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An Improved Perturbation Observation Method with Variable

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Abstract: Aiming at the problems of oscillation and misjudgment in traditional MPPT technology, the influence of voltage disturbance step size on the tracking of the maximum power point is studied. On this basis, an improved method based on the slope and space division of output characteristic curve is proposed. The voltage disturbance is carried out by using a fixed step length outside the set search interval, so that the photovoltaic cells can quickly work near the maximum power point. Reduce the early search time; When the photovoltaic cell is working near the maximum power point, the voltage disturbance is carried out with small steps to avoid the oscillation caused by repeated pulsation of the operating point around the maximum power point. Meanwhile, the search space is further divided to reduce the search interval. Static and dynamic lighting modes were simulated by Simulink.

Keywords: Oscillation and misjudgment, Disturbance compensation, Simulink simulatin.

1. Introduction

Perturbation observation (P&O) is one of the common control algorithms for maximum power point tracking. Firstly, the output voltage of the photovoltaic cell is disturbed by a certain step to observe the change of the output power. The disturbance direction of the output voltage is controlled according to the variation trend of the output power of the photovoltaic cell, and the output voltage of the photovoltaic cell is finally placed at the maximum power point voltage . In this paper, the inverter input voltage disturbance observation method, through the collection of photovoltaic cell output voltage and current, calculate the output power automatic optimization method to track the maximum power point.

The perturbation observation method adopts step - by - step search method. When the output power point is on the left side of the maximum power point, MPPT controls the power point voltage to search for the rising voltage in the positive direction with the step value. When the output power point is on the right side of the maximum power point, MPPT controls the voltage of the power point to search for the voltage reduction in the reverse direction with the step value. This search process continues, and finally the output power point runs at the maximum power.

By repeatedly adjusting the direction of voltage disturbance, the voltage continuously searches for the maximum power point until the photovoltaic cell works at the maximum power point. The perturbation observation method adopts step size search method. According to whether the search step size is fixed in the process of perturbation voltage, the perturbation observation method can be divided into fixed step size method and variable step size method. Therefore, the perturbation voltage step size has a great influence on the tracking accuracy and speed of the maximum power point. Figure 1 shows the flow chart of the disturbance observation method.

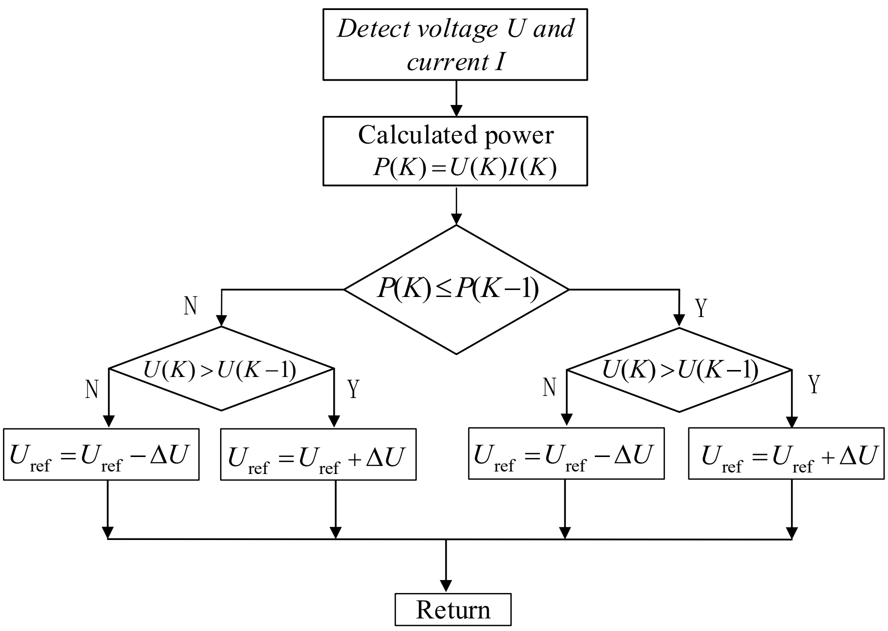


Figure 1. Flow chart of disturbance observation method

The perturbation observation method uses the step search method, so there are two shortcomings, namely oscillation and misjudgment. The minimum step size of the disturbance voltage in the perturbation observation method is fixed. The smaller the perturbation step size is, the smaller the output power oscillation will be. However, too small step size will increase the search time of the system, and the system cannot work quickly at the maximum power point. When the voltage search reaches near the maximum power point voltage, the situation of crossing the maximum power point will occur in the next search process due to the fixed step size. When the direction of the disturbance step size is adjusted for reverse search, the difference between the working voltage and the maximum power point voltage is less than the step size, which will again lead to the situation of crossing the maximum power point and failing to reach the maximum power point. Two-way reciprocating operation near the maximum power point.

