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Simulation study on maximum power tracking technology of photovoltaic power generation system in three-dimensional coordinate

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Abstract. Solar has great potential to become the main source of energy for the future. The maximum power tracking control technology referred to as MPPT technology is the core technology of the photovoltaic power system and its research can not only improve the efficiency of the system, but also reduce operating costs. Firstly, the functional principle and algorithm classification of the maximum power tracking technology (MPPT) of photovoltaic power generation system are classified. Then, based on the simulation of MPPT technology based on MATLAB, a simulation is carried out to consider two factors. Three-dimensional map for simulation analysis, the maximum power tracking technology of photovoltaic power generation system was simulated. Through the analysis of the simulation results show that the output power of photovoltaic power generation system is affected by temperature and light intensity.

Key words. Photovoltaic power generation, maximum power tracking technology (MPPT), dimensional drawing ,three-dimensional figure..

1. Introduction

In recent years, environmental pollution has become the focus of attention. Photovoltaic power generation as an important part of solar energy utilization, in the world has been highly valued and made great progress[1]. However, the current photovoltaic power generation system is low efficiency, high cost, which still restricts large-scale photovoltaic power generation applications. In order to maximize the efficiency of the solar cell, make the solar cell module in any case the maximum output power, improve the efficiency of solar energy, shorten the system cost recovery cycle,

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the photovoltaic power generation system needs to be subject to maximum power tracking (MPPT) control[2].

There are 5 common MPPT technical methods: constant voltage tracking (CVT) method, disturbance observation method, conductance increment method, fuzzy logic control method and neural network control method. Based on MPPT technology, the influence of temperature and light intensity on the output power of PV power generation system is analyzed by using Matlab to simulate the photovoltaic power generation system.

2. Methods of MPPT Technique Classification

2.1. Constant voltage tracking (CVT) method

This is a simplified MPPT voltage control method.By adding a certain impedance in the photovoltaic cell array, the user and other loads to achieve the transformation, the system becomes a voltage regulator, constitute the CVT-type MPPT control[3].As shown in Fig. 1, the I-V and P-V characteristic curve of the photovoltaic device in the case of different temperatures can be seen.

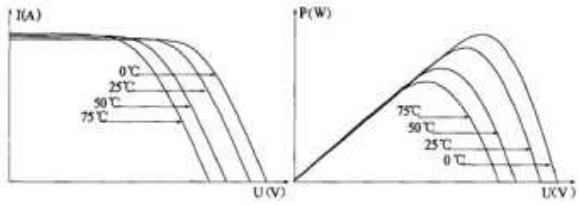

Fig. 1. I-V, P-V characteristic curves for different temperatures

The advantages of constant voltage tracking method:

(1)It is simple to control, easy to implement, it has high reliability;(2)Its system will not appear oscillation and stability is higher;(3) It is easy and easy to implement through hardware.

The disadvantages of constant voltage tracking method:

(1)Its control accuracy is poor, power loss suffered heavy, especially in the external environment changes in the region; (2) Since the change in external conditions is difficult to predict, good operation must be carried out by manual intervention.

2.2. Disturbance observation method (P & O method

The P & O, Perturbation and Observation method is the most commonly used and easy MPPT control algorithm[3]. The method is to determine the position of the maximum power point by constantly disturbing the operating point voltage. This method does not directly detect changes in the external environment and other factors, but directly according to the system to measure the size of the voltage and current, and then directly calculate the power size, in order to determine the

maximum power point position. Fig. 2 is the algorithm Model of Disturbance Observation.

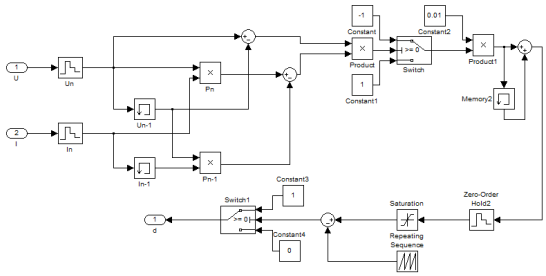

Fig. 2. The algorithm model of disturbance observation

The advantages of perturbation observation are:

(1) Its modular control loop is simple;(2) Its tracking algorithm is simple, less measured parameters, easy to control;(3) It is not demanding on the sensor accuracy.

The shortcomings of the disturbance observation method are:

(1)The disturbance will cause loss of output power at the MPP point;(2) The disturbance step determines the tracking accuracy and speed. When the step size is small, the tracking speed is improved, the accuracy is low, the stability is also low, the steady state is easy to oscillate;(3) Tracking accuracy is affected by the change in light intensity.

