Drift Avoidance in Photovoltaic Systems by Modification in Perturb and Observe MPPT Algorithm

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Abstract- **Solar energy is one of most readily available source of energy. It is Nonpolluting and maintenance free renewable source. While, the disadvantage is that PV generation depended on weather conditions. The problem associated with photovoltaic (PV) systems is that amount of power generated by solar depends up on a number of conditions (i.e. solar irradiance, temperature and angle of incident light etc.). To make best use of the solar PV systems the output is maximized either by mechanically tracking the sun or by electrically tracking the maximum power point under changing condition of insolation and temperature. The perturb and observe (P&O) maximum power point tracking algorithm is the most commonly used method due to its ease of implementation and low cost. A drawback of P&O is that, at steady state, the operating point oscillates around the MPP giving rise to the waste of some amount of available energy; moreover, it is well known that the P&O algorithm can be confused during those time intervals characterized by rapidly changing atmospheric conditions. This paper addresses both the issues, A modified P&O technique is proposed to avoid the drift problem by incorporating the information of change in current (ΔI) in the decision process in addition to change in power (ΔP) and change in voltage (ΔV). The simulation and experimental results showed that the proposed algorithm accurately track the maximum power and avoids the drift in fast changing weather conditions.**

Keywords- — Photovoltaic (PV), maximum power point tracking (MPPT), perturb and observe (P&O), drift phenomena.

I. INTRODUCTION

The increase in level of greenhouse emission gas and climb in fuel prices are the main driving force behind efforts to utilize various uses of renewable sources of energy. Among the alternative sources, the electrical energy from photovoltaic (PV) cells is currently regarded as a natural energy source that is more useful, since it is free, abundant, clean, and distributed over the Earth and participates as a primary factor Among the alternative sources, the electrical energy from photovoltaic (PV) cells is regarded as a natural energy source that is more useful, because it is free, abundant, clean, and distributed over the Earth and contributes as a primary factor of all other processes of energy production on earth. , the photovoltaic panels remain a real promise for the future. The main difficulty of solar energy is the initial high capital cost of pv modules. The disadvantage of solar energy production is that the power generation is not constant throughout the day, it changes with weather conditions. The efficiency of solar energy conversion to electrical energy is very low. This means that a fairly vast amount of surface area is required to produce high power.[1]-[3] Therefore, maximum power point tracking (MPPT) is an essential part of the photovoltaic (PV) system to ensure that the power converters operate at the maximum power point (MPP) of the solar array. . Until now a large number of MPPT techniques have been developed [4]–[26] to increase the efficiency of the PV system. MPPT algorithms such as fractional open circuit voltage [4], fractional short circuit current [4], Hill-climbing [5], perturb and observe (P&O) [6]–[13], incremental conductance (IncCond) [14]–[18], incremental resistance (INR) [19], ripple correlation control (RCC) [20], fuzzy logic [21], neural network [22], particle swarm optimization (PSO) [23], [24], sliding mode [25], [26] techniques are some of the MPPT techniques. Overview of various MPPT techniques are discussed in [27]–[30].

The drawbacks met while generating power from PV systems are: the efficiency of electric power generation is very low, particularly under low radiation , and the other disadvantage is the amount of electric power generated by solar arrays is always fluctuating with weather conditions,(i.e., irradiance and temperature).It is be observed that the output power characteristics of the PV system is function of irradiance and temperature is nonlinear and is critically prejudiced by solar irradiation and temperature. Thus, in order to over come this problem, several methods for extracting the maximum power has been proposed.

The P&O MPPT algorithm is widely used, due to its easiness of implementation. It is based on : if the operating voltage of the PV array is perturbed in a given direction and the power drawn from the PV array increases, this means that the operating point has moved toward the MPP and, thus, the operating voltage must be additional perturbed in the same direction. Else, the power drawn from the PV array decreases, the operating point has moved away from the MPP and, thus, the direction of the operating voltage perturbation must be reversed.

