Research on MPPT Control Strategy Based on Improved Perturbation Observation Method

Dashuang Li*

Hechi University, Hechi, China

lidashuang520@126.com

*Corresponding author

Keywords: Perturbation Observation, Control Strategy, MPPT, Steady-State Accuracy

Abstract: Aiming at the problems of dynamic response and steady-state accuracy of traditional perturbation observation method,a composite MPPT (maximum power point track)control strategy combined of perturbation observation method and variable step size perturbation observation method is proposed. The variable step size perturbation observation method is used at high light intensity and low temperature, the perturbation observation method is used at low light intensity and high temperature. The simulation model of MPPT is established in Matlab / Simulink. The simulation results show that the composite MPPT control strategy not only starts rapidly, but also responds quickly and has high steady-state accuracy when the external environment changes abruptly compared with the traditional perturbation observation method.

1. Introduction

Solar energy is a kind of clean energy and an important part of the world's energy. The output characteristics of photovoltaic cells in v-generation system are affected by their own characteristics and the light intensity, ambient temperature and load. In order to improve the efficiency of photovoltaic power generation system and maximize the use of solar energy, the maximum power tracking technology (MPPT) is used in photovoltaic power generation system [1]. The MPPT module of photovoltaic power generation system consists of photovoltaic cell array, MPPT algorithm, pulse width modulation module, DC / DC converter and other modules [2]. At present, the commonly used MPPT methods include constant voltage method, disturbance observation method, conductance increment method, hysteresis comparison method, fuzzy control method and neural network method [3-7]. In this paper, a composite MPPT (maximum power point track) control strategy combined of perturbation observation method and variable step size perturbation observation method is proposed. The variable step size perturbation observation method is used at high light intensity and low temperature, the perturbation observation method is used at low light intensity and high temperature. In the start-up stage of MPPT control, the fast speed of constant voltage method is used to locate the vicinity of the maximum power point, and then the variable step perturbation observation method is adopted for accurate location.

2. Photovoltaic cell modeling

2.1 Photovoltaic cell circuit model

The external characteristic model of photovoltaic cell can be regarded as a parallel circuit of a constant current source and a forward diode. The equivalent circuit model of photovoltaic cell is shown in Figure 1.

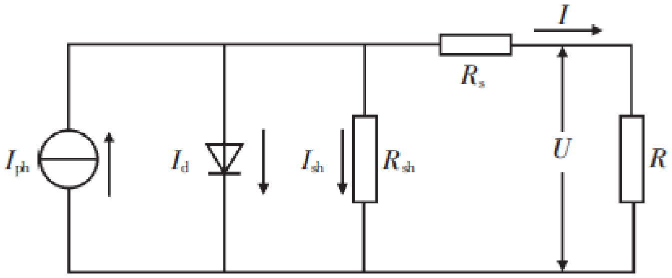


Figure 1. The equivalent circuit model of photovoltaic cell.

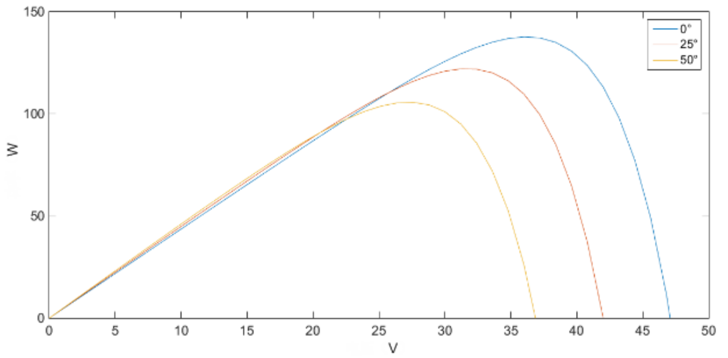
The I-U relationship of PV cell is shown in formula (1):

$$I = I_{ph} - I_0 \left\{ \exp[\frac{q(I_L \bullet R_s + U)}{AKT} - 1] \right\} - \frac{(I_L \bullet R_s + U)}{R_{sh}} \quad (1)$$