2. Organization of the Text

For the problem of oscillation and misjudgment in the search of the maximum power point with the fixed voltage disturbance step size, the system cannot track the maximum power point quickly and accurately. Therefore, it is necessary to improve the disturbance observation method with the fixed step size. In this paper, variable step size perturbation observation method is adopted to reduce system oscillation while rapidly tracking the maximum power point. The principle diagram of the improved perturbation observation method is shown in Fig 2. In the early search interval, appropriate stride length is used for search, so that the system can quickly search the interval near the maximum power point, and then switch to appropriate small step length for search, so that the working point is closer to the maximum power point. Improve the system search accuracy. Graph $K = |\Delta P/\Delta U|$, first sampling current moment and the moment of work voltage and current, respectively calculate ΔP and ΔU value, and then judge $| \Delta P/\Delta U |$ and K, the size of the search using the search range is greater than K large step, in less than the search interval with long steps of K, at the same time each search will narrow range is divided into $K/2$ .Finally, according to the flow of perturbation observation method, the size of P_1, P_2, U_1, U_2 is determined to determine the direction of voltage disturbance. For the value of K is not fixed, the appropriate value is chosen according to the photovoltaic characteristic curve. For small long value, can use $|\Delta P/\Delta U|$ the value of the dynamic update steps grew up small, specific expression is:

$$\begin{cases} K_{t+1} = K_t / 2^n \\ \Delta U' = \lambda \left| \dfrac{\Delta P}{\Delta U} \right| \end{cases} \tag{1}$$

Thereinto, K_t is the search interval of the current short step length, K_{t+1} is the search interval of the next short step length, n is the search times, is the search short step length, λ is a constant, and the value is calculated according to the slope of the photovoltaic characteristic curve.

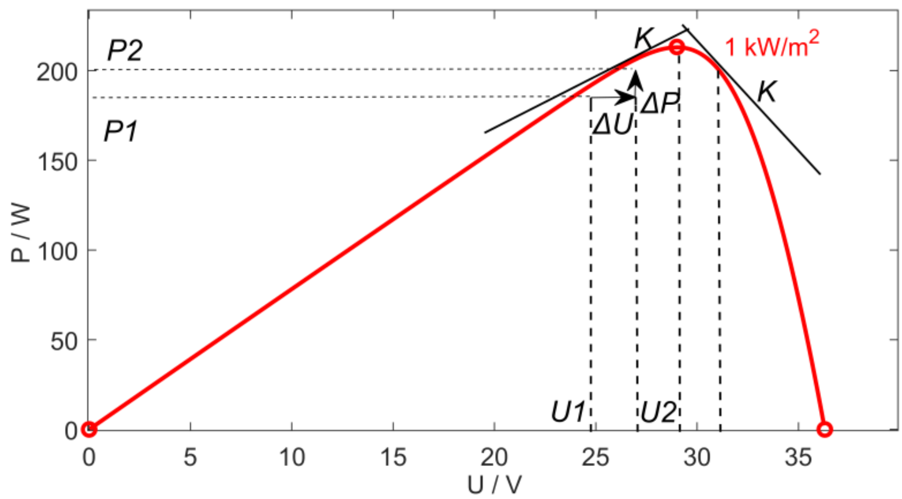


Figure 2. Schematic diagram of improved perturbation observation method

3. MPPT Control Strategy Simulation

In order to verify the effectiveness of the control effect of the improved perturbation observation method, Matlab/Simulink module respectively compares the perturbation observation method and the improved algorithm. The simulation model is built as shown in Fig 3.

