Numerical Analysis of Diode Currents and Voltages of a PV Module Reflected by Partial Shadow

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1 Introduction

A real solar PV power plant needs a wide outer surface for installation and also has high costs. Moreover, the energy it produces is strongly dependent on uncontrollable weather condition [1]. It is important to know several diagnostic methods of PV panels in order to investigate the change in their I-V characteristics with the change in weather conditions. Light-generated current I_{ph} increases linearly with the solar irradiation. The smaller the diode current I_D, the more current is delivered by the solar cell [2]. In case of shadow, the output I-V characteristics in series-connection change with the increase in saturation current flowing through the diode that represents the p-n junction of a solar cell.

The objective of this simulation is to obtain natures of diode voltage and current behavior for the solar cell under different shadow conditions. In this paper, numerical results of such characteristics which were obtained using LTspice IV simulation are demonstrated and discussed.

2 Methodology

In the present simulation, a single PV module which is composed of 3 solar cells connected in series is employed as shown in Fig. 1. A battery which simulates e.m.f of a load is connected to the output terminal.

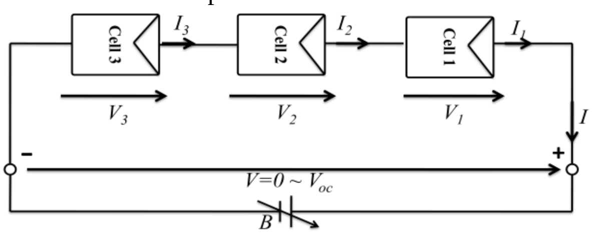


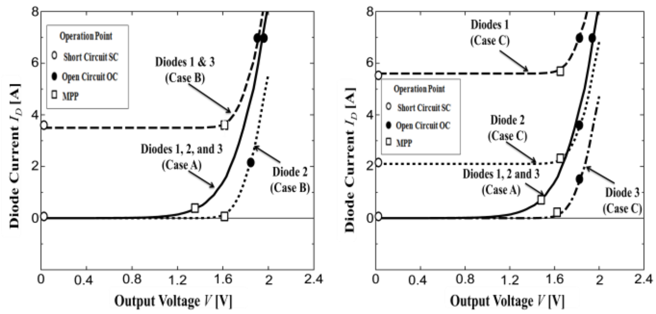
Fig. 1. A PV module which is composed of 3 cells connected in series.

Symbols α and β are used to give the different level of shadow transmission. In this paper, simulated results obtained under the shadow conditions of α = 0.5 and β =0.2 are demonstrated. The rated current of I_0 is set to be 7A. In general, we designated various levels of transmission under shadow conditions so that the transmission ratio of cell A was 100% in all cases, that of the cell B was α, and that of the cell C was β. In this simulation, 3 cases of the shadow conditions were estimated as follows:

- Case A: $\alpha = \beta = 1$; no shadow.
- Case B: $\alpha < \beta = 1$; α is the lowest shadow transmission ratio.
- Case C: $\beta < \alpha < 1$; β is the lowest shadow transmission ratio.

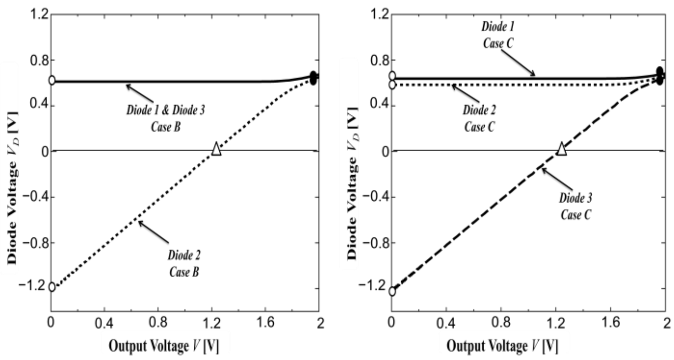
3 Results and Discussion

The relationship between the current of each diode I_D and output voltage V are shown in Fig. 2 for the (cases A and B) and for the (Cases A and C). And Fig. 3 shows the relationship between diode voltage V_D and output voltage V for the (cases A and B) and (cases A and C).



(a) (Cases A and B) **(b)** (Cases A and C)

Fig. 2. I_D-V curve of the saturation current (Cases A and B) and (Cases A and C).



(c) (Cases A and B) **(d)** (Cases A and C)

Fig. 3. V_D-V curve of the diode voltage in the diode (Cases A and B) and (Cases A and C).

4 Conclusions

In the solar cell which has the lowest transmission ratio of sunlight, the saturation current flowing through the diode is almost zero. In the other solar cells with higher transmission ratios, the saturation currents are larger than zero, depending on the ratio of transmission. That is to say, the diode currents concentrate to the cell which have the highest transmission ratio. Meanwhile, all photo-currents flow on a cell through the diode of the given cell in the case of open circuit, independently of the shadow conditions.

Acknowledgement

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