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The Influence of Partial Shading on the Output Performance of PV Modules

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Abstract

In recent years, in the context of the global energy crisis, the development and application of solar energy resources has been widely concerned by the international community. How to make full use of solar energy and increase the generating capacity of photovoltaic system has been concerned and studied widely in the crystal silicon solar cell industry. In this paper, the effect of partial shading on the output performance of photovoltaic modules was studied. The results show that when the shielding area of a single cell in any branch of the PV module exceeds 50%, the branch bypass diode is activated and the branch has no power output. When the three bypass diodes are fully switched on, the output power of the component is almost zero.

Keywords

Generating capacity; partial shading; PV module; Bypass diode; Output powers.

1. INTRODUCTION

Photovoltaic modules work outdoors for a long time, and their power generation performance is easily affected by the working environment. For example, environmental temperature, radiation amount, light conditions, wind speed and other factors will cause changes in photovoltaic module power generation. In addition, cloud cover, the shadow of buildings and trees and other effects on the surface of photovoltaic modules will produce local shadow cover. For one thing, this situation causes uneven distribution of light intensity on the surface of components, which affects their power generation performance; and for another, shielding will form a "hot spot effect", damaging the components and reducing their service life.

Domestic and foreign experts and scholars have done a lot of research on the influence of local shadow on photovoltaic module power generation performance. Alonso-garcia M C[1] studied the change of output performance of photovoltaic modules in the case that a single cell was shaded by shadows on photovoltaic modules equipped with bypass diodes. Engin Karatepe et al. [2] proposed a model to analyze the influence of local shadow occlusion on photovoltaic system based on the analysis of the influence of shadow occlusion on solar cells. Feng Zhicheng et al. [3] of Inner Mongolia University of Technology studied the changes of output performance of photovoltaic modules under different shielding areas, and found that as the proportion of photovoltaic modules under shadow shielding increased, their output characteristics became worse. Lulu Wu et al. [4] studied the changes of output performance of photovoltaic modules under different proportion of local shadow shielding, and found that the power loss caused by concentrated shielding was greater than that caused by dispersed shielding, and the more dispersed the shielding, the smaller the power attenuation caused by the photovoltaic system.

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It can be seen that shadow shielding has different effects on the power generation performance of a single photovoltaic module and even the photovoltaic system. At the same time, shielding will cause local "hot spot effect" of photovoltaic modules, resulting in the decrease of reliable performance of photovoltaic modules. In the practical application of photovoltaic modules, the area formed by local shadows on photovoltaic modules has no fixed rule, and changes in position or area along with the movement of the sun, and continuously affects the output performance of photovoltaic modules. Aiming at this problem, this paper explores the influence of shadow shielding on the output performance of a single photovoltaic module by designing different shielding methods and comparing the variation trend of the maximum output voltage, maximum output current and maximum output power of photovoltaic modules under different shielding conditions.

2. MATERIALS AND METHODS

2.1. Encapsulation of Components

The packaging process flow of conventional photovoltaic modules [5] is as follows:

(1) String welding: the interconnection strips connect the positive and negative electrodes of multiple batteries in series;

(2) EL test before lamination and lamination: lay the glass, EVA, battery series, EVA, and back plate in accordance with the sequence shown in Figure 2, and connect the battery series with a bus bar; Then, the stacked half-layer components were tested by EL to confirm that there was no exception.

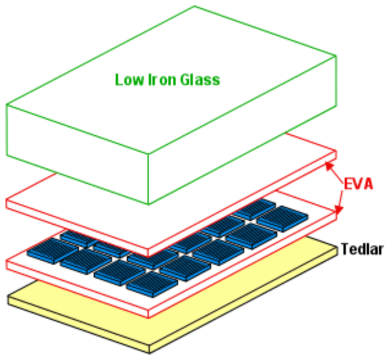

Figure 1. Packaging materials stacking sequence of photovoltaic modules

(3) Laminating and framing: The EL test normal components are placed in the middle layer of the laminating machine. The molten EVA in this process binds the glass, the battery sheet, and the back plate firmly together. After laminating, no abnormal laminates shall be framed and the junction box shall be installed, and put into the curing room for curing, so as to ensure the reliable performance of the components.

(4) Test packing: After curing, photovoltaic modules are tested for their power. Photovoltaic modules with the same power are placed together to ensure the consistency of the modules in the system and ensure the generation of electricity.

