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Modeling of photovoltaic module and experimental determination of serial resistance

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Abstract

An explicit model is presented for accurate simulation of the I-V curve characteristic of photovoltaic (PV) module. The model is compared with the traditional I-V curve characteristic and to some experimental results to show the accuracy of the method. The explicit model proposed is found to be reliable and accurate in situations where this model is a good approximation of cell or module performance. Also, an experimental method is presented to determine the series resistance and shunt resistance of the PV cells and PV modules.

Keywords: *I-V characterization; Simulation models; Experimental measurement; Series resistance; Shunt resistance.*

1. Introduction

The determination of solar cell model parameters from experimental data is important in the design and evaluation of solar cells.

The work described in this paper is to characterize the photovoltaic (PV) modules in real conditions. Also, we give a method to determine the serial resistance R_S and the shunt resistance R_{Sh} of PV module. The serial resistance is mainly the sum of contact resistance on the front and back surfaces and the resistances of the bulk and the diffused layer on the top. The shunt resistance represents a parallel high-conductivity path across the p-n junction. The shunt resistance can affect the short circuit current I_{SC} density as well. The PV performance depends on the values of R_{Sh} and R_S.

Therefore, R_S and R_{Sh} both need to be recognized and understood in order to analyze the cell and module performance. The most commonly used method for measuring the series resistance of a solar cell was first proposed by wolf and Rauschenbach [1]. This involves measuring the characteristic of a cell at two different illuminations.

Several other methods are available in the literature for the measurement of series and shunt resistances [2-6]. All these methods are based on single exponential model of solar cell and assume that R_{Sh} is infinite and presume R_S to be independent of the intensity of illumination, which may not be valid.

In this paper we propose a new approach to simulate the IV characterization by given a photovoltaic resistance for any materials properties of the solar cell. Also, the photovoltaic resistance is given for silicon cell. We present an experimental method for determination of R_S and R_{Sh} of a solar cell using the I-V characteristic based on explicit model proposed.

2. Review of Existing models of solar cell Characteristic

Several models of PV generator have been developed in literature [1-6]. The aim is to get the I-V characteristic in order to analyze and evaluate the PV systems performance. The difference between all models is the number of necessary parameters used in the computational. The most models used are:

- Explicit Model
- Solar Cell Model using four parameters
- Solar Cell Model using five parameters
- Solar Cell Model using two exponential

2.1. Explicit Model

This model needs four input parameters, the short-circuit current I_{SC} , the open-circuit voltage V_{OC} , the maximal current I_m, and the maximal voltage V_m [2]. The relation between the load current *I* and the output voltage *V* is given by:

$$I = I_{SC}\left[1 - C_1\left(Exp\left(\frac{V}{C_2 . V_{OC}}\right) - 1\right)\right] \qquad (1)$$

Where

$$C_1 = \left(1 - \frac{I_m}{I_{SC}}\right).Exp\left(\frac{-V_m}{C_2 . V_{OC}}\right)$$

And

$$C_2 = \frac{\dfrac{V_m}{V_{OC}} - 1}{Ln\left(1 - \dfrac{I_m}{I_{SC}}\right)}$$

2.2. Solar Cell model using four parameters

The classical equation describing the I-V curve of a single solar cell is given by:

$$I = I_{Ph} - I_0 . \left[Exp\left(\frac{q}{A.K.T}(V + R_S . I)\right) - 1\right] \qquad (2)$$

Where I is the load current and V the output voltage, I_0 is the diode reverse saturation current, I_{Ph} is the photo-generated current, R_S is the series

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