2.3. Conducting incremental method

This method is based on the relationship between the voltage and power output by the photovoltaic device, so as to derive the change of conductance and instantaneous conductance, so as to realize the tracking of the maximum power point[4]. This method is by comparing the output conductance of the amount of change and the size of the instantaneous conductivity to determine the direction of the reference voltage changes, the following situation to be analyzed:

(1) Assuming that the operating point of the current PV array is on the left side of the maximum power point, that is $dI/dU > -I/U$, indicating that the reference voltage should be changed in an increasing direction.

(2) Similarly, assuming that the current PV array operating point is located on the right side of the maximum power point, that is $dI/dU < -I/U$, indicating that the reference voltage should be reduced in the direction of change.

(3) Assuming that the operating point of the current PV array is at the maximum power point (near), that is $dP/dU = 0$, indicating that the reference voltage will remain unchanged, i.e .the PV array will operate at the maximum power point.

The difference between the conductance increment method and the disturbance observation method is that the difference between the measurement parameters and the logic judgment formula is very similar. Obviously, the conductivity incremental method by changing the size of the output voltage, and constantly adjust the logic judgment, can reduce the stability of the system at the point of shock, compared

with the disturbance observation method, more able to adapt to the light intensity and temperature and other external conditions that changes in the situation of large fluctuations. Fig.3 is the algorithm model of perturbation observation method

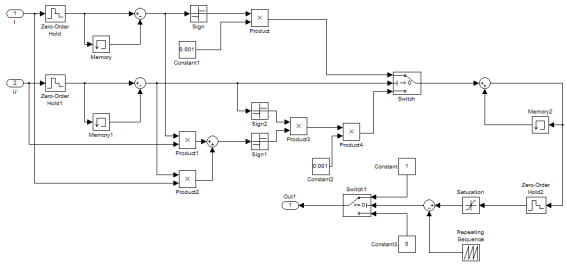

Fig. 3. The algorithm model of perturbation observation method

The advantages of the conductance increment method are:

(1) Its voltage fluctuation is small;(2) Its control accuracy and stability is high;(3)The system still has good tracking performance in the case of rapid environmental conditions.

The disadvantage of the conductance increment method is:

(1) Its control algorithm is relatively complex;(2) Its response to hardware and system requirements are higher;(3) The fixed change step cannot take into account the system's maximum power point tracking accuracy and response speed.

2.4. Fuzzy logic control method

Fuzzy logic control method to use some of the fuzzy processing to track the maximum power point is more idealized[4]. Fuzzy logic control method is based on fuzzy logic MPPT control method, the implementation of the algorithm include: fuzzy, fuzzy rules and anti-fuzzy fuzzy operation. Fuzzy control of the fuzzy processing makes the system can always output the maximum power, and can make the system in the MPP point of the shock amplitude is smaller. It has excellent dynamic and steady state performance Fi.4 is a block diagram of MPPT fuzzy control simulation.

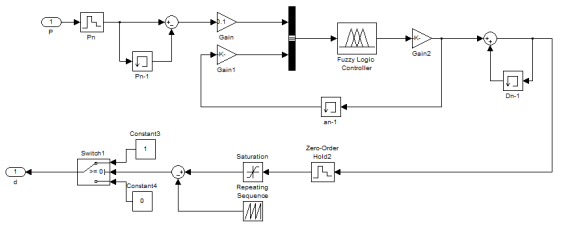

Fig. 4. MPPT fuzzy control simulation

The advantages of fuzzy logic control method are:

(1) it does not need to establish a precise mathematical model for the control

object;(2) it has good dynamic and steady-state performance, tracking speed, it is close to the maximum power point when the small fluctuations.

The shortcomings of the fuzzy logic control method are:

(1) its algorithm is complex;(2) the setting of its algorithm variables depends to a large extent on the designer's experience.

2.5. Neural network control method

Neural network method is based on the neural network and developed MPPT technology control method. The neural network structure generally includes the input layer, the output layer and the hidden layer of the three layers of neurons. The difficulty and complexity of solving the problem are determined by the number of layers and complexity of the neural network structure. When it is applied to a photovoltaic array, the input signal can be a parameter or a factor such as light radiation, temperature, etc., or other complex parameters. The output signal can be open circuit voltage U_{oc}, short circuit current I_{sc} and other photovoltaic array output signal, duty cycle and other parameters [5].