Although P&O has remarkable advantages, the sudden change in atmospheric conditions causes this P&O

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algorithm [31]-[33] to drift away from Max power point. This paper presents a clear analysis of drift such as, when the drift can occur, the movement of operating point and effect of drift in case of one time insolation change, as well as rapid change in insolation. The drift phenomena in case of adaptive P&O technique are also incorporated in this paper. The solution to the drift in the name of full curve evaluation is presented in by evaluating the entire trend in P − V curve but it is not possible to evaluate entire trend in P − V curve in case of a rapid change in insolation as the operating point moves into the new point on the corresponding insolation curve for each insolation change. This paper presents an accurate and simple solution to this drift problem by evaluating an another parameter, i.e., change in current (ΔI) by modifying the conventional P&O MPPT algorithm

II . CONVENTIONAL PERTURB AND OBSERVE (P&O) METHOD

The P&O method is most widely used in MPPT because of its simple structure and it requires only few parameters [6]. Shows the flow chart of P&O method. It perturbs the PV array's terminal voltage periodically, and then it compares the PV output power with that of the previous cycle of perturbation. When PV power and PV voltage increase at the same time and vice versa, a perturbation step size, ΔD will be added to the duty cycle, D [7]-[13] to generate the next cycle of perturbation in order to force the operating point moving towards the MPP. When PV power increases and PV voltage decreases and vice versa, the perturbation step will be subtracted for the next cycle of perturbation . This process will be carried on endlessly until MPP is reached. However, the system will oscillate around the MPP throughout this process, and this will result in loss of energy. These oscillations can be minimized by reducing the perturbation step size but it slows down the MPP tracking system [7].

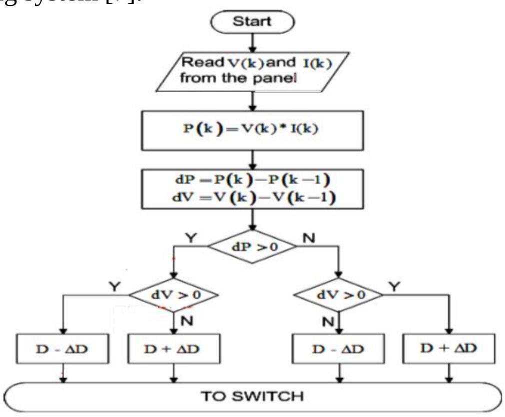

Fig. 1. Flow chart of P&O MPPT Algorithm

A. Steady State Three Level Operation

Assume that the operating point is been moved from point 1 to point 2 and the[6],[11] decision is to be taken at point 2 by considering the values of dP and dV. As dP = (P2 − P1) > 0 and dV =(V2 − V1) > 0, the algorithm decreases the duty cycle and the operating point moves to the point 3. At point3 as dP = (P3−P2) < 0 and dV = (V3−V2) > 0 the algorithm increases the duty cycle and hence the operating point moves back to point 2.

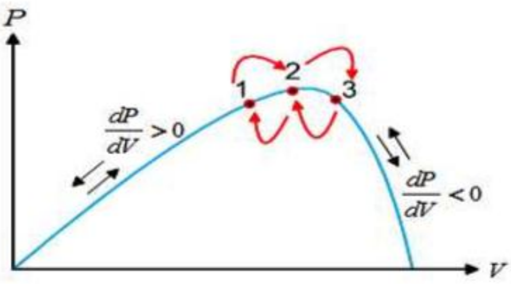

Fig. 2. Steady State Three Level Operation

B. Drift Analysis

Drift problem occurs for an increase in insolation and it will be severe for a rapid increase in insolation. Occurance [6] of drift in case of increasing insoltion is the major draw back of conventinal p & o. Drift can occur from any of the three points as shown in Fig.3 .Depending on the instant of change in insolation in between the perturbation time (Ta) interval. Drift problem is due to the lack of knowledge in knowing whether the increase in power (dP > 0) is due to perturbation or due to increase in insolation .Suppose there is an increase in insolation while operating at point 1as shown in above Fig, then the operating point will be settled to a new point 4The point 4 is in new insolation curve during the same kTa perturbation interval. Now at point 4 as dP = P4(kTa) − P2((k − 1)Ta) > 0 and dV = V4(kTa) − V2((k − 1)Ta) > 0 the algorithm decreases the duty cycle and thereby moving to point 5Point 5 is away from the MPP in the new curve which is called drift.

The drift problem occurs due to confusion of this conventional P&O MPPT technique. This drift problem will be severe in case of a rapid increase in insolation as shown in Fig.4 and in case of adaptive P&O, as ΔD is large for a change in insolation which will results in the operating point to move in a wrong direction far away from the MPP.

