Advances in Engineering Research, volume 123
2nd International Conference on Materials Science, Machinery and Energy Engineering (MSMEE 2017)

Research on Maximum Power Tracking Method of Photovoltaics

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Abstract: The research on photovoltaic power generation is an important part of clean energy .In order to improve its efficiency, this paper proposed an adaptive variable step - length hysteresis control method, based on the traditional MPPT control. The duty cycle disturbance step size is determined by analyzing the influence of light intensity on photovoltaic cells and the power characteristics near the maximum power point. The MPPT simulation model is built on the MATLAB / Simulink simulation platform and the algorithm is validated. The simulation results show that the algorithm can quickly track the output power of photovoltaic cells when the light is abruptly changed and effectively suppress the oscillation phenomenon near the MPP point, which proves the validity and correctness of the algorithm.

Keywords: photovoltaic power generation; MPPT; hysteresis control

1. Introduction

Nowadays, energy is becoming more and more limited. Meanwhile, solar energy impressed the public with its environmental friendly advantage. Photovoltaic power generation is the main way the people make use of solar energy. Photovoltaic cell is the essential part of solar energy transformation. The efficiency of photovoltaic cell transformation plays an important role in the way that people can utilize the solar energy. Many factors, such as temperature, illumination and the structure of photovoltaic cell will influence the energy transformation efficiency. However, MPPT technology would raise the solar energy transformation efficiency dramatically. The disturbance observation method, the conductance increment method and the short circuit current coefficient comparison method are still flaw.[1] In order to improve the imperfect, this paper provide a combination method based on the adaptive disturbance observation method and hysteresis comparison method. What's more, we make a comparison of the new and traditional methods to prove our methods is correct.

2 Principles of photovoltaic power generation

2.1 Photovoltaic power generation system circuit structure

The photovoltaic power generation system used in this paper mainly includes the photovoltaic cell module, the maximum power tracking module, the PWM module and so on.[2] The circuit is shown in Figure 1

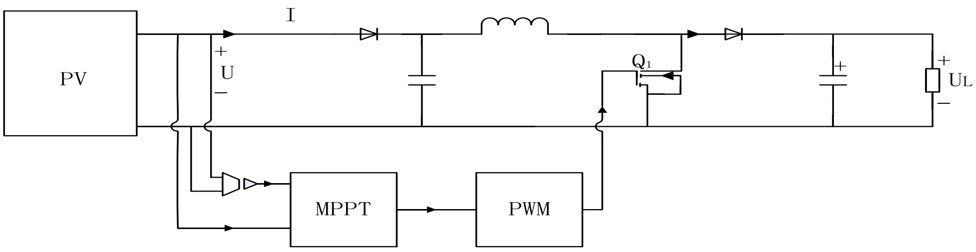

Fig. 1 Photovoltaic power generation system circuit structure

2.2 Photovoltaic battery equivalent circuit

How the photovoltaic cell works depends on the photovoltaic effect generated by semiconductor. Electron hole pairs are generated when we through light on semiconductor material. Electron hole pairs are separated in the influence of PN electric field. Electronics are moving to the N area and holes are moving to the P area As a result, Electric flow are generated because of the voltage in the external terminal. The equivalent circuit of single photovoltaic cell is shown in figure 2.

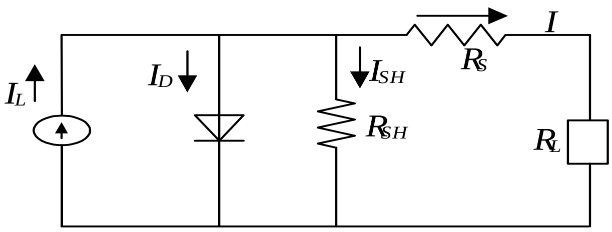

Fig. 2 Photovoltaic battery equivalent circuit

I_L is the photogenic current, its size will change with the intensity of light, so when the light intensity is constant, it can be seen as a constant current source. When the load R_L is connected, due to the presence of the photocurrent current, the voltage V will be generated at both ends of the load. On account of the adverse effects of load voltage, I_D is generated by the PN junction of the PV cell, which is in the opposite direction to the photogenic current.[3]

Mathematical models of engineering applications are generally more practical and accurate. Under the standard experimental conditions, the engineering mathematical model of photovoltaic cells is:

$$I = I_{SC}\{1 - C_t[\exp(\frac{U}{C_2 U_{OC}}) - 1]\} \tag{1}$$

After setting:

$$C_2 = \frac{\frac{U_m}{U_{OC}} - 1}{\ln(1 - \frac{I_m}{I_{SC}})} \tag{2}$$

$$C_t = (1 - \frac{I_m}{I_{SC}})\exp(-\frac{U_m}{C_2 U_{OC}}) \tag{3}$$

Including:

I_{SC} is the short circuit current;

U_{OC} is the Open circuit voltage;

I_m is the maximum current at the power point;

U_{m} is the voltage at the maximum power point;
P_m is the maximum output power.

