

Improvement of Voltage Collapse of MPPT Single-stage Photovoltaic Grid-connected based on Conductance Increment Method

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Abstract. In order to make the supply of resources meet the rapidly developing world situation, it is of great practical significance to further develop and apply renewable resources. PV power system has many advantages, such as cleanness, environmental protection, high efficiency, etc., and shows great application potential in the field of new energy. At present, solar cells are easily affected by external factors such as light intensity, temperature, etc., and can't work at the maximum power point continuously and stably, resulting in low power generation efficiency. Therefore, the introduction of Maximum power point tracking (MPPT) technology is particularly important. In this paper, a variable step conductance increment method is proposed, which can identify the current distance from the maximum power point by observing algorithm, change the tracking step and quickly identify the maximum power point, so as to solve the voltage collapse problem of single-stage photovoltaic grid-connection. Simulation results show that the new algorithm can optimize both dynamic response and steady-state oscillation, and improve the accuracy and speed of MPPT.

Keywords: MPPT; Conductivity Increment; Photovoltaic Grid Connection.

1. Introduction

With the rapid consumption of fossil energy and worsening environmental pollution, it is urgent to establish an efficient new energy utilization system, and the most representative solar power generation is favored by all countries. In order to make the supply of resources meet the rapidly developing world situation, it is of great practical significance to further develop and apply renewable resources [1]. Compared with other renewable resources, such as bioenergy, wind energy and tidal energy, PV power technology has been recognized and applied in many countries all over the world because of its abundant reserves, easy installation and low maintenance cost of related equipment. PV power system has many advantages such as cleanness, environmental protection, high efficiency, etc., and shows great application potential in the field of new energy [2]. The biggest advantage of grid-connected PV power system is that it doesn't need to store energy in the middle of the battery, thus saving investment, simplifying the system and making it easy to maintain. Grid-connected PV power system is mainly used for peak-shaving photovoltaic power stations and roof photovoltaic systems [3]. Because there are many factors that affect the output power of solar cells and most of them are uncontrollable, PV power is random, and the output of solar cells is also changing.

At present, solar cells are easily affected by external factors such as light intensity, temperature, etc., and can't work at the maximum power point continuously and stably, resulting in low power generation efficiency. Therefore, the introduction of MPPT technology is particularly important [4-5]. The energy output of solar cells has obvious nonlinear characteristics, which makes them lack of stability and low energy conversion efficiency. Therefore, MPPT algorithm is needed to improve the power generation efficiency of PV power system [6]. Because the output power of photovoltaic module is approximately smooth DC, while the output power of grid-connected inverter fluctuates periodically, a large enough filter capacitor is needed between photovoltaic module and grid-connected inverter to balance the instantaneous power difference between grid-connected inverter and photovoltaic module [7]. The introduction of this capacitor leads to the energy coupling among photovoltaic module, grid-connected inverter and filter capacitor [8]. To solve this problem, scholars have designed many intelligent control methods, but most of them are complicated and difficult to

realize. In this paper, a variable step conductance increment method is proposed, and the constant voltage startup is added to improve the algorithm.

2. Independent PV Power System

PV power system is mainly composed of photovoltaic array, energy storage system, controller and inverter, among which the basic unit of photovoltaic array is solar cell, and the device composed of photovoltaic array and controller is the core component of the whole PV power system. PV power system uses photovoltaic array to convert solar energy into electric energy and supply it to power grid and users. The application of photovoltaic effect in semiconductor materials can make photovoltaic panels [9]. Because the output voltage of each original solar cell is very low, in order to meet the specific output voltage demand in actual production and use, it is necessary to combine a plurality of solar cells in series and parallel to form a solar cell assembly, and then connect the solar cell assemblies in series and parallel to form a solar cell array. The components of the independent PV power system are photovoltaic array, charge and discharge controller, energy storage system and inverter, as shown in Figure 1.