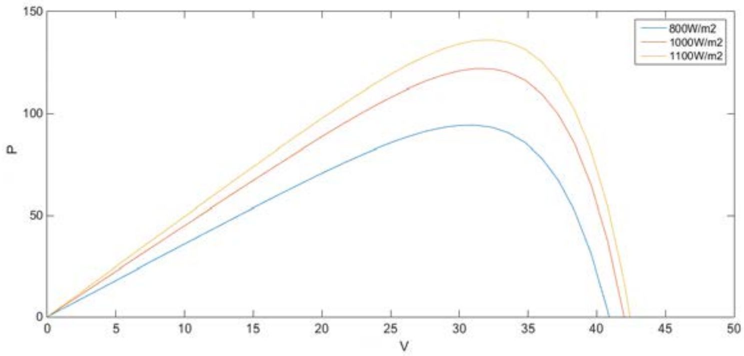
where I is the output current of photovoltaic cell (A), I_{ph} is the photocurrent (A), I_0 is the reverse saturation current (A), R_s is the equivalent series resistance(Ω), R_{sh} is the equivalent side leakage resistance(Ω), A is the diode factor, q (electronic charge) =1.6×1019C, K (Boltzmann constant) =1.38×10-23J/K, T is the absolute temperature(K).

2.2 Output characteristic curve of photovoltaic cell

The photovoltaic module model is built on the MATLAB / Simulink platform and set the relevant parameters: U_{OC}=42V,U_m=34V,I_{SC}=4.5A,I_m=3.5A. The output characteristic curve of P-U under different light and temperature conditions can be obtained, as shown in Figure 2. It can be seen from Figure 2 that any temperature and light will correspond to a single peak curve. This peak point (U_m) is the MPPT point, which will correspond to a voltage value. To achieve maximum power output at any time, photovoltaic modules need to track the peak point of the curve. Therefore, it needs to be realized by MPPT technology.



(a) PV characteristic of temperature change

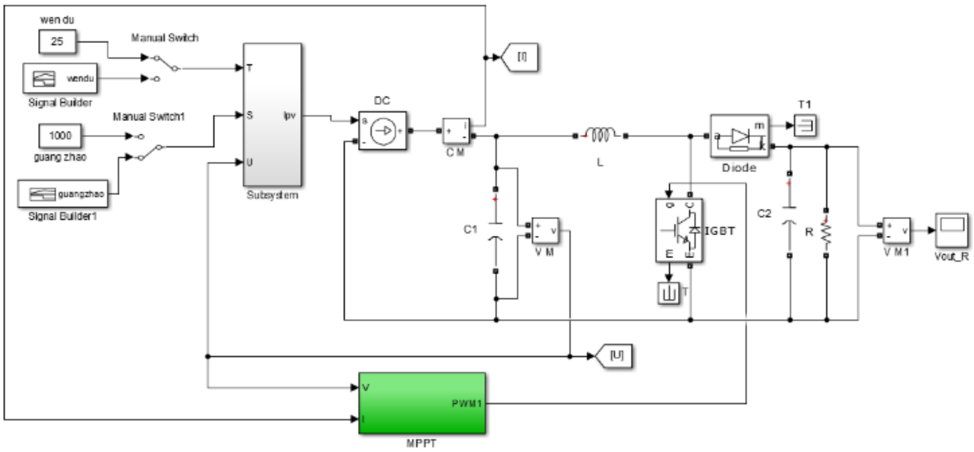


(b) PV characteristic of light change

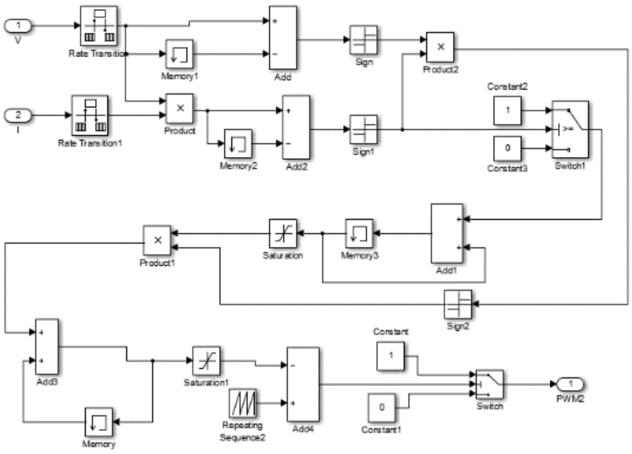
Figure 2. Output characteristic curve of PV module under the condition of temperature and light change.

