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PV MPPT based on Improved Perturbation Observation Method

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Abstract

A modified perturbation observation method is proposed to address the shortcomings of the traditional MPPT algorithm that cannot combine tracking speed and steady-state accuracy. The method achieves accurate tracking of the maximum power point by estimating the voltage value Vref at the maximum power point in real time, using a constant voltage start and a perturbation observation method with small step size. Simulation experiments are carried out in Simulink environment, and the results show that the algorithm is simple to implement, fast in dynamic response tracking, and can improve power generation efficiency.

Keywords

Maximum Power Tracking; Perturbation Observation Method; Simulation.

1. Introduction

Solar energy is one of the important renewable energy resources as it is pollution free, clean, never-ending and abundant. Photovoltaic power generation is a technology that has received a lot of attention. However, the output characteristics of photovoltaic power generation are greatly influenced by light and ambient temperature. In order to improve the output efficiency and ensure that the cells carry out the maximum power output, some algorithms are needed for maximum power tracking.

Some of the more common algorithms currently used in engineering are generally the constant voltage method, the perturbation observation method(P&O), and the intelligent algorithm, each of which has its own advantages and disadvantages[1]. The constant voltage algorithm[2], is easy to implement and has high power losses. The perturbation observation method[3], with a simple control principle and easy implementation method, the choice of step size causes oscillations with long tracking times.

In this paper, a modified perturbation observation method with small step size is proposed based on the PV cell model to estimate the voltage parameters at the maximum power point. The algorithm has a simple control process, rapid algorithm start-up, good dynamic performance and smooth steady-state process.

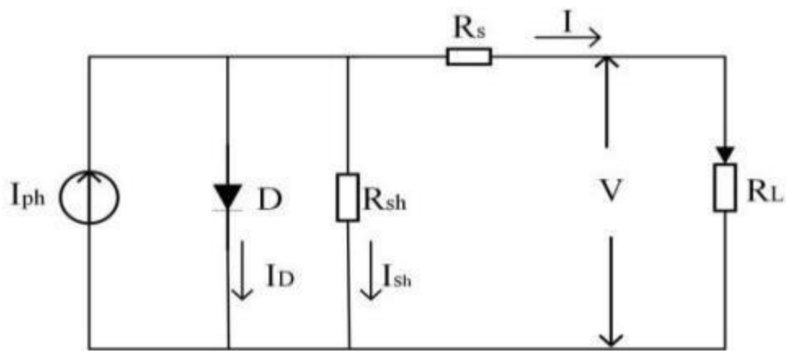

Fig. 1 The equivalent circuit of PV

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2. PV Cell Model

The equivalent circuit of the photovoltaic cell is shown in Figure 1, the current source Iph in this figure represents the photogenerated current, Rsh represents the equivalent parallel resistance, Rs represents the series resistance, V and I represent the output voltage and output current respectively[4].

$$I = I_{ph} - I_{DO}\left\{exp\left[\frac{q(V+IR_S)}{ATK}\right] - 1\right\} - \frac{V+IR_S}{R_{sh}} \tag{1}$$

In practical engineering use, as equation (1) is an implicit equation that cannot be solved, the thermal voltage VT is introduced and the model is simplified to a thermal voltage dynamic model [5-6]:

$$V = V_{oc} + V_T In\left(1 - \frac{I}{I_{sc}}\right) - IR_s \tag{2}$$

$$I_{sc}(G,T) = I_{sc0}\frac{G}{G_0}[1 + \alpha(T - T_0)] \tag{3}$$

$$V_{oc}(G,T) = V_{oc0} + \beta(T - T_0) + V_T\frac{T}{T_0}In\left(\frac{G}{G_0}\right) \tag{4}$$

$$V_T(T) = V_{T0}\frac{T}{T_0} \tag{5}$$

α and β are the short-circuit current and open-circuit voltage temperature coefficients. Voc is the open-circuit voltage, Isc short-circuit current, G is the light intensity, T is temperature. where the thermal voltage VT and the series resistance Rs can be calculated from the cell parameters under standard operating conditions.

Monocrystalline silicon solar photovoltaic cells produced by JinkoSolar were used for the study, and their parameters are shown in Table 1.