The neural network has a strong ability to adapt to the environment, and has the characteristics of black box learning mode in modeling. But after learning is complete, the relationship from the input / output data cannot be expressed in a way that is easy to accept.

The advantages of the neural network control algorithm are:

(1) it can match a variety of patterns after training;(2) it has flexibility and adaptability.

The shortcomings of the neural network control algorithm are: for different photovoltaic systems, it requires a longer training time.

3. Research on MPPT Simulation Based on Matlab

The output power of the solar PV system is unstable and difficult to control due to the influence of many factors such as outside. There are many factors that affect the power output of solar photovoltaic power generation system. The main influencing factors are solar intensity, component temperature and solar photovoltaic cell conversion efficiency. This paper considers only two main factors: solar radiation intensity and temperature.

3.1. Simulation analysis of the influencing factors

3.1.1 Simulation analysis of temperature influence

Under normal circumstances, the temperature of the photovoltaic cell has a certain influence on the conversion efficiency of the photovoltaic cell and is inversely proportional to the conversion efficiency. And high temperature will reduce the conversion efficiency of photovoltaic cells. The temperature rise of 1 degree Celsius crystalline silicon cell output voltage is reduced by about 0.5%, so try to ensure that the battery board installed after the air flow up and down to achieve the lowest pos-

sible temperature. The temperature inside the solar cell is generally not higher than the ambient temperature. The temperature of the solar cell running in the century is determined by a number of parameters. Generally, the internal temperature of the battery is equal to the ambient temperature[6].

First, when the intensity of light irradiation is 230, the temperature and power size data of 13 points are taken at equal intervals, and a single two-dimensional graph is drawn by coordinate method, as shown in Fig. 5:

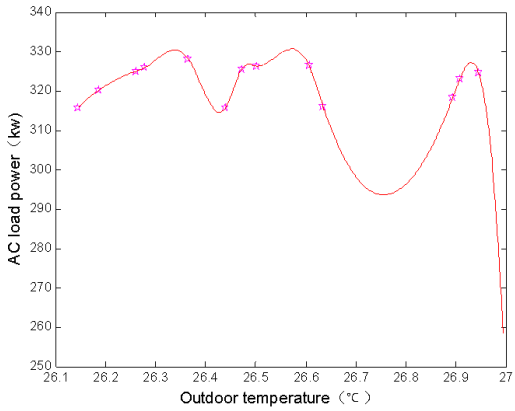

Fig. 5. Under a radiation condition, the power and temperature dimensional map

It can be seen from Figure 5, the outdoor temperature changes on the photovoltaic power generation system output power have a certain impact, from the two-dimensional figure shows that the same light in the case of radiation, the higher the temperature, the output power first rise and then flat, and then exponentially increased. And in the case of high temperature, the output power of the rising trend is relatively slow.

After that, the influence of temperature and power under different radiation conditions was studied by two methods, as shown in Fig. 6 and Fig.7:

As can be seen from Fig. 6 or Fig. 7, the power generation power varies with the fluctuation of the intensity of the solar radiation. When the area of the battery pack is determined, the output current thereof is proportional to the solar irradiation intensity. So when the solar radiation intensity increases, the photovoltaic power generation system output power will increase.

3.2. Simulation analysis of two influencing factors

Use Matlab to simulate the power of photovoltaic systems and temperature, light intensity of the relationship, as shown in Figure 8:

It can be seen from Fig. 8 that the output power is the largest when X = 25.94, Y = 293.6, Z = 351.8kw; the output power is the smallest when X = 11.88, Y = 18.99, Z = 140.7kw. The output power of the PV system is affected by the temperature and light intensity, and is affected by two factors. When the temperature is low and

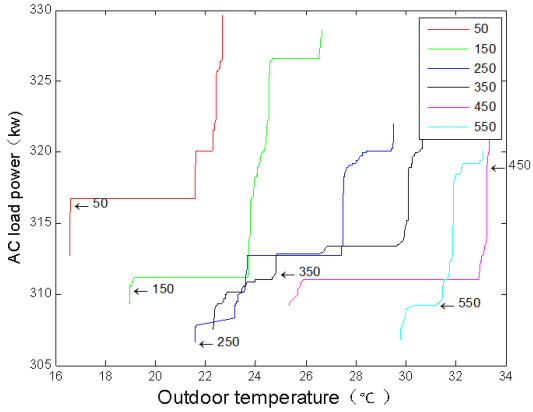

Fig. 6. Method 1 under different radiation conditions under the power and temperature dimensional map