3. Analysis of traditional MPPT control method

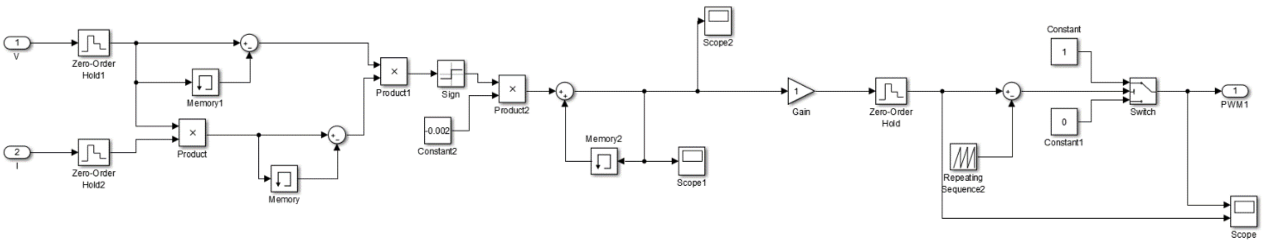
In order to study the maximum power tracking of photovoltaic power generation system with perturbation observation method [8] and variable step size perturbation observation method [1], a simulation model as shown in Figure 3 is built according to the control logic of the two control methods. The simulation model consists of signal generator module, photovoltaic cell module, boost circuit module, MPPT control module using perturbation observation method and variable step size perturbation observation method. The temperature and light signals are simulated by the signal generator, and the voltage and current are obtained by the photovoltaic cell. The maximum power is tracked in the MPPT control method module, and the output voltage of the boost converter is controlled by the conduction ratio of the IGBT.



(a) photovoltaic power generation system.



(b) Variable step size perturbation observation model.



(c) Perturbation observation model.

Figure 3. Simulation model of MPPT photovoltaic power generation with traditional methods.

In the photovoltaic cell simulation model, the s = 1000W/m^2, T = 25°C, U_m=34V, Im=3.5A, the theoretical maximum power P_{max} = 119W. In the next paper, the maximum power tracking of photovoltaic power generation system is observed through two situations of constant light, temperature change and constant temperature, light change.

Case 1: The temperature is constant T = 25°C, the light intensity is set to 800W/m^2,1000 W/m^2,1100 W/m^2 at 0s, 0.2s and 0.4s. The maximum power tracking of two simulation algorithms is shown in Figure 4.

According to the simulation results in Figure 4, the maximum power tracking effect of perturbation observation method is better than variable step size perturbation observation method at 0s - 0.2s. However, the maximum power tracking effect of variable step size perturbation observation method is better than perturbation observation method and is no obvious fluctuation after 0.2s.

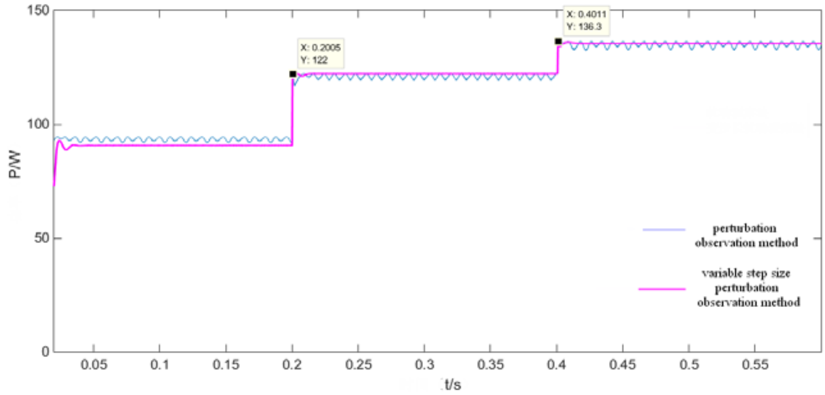


Figure 4. Comparison of maximum power

tracking of *two* control methods under different illumination.

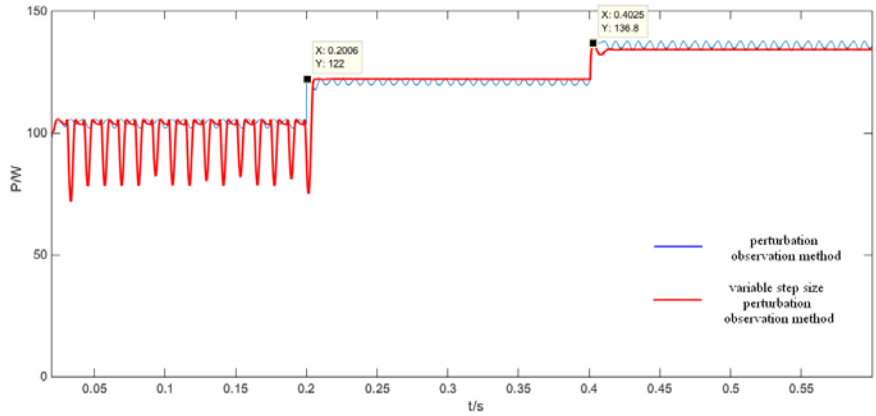


Figure 5. Comparison of maximum power tracking of two control methods under different light intensity.