Table 1. Photovoltaic cell parameters

I_{sc}/A	V_{oc}/V	I_m/A	V_m/V	Pm/W
8.09	44	7.47	34.8	260

At an ambient temperature of 298K and varying the light intensity from 400-1200W/m2, the PV cell characteristic curves simulated using the thermo-voltage dynamic model are shown in Fig. 2. As can be seen from the curves, the maximum power rises significantly, the open circuit voltage remains largely unchanged and the short circuit current rises.

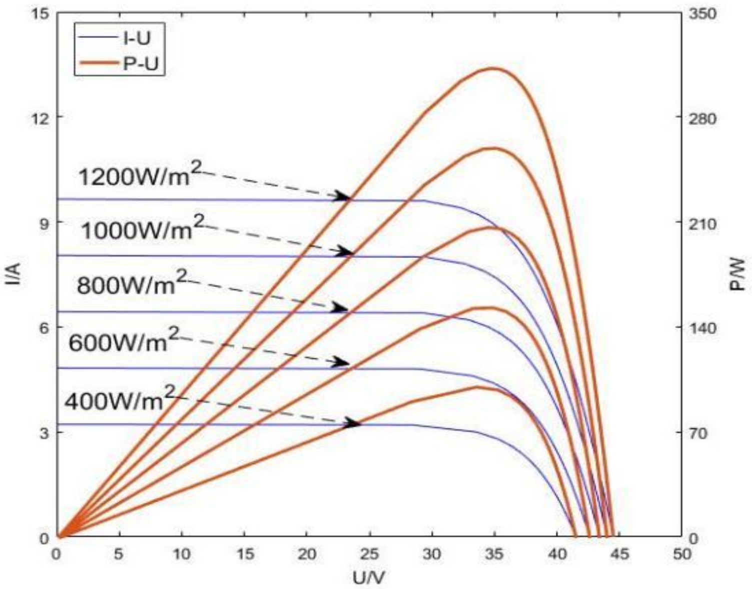

Fig. 2 P-U and I-U plots at 298 K for different light intensities

3. Improved Algorithms

The traditional perturbation method has the disadvantages of too large a step size generating oscillations at the peak not accurately tracking the maximum power and too small a step size resulting in too slow a response. In this paper, the reference voltage value Vref at the maximum power point is calculated using a simple approximation in conjunction with the thermal voltage dynamic model using the following equation [7]:

$$V_{ref} = V_{oc}(G,T)\left[1 - \left(\left(\frac{1+In(\gamma)}{2+In(\gamma)}\right)\frac{In(1+In(\gamma))}{In(\gamma)}\right)\right] \tag{6}$$

$$\gamma = exp\left(\frac{V_{oc}(G,T)}{V_T}\right)\text{-1} \tag{7}$$

The improved perturbation method uses a constant voltage start based on Vref so that the maximum power can be approached quickly and the tracking distance of the P&O method can be reduced. After the algorithm is started at constant voltage, the P&O method with small steps is carried out for tracking, and the flow chart of the improved P&O method is shown in Figure 3.