2.2. Experimental Materials and Testing Instruments

The experimental photovoltaic module is produced by Shandong Linuo Photovoltaic high-tech Co., LTD., and the version is 1650mm*992mm*35 mm; The power test of photovoltaic modules under different shielding conditions adopts Pasan solar transient simulation instrument: Sunsim3C.

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2.3. The Experimental Scheme

Four groups of experiments were designed according to the equivalent circuit diagram of photovoltaic modules, as shown in FIG. 1. In the experiment, 5 mm thick opaque board was used as a mask to carry out shielding experiments in turn and test the output characteristics of the components.

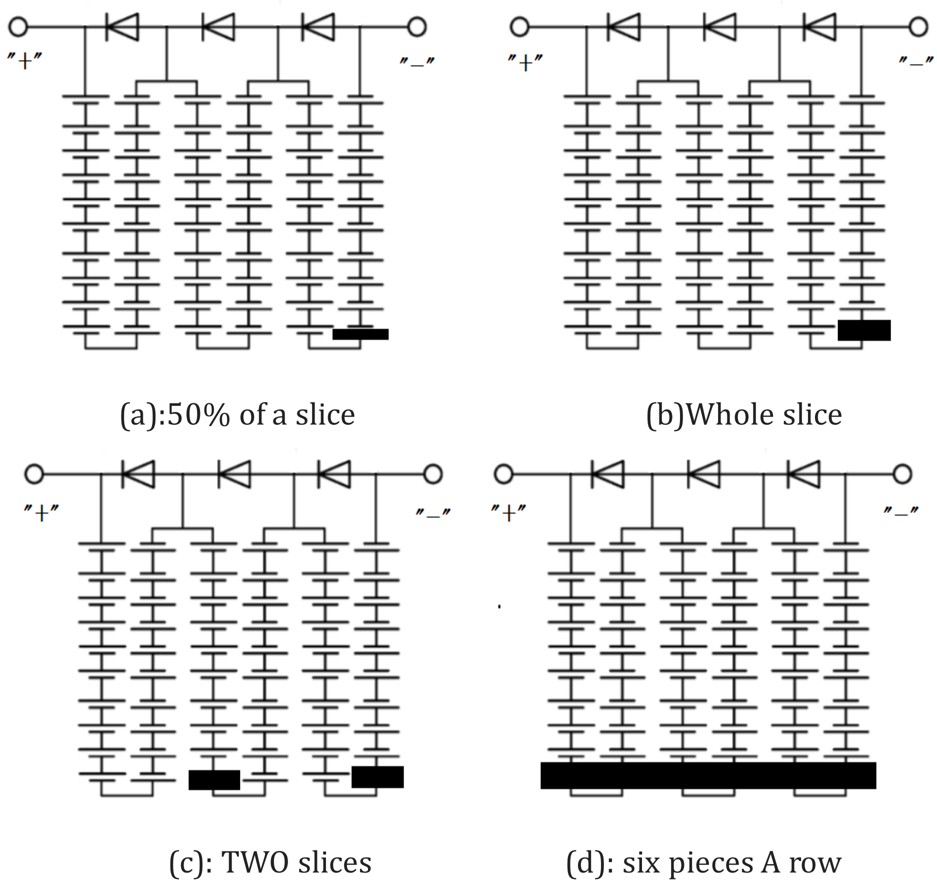

Figure 2. Component equivalent circuit diagram

3. RESULTS AND DISCUSSION

3.1. Influence of Shielding on I-V Curve and P-V Curve of PV Module

FIG. 3 shows the I-V curve and p-V curve of photovoltaic modules under different shielding conditions. Can be seen from the diagram, the experiment one, two, three a ladder-like i-v curve and multi-peak PV curves, this is because the shadows hide uneven distribution between pv modules each branch, obscured (more) or obscured photoproduction of photovoltaic modules branch current is less than the other branch, caused the current mismatch between different directions, so as to make the photovoltaic modules i-v curve appears ladder-like, P - V curves to produce bimodal or multi-peak [3]. Experiment 4 shows that when the three branches in the PHOTOVOLTAIC module are uniformly blocked, the photogenerated current of each branch in the photovoltaic module attenuates equally, the current flowing through the three sub-strings is always the same, and the characteristic curve has a normal trend.