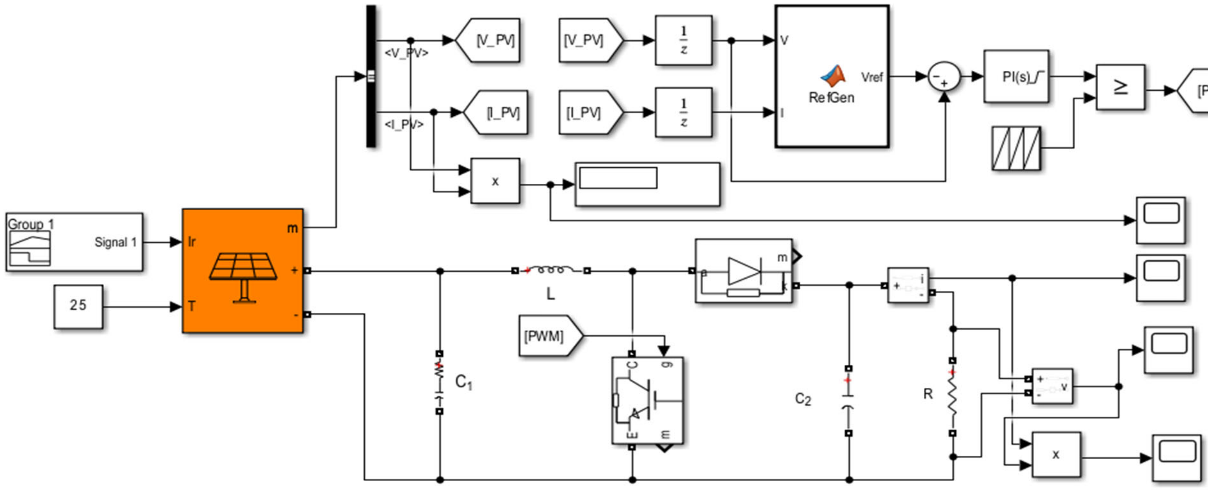
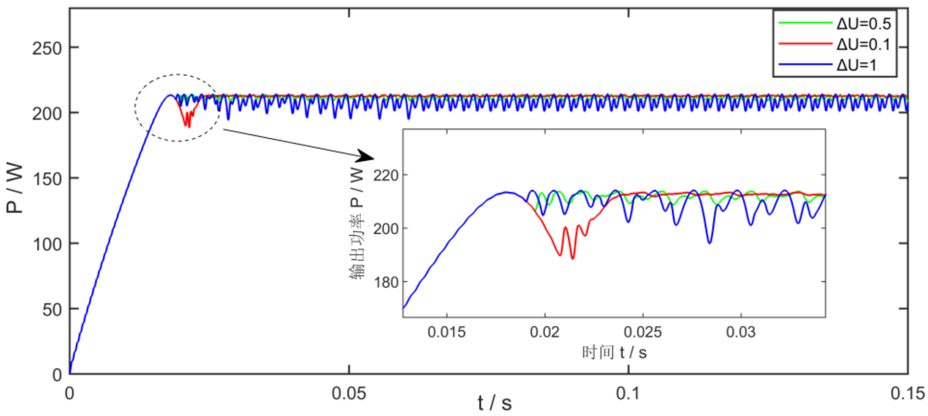


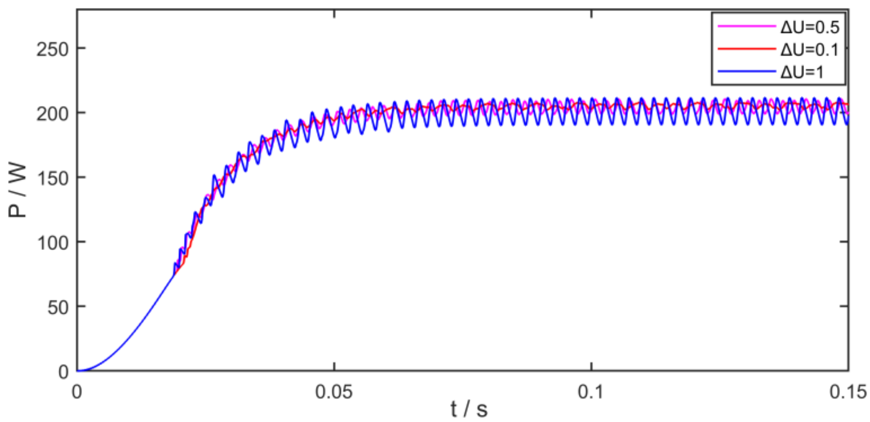
Figure 3. MPPT control policy simulation model

3.1. Influence of voltage disturbance step size on perturbation observation method

By analyzing the principle of perturbation observation method, it can be seen that too large perturbation step size will lead to system oscillation and affect the accuracy of the system, while too small step size will lead to too long search time of the system and cannot reach the maximum power point quickly. Therefore, under standard test conditions, step sizes Δ*U*= 0.2V, Δ*U*= 0.5V and Δ*U*= 1V were respectively taken to conduct simulation experiments of disturbance observation method. The system simulation time was 0.3 s, and the maximum power point tracking of non-synchronous long disturbance observation method was shown in Fig 4.