Case 2: The light intensity is constant s = 1000W / m^2, the temperature is set to 50°C,25°C ,0°C at 0s, 0.2s and 0.4s. The maximum power tracking of two simulation algorithms is shown in Figure 5. According to the simulation results in Figure 5, the maximum power tracking effect of perturbation observation method is better than variable step size perturbation observation method and is more stable at 0s - 0.2s. However, the maximum power tracking effect of variable step size perturbation observation method is better than perturbation observation method and is no obvious fluctuation after 0.2s.

It can be seen from Fig. 4 and Fig. 5 that the maximum power tracking effect of variable step size perturbation observation method is better at high light intensity and low temperature, and the maximum *power* tracking effect of perturbation observation method is better at high temperature and low light intensity.

4. Analysis of improved disturbance observation MPPT method

It can be seen from the simulation analysis in the third section that the maximum tracking effect is not optimal when the perturbation observation method and the variable step size perturbation observation method is used separately. In this paper, an improved MPPT control method combined of perturbation *observation* method and variable step size perturbation observation method is proposed. The improved MPPT control method switches the control method according to different light intensity and temperature, that is, the method of variable step size perturbation observation method is selected when the light intensity is greater than 1000 W / m^2 and the temperature is lower than 25°C and the method of perturbation observation method is selected when the light intensity is less than 1000 W / m^2 and the temperature is higher than 25°C. Based on the improved control method, the simulation model is shown in Figure 6.

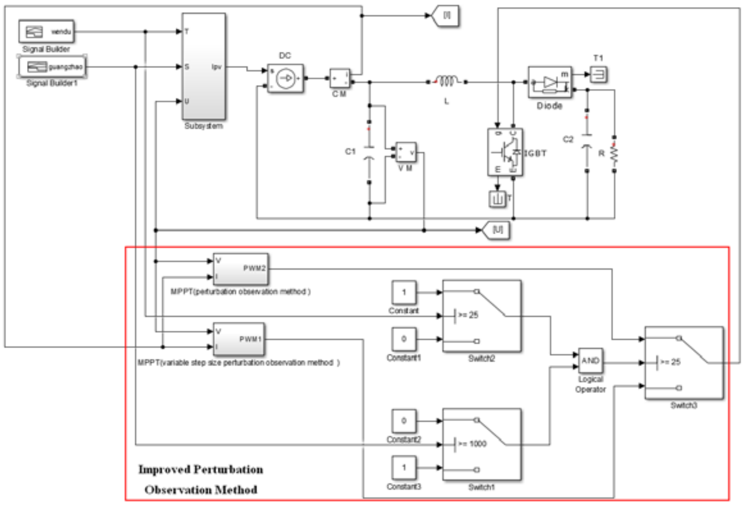


Figure 6. Simulation model of improved MPPT control method.

Case 1: The *temperature* is constant T = 25°C, the light intensity is set to 800W/m^2,1000 W/m^2,1100 W/m^2 at 0s, 0.2s and 0.4s. The maximum power tracking comparison of improved MPPT control method and variable step size perturbation observation method is shown in Figure 7.

According to the simulation results in Figure 7, the improved control method can track the maximum power point more *accurately* when the illumination is 800 W/m^2at 0s-0.2s. Then the system switches to the variable step size perturbation observation method at 0.2s, and can track the maximum power quickly and smoothly.

Case 2: The light intensity is constant s = 1000W / m^2, the temperature is set to 50°C,25°C ,0°C at 0s, 0.2s and 0.4s. The maximum power tracking comparison of improved MPPT control method and variable step size perturbation observation method, perturbation observation method is shown separately in Figure 8 and Figure 9.

According to the *simulation* results in Figure 8, the improved control method can track the maximum power point more smoothly and accurately when the light intensity is 50°C at 0s-0.2s. Then the system switches to the variable step size perturbation observation method at 0.2s, and can track the maximum power quickly and smoothly.

