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Determination of Parameters of PV Cell Using Single Diode Model

Kuncham Neeraja[1], Ambati Revathi[2]

[1,2] UG Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India.

ABSTRACT:

Solar energy is affordable and incredibly efficient because of its cheap cost and pollution free. Therefore, regardless of motivation, everyone chooses solar energy to meet their daily needs. As a result, to produce electricity more efficiently, the ratings of solar PV cell must take into account which panels have a significant role in determining the performance of the solar panel as well as which is also used in the construction of solar panels. And at the same time, the performance of a photovoltaic (PV) system can be obtained by estimating the accurate solar PV cell variables such as diode saturation current (I_d), photocurrent (I_{photo}), ideality factor (α), shunt resistance (R_{sh}), series resistance (R_{se}). All these five parameters are estimated by using the Single Diode Model (SDM) and it demonstrates the deficits in the quasi-neutral region. Researchers used a lot of methods to find out these parameters. But in this context, these parameters can be extracted by considering the series and shunt resistances.

KEYWORDS: PV cell, Parameter Extraction, PV cell modeling, SDM.

1. INTRODUCTION:

Usage of non-renewable energy sources like coal, nuclear, diesel/petrol, is reduced day by day. Due to the pollution caused by their usage, and their limited availability in nature. So, to compensate for this everyone shows their interest to use renewable energy sources like solar, wind, ocean tides, and biomass for their needs. Solar is mostly preferred use in all of these renewable energy sources due to its efficiency, cheap cost, pollution-free, noiseless, flexible sizes and requires less maintenance.

Solar PVs are becoming increasingly popular as a source of renewable energy as a result of the extremely positive asset earlier. Almost 100 nations mostly use renewable Solar panels on a global scale. Authorities provide monetary incentives to renewable power production to stimulate expenditures. The quantity of implemented PV power was 177 GW globally in 2014, and by the end of 2015, there is predicted to rise to 220 GW. The electricity production for 2006 is almost 40 times the above amount. Solar Photovoltaic systems can be installed on the surface, on rooftops, on patios, or as building-integrated PV systems (BIPVs) that are built into a building's walls or roof. Both large-scale centralized power plants and smaller-scale decentralized energy stations can use solar photovoltaic (PV) technology. Photovoltaic decentralized energy systems produce the majority of solar energy. Grid-connected PV systems (GCPVs), which are linked to the electricity grid, are known as such. Alternatively, grid-connected PV systems, which operate freely, are known as such systems.

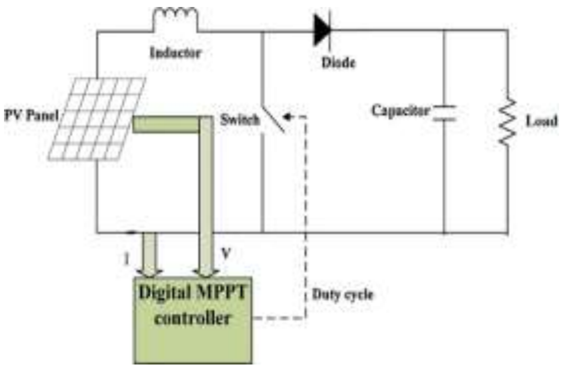

Fig-1: illustration of a general PV system

However, it is very important to obtain the efficient performance of solar PV systems and it is possible by accurately estimating the parameters of solar cells. As a result, appropriate photovoltaic cell modeling and its computation are essential in the research on photovoltaics, including sympathetic blending consequences, on-grid, and off-grid PV power stations, maximum power point tracking, and enthalpy effects. In the earlier year, investigation on solar PV parameter extraction also received significant focus. At that point, research into the PV cell structure leads the researchers to suggest proper PV cell modeling. The mathematical equations for determining these parameters are likewise obtained from the sculpting of a Photovoltaic cell. The models like

Single Diode Model (SDM), Double Diode Model (DDM), and Three Diode Model (TDM) are used to represent the PV cell in an electrical model. Where the Single Diode Model (SDM) demonstrates the deficits in the quasi-neutral region and can be applied to calculate the five variables. Similarly, Double Diode Model (DDM) demonstrates the losses in space-charge, quasi-neutral regions and is employed to calculate the seven variables, whereas Three Diode Model (TDM) demonstrates the deficits in all three regions and is used to estimate the nine parameters.

