WEENTECH

International Seminar on Renewable Energy and Sustainable Development, Royal University of Bhutan, Thimphu, Bhutan
15-17th June, 2015 Bhutan

Modeling of solar cell with/without considering leakage current through its periphery

Jagdish Chander, Aeidapu Mahesh
School of Renewable Energy and Efficiency
NIT Kurukshetra, India; Email: jagdish_3137519@nitkkr.ac.in

1.Introduction

This article presents the modeling and experimental verification of solar cell using four and five parameter analytical models. The leakage current through periphery of PV cell is not considered in four parameter model while in five parameter model a shunt resistance is used to consider the leakage current due to crystal defects. After determining the model parameters, modeling results are obtained using both models and compared with the measured results obtained by performing experiment on SOLAR SIMULATOR designed by Western Regional Instrumentation Centre, Mumbai and IIT Mumbai. The relative errors between modeling and experimental results are computed and it is envisaged that the proposed work helps the PV power designers in selecting an accurate model among four and five parameter models.

- Modeling of Photovoltaic System (PV) is necessary to obtain its realistic behavior.
- The output power produced by photovoltaic array depends upon solar irradiance.
- The experimental data for all solar irradiance and for all module orientation and inclination are never available.
- The experimental data is available only for hourly or daily irradiance on a horizontal plane.
- Modeling of photovoltaic array is required in order to deduce its realistic behavior from available experimental data.

2.Methodology

1. Modeling of PV cell without considering leakage current

Figure 1 shows the Rs-model of a PV cell. This model is the improved version of ideal model. The Rs-model does not consider the leakage current.

The current-voltage equation is given as follows:

$$I = I_{ph} - I_o\left[exp\left(\frac{V + IR_s}{aV_T}\right) - 1\right] \qquad (1)$$

Where I = Output current
Iph = Photon-generated current
I_D = Diode current
Io = Reverse saturation current of the diode
V = Output voltage
a = Diode ideality factor
V_T = Thermal voltage

2. Modeling of PV cell considering leakage current

As discussed earlier, Rs-model does consider the leakage current component. Therefore, in order to get an accurate model a shunt resistance Rsh is added to the equivalent circuit of Rs-model as shown in fig. 2.