(a) Maximum power point tracking of photovoltaic cells



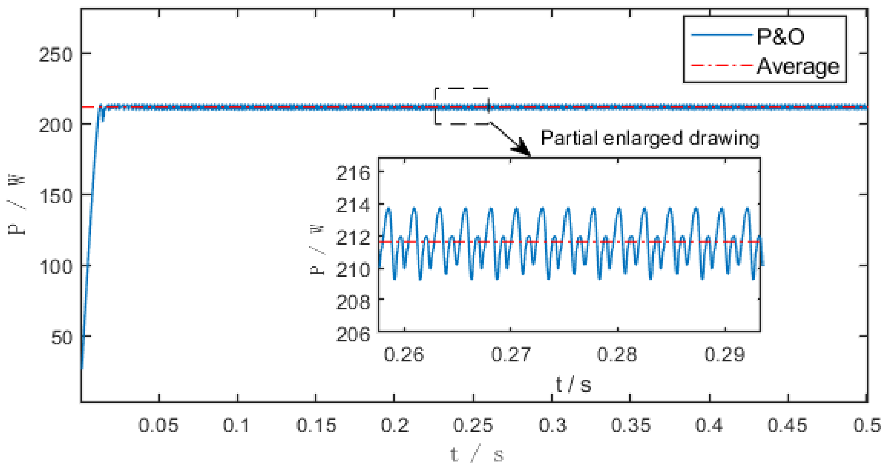
(b) The output power of the load

Figure 4. Tracing the maximum power point in an asynchronous period

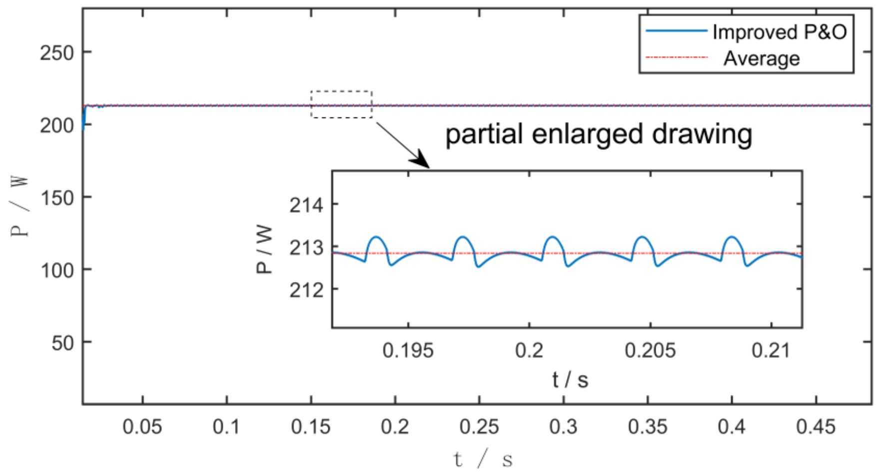
As can be seen from the figure 4, when the step length ΔU= 0.1V, the system will track the maximum power point at around 0.024s, which takes the longest time, but the oscillation amplitude is the smallest. The tracked maximum power is about 212.1 W, which is 0.6 W different from the theoretical maximum power point 213.1 W, and the conversion efficiency reaches 99.5%. When the step length ΔU= 1V, the tracking time is the shortest, the maximum power point is tracked at about 0.018s, the maximum power is tracked P= 214.1W, the minimum power is tracked P= 195W, and the amplitude of oscillation is large. When the step length ΔU= 0.5V, the system tracks the maximum power point at about 0.02s, and the oscillation amplitude is relatively small. The perturbation step size has great influence on the tracking accuracy and speed of the maximum power point, so it is necessary to select the appropriate perturbation step size according to the actual situation.

