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Review on Comparison of Various Maximum Power Point Tracking Algorithms

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Abstract: Tracking the maximum power operating point (MPPT) is emphasized most heavily during the designing of an efficient PV system. When considering the field of power optimization in case of photovoltaic cells, a lot many number of maximum power points tracking techniques may exist. Some of these techniques include: the perturb and observe (P&O) one, the algorithms based on fuzzy logic and the ones using a neural network approaches. P&O is one of the most widely used MPPT control techniques due to its simple implementation. However, the lack of accuracy of this technique due to oscillations/perturbations around the maximum power poses as a major drawback. Hence, in this paper we propose an original optimization of the P&O MPPT control technique leading to a significant reduction of the oscillations around the MPP.
Keywords: MPPT, P&O, Optimization, PV panel, perturbation

I. INTRODUCTION

In the present world where new developments and inventions of technologies is taking place, there has been a significant increase the use of renewable energies due to fast depletion of exhaustible sources of energy like fossil fuels, coal, timber etc. Among the renewable sources, the solar one is becoming increasingly adopted due to the decrease of the fossil energies, and to their adverse environmental impact. In effect renewable energies are known as "clean" and favourable to the environment. However extraction of power through solar sources is an expensive method due to number of advanced hardware and technology used. So it is necessary to extract the maximum power for greater efficiency. One of the existing solutions to improve the solar energy use consists of exploiting the photovoltaic panels at an optimal rate.

Power generated by solar cells can face losses. These losses can be due to various environmental conditions like decreased irradiance levels, adverse weather conditions from cloudy or rainy days, temperature changes etc. At times the MPPT method which is adopted for power regulation can cause energy losses in the solar cells [1]. Fine tuning is required for all solar designs so as to produce maximum output power throughout a period of time. In the recent times most solar panel designs use maximum power point tracking for maximum power generation regardless of the weather condition limitations and their effects on solar modules. A lot many different algorithm methods that are available can be applied for MPPT. These methods of MPPT implementation can be distinguished based on factors such as complexity of implementation, , number of sensors required, cost etc. [1]. The most familiar method is perturb and observe (P&O) [3-5].

Maximum power point tracking (MPPT) is a technique used with wind turbines and photovoltaic (PV) solar systems to maximize power output. With the help of analysis on the I-V curve of the solar cell output it is found that solar cells have a complex relationship between temperature and total resistance that produces a non-linear output efficiency. Hence, the role of an MPPT system is to sample the output of the PV cells at certain fixed points and apply the proper resistance (load) to obtain maximum power for any given environmental conditions. MPP (Maximum power point) is the product of the MPP voltage (V_{mpp}) and MPP current (I_{mpp}).

II. MAXIMUM POWER POINT TRACKING

The working of Maximum power point tracking is based on the Maximum power transfer theorem. The main usage of MPPT algorithm lies in maximizing the efficiency of energy conversion. Referring to Fig.1, the MPPT algorithm tracks the voltage where the power is maximum. The maximum power is traced after a few seconds of time delay. The I-V and P-V curves that define the solar PV panel characteristics, pose a nonlinear relationship with temperature and irradiance. The MPPT techniques are incorporated in PV systems so as to ensure maximum power harvest from the solar panels. Yet, on the characteristic curve of the solar panel, a unique point is present where the whole system works with maximum efficiency. This point is referred to maximum power point MPP as shown in fig.1. This point needs to be calculated, traced

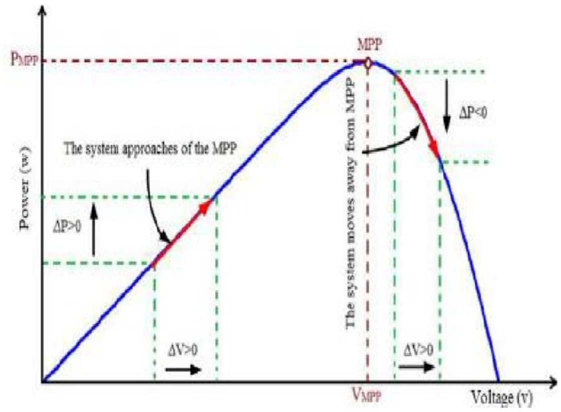

Fig.1. Maximum Point on P-V curve

and applied with control techniques in order to ensure that the PV system is sustained at this unique point so that maximum power for various applications can be harvested. referring to the entire model of the solar PV system in fig.2, MPPT is used for sustaining the system at maximum power, obtaining this power from the solar PV module and then coupling that power to the load [6, 7]. A DC-DC converter acts as an interface between the load and the module. It is used to fulfil the need of transferring maximum power from PV module to the load.