3.Rs-model and single diode model

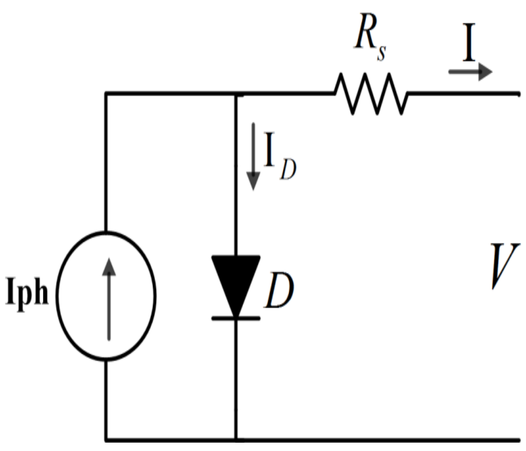

Fig. 1 Rs-model

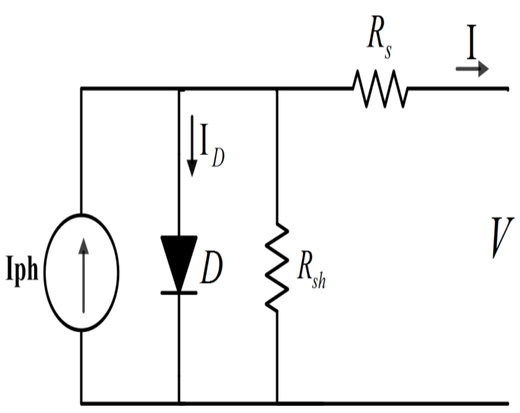

Fig. 2 SDM model

Table I specifications of PV cell

Voc	600 mV
Isc	490 mA
K_V	-0.1230 V/K
K_I	0.0032 A/K

Fig. 3 Solar simulator kit

4. Results

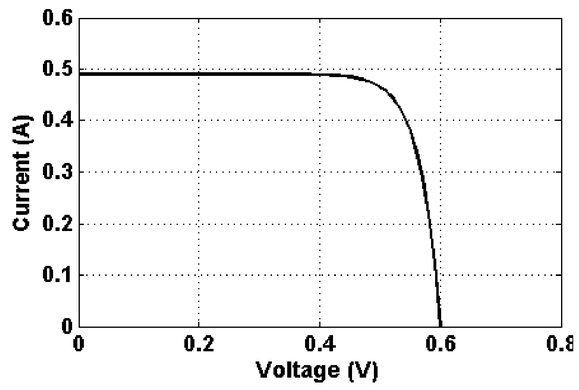

Fig. 4 I-V curve of Rs-model at STC

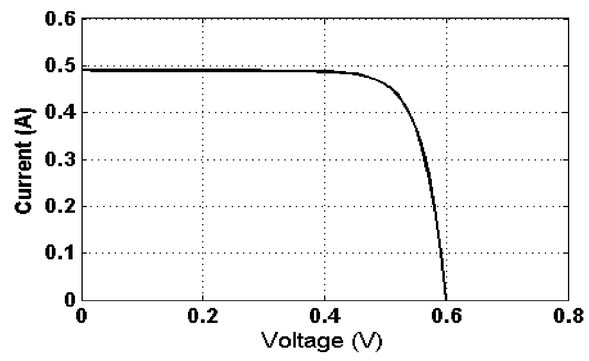

Fig. 5 I-V curve of SDM at STC

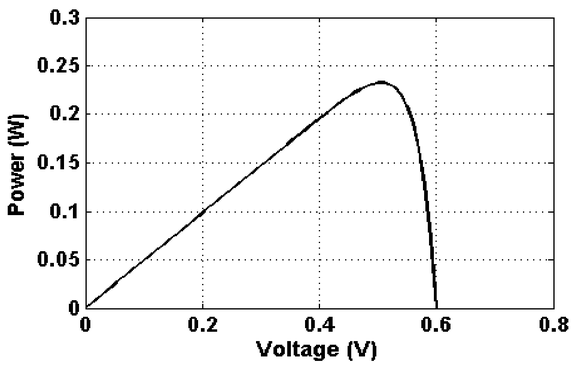

Fig. 6 P-V curve of Rs-model at STC

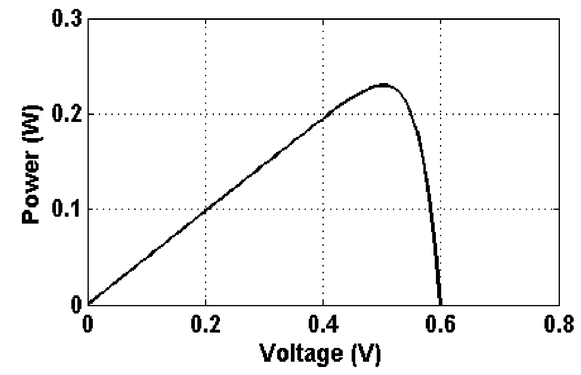

Fig. 7 P-V curve of SDM at STC

5.Impressions

The specifications of PV cell provided by the BHEL (Bharat Heavy Electrical Limited) are summarized in table I. I-V and P-V curves using Rs-model are shown in fig 4 and fig. 6 respectively. I-V and P-V curves of PV cell used in solar simulator obtained by SDM are shown in fig. 5 and fig. 7 respectively. It can be seen from fig. 5 that there is lower value of short-circuit current in I-V curve of SDM than short-circuit current value in Rs-model. This decrease in short-circuit corresponds to the leakage current through the periphery of PV cell.

The Rs and single diode model is implemented using MATLAB/SIMULINK. I-V and P-V curves of a PV cell are obtained in two ways. In one way of modeling, leakage current through periphery of PV cell is considered while in other way it is neglected.

Considering the leakage current increases the parameter to five which cannot be determined using analytic methods. Therefore, for the determination of these unknown parameters, iterative techniques are used. In this work, authors have used Newton-Raphson method for this purpose.

The experimental results are obtained by performing experiment on SOLAR SIMULATOR designed by Western Regional Instrumentation Centre, Mumbai and IIT Mumbai. These results are obtained at standard test condition (STC). The modeling results provided by Rs-model and single diode model at STC values are compared with experimental results for validating the Rs-model and SDM.

6.Scope

This work is carried out at constant temperature and irradiation values corresponding to STC values. In order to modeling a cell according to its operating range of temperature and solar irradiance, this work can be extended for selecting an accurate model among Rs-model and SDM for modeling a PV cell operating under temperature and irradiation values other than STC values.

The leakage current value varies according to the size of PV cell. The size of PV cell used in solar simulator is 14 centimeter square which is provided by the BHEL.

This work can also be extended for selecting an accurate model among Rs-model and single diode model according to the size of PV cell. In some cases of modeling a very small size cell an extra diode is used for compensating the large leakage current flowing through the periphery of PV cell

Authors found that the single diode model i.e. modeling of PV cell by considering the leakage current gives results close to those which are obtained by performing the experiment on solar simulator kit.

It is envisaged that the proposed work helps the PV power designers, who requires an accurate model, in selecting an accurate model among four and five parameter models.