3.2. Simulation in static lighting mode

The perturbation observation method and the improved perturbation observation method were simulated respectively under standard conditions, and the tracking speed and tracking accuracy of the maximum power point of the two MPPT algorithms were compared. The initial search step size was 0.5, and the system sampling time was 0.5 s. The tracking of the maximum power point of photovoltaic cells obtained by simulation is shown in Figure 5. The maximum power point is tracked by the improved disturbance observation method at around 0.021s, and the maximum power point is tracked by the disturbance observation method at around 0.023s, with little difference in tracking time. However, through the data analysis of 0.2~ 0.4s after the maximum power point reaches stability, The improved perturbation observation method has smaller oscillation, and the tracked power is 212.496 W~213.235 W, while the tracked power is 209.211 W~213.753 W. The standard deviation of tracking power of the improved disturbance observation method is only 0.179, while the standard deviation of tracking power of the improved disturbance observation method is 1.245. The specific simulation data are shown in Table 1, indicating that the improved disturbance observation method system is more stable with smaller oscillation.



(a) Static simulation with perturbation observation method



(b) Static simulation with improved perturbation observation method

Figure 5. Simulation in static illumination mode

Table 1. Simulation data after the system is stabilized

MPPT(t=0.2 s~0.4 s)	Maximum (W)	Minimum (W)	Average (W)
P&O	213.753	209.211	211.614
Improved P&O	213.235	212.496	212.839

3.3. Simulation in dynamic lighting mode

Due to the complex and changeable working environment of photovoltaic cells, the illumination intensity may change abruptly under certain conditions. In order to prove the practicability of the improved perturbation observation method, dynamic illumination mode simulation is adopted. The simulation time of the system is set at 0.6s, and the illumination intensity is 1000 W/m^2. When the system tracks the maximum power point, the illumination intensity is suddenly changed to 600 W/m^2 at 0.3s. The tracking effects of the two algorithms are compared. The light intensity was changed from 1000 W/m2 to 600 W/m2 through Simulink Signal Builder module, and the maximum power point tracking diagram was obtained, as shown in Fig 6 and Fig 7.