III. MPPT TECHNIQUES

A. Constant voltage technique

The constant voltage (CV) technique is the simplest MPPT method which has a quick response.

Constant voltage method was applied on the MPPT

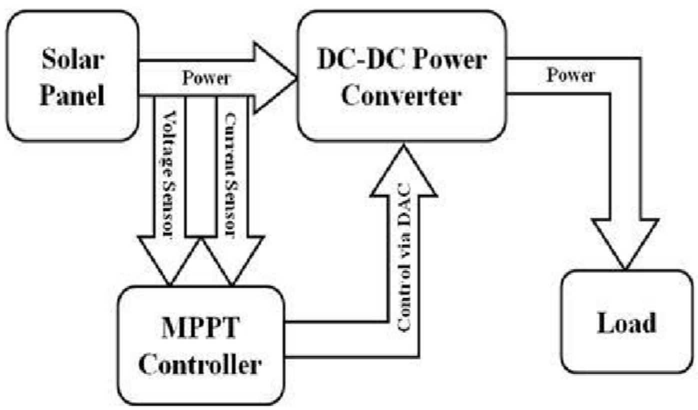

Fig.2. DC-DC converter for operation at MPP

algorithm to produce maximum power of PV system. CV method was used to determine the output voltage of PV system on the maximum condition. Thus, it was expected that system produced the maximum output power. V_{mpp} value is a result of multiplication of the characteristics value of solar module with an open-circuit module voltage [8], as shown in the Eq. (1),

$$V\,mpp = kVoc \qquad (1)$$

Where:

V_{mpp}= maximum power voltage (V) k = characteristic module PV

Voc = open-circuit voltage (V)

This method requires a PI controller to vary the duty cycle of the converter in order to maintain the PV voltage near the MPP. In this method, the controller regulates the PV module voltage and operates it close to its MPP, by matching the PV module output voltage to a constant reference voltage (V_{ref}). The value of V_{ref} is equal to the measured PV module maximum output voltage at standard test conditions (STC) or set to a fixed calculated value. For the CV method therefore, the operating point is never exactly at the MPP [1].

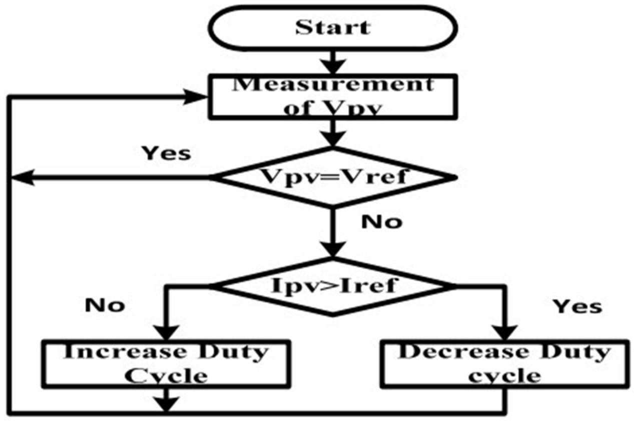

Fig.3. Control voltage method Flowchart

B. Open Voltage Technique

The Open Voltage (OV) method depends on the perception that the voltage of the maximum power point V is constantly near a fixed percentage of the open-circuit voltage V_{oc}. Temperature and sunlight based insolation levels change the situation of the maximum power point within a 2% tolerance band. This system utilizes 76% of V_{oc} value as estimation of the working voltage V (at which the greatest yield power can be obtained) [9]. By and large, this value is near V_{MPP} of the solar array. The OV control calculation requires estimations of the voltage V when the circuit is opened. Here again it is important to bring a static switch into the PV framework; for the OV technique, the switch must be utilized to open the circuit. At the point when V_{oc} = 0V, no power is provided by the PV framework and subsequently no energy is created. Additionally in this strategy estimation of the PV array voltage V_{pv} is required for the controller [10].