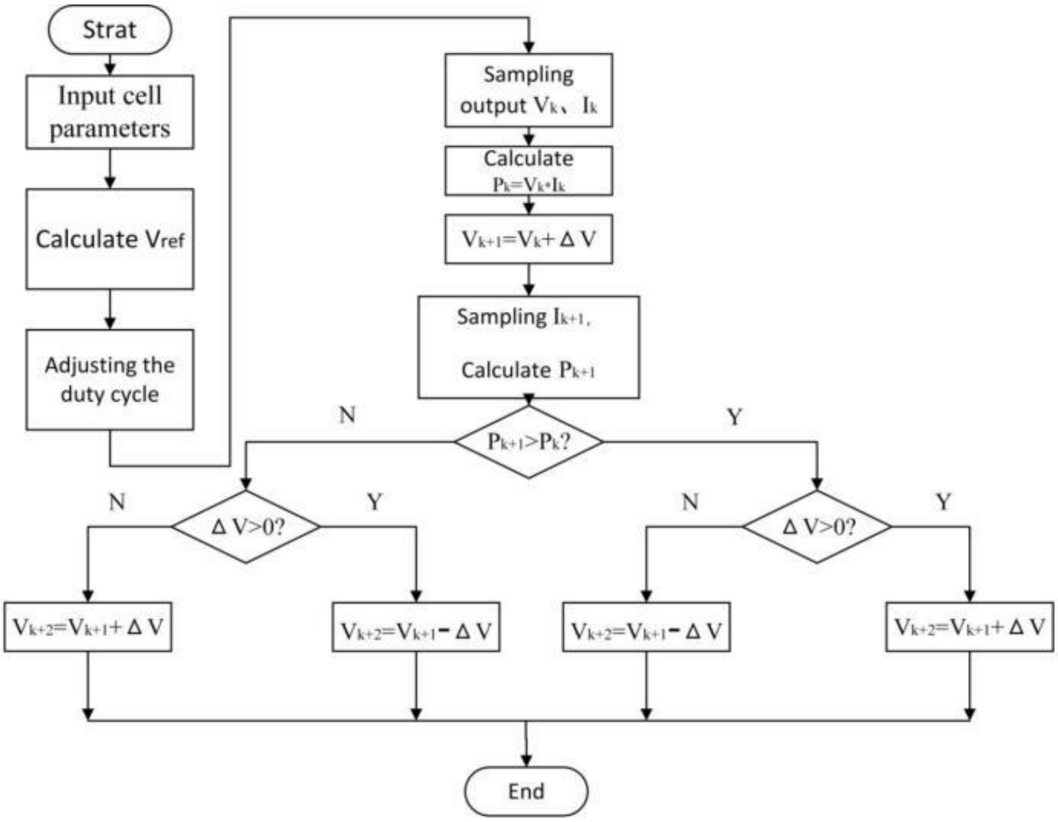

Fig. 3 The flow chart of the improved P&O

4. Simulation Experiments

Based on the control strategy proposed in this paper, a simulation model of the PV power generation system is established in the MATLAB/ Simulink environment, see Fig. 4.

In order to verify the performance of the improved perturbation method, a control experiment with the traditional perturbation observation method with small step sizes was used. The experimental conditions are: the initial state is G=1000W/m2 and the light intensity suddenly changes to 600W/m2 at t=0.5s. Simulation experiments are carried out in Simulink for both conventional and improved perturbation observation method algorithms and the output power waveforms are shown in Figure 5(a), (b).