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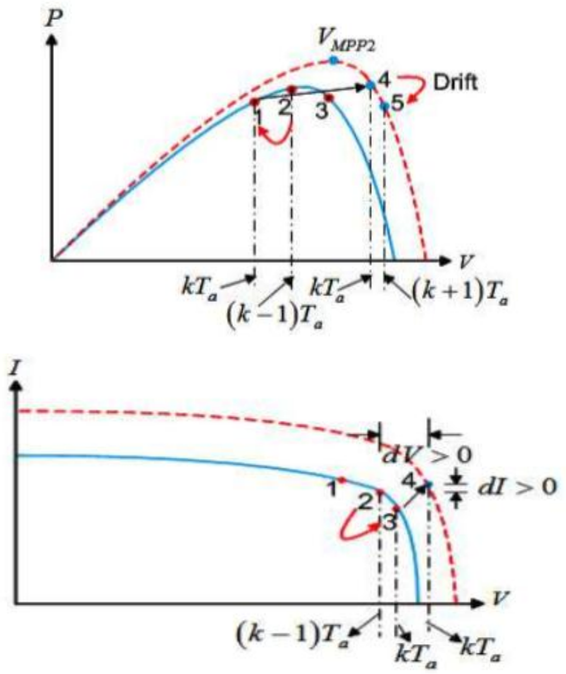

Fig.4. Observation of change in current

1) Effect of drift on Adaptive P&O: To improve performance of the P&O algorithm, an adaptive step size is [8],[14],[33]chosen.The duty ratio with adaptive step size can be realized as follows

$$D(k) = D(k-1) \pm M *(dP/ dV)$$

it can be inferred that step size depends on scaling factor (M) and ratio of change in power to change in current dp/dv. M is calculated by $M < \frac{\Delta Vmax}{\frac{dP}{dV}}$. Delta Vmax-Maximum perturbation step size is due to changes in environmental condition. From above eqn it can be observed that for an increase or decrease in insolation, the adaptive technique generates large value of ΔD. It depends on the value of dP/ dV ,Thus in case of adaptive P&O, as ΔD is large for a change in insolation will results in the operating point to move in a wrong direction far away from the MPP.

III. DRIFT FREE MODIFIED P&O MPPT

Conventional P&O has a demerit of drift in case of a rapid increase in insolation due to confusion .This confusion can be eliminated by evaluating another parameter dI. It can be noticed that for an increase in insolation both V PV and I PV increases. Thus, with the information of ΔV and ΔI the drift phenomena can be avoided by detecting the increase in insolation [34] The I −V characteristics of the PV module and the change in operating point due to increase in insolation is shown in Fig.4. suppose there is an increase in insolation while operating at point 3,then the operatingpoint will settle to a new point 4 in the new insolation curve. Now the decision has to be taken by the algorithm at point 4 where dI = I4(kTa) − I2((k − 1)Ta) > 0 as shown in Fig5.. At the same time on the P − V characteristics at point 4, both dP = P4(kTa) − P2((k − 1)Ta) > 0 and dV = V4(kTa) − V2((k − 1)Ta) > 0 as shown in Fig. 3.. Thus, all three parameters dP, dV and dI are positive at point 4,as shown in Fig.3, and Fig.4. Thus, the positive value of dP is due to whether perturbation or due to increase in insolation can be detected by using the additional parameter dI. From the I −V characteristics it can be observed that the two parameters both dV and dI can never have the same sign for a single insolation. Both dV and dI will be positive only for an increase in insolation. Thus, an increase in insolation can be detected by using the additional parameter dI and thereby increasing the duty cycle (decreasing the operating voltage) Where both dV as well as dI are positive can eliminate the drift problem by moving the operating point closer to the MPP. From the I −V characteristics it can be observed that the two parameters both dV and dI can never have the same sign for a single insolation. Both dV and dI will be positive only for an increase in insolation. Thus, an increase in insolation can be detected by using the additional parameter dI and thereby increases the duty cycle decreasing operating voltage .Where both dV as well as dI are positive can eliminate the drift problem by moving the operating point closer to the MPP.

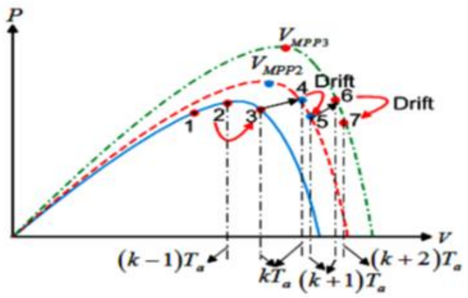

Fig.5. Rapid Time Increase In Insolation

Similarly in case of an increase in insolation at point 1and at point 2the drift problem can be solved by incorporating dI into the algorithm and the movement of operating point with the proposed drift free modified P&O MPPT technique in case of a rapid increase in insolation is shown in Fig.5. The flowchart of this drift free modified P&O MPPT technique is shown in Fig. 6.