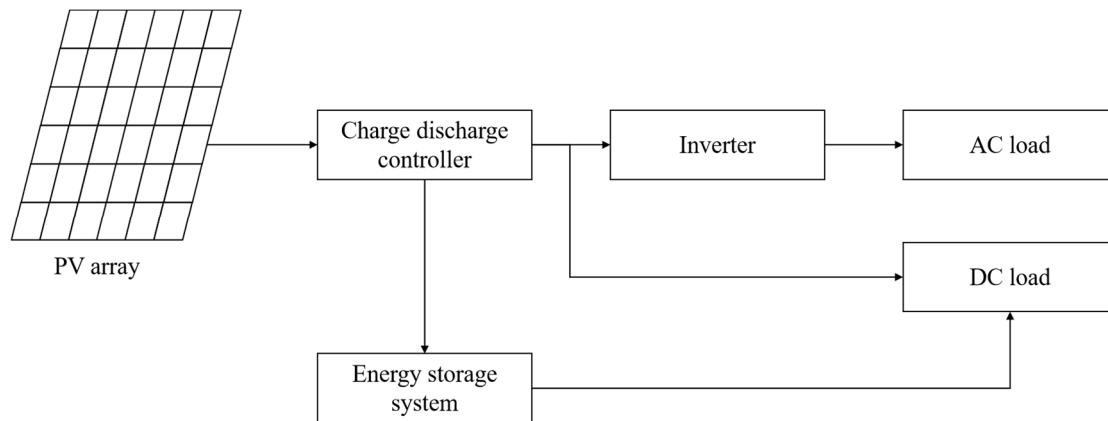


Figure 1. Independent PV power system

Photovoltaic array can convert solar energy into electric energy for users to use. When the electric energy required by users' load is relatively small, photovoltaic array will charge the energy storage system through the charge and discharge controller to store the excess electric energy. When the user's load is large, and the electric energy generated by the photovoltaic array is insufficient to meet the user's needs, the energy storage system starts to supply power to the load together with the photovoltaic array, in which the inverter is used to change the direct current to the alternating current and provide it to the alternating current load. Under the condition of constant external conditions, it is not difficult to track the maximum power point of the system by traditional methods, but the change of weather makes the system unable to work in an ideal state, so the traditional methods are improved accordingly [10]. Compared with the light, the temperature change is very slow, so when studying MPPT tracking technology, it can be roughly determined that the surface temperature of the material will remain unchanged in a short period of time, and only the change of light intensity will be considered. Under the standard condition, the output power of solar cells and the irradiation dose can be approximately linear when the voltage at the operating point is kept constant. When the irradiation dose changes, the output current will also change accordingly.

3. Improvement Strategy of Incremental Conductance Method in MPPT of Photovoltaic System

The maximum output power of solar cells is not only related to external environmental factors, but also related to external loads. When the external load impedance is equal to the internal impedance

of the photovoltaic array, the solar cell has the maximum output power at this time. In order to keep the solar cell always working at the maximum power point, it is necessary to adjust the solar cell according to the external environmental conditions and the external load at this time. As a complex system, the output characteristics of solar cells are significantly affected by the external environment and load state. Analyzing the influence of external environmental parameters on the output characteristics of solar cells is of great significance to the extraction of model parameters, the design of photovoltaic array topology and the practical application of solar cells.

Solar cell is the most basic unit of photovoltaic array and one of the core components of the whole photovoltaic system. The quality of solar cell will affect the quality of the whole PV power system. Improving the energy conversion efficiency of solar cells can effectively reduce the system cost and energy loss. When the power tube is turned on by the trigger signal, energy is accumulated in the inductor L . Assuming that L is sufficiently large, the current flowing through L is a constant value I_1 . When the diode is on, assuming the on-time is t_{on} , the energy accumulated in L is $E_1 I_1 t_{on}$:

$$E_1 I_1 t_{on} = (E_2 - E_1) I_1 t_{off} \quad (1)$$

Thereby obtaining:

$$E_2 = \frac{t_{on} + t_{off}}{t_{off}} E_1 = \frac{T}{t_{off}} E_1 \quad (2)$$

Define the duty cycle of power tube:

$$D = t_{on} / T \quad (3)$$

The input-output voltage relationship of the system can be obtained as follows:

$$E_2 = \frac{E_1}{1 - D} \quad (4)$$

It can be seen that the MPPT control module outputs the voltage signal to the PWM drive circuit to generate the power tube drive signal to control the duty ratio D , and finally the solar cell works at the maximum power point.