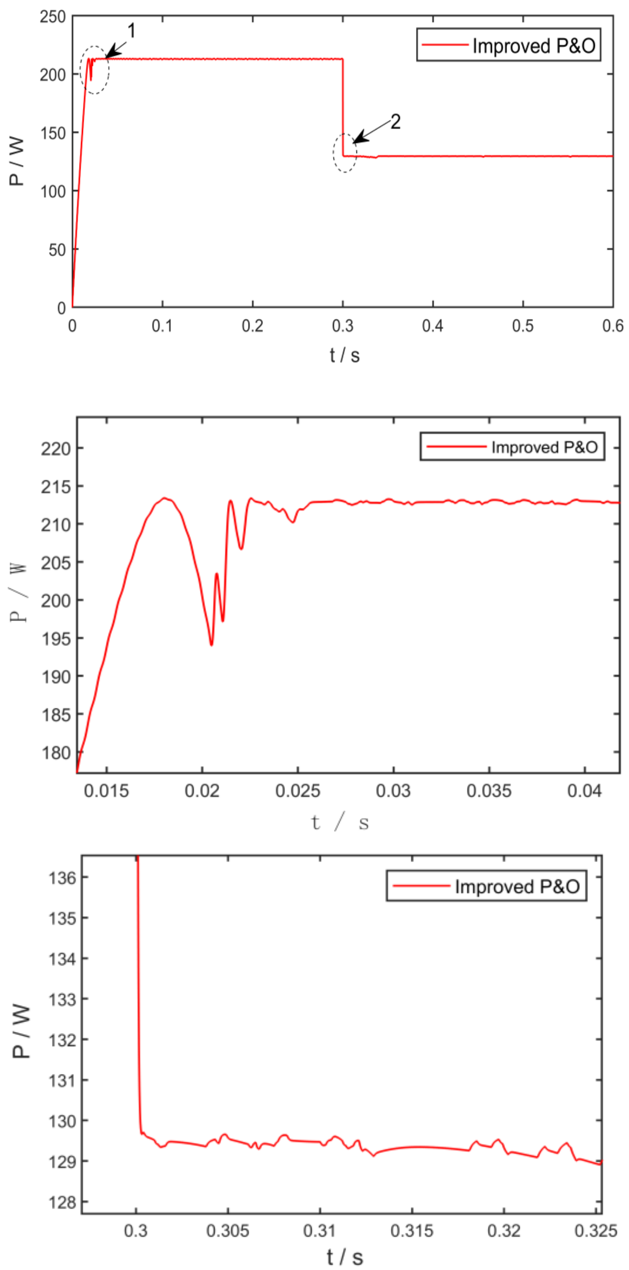


Figure 6. Tracking chart of improved perturbation observation method

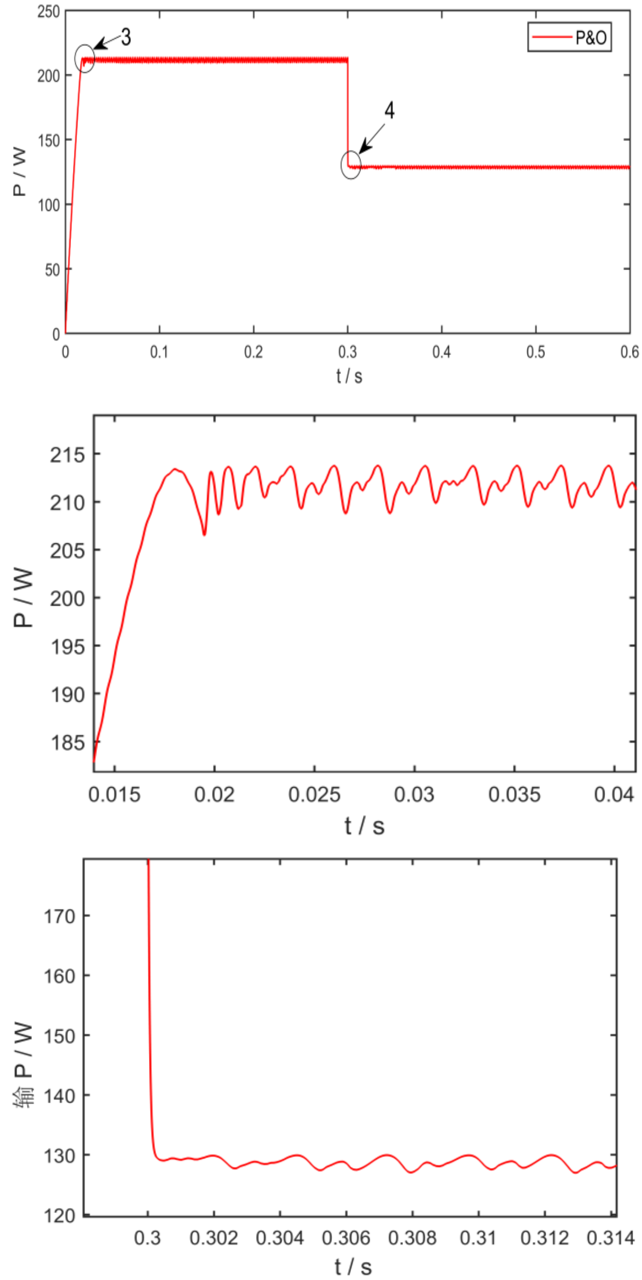


Figure 7. Tracking chart of disturbance observation method

According to the analysis in the figure, the maximum power tracking effect of the improved perturbation observation method is obviously better than that of the traditional perturbation observation method. When the maximum power point is stable, the system oscillation of the improved perturbation observation method is smaller and the output is more stable. When the illumination intensity suddenly changes to 600 W/m^2, the traditional perturbation observation method reaches the equilibrium at about 0.04 s, and the maximum power is stable at 129.1 W. The improved perturbation observation method has smaller oscillation, and the maximum power is stable at 129.7 W, which is less different from the theoretical value of 129.5 W.

4. Summary

Aiming at the problems of oscillation and misjudgment in traditional MPPT technology, the influence of voltage disturbance step size on the maximum power point tracking was studied. On this basis, an improved method based on the slope and space division of output characteristic curve was proposed. The simulation under static and dynamic lighting modes was carried out by Simulink. The average power of the perturbation observation method is 211.614 W, and that of the improved perturbation observation method is 212.839 W, with a difference of 0.311 W between the improved perturbation observation method and the ideal experimental value of 213.15 W. The experiment shows that the improved perturbation observation method has smaller oscillation and shorter tracking time.

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