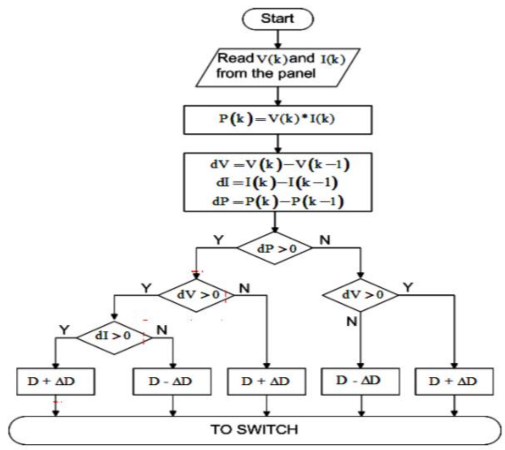

Fig.6.Flowchart of drift free modified P&O MPPT algorithm.

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IV. MODELING AND SIMULATION

The block diagram of the full MPPT system is shown in Fig.7. This section deals with the mathematical modelling and analysis of the various components.

A. Design of Solar Cell

The solar cell has a nonlinear relationship between its output voltage and current. The values of these parameters depend upon solar irradiance and cell temperature[34] The proposed system is designed for the peak power capacity of 50 kW, the 100 W solar power module is taken as the reference module for simulation and the detailed parameters of module is given in Table 1. The electrical specifications under test conditions of irradiance of 1 kW/m2 range of 1.5 air masses and cell temperature of 25 °C [35].

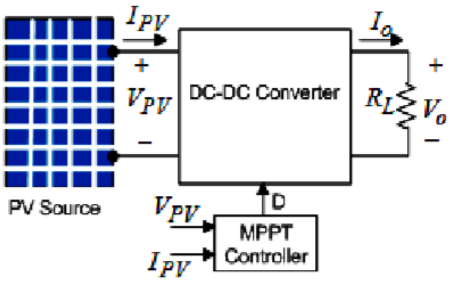

Fig.7.Block diagram of PV system with MPPT control.

NAME	DS-100M
Rated power (Vmp)	100W
Voltage at maximum power (Vmp)	18V
Current at maximum power (Imp)	5.55A
Open circuit voltage (VOC)	21.6V
Short circuit current (ISC)	6.11A
Total number of cells in series (Ns)	36
Total number of cells in parallel(Np)	1
Range of operation temperature	−40 °C to 80 °C

Table 1 Electrical characteristics data of DS-100 M PV module

The maximum power for SPV array is given as, Pmp = (ns*Vmp)*(np*Imp) = 50 kW

where ns and np represent series and parallel strings of PV module, Vmp is the voltage of a module at MPPT, Imp is the current of a module at MPPT and Pmp is the nominal power of a module at MPPT. The Pmp is generally achieved under the condition given as,

Pmp = (ns*85% of Vocn * np*85 % of Isc) = 50 kW

Thus, Imp is 5.5 A and Vmp is 18 V of each module Considering, PV array open circuit voltage (VOCT) = 700 V. The PV modules connected in series string are estimated as,

VOCT = ns * Vocn, thus ns = 700/21.6 = 33 Modules. Maximum current of the PV array is given as, Imp = Pmp / (0.85 * VOCT) = 84.03 A The PV modules connected in parallel string are estimated as, Imp = np*Isc, thus np = 14 Modules Thus the array of 50 kW peak power capacity is designed with 14 modules in parallel and 33 modules in series with an PV array of 14*33 modules.

B. Design of DC-DC Boost Converter

The ripple current for inductor at D = 0.2 [35]

VMpp =VOCT*85%, thus VMpp=595≅600V. ΔI is input current ripple, and it is considered as 6 % of dc-dc boost converter inductor current IMPP (PMPP/ VMPP) = 84.03 A. Thus a calculated value of ΔI is 5.041 A. The inductance Lb= $\frac{VMPP*D}{\Delta I*fs}$ value is selected 2.36Mh. The capacitance Co=$\frac{IMPP*D}{\Delta Vo*fs}$ where Δ Vo = Vmpp * 2% , thus ΔVo=11.9

The capacitance Co is selected as 1.41*10^-4F.

