Improved Photovoltaic Power Generation Maximum Power Tracking Method

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Abstract. The output power of photovoltaic modules is affected by factors such as temperature and illumination. In order to improve the efficiency of photovoltaic power generation systems, it is necessary to track and control their output power. This paper introduces the advantages and disadvantages of the traditional maximum power point tracking method, and proposes a three-stage maximum based on the combination of constant voltage method-variable step disturbance observation method-conductance method based on the traditional maximum power point tracking method. Power point tracking method. The method starts tracking from the vicinity of the maximum power point, reduces the tracking time, and avoids the problem that the oscillation cannot be stabilized near the maximum power point and the tracking failure occurs due to the change of the external environment. To further study the maximum power point tracking method and lay a foundation for improving the efficiency of photovoltaic power generation.

1. Introduction

With the continuous development and utilization of new energy, the maximum power point tracking technology of photovoltaic power generation system has become the focus of attention. Since the voltage and current outputted by the photovoltaic array are affected by external environment, temperature and light intensity, and thus exhibit nonlinear characteristics, it is necessary to regulate the photovoltaic power generation system so that the system can output the maximum power as much as possible, that is, the maximum power point of photovoltaic power generation. Tracking technology. In [1], the unknown parameters of the photovoltaic power generation equivalent model are solved by an iterative algorithm, and the distribution of the maximum power point is studied according to the distance analysis method. In [2], a sliding parameter extraction method based on adaptive parameters is proposed for maximum power point tracking. In [3], based on the methods of dynamic impedance matching and center difference, a self-optimizing maximum power point tracking method is proposed. In [4], a maximum power point tracking method based on adaptive weight particle swarm optimization algorithm is

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proposed, and the tracking effect error is large. In [5], for the traditional maximum power point tracking method, the tracking speed is slow and the voltage is oscillating. It is proposed to collect the voltage and current first, then filter and track the maximum power point, and the tracking process adopts a variable step size method. The problem of unstable output power at the maximum power point is not overcome. This paper combines the traditional constant voltage method, disturbance observation method and conductance method to overcome the problem that the traditional maximum power point tracking speed is slow and the instability is caused by the oscillation near the maximum power point, and the tracking can be interrupted when the environment changes greatly. It solves the problem that the misjudgment is easy to occur and the voltage continues to drop when the environment changes greatly.

2. Mathematical model of photovoltaic cells

The equivalent circuit of the photovoltaic cell is shown in Figure 1.

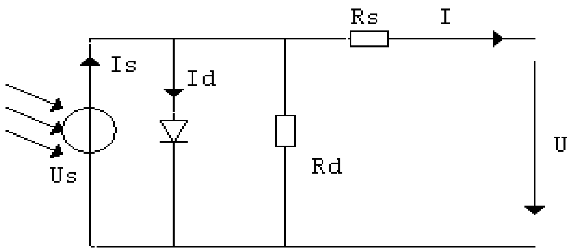

Figure 1. Photovoltaic cell equivalent model.

As can be seen from Figure 1, the I-U characteristic curve of the photovoltaic cell can be expressed as:

$$I = I_{\text{ph}} - I_0[\exp(\frac{q(U + IR_S)}{AKT}) - 1] - \frac{U + IR_S}{R_d} \tag{1}$$

Where, I_0 is the reverse saturation current of the diode, I_{ph} is the photo-generated current, T is the absolute temperature, K is the Boltzmann constant, R_d is the equivalent parallel resistance, and R_s is the equivalent series resistance.

3. Traditional maximum power point tracking method

The maximum power tracking control methods are various and the control effects are also different. The constant voltage control method is less used because the control precision is not high enough. The disturbance observation method and the conductance increment method are the most common and most commonly used maximum power point tracking control methods. The disturbance observation method has the advantages of small calculation amount, fast tracking speed of the maximum power point, and low requirements on the accuracy of the sensor. However, when the system operates near the maximum power point, oscillation occurs, and the power loss is large when the environment changes greatly. The conductance increment method has a much lower power oscillation at the maximum power point than the disturbance observation method, but requires a complicated derivation operation and a slower tracking of the maximum power point. The output voltage and current of the PV array change continuously with changes in the external environment and load. The output U-P curve of the photovoltaic cell is shown in Figure 2.

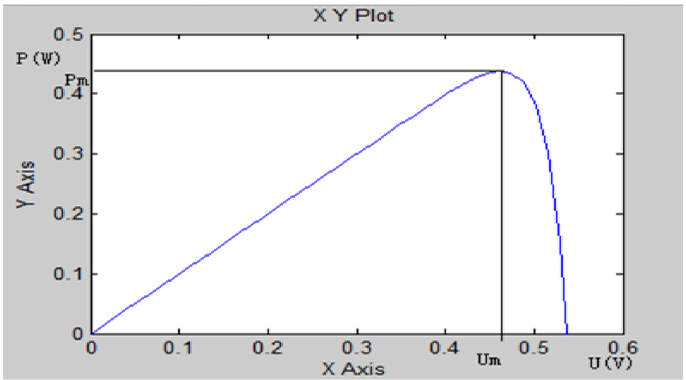

Figure 2. Output U-P curve of photovoltaic cell.