But in this context, only five parameters of PV cells using SDM are estimated because the estimation of SDM is easy compared to DDM & TDM. At the same time, there is no complexity in its electrical equivalent diagram compared to DDM and TD

2. EXPLANATION:

2.1. Solar Cell Modeling:

The electrical properties of the solar cell and the PV system must be accurately modeled mathematically. Even though the fact that various equivalent circuit models have been invented and brought out there to characterize the solar cell's performance over the past forty years, only three models are implemented in practice. In this section, only one method is briefly presented.

2.2. Equivalent circuit:

The following is the corresponding layout diagram for a PV cell in the SDM model:

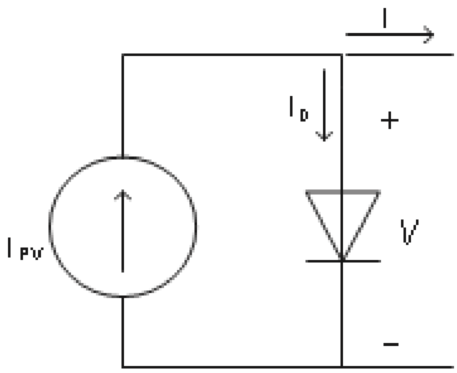

Fig-2: Ideal PV Circuit Model

An ideal PV cell can be represented as shown in the above figure, which has a photocurrent source in shunt with the single diode whose output current is determined by the expression

$$\mathrm{I} = \mathrm{I}_{pv} - \mathrm{I}_0[\exp \frac{\mathrm{V}}{\mathrm{a\,V_t}} - 1]$$

Where q is known as the electron charge ($1.60217646*10^{19}$ C), k is the Boltzmann constant ($1.3806503*10^{23}$ J/K), T is the temperature of p-n junction in K, and a is the ideality factor, V_T ($=N_S*k*T/q$) known as the temperature coefficient of the PV module having N cells linked in series, and the I_0 is the reverse saturation current.

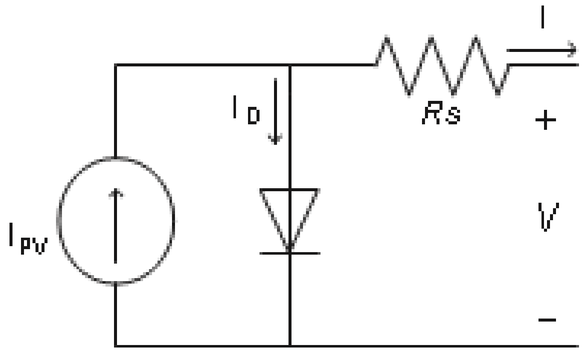

Fig-3: Series Resistance (R_s) model of PV cell

The photocurrent source is linked in shunt with the single diode at the same time, it is connected in series with the resistance known as the PV cell's Rs model. The output current expression for this model can be expressed as:

$$\mathrm{I} = \mathrm{I}_{\mathrm{pv}} - \mathrm{I}_0[\exp\left(\frac{\mathrm{V+IR_S}}{\mathrm{aV_t}}\right) - 1]$$

This equation does not accurately represent how the PV cell reacts whenever subjected to environmental fluctuations, below certain temperatures.

2.3. Single Diode Model (SDM):

Considering the linear independence of the diffusion and recombination currents, dual currents are frequently mixed when a non-physical diode ideality factor n is present. This strategy is also known as the SDM model. A monolithic, photo Voltaic cell functions exactly like a semiconductor diode when not exposed to radiation. Currently, there has been much discussion on using this model to characterize the static I-V characteristic, it has been employed to satisfactorily accommodate the results of the experiment.