2.3 Simulation model and result of photovoltaic cell

The output voltage and current are not constant and would change with different resistance, which means that different resistance have different voltage and current. We will draw the relationship of them as volt-ampere characteristic curve. We use MATLAB/Simulink to construct a simulation solar battery according to the physical character and practical model.The simulation is shown in Figure 3

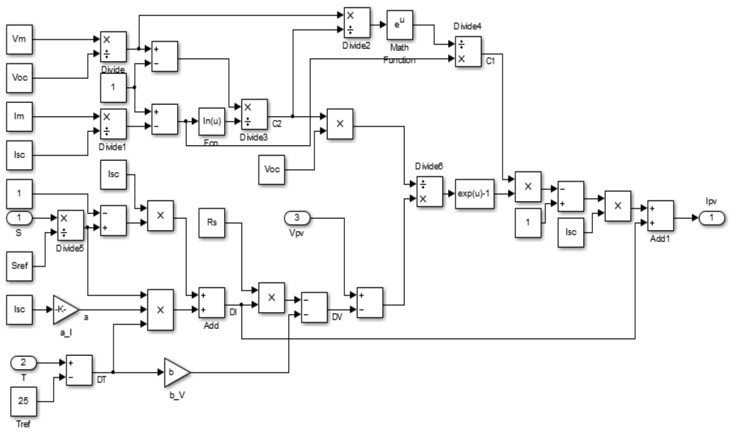

Fig. 3 Simulation model of photovoltaic cell

According to the above model, the photovoltaic cell model is simulated to obtain the output characteristic curves at different light intensities and different temperatures. The simulation results are shown in Fig. 4 and Fig. 5.

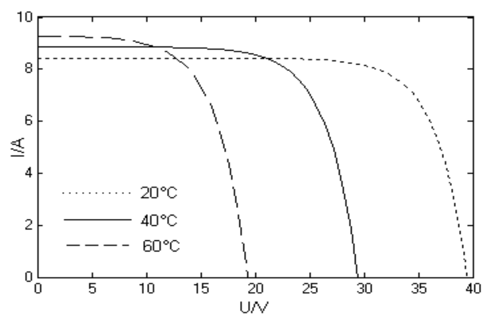

Fig. 4 U-I characteristic curve

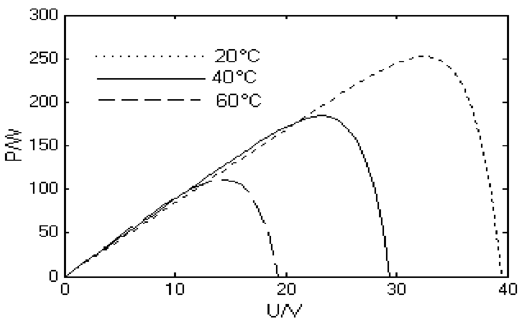

Fig. 5 U-P characteristic curve

From the simulation result we can see that the maximum power is increasing as illumination increasing and decreasing as temperature increasing. When the temperature of battery is stable, the short circuit current are highly correlated with illumination and would increase as illumination increase. When illumination is stable, the increase of temperature would decrease open circuit voltage and the shape of I-U curve would change. As a result, the energy transformation efficiency would decrease and would cause the drop of output current. Based on the simulation result, we can see that the models built on MATLAB/Simulink is correct.

3 MPPT control scheme

3.1 The traditional interference observation method

The traditional interference observation principle is as follows: PV system controller in each control cycle with a smaller step to change the output of the PV array, the changing step size is certain, the direction can be increased or reduced, the control object can be photovoltaic array output voltage or current, this process is called interference. And then compare the output power of the PV array before and after the interference period. If the direction of the reference voltage adjustment is correct, it can continue to interfere with the original direction. If the direction of the reference voltage adjustment is wrong, it needs to change the direction of the interference. In this way, the actual operating point of the PV array can be gradually close to the current MPP, and finally oscillates around the MPPT point.[4]

The traditional method adopts the modular control circuit, the sensor accuracy requirement is not high, the tracking method is simple and easy to implement, but the response speed is slow, the oscillation will be repeated in the vicinity of the maximum power point, resulting in a certain power loss.[5] And when the lighting conditions change violently, misjudgment phenomenon is easy to occur, seriously affect the tracking accuracy.