It can be seen from Figure 2 that the output UP curve of the photovoltaic array exhibits a convex shape, and there is a maximum power operating point of a single pole. At this time, the voltage Um is called the maximum power point operating voltage, and the corresponding output power is the maximum of the system. Output Power. We can change the system output power by adjusting the current working voltage of the photovoltaic panel, and generate the PWM signal through the maximum power point tracking module to control the BUCK-BOOST circuit to adjust the output duty cycle to make the system approach the maximum power operating point.

Interference observation methods are widely used in maximum power point tracking. The working principle is: based on the reference voltage, first apply an increased voltage superposition, and then detect the output value of the photovoltaic panel. When the output power of the photovoltaic panel increases, the maximum power point is at the right of the working point. On the side, the forward voltage disturbance amount should be applied again on the basis of the voltage value until the measured output power value begins to decrease, indicating that the maximum power point is near the operating point. At this time, a reverse voltage disturbance is applied to shift the current operating point to the left until the reverse voltage disturbance is applied, and the power begins to drop, and then the forward voltage disturbance is applied. After multiple optimizations, the maximum power operating point is finally found.

4. Constant voltage-variable step-distance interference-conductance method for maximum power point tracking

When the external temperature changes little, the maximum power operating point under different illumination intensities is approximately distributed on a vertical line. According to this feature, the maximum power tracking process can be divided into three segments, and the disturbance observation method adopts a variable step size. The control process is divided into three phases.

(1) The study shows that the temperature and the light intensity change are small, the corresponding voltage value at the maximum power operating point has a linear relationship with the open circuit voltage of the system, that is, Um=kUo. The system open circuit voltage is collected in the initial state of the system, and the corresponding maximum power point operating voltage value is calculated. This value has been experimentally shown to be about Um=0.78Uoc. In order to ensure the response speed of the system, the initial system can be directly introduced at the initial moment. The operating voltage is set near the theoretical maximum power point.

(2) According to the characteristics of the power-voltage characteristic curve, the portion to the left of the maximum power point is approximated as a rising straight line, and the portion to the right of the maximum power point is approximated as a falling straight line, so in this linear phase, The voltage disturbance is applied, and the step size is gradually reduced to avoid excessive disturbance when the system is close to the maximum power point. The specific step calculation satisfies the following formula:

$$\theta_k = \lambda \left| \frac{p_k - p_{k-1}}{u_k - u_{k-1}} \right| \tag{2}$$

Where: θ_k represents the step size and λ represents the scale factor.

(3) The power-voltage characteristic curve at the maximum power point is approximately a convex sinusoid, so a more stable conductance method can be used for tracking in this region. When the absolute value of the conductance is below a certain threshold, at the maximum power point with a certain threshold hysteresis comparison, when the step size is reduced below a certain value, the system is no longer disturbed and stabilizes at the maximum power point.

The composite power maximum power point tracking flowchart is shown in Figure 3.

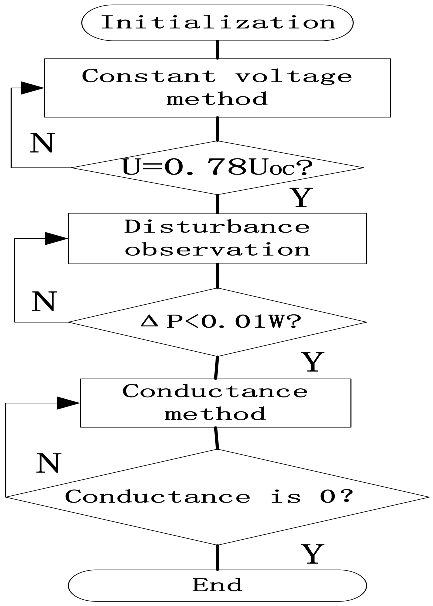

Figure 3. Composite method maximum power point tracking flowchart.

The system detects the open circuit voltage of the system in the initial state, and theoretically calculates the approximate voltage value corresponding to the maximum power point and uses it as the initial tracking voltage to make the system perturb from the vicinity of the maximum power point. Finally, the system is stabilized at the maximum power point by the conductance method. Down, thus solving the problem of slow system response and instability at the maximum power point. When the system misjudges and causes a voltage drop, the maximum power operating point is outside the voltage threshold range determined by the constant voltage method, the system locks to the left and right threshold points and re-tracks the maximum power point in the next cycle, thereby avoiding system voltage collapse.

5. Conclusion

Compared with the traditional maximum power point technology, the maximum power point tracking method of constant voltage-variable step-distance motion-conductance method proposed in this paper has the advantages of fast tracking speed and good stability, and has certain practical value.

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