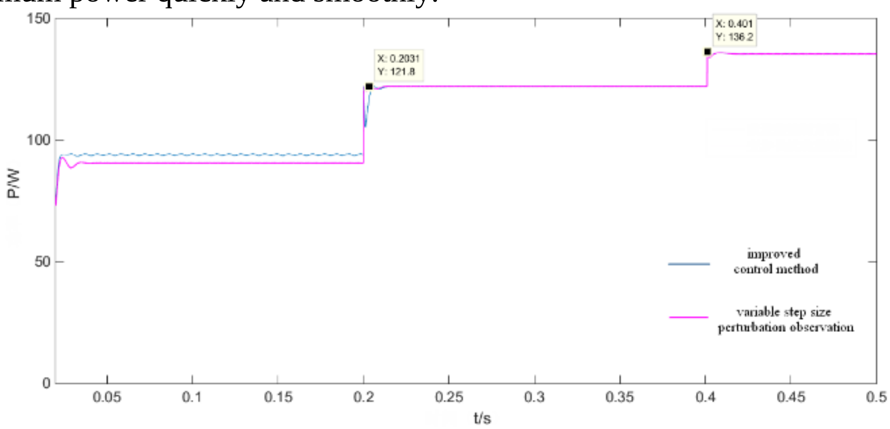


Figure 7. Comparison of maximum power

tracking of two *control* methods under different illumination.

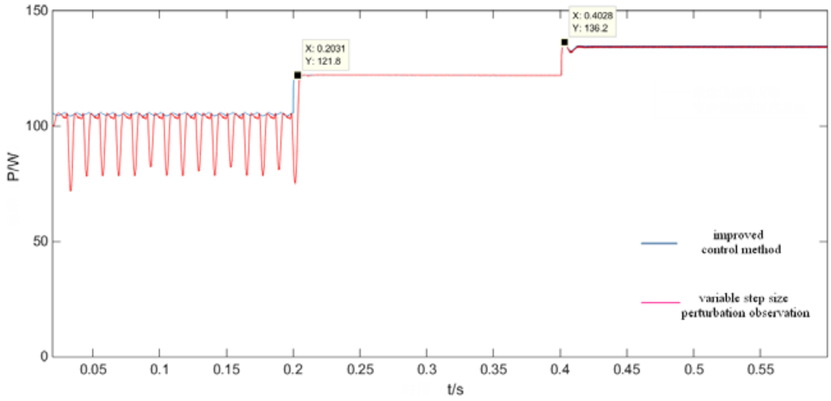


Figure 8. Comparison of maximum power tracking of two control methods under different light intensity.

It can be seen from the simulation results in Figure 7, Figure 8 that the improved MPPT control method can *better* make up for the defects of the two control strategies used separately in high temperature, low light intensity or high light intensity and low temperature, and improve the generation efficiency of photovoltaic power generation system and the accuracy of maximum power tracking.

5. Conclusion

To solve the problems of dynamic response and steady-state accuracy of traditional perturbation observation method of photovoltaic power generation system, an improved MPPT control method combined of *perturbation* observation method and variable step size perturbation observation method is proposed. The feasibility and effectiveness of the proposed method are verified by building a simulation model in Matlab / Simulink platform.

Acknowledgments

This work was *financially* supported by Young and middle-aged teachers' basic scientific research ability improvement project of Guangxi University fund(2019KY0620).

References

[1] Rong Desheng,Liu Feng. Application of Improved Perturbation and Observation Method to Photovoltaic MPPT[J]. Proceedings of the CSU-EPSA, 2017,29(03):104-109.

[2] Xu Xiaochun, Liu Chunsheng, Li Feng. Improved fuzzy control on MPPT method of solar system [J]. Proceedings of the CSU-EPSA,2014,26(9):81-84.

[3] Hang Feng-hai1, Yang Wei, Zhu Wen-yan. Analysis and improvement of MPPT disturbance observer method for PV system[J]. Power System Protection and Control, 2014,42(09):110-114.

[4] Wang Hong-bo1, Xiao Yao, Xiao Ren-jun, Chen Xin, Ding Hao-tian. Photovoltaic MPPT based on improved voltage perturbation method[J]. Power Technology, 2019,43(11):1847-1851.

[5] Su You-gong, Wang Da-cheng, Wang Yi, Jiang Fan. Simulation of MPPT Control Strategy Based on Improved Variable Step Conductance Increment Method[J]. Control Theory and Applications, 2019,38(10):11-15.

[6] Zhang Wei, Wang Yang, Ni Hao, Liang Yuan-ran. Research of MPPT double fuzzy adaptive disturbance observer method for PV system[J]. Power Technology, 2019,43(09):1520-1524.

[7] Wang Zhendao,Guo Jingxun,Xiao Wang. Photovoltaic System MPPT Algorithm Based on Adaptive Radial Basis Function Neural Network[J]. Journal of Hunan University (Natural Sciences), 2019,46(10):96-100.

[8] You Yi-long, Huang Ke-ya, You Feng-xiang. A Comparative Studyonthe Typical MPPT Control Method for Photovoltaic System[J]. Scientific and Technological Innovation, 2013(20):115-117.