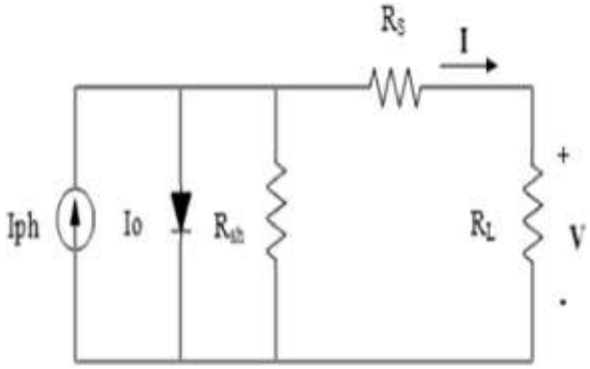

Fig-4: SDM Model of PV cell

A parallel non-ideal diode (I_o), a series resistance (R_s), a shunt-connected resistance (R_{sh}), and a current source (I_{ph}), are all included in the PV cell electrical modeling of SDM. Three variables, the ideality factor, a, and diode saturation current, I_d, photocurrent, and $I_{photo,}$ symbolize the Photovoltaic cell's intrinsic deficits. The five parameters that were to be evaluated for the model SDM represented the losses in the zone of quasi-neutrality. The absorption coefficient or q-factor, which is another name for the ideality factor, depends on the semiconductor material and production method to define its typical range of 1 to 2 but may occasionally be higher. It is frequently omitted since it is presumed that n is roughly equal to 1.

The longitudinal displacement of the current-voltage curve for a component which is almost completely linked to the interfacial tension of such radiation emitted is brought about by the photo-generated current, I_{ph}, that is produced when the semiconductor diode is illuminated.

To simulate an ideal cell, a current generator is linked to a coupled diode with such an I-V characteristic. The following can be used to derive the algebraic equations for the overall Photo voltaic current in SDM:

Kirchhoff's principle may be employed to indicate the current "I" as a Photo - voltaic capsule outlet shown by eq (1).

$$I=I_{photo}-I_0-I_{sh} \quad \text{-----(1)}$$

The diode current can be expressed as:

$$I_d=I_0[\exp(\frac{V_d}{n.V_t})-1] \quad \text{-----(2)}$$

Whereas,

$$V_t=\frac{N_q.K.T}{q} \quad \text{-----(3)}$$

Additionally, Vd: represents potential across the diode, which would also be defined as

$$V_d=V+I.R_s \quad \text{-----(4)}$$

The following eq (5) represents the current measured through the shunt resistance:

$$I_s=\frac{V+I.R_s}{R_{sh}} \quad \text{-----(5)}$$

By replacing Eqs. (2)-(4) in Eq. (1), the resultant current of a photovoltaic module is can be written as

$$I = I_{photo} - I_d(\exp(\frac{V_{pv}+I_{pv}R_s}{a\,V_t}) - 1) - \frac{V_{pv}+I_{pv}R_s}{R_p}$$

Where 'V' reflects the overall output potential of the photovoltaic cell, 'a' indicates the diode ideality factor, and 'I_d' represents the diode saturation current of the SDM. Consequently, the five unknown variables are as I_{photo}, a, I_d, R_p, R_s are estimated by plotting the graph between V and I for different values. And it is noted that when the data are within the range of a standard experimental procedure, the derived n, R_s, R_{sh}, and I_{ph} have extremely few proportion flaws. The retrieved "I" possesses weak positive proportion flaws whenever the noise level is less than 3%, but "I" has problems whenever the noise exposure is larger.

3. CONCLUSION:

The method for obtaining the variables of lighted photovoltaic cells includes a series resistance and a shunt conductance - and extracting their values is discussed in this research. The observed or speculative current-voltage parameters are the foundation of the suggested approach. The observed outcomes agree well with empirical evidence and earlier published findings. Even though the presence of electromagnetic interference or unexpected mistakes in the recorded I-V values, the method is nevertheless quite precise. The suggested approach can be automated, is straightforward, need not necessitate any previous understanding of most of the pertinent properties, and places lower demand on the measuring product's accuracy.

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