3.2 Hysteresis comparison method

The basic principle of hysteresis comparison is: when the power is in the set hysteresis, the photovoltaic cell operating point voltage remains unchanged, only when the power fluctuation exceeds the set hysteresis, that the work point can be changed in accordance with some certain laws. The specific working process is: set a current operating point a, according to the direction of perturbation interfere a step to point c, and then interfere two steps on the opposite direction to the point b. By measuring the power value of the 3 points, and making comparisons to determine the direction of disturbance.[6] The possible results are shown in figure 6.

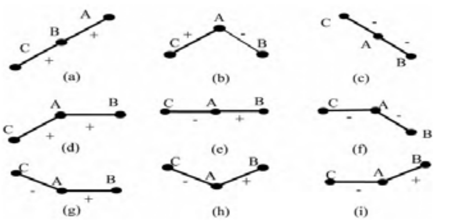

Fig. 6 Power relationship schema

From the relationship we can see that hysteresis comparison ues two-way perturbation to ensure the reliability of the disturbance to avoid errors, effectively suppress the phenomenon of misjudgment.

3.3 MPPT Control Method Based on Adaptive Duty Cycle and Hysteresis Control

The principle of duty cycle disturbance control method is based on the relationship between the DC / DC converter duty cycle and the output power of the photovoltaic cell curve. Make comparisons of current power and the previous time power phase through a certain duty cycle of the disturbance. The position of the current operating point and the increase or decrease in the duty cycle of the DC converter at the next time can be determined by the direction of power change.

When using the duty cycle control, we can increase the tracking speed by setting the initial duty cycle value, and use the stepwise approach to search for the maximum power point. When reaching near the maximum power point, we need small perturbation, so the invariant factor should be set small. This method avoids the system oscillation due to the excessive disturbance step and the tracking efficiency is improved.

3.4 Simulation verification

In the matlab simulation environment, we build the simulation platform in order to better make comparison of traditional method and interference observation with MATLAB/Simulink. As we all know, the change of environment could heavily influence the experiment result. In order to the make our result convincing and have a better understanding of what would happen under sudden environment change, we simulate the sudden change of both illumination and temperature. When the temperature is 25C, at 0.1s, the illumination raises from 1000W to 1200W, and the maximum output is shown as figure 7. When the illumination is 1000W, the temperature increase from 25C to 35C and the maximum output is show as figure 8.

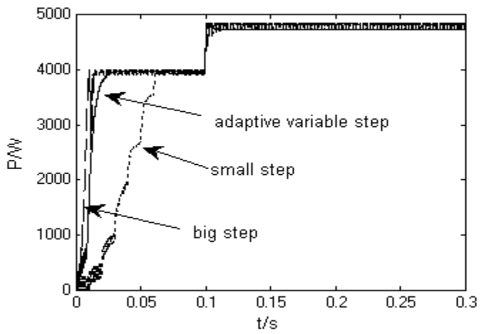

Fig. 7 Light intensity change

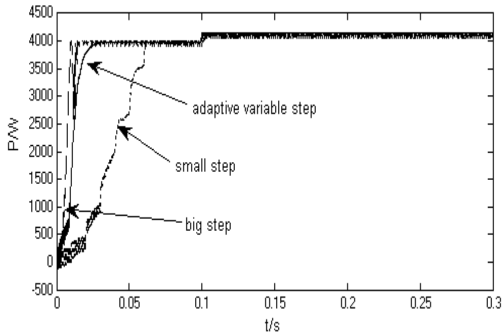

Fig. 8 Temperature change

From the simulation result we can see that when we use traditional Fixed - length perturbation observation method, when the step is big, the maximum output is generated at 0.015s. When the stop is small, we reach the maximum output at 0.06s. However, when the system is highly unstable and with increasing step, the faster the trace speed, the more turbulence it would be and more energy are wasted. When we utilize the improved tracing method, at 0.03s, we get the maximum output and could quickly reach the stable status. We prove the our algorithm is correct based on the experiment result.

4 Conclusion

This article introduced the concept of hysteresis based on the adaptive duty cycle disturbance observation method and provide a new MPPT control method. Based on the simulation result we can see that our method have some advantage in that it can quickly trace the maximum power point and can prevent system unstable and wrong judgement. What's more, our system can quickly get the maximum power point even under sudden environment change.

5 References

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