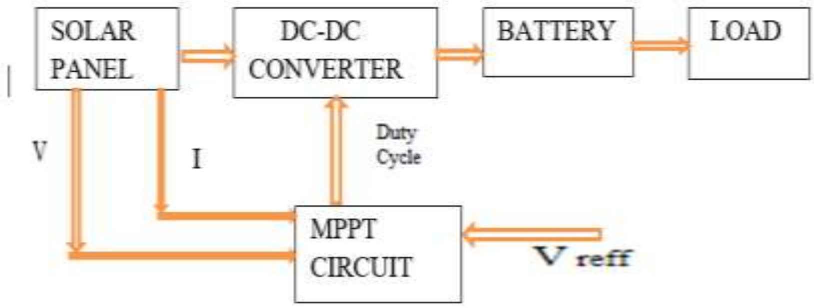

Figure 3 .Block Diagram of Solar Panel with MPPT Circuit

To follow the maximum power from solar PV array, many algorithms have been proposed and some important methods for tracking MPP are given as, [6,13].

- Fuzzy logic control,
- Hill climbing / Perturb And Observe (PAO),
- Neural network,
- Incremental Conductance (Inc Cond),
- Fractional short-circuit current,
- Fractional open-circuit voltage,
- Ripple Correlation Control (RCC) etc.

Out of these, the Perturb And Observe method was used by the proposed converter to track the MPP in its control strategy.

IV. IMPLEMENTATION OF PERTURB AND OBSERVE (PAO) METHOD

In this method there is a perturbation in the duty ratio of the proposed B4 converter and PAO includes a perturbation in the PV array operating voltage [7]. If a PV array is connected to a power converter, then the duty ratio of power converter is perturb also the current of PV array and subsequently perturbs the voltage of PV array.An increase or decrease in the voltage increases or decreases the power while working on the left of the MPP and the power is decreased or increased while operating on the right side of the MPP. Hence if power is increased the consequent perturbation must be kept at the same value in order to achieve the MPP and suppose if the power is decreased then the perturbation must be inverted [8,12].The sign of dP/dv at various positions of the Voltage/ Current characteristics of a PV module is indicated in Figure 4.

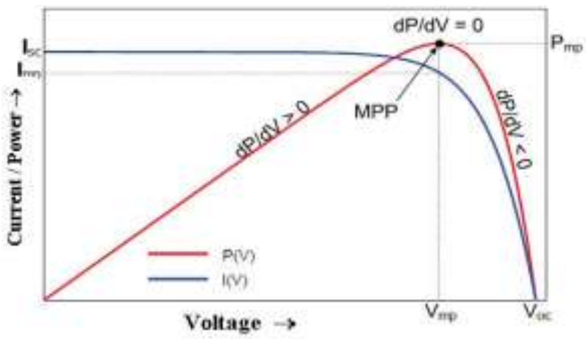

Figure 4 Sign Indication of dP/dV at Various Positions

This process is repetitive till the MPP is grasped. Then the system is starts oscillating around the MPP. The summary of PAO algorithm is listed in the Table 1. From the table it is observed that, when perturbation is made positive then change in power is also positive then the next perturbation is also positive.

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Table 1. Summary of PAO Algorithm

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

While implementing the PAO algorithm a small perturbation of $\Delta D = 0.01$ is introduced in the system. Then the power of the solar module is also changed due to the perturbation . If the power increases due to perturbation, then the perturbation is continued in the D+ΔD direction till the peak power is attained whereas if the power at the next instance is decreased then the perturbation is continued in the direction of D-ΔD. The SIMULINK model for PAO algorithm is developed based on the flow chart and it is shown in the Figure 5.

