Drift avoidance in Photovoltaic systems using modified Perturb and Observe MPPT algorithm

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Abstract: This project presents the modified Perturb and Observe MPPT Algorithm and this algorithm is the one most tracking technique. The proposed system is used to avoid the drift problem in the PV system by adding the information of change in current and in addition to change in power and change in voltage. The existing system of P&O tracking method suffers from drift because increase in insolation. And the drift effect is severe in the PV system rapidly increase in insolation which generally occurs in cloud days. Mainly drift occurs in P&O algorithm the sudden change in atmosphere conditions. This modified P&O algorithm the single ended primary inductance converter is considered to avoid drift free problem using direct duty ratio control technique. The proposed algorithm accurately track the maximum power and avoids drift in fast changing weather conditions.

Keywords: Photovoltaic Systems(PV), Modified Perturb and Observe Maximum Power Point Tracking (P&O MPPT) , single ended primary inductance converter(SEPIC), Drift analysis.

1. Introduction

Photovoltaic Power generation is one of the most remarkable renewable energy sources and it has advantages like eco-friendly in nature, less maintenance and no noise. Photovoltaic systems are directly converts sunlight into electricity. The voltage and current available at the terminals of a PV device may directly feed small loads such as lighting systems and dc motors. Maximum Power Point Tracking is one of the main function in every PV system should included. The characteristics of the PV module depends on solar insolation level and temperature. Until now a large number of techniques have been developed to increase the efficiency of the PV system. MPPT algorithms such as Hill climbing, Perturb and Observe, incremental conductance(INC), incremental resistance (INR) ripple correlation control(RCC), particle swarm optimization(PSO). Perturb and observe (P&O) method is also known as perturbation method is a type of MPPT algorithm. This algorithm is used to modify the voltage or current of the photovoltaic panel until you obtain maximum power from it. The voltage to a cell is increased initially. If the output power increases, the voltage is continuously increased till the output power start decreasing. once the output power start decreasing the voltage to the cell is decreased till maximum power is reached. This process is continued till the MPP is reached. This results in an oscillation of the output power around the MPP. The P&O algorithm is a simple algorithm that does not require previous knowledge of PV generation characteristics or the measure of solar intensity and temperature. P&O technique is developed by checking slope dP/dV on the P−V characteristics of the PV module. The slope dP/dV > 0 on the left of MPP and dP/dV < 0 on the right of MPP. Thus, depending on the sign of the slope operating voltage has to be perturbed to track the peak power.

2. Existing System

The operating point on the characteristics of the PV module mainly depends on the impedance matching of the PV module with respect to the connected load. A DC-DC converter between the PV module and load acts as an interface to operate at MPP by changing the duty cycle of the converter generated by the MPPT controller.

2.1 Steady State Three Level Operation

Assume that the operating point has been moved from point 1 to point 2 and the decision has 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 hence 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 thereby the operating point moves back to point 2.
3. **Proposed System**

The proposed system is used to avoid the drift problem. The solution to avoid the drift problem is given by applying a constraint on perturbation stepsize. However to avoid the drift for large change in insolation a high value of stepsize is required to which will effectively increase the power loss in steady state. This paper presents an accurate and simple solution to this drift problem by evaluating another parameter change in current by modifying the P&O MPPT algorithm.

Insolation is the total amount of energy that has been collected on a surface area within a given time while irradiance denotes the instantaneous rate at which power is delivered to a surface.

### 3.1. Drift Analysis

At point 2 as $dP = (P_2 - P_3) > 0$ and $dV = (V_2 - V_3) < 0$ the algorithm increases the duty cycle and hence the operating point moves to point 1. At point 1 as $dP = (P_1 - P_2) < 0$ and $dV = (V_1 - V_2) < 0$ the algorithm decreases the duty cycle and thereby the operating point moves back to point 2. The slope is positive on the left of MPP and negative on the right of MPP. Depending on the sign of the slope the duty cycle has to be perturbed in order to track the peak power and flowchart of this P&OMPPT algorithm. The duty cycle and the PV voltage ($V_{PV}$) are inversely proportional to each other i.e., increase in duty cycle causes the $V_{PV}$ to decrease. Drift problem is due to the lack of knowledge in knowing whether the increase in power is due to perturbation or due to increase in insolation. Suppose there is increase in insolation while operating at point 1 as fig 3.