The photovoltaic array generates electric energy, which is supplied to the load after passing through the controller and inverter, and the remaining electric energy will be delivered to the power grid. When the power generation of the system is insufficient, the public power grid supplies power to the load to ensure the normal operation of the load. Grid-connected photovoltaic systems can be divided into schedulable photovoltaic systems and non-schedulable photovoltaic systems according to whether there are energy storage links.

The new variable step size algorithm adopts the disturbance step size adjustment coefficient, which greatly improves the tracking accuracy and response speed of the system. The improved conductance increment method introduces the instantaneous variation of power and voltage for detection and judgment, and the allowable error and flag value, which not only solves the misjudgment phenomenon when the external environment changes, but also eliminates the power oscillation near MPPT and in steady state, and does not need to adjust any parameters, thus avoiding the inapplicability of the traditional algorithm caused by human factors.

4. Result Analysis and Discussion

The output characteristics of solar cells are determined by many factors. Under different external environmental factors, the output characteristics of solar cells will be different, but there will always be only one maximum power point. Under the influence of different external environmental factors, the position of the maximum power point will be different. How to ensure that the solar cells can output at the maximum power under the changing environmental conditions is the main method to reduce the energy loss of the photovoltaic system. In order to verify the effectiveness of this method, the simulation models of MPPT control system to PWM control system of traditional and improved

conductance increment method are built in MATLAB /Simu-link system. The simulation results of output power are shown in the Figure 2.

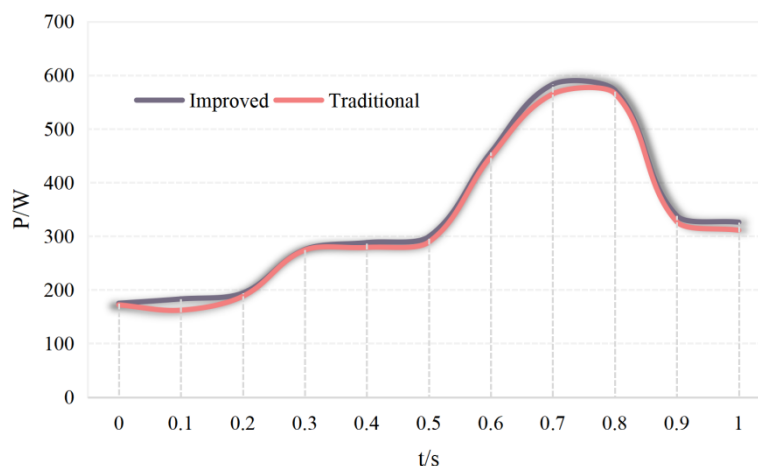


Figure 2. Simulation results of output power

When the voltage gradually increases, the output power of solar cells also begins to increase gradually. When the voltage increases to a certain value, the output power reaches the maximum value, and then the output power begins to decrease. However, the current basically keeps a certain value at first, and when the voltage increases to a certain value, the current drops sharply. But no matter what the conditions, solar cells have and only have one maximum power point. From the simulation results of output power in Figure 7, it can be seen that when the light intensity changes abruptly, the traditional conductance increment method will cause short-term energy loss due to insufficient tracking, especially when the light intensity changes abruptly, and the improved variable step conductance increment method can fix this problem and realize MPPT control better.

5. Conclusion

Compared with other renewable resources, PV power has the advantages of easy maintenance, low operating cost, zero pollution, etc., so as to obtain a wide range of light pillars all over the world. Although the cost of PV power equipment and components is relatively high, its potential long-term benefits also make this part of the higher cost-benefit huge. In this paper, based on the relationship between the working current, voltage change and light intensity change of solar cells, aiming at the principle and misjudgment of the traditional conductance increment method INC, an improved conductance increment method with variable step size is proposed. When the light intensity suddenly changes, the traditional conductance increment method will cause short-term energy loss due to insufficient tracking, especially when the light intensity suddenly changes greatly. The improved variable step conductance increment method can fix this problem and realize MPPT control better. The complexity of the algorithm increases slightly, which fully meets the conditions of embedded controller engineering migration and has high engineering realizability. The proposed method can decouple the filter capacitors in a single power cycle and improve the dynamic performance of maximum power tracking control.

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