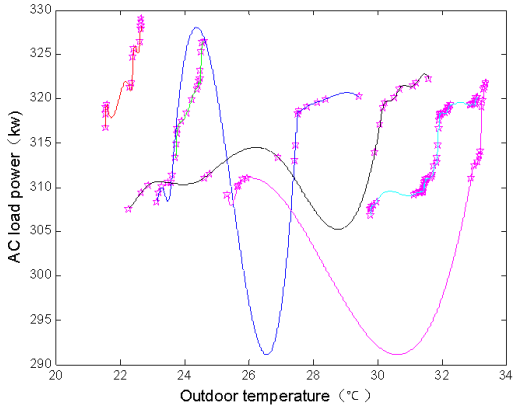

Fig. 7. Method 2 under different radiation conditions for both power and temperature map

the light intensity is low, the power is low and the fluctuation is large. In the case of high temperature, high light intensity, the power is also low. When the temperature and light intensity are in the middle of the appropriate value, but too low, but too high, the output power of the fluctuations are more gentle, stable power in about 310kw, and the temperature of 25.9 ℃, light intensity of 293.6, the maximum output power of 351.8kw.

4. Conclusion

This paper describes the functions and principles of several MPPT control technologies. They have their own advantages and disadvantages, the control method,

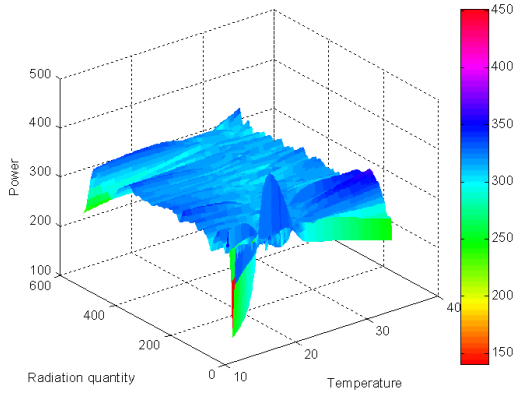

Fig. 8. Power and temperature, light intensity three-dimensional map

the disturbance observation method and the conductance increment method is the traditional control method, the disturbance observation method is more accurate and the stability is not high. Conductivity increment method is better, but the accuracy is worse than the disturbance method. The fuzzy logic control method and the neural network control method belong to the new intelligent control method. The fuzzy algorithm is more complicated, but the fast dynamic stability is good, and the neural network method is flexible and the adaptive ability is strong, but the speed is slower. These methods have their own advantages and disadvantages, each with its own use.

Based on the basis of MPPT technology, the simulation of PV system is carried out by using MATLAB software. The effects of temperature and light intensity on the power and the influence of two factors on the output power are considered respectively. Two - dimensional curve and three - dimensional surface map are drawn. The results show that the output power of photovoltaic power generation system is affected by temperature and light intensity, and increases with the increase of temperature and decreases with the increase of light intensity in a certain range. And, by the unity of the two factors, the temperature is higher than the low, light intensity, but too high, the PV system output power fluctuations are more gentle, power stability in about 310kw. And the maximum output power is 351.8 kw at a temperature of 25.9 ℃ and a light intensity of 293.6.

References

[1] H. J. Liu: *Analysis of China's Solar Photovoltaic Industry Status.* Science and Technology Information (2011), No. 33, 78.

[2] X. Liu, L. Jun, C. Rosenberg: *Compressed Data Aggregation: Energy-Efficient and High-Fidelity Data Collection.* Networking, IEEE/ACM Transactions on *21* (2013), No. 6, 1722–1735.

[3] S. C. Li, L. D. Xu, X H. Wang: *Compressed Sensing Signal and Data Acquisition*

in Wireless Sensor Networks and Internet of Things. Industrial Informatics, IEEE Transactions on *9* (2013), No. 4, 2177–2186.

[4] F. W. Ceng: *Adjustable sensing data compression algorithm related to time of the reconstruction error* . Journal of computer applications and software *28* (2011), No. 11, 279–282.

[5] M. Y. Zhang: *Snake model based on improved genetic algorithm in fingerprint image segentation.* Int. J. BIOAUTOMATION *20* (2016), No. 4, 431–440.

[6] W. Xi: *The application of genetic algorithms in the biological medical diagnostic research.* Int. J. BIOAUTOMATION *20* (2016), No. 4, 493–504.

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