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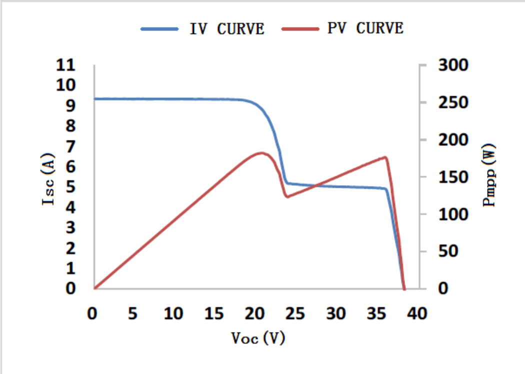
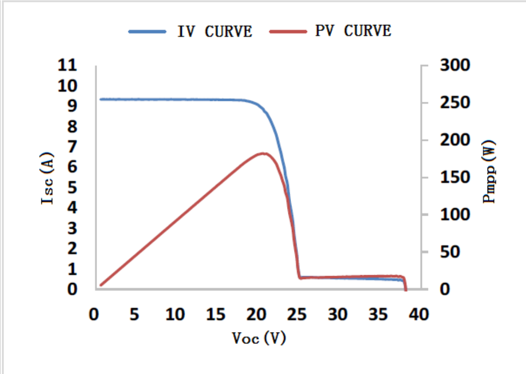
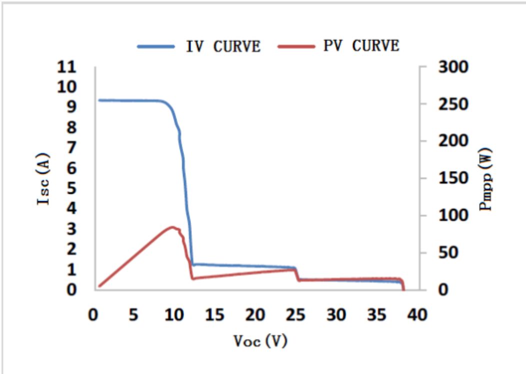


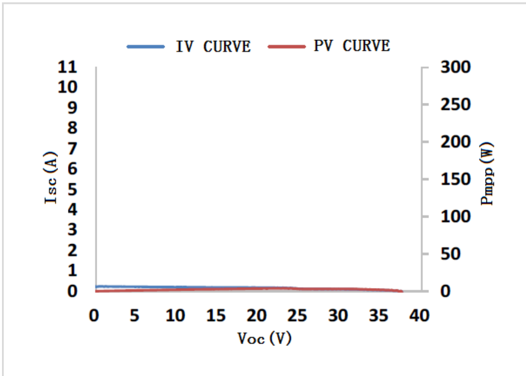
(a):50% of a slice



(b):Whole slice



(c): TWO slices



(d): six pieces A row

Figure 3. I-v curve and P-V curve of components with different shielding ratios

3.2. Influence of Shielding on Output Electrical Performance of PHOTOVOLTAIC modules

Table 1 shows the output electrical performance of photovoltaic modules under different shielding modes. It can be seen from the table that, under the conditions of experiment 1 and Experiment 2, the output performance of pv modules under the condition of blocking 50% and 100% of a single cell is the same, the Im is basically unchanged, the Vm is reduced to 2/3 of the one without blocking, and the power loss is 35%. This is because in this shielding mode, the blocked cells of the PHOTOVOLTAIC module are connected with the bypass diode to achieve the maximum power output. Also under the occlusion condition of Experiment 3, when two branches of the three paths of the PHOTOVOLTAIC module were blocked, THE Im was unchanged, Vm was reduced to one third of the one without occlusion, and the power loss was 69%.

In experiment 4, when the three branches of the PHOTOVOLTAIC module were blocked by more than one battery, the Im and Pm of the module were close to zero, and the complete I-V curve and P-V curve could not be obtained, and the power loss was about 99%.

Table 1. Output electrical performance parameters of components under different shielding conditions

Item	Vm(V)	Im(A)	Pmpp(W)	Power loss
Without sunscreen	31.79	8.89	282.6	0%
Experiment 1	20.83	8.86	184.6	35%
Experiment 2	20.81	8.86	184.4	35%
Experiment 3	10.05	8.81	88.5	69%
Experiment 4	22.78	0.13	3.0	99%

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4. CONCLUSIONS

By studying the influence of different shielding conditions on the I-V curve, P-V curve and output electrical performance parameters of photovoltaic modules, this paper draws the following conclusions: When the shielding area of a single cell in any branch of photovoltaic modules exceeds 50%, the branch bypass diode conducts, and the branch has no power output; When the three bypass diodes are fully switched on, the output power of the component is almost zero. Therefore, in the practical application of photovoltaic modules, it is necessary to choose an open place with few building facilities and trees, so as to effectively reduce the impact of shadow blocking on photovoltaic module power generation performance.

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