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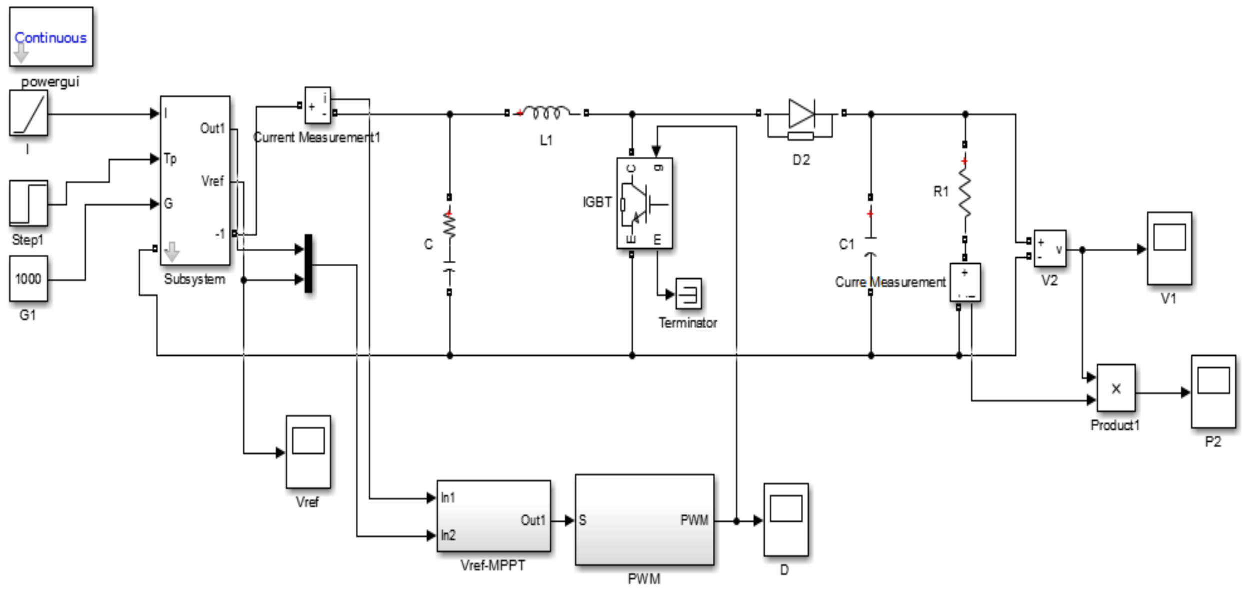
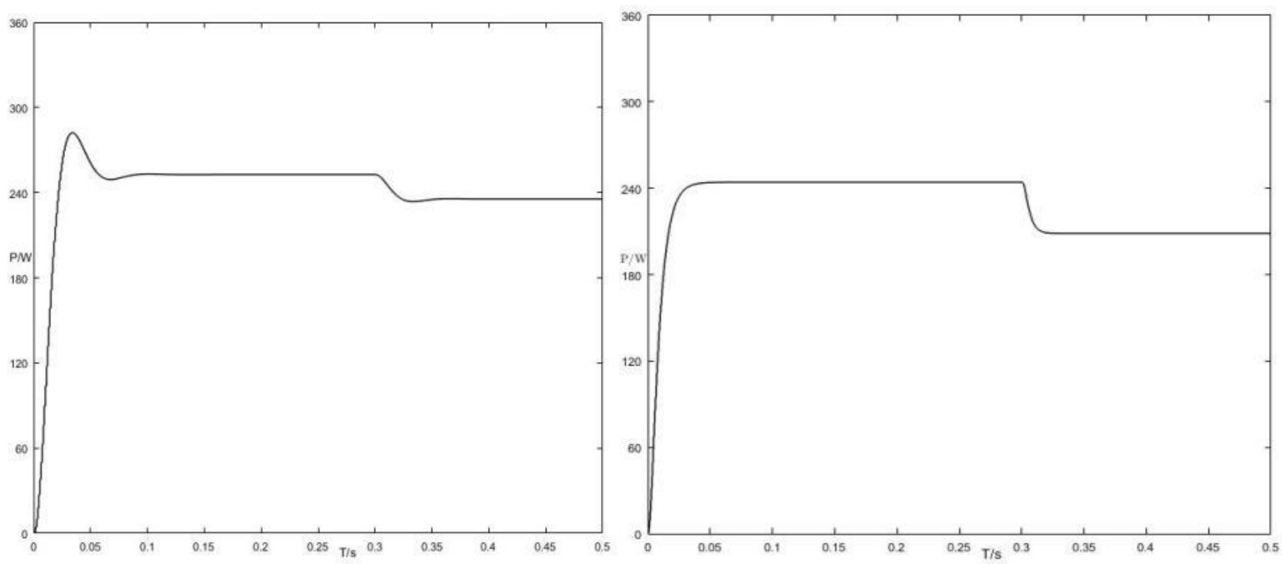


Fig. 4 Simulation model of MPPT algorithm



(a) the improved algorithm (b) traditional P&O

Fig. 5 Comparison of simulation plots of the two algorithms

During the start-up phase, at standard conditions (T=298K, G=1000W/m2), the improved perturbation observation method based on Vref takes a short time to reach steady state in the start-up phase, 0.04s, while the conventional perturbation method takes 0.09s, which is slower. The traditional perturbation observation method also shows a spike in the curve before reaching steady state. When the light intensity changes abruptly to 700 W/m2 at t=0.5s, the time taken by both algorithms to reach the new steady state is about 0.03s, which is a faster response, and the traditional perturbation method also shows a spike in the process of reaching the steady state.

5. Conclusions

In response to the problems of the traditional perturbation observation method in terms of long step size which leads to steady-state oscillation and long time spent for small step size, this paper proposes a perturbation observation method based on Vref initiation. The method is an improved MPPT

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algorithm based on the PV cell hotspot voltage model by estimating the voltage Vref at the maximum power and combining the constant voltage method with the perturbation observation method. Simulation experiments are carried out in the Simulink environment, and the results verify that the improved perturbation method based on Vref can track the MPP well and has excellent performance with fast response and no spikes in the steady-state process.

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