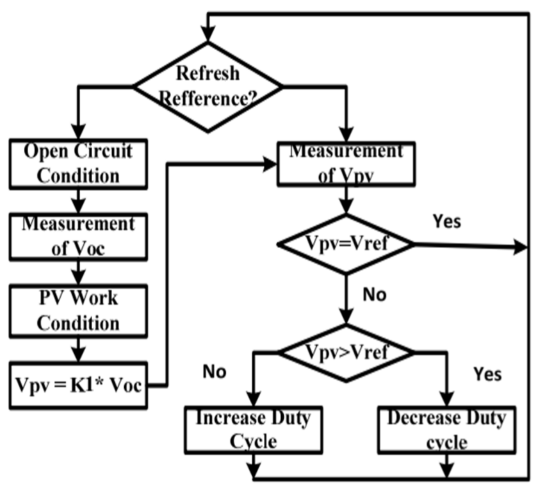

Fig.4. Open Voltage method Flowchart

C. *Perturb and Observe (P&O)*

The P&O method is the most ordinarily utilized MPPT technique. The algorithm uses a simple feedback technique. This method is based on investigating the relationship between PV module output power and its voltage. When the PV module operating point is on the left of the P-V curve (dP is positive), which means the PV module output power increases, then the perturbation of the PV module voltage will continue in the same direction towards the MPP (Fig.1.). If the operating point of the module was on the right side of the PV curve then the controller would move the PV module operating point back searching for the true MPP. This can be achieved by reversing the perturbation direction. This procedure is proceeded until the MPP is reached and it oscillates around MPP [11].

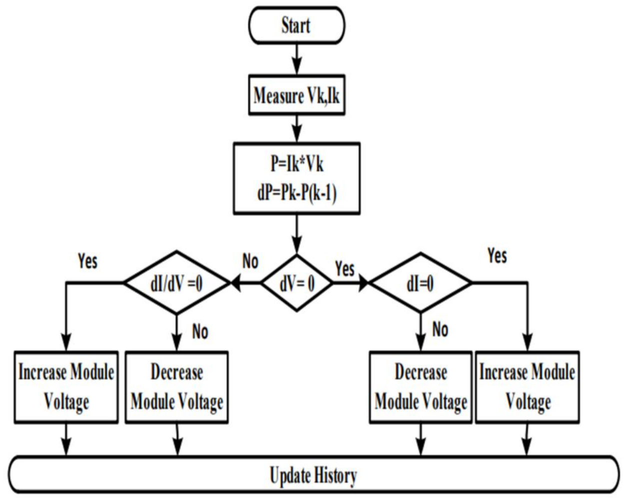

Fig.5. Flowchart for P&O technique

$dI/dV = -I/$At MPP (3)

$dI/dV > -I/$Left of MPP (4)

$dI/dV < -I/V$ Right of MPP (5)

Where I and V are P-V array output current and voltage respectively. The left hand side of equations represents incremental conductance of P-V module and the right hand side represents the instantaneous conductance. When the ratio of change in output conductance is equal to the negative output conductance, the solar array will operate at the maximum power point.

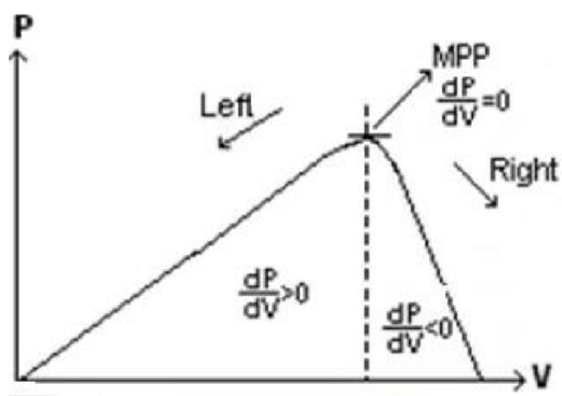

Fig.5. Incremental Conductance method on P-V curve

In the IncCond method only two sensors (the voltage and current sensors) are required in order to measure the PV module output current and voltage, assuming there is only one point on the P-V characteristic in which the PV module can produce its MPP. This is to say that by comparing the conductance at each sampling time, the algorithm will track the maximum power of the solar cell [13][14].

IV. CONCLUSION

A variation of the classic maximum power point tracking perturb & observe method for photovoltaic power systems has been proposed, implemented and tested. The main limitation of perturb & observe algorithms is the compromise between fast dynamic response and steady-state stability. To improve the dynamic performance and ensure good stability, a criterion for choosing the optimal perturbation step and its coefficients has been discussed.

The chosen function enables more flexibility of algorithm to the actual photovoltaic system conditions. The modified perturb & observe algorithm has been implemented on a dual input inductor push-pull converter and experimentally compared to traditional P&O and IC techniques. For both these algorithms, the perturbation step was adjusted with tuning tests in order to extract the maximum average power from the PV panel and, consequently, penalizing the proposed system in the comparison. The experimental results have demonstrated clearly that the proposed modified perturb & observe algorithm is better than the standard P&O and IC at steady-state and shows comparable reactivity during transients, even if no adjustment is operated on the perturbation voltage step for different operating conditions. This is due to the intrinsic adaptive characteristic of the algorithm: the perturbation step is higher when the irradiation changes suddenly and is lower when the operating point is close to the maximum power point. From the analysis of the results, it is evident that the proposed perturb & observe algorithm has higher efficiencies than the algorithms already proposed in the technical literature.

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