![Fig. 3. Drift from point 1](image)

The operating point will be settled to a new point 4 in corresponding insolation curve during same $K_{Ta}$

![Fig. 4. Drift in case of rapid increase in insolation](image)
perturbation interval. Now at point 4 as \( dP = (KT_a) - P_2((K-1)Ta) > 0 \) and \( dV = V_4(KT_a) - V_2((K-1)Ta) > 0 \) the algorithm decreases the duty cycle and thereby moving to point 5 away from the MPP in the new curve which is called drift effect.

### 3.2. Effect of drift on adaptive P&O

The tracking time and the steady state performance are mainly depends on the perturbation stepsize. To improve both steady state and dynamic performance of the P&O algorithm an adaptive stepsize. The duty ratio with adaptive size can be realized as follows,

\[
D(N) = D(N - 1) + M \cdot |dP/dV| \quad ---- (1)
\]

This problem can be eliminated by evaluating another parameter \( dI \) using modified P&O. The \( I-V \) characteristics of the PV module and the change in operating point due to increase in insolation is shown in fig 5. Suppose there is an increase in insolation while operating at point 3, then the operating point 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 \( dI = I_4(kT_a) - I_2((k-1)Ta) > 0 \) as shown in fig 5. At the same time on the \( P-V \) characteristic at point 4, both \( dP = P_4(kT_a) - P_2((k-1)Ta) > 0 \) and \( dV = V_4(kT_a) - V_2((k-1)Ta) > 0 \)

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.

\[
\text{Fig. 5. Observation of change in current}
\]

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. Similarly for an increase in insolation at point 1 and at point 2 the 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. We can step up or step down voltage. For duty cycle above 0.5 it will step up and below 0.5, it will step down the voltage to required value. The input and output relation for SEPIC is expressed as

\[
V_o = \frac{D}{1 - DV_{PV}} \quad ---- (2)
\]

\[
V_o = \frac{D}{1 - DV_{PV}}
\]

\[
\text{Fig. 7. Flow chart of Modified P&O MPPT Algorithm}
\]
3.3. Circuit Diagram

PV module is used to generate the power and efficiency of the PV system depends upon the operating point on the characteristics of the PV model. The electrical power output from a PV panel and depends on the solar insolation and temperature.

Fig.8. circuit diagram of modified P&O MPPT algorithm

SEPIC is a DC to DC converter and is capable of operating in either step up or step down mode and widely used in battery operated equipment by varying duty cycle of gate signal of MOSFET.

Fig. 9. circuit diagram of SEPIC coevter

The main demerits in P&O MPPT controller to drift away from the MPP and the drift occurs in PV system because of increase in insolation and this drift effect is severe in case of a rapid increase in insolation. And the loss power is high, so a modified perturb and observe controller is proposed to avoid the drift problem. This controller is used to increase the output power and improve the efficiency of the PV system.

3.4. Simulation of Proposed System

The Simulink model of Modified P&O MPPT algorithm is shown in Fig 10. It represents the PV module and SEPIC converter then load. The output from the PV module is given to the SEPIC converter. In order to SEPIC converter is used to validate the proposed drift free P&O using direct duty ratio control.

Fig.10. simulink model existing system

Fig.11. Input voltage of conventional P&O MPPT algorithm

The input voltage of conventional P&O MPPT algorithm is shown in Fig 11. It gives the information of PV voltage and the maximum voltage is 16.8v for the insolation level from 270 W/m² to 480 W/m².
Output power of conventional P&O MPPT algorithm as shown in Fig 12. In this algorithm the output power is fed from the PV module is 40watts .The main problem in this algorithm the insolation increases voltage is increased but the current is decreased. so it causes to decreases the power output and the system efficiency is decreased.

The output power of Modified perturb and observe MPPT algorithm as shown in fig 13. The output power is 340watts and the power output is increased for constant insolation. It is the maximum power of PV system.

The constant insolation of Modified P&O MPPT algorithm as shown in Fig 14. Then the insolation level is 1000w/m². This is the constant level in PV systems.

The output power of Modified perturb and observe MPPT algorithm as shown in Fig 15. The output power is 160 watts and the power output is decreased from variable insolation. The maximum power of PV system is varies from 65v to 160 v and the insolation level is 270 w/m² to 480 w/m².
The rapid insolation of Modified P&O MPPT algorithm as shown in Fig 16. Then the insolation level is varies from $270 \text{ W/m}^2$ to $480 \text{ W/m}^2$.

4. Conclusion

This project is used to discuss the drift avoidance in PV system. The basic principle of the modified P&O algorithm is to use an extra checking condition($\Delta I$) in the traditional P&O algorithm to avoid the drift. The proposed modified P&OMPPT 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.

REFERENCES