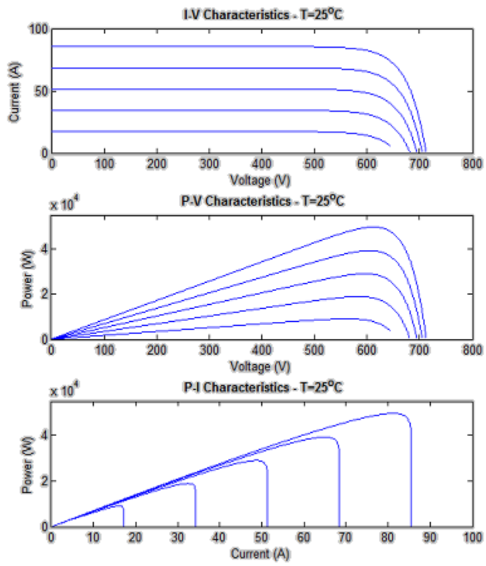

Fig.8.characteristics of the PV module for different insolation levels.

Characteristics of the simulated PV module are shown in Fig. 8 and from the P −V characteristics it can be noticed that the MPP voltagr varies corresponding to varing insolation level.

A. Drift analysis for one step change in insolation

The proposed MPPT algorithm has been tested for a step change in insolation level from 500 W/m2 to 1000 W/m2 at 0.7s. The perturbation time (Ta), and the perturbation step size (ΔD) are chosen as 0.1 ms and0.001 respectively. conventional P&O and drift free modified P&O algorithm and corresponding tracking waveforms are shown in Fig.10

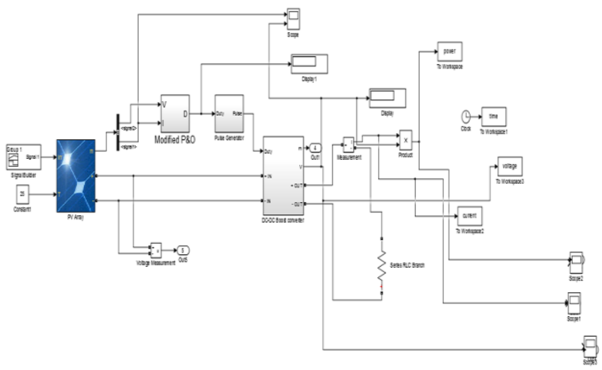

Fig. 9. MATLAB/Simulink Model of Simulated PV system.

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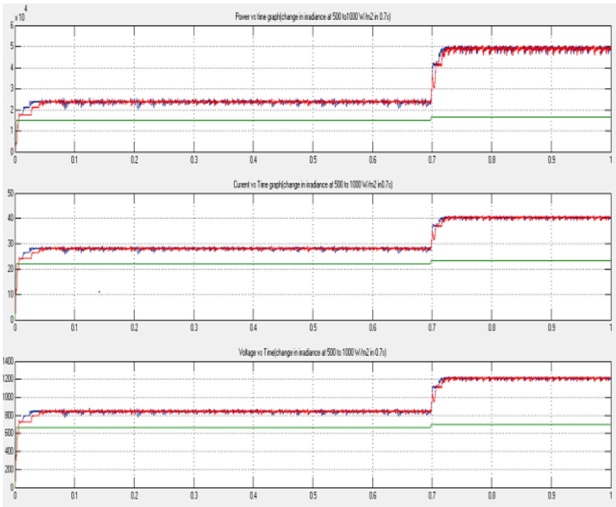

Fig.10. Without MPPT, With conventional P&O, and proposed drift free modified P&O MPPT for rapid change in insolation (a) Powe (b) Current and (c) Voltage

V. CONCLUSION

In this paper, the drift phenomena of P&O MPPT algorithm is thoroughly discussed and then a modification to the existing algorithm is proposed to avoid the drift. The basic principle of modifird the algorithm is to use an extra checking condition (ΔI) in the traditional P&O algorithm to avoid the drift and the mathematical justification of checking this extra condition is also proved. The simulation of the proposed method are done by considering BOOST converter topology with direct duty ratio control The algorithm has been validated by means of numerical simulations, considering the PV panel that has been experimentally identified and characterized. The simulation prove that the proposed modified P&O MPPT technique is free from drift and is accurately tracking the maximum power from the PV panel. The proposed algorithm improves the efficiency of the PV system by gaining the extra power during drift compared to the conventional P&O algorithm, considerable amount of energy gain can be achieved over the life cycle of the PV panel by using the proposed method.

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