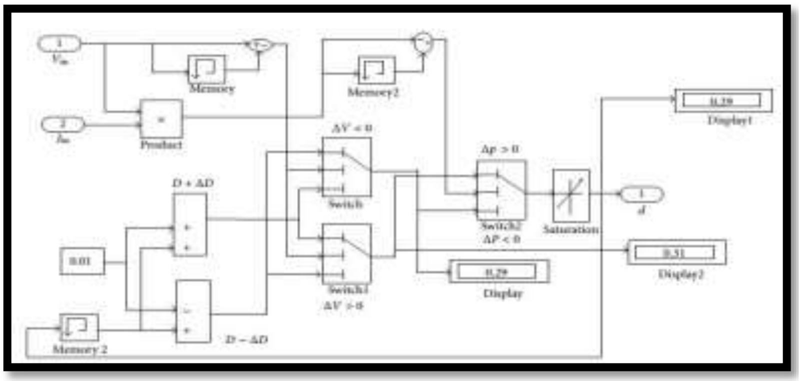

Figure 5. Simulink Model for PAO MPPT Algorithm

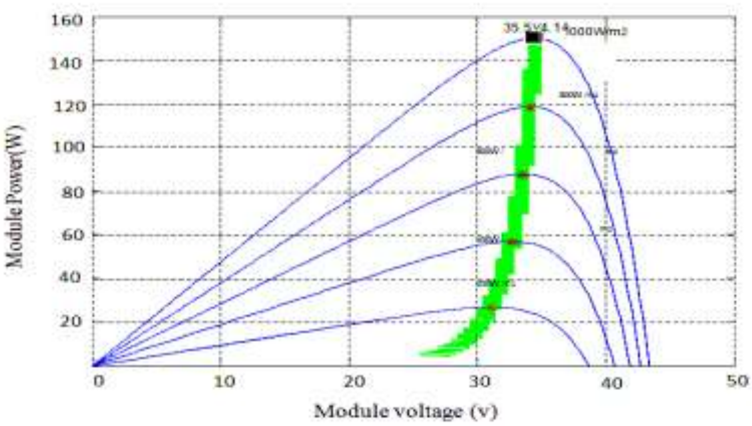

Figure 6 PAO Algorithm based P-V curves at various irradiance levels

V. NEED FOR THE IDENTIFIED CONVERTER

The various power converters used in solar PV system for MPPT with PAO algorithm are analysed, in the aspect of their maximum tracking power and efficiency [15]. A comparative analysis was made between various conventional converters such as SEPIC, ZETA and B3 converter for tracking the maximum power and the parameters are listed in Table 2.

From the Table 2. it is observed that the suitability of various conventional converters for MPPT with PAO technique. Their comparative analysis indicates all the conventional converters have a tracking efficiency of around 97% with equal tracking time of 0.9011 hours. Also the comparison results prove the requirement of a

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suitable power converter with superior tracking efficiency and better tracking time to be identified and which is fit for solar PV powered backup systems.

Table 2. Comparative Analysis of Various Converters for MPPT with PAO Technique

Parameters	SEPIC	ZETA Converter	B3 Converter
Maximum Power (Pmax) (W)	135.96	135.55	136.37
Maximum Voltage (Vmp) (V)	34.6	34.5	34.7
Maximum Current (Imp) (A)	4.2	4.2	4.2
Tracking Energy (Wh)	1585.75	1581.014	1590.48
Theoretical Energy (Wh)	1631.23	1631.23	1631.23
Tracking Efficiency (%)	97.37	97.09	97.64
Tracking Time of MPP (hours)	0.9011	0.9011	0.9011
Tracking Time of MPP(min)	54	54	54

VI. CONCLUSION

In this paper**, a** brief study of MPPT method with PAO algorithm used for harvesting a maximum power from solar array was discussed. This chapter also described the detailed analysis of power converters such as SEPIC, ZETA and B3 converters used for MPPT with PAO technique. Their simulation results are compared in terms of tracking energy and tracking efficiency. Finally, a requirement of suitable converter with improved tracking efficiency was identified which is very much appropriate for MPPT.

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