A photovoltaic system simulation for Matlab-simulink

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Abstract - This paper presents modeling and simulation of PVA system in matlab simulink. The model based on exponential equation of pv module. It needs less input values and is more accurate. Here by varying temperature and irradiance as input variables we obtained the I-V, P-V characteristics and hence the harmonic distortion analysis can be made in different phases of supply system. The model has been validated with experimental data of a commercial PV module KC200GT.

Key Words

Photo voltaic(pv), Matlab, Modelling,(RES)- Renewable energy source, MPPT.

Non linear I-V characteristics of P-V Cell (Nomenclature)

*\( I_{pv,cell} \) - current generated by incident light
*\( I_0,cell \) - Reverse saturation current
*\( I_d \) - Shockley diode equation
*\( k \) - Boltzmann constant
*\( T \) - Temperature of p-n junction
*\( I_o \) - Saturation current of array
*\( V_t \) - Thermal voltage or array
*\( N_s \) - Cell connected in series
*\( R_s \) - Equivalent series resistance
*\( R_p \) - Equivalent parallel resistance
*\( I_{sc} \) - Short circuit current
*\( V_{oc} \) - Open circuit voltage
*\( (O,I_{sc}) \) - Short circuit point

*\( K_i \) - Current coefficient
*\( P_{max,m} \) - Maximum power
*\( P_{max,e} \) - Maximum experimental power

\( (V_{oc},0) \) - Open circuit point
\( (V_{mp},I_{mp}) \) - Maximum power point

Introduction - With the rapid development of study on solar cells, many models are presented to describe the characteristics of solar cells. This method helps us to construct the circuit model of pv cell. Computer simulation seems to reduce the tests for solar cells. This model accepts irradiance and temperature as environmental parameters as input variables, simulate the I-V characteristics of solar cells.

Fig-a, P-V Cell, P-V Module, P-V Array
No of cell combine to form PV module, no of module combine to form PV array.

The I-V characteristic of the ideal photovoltaic cell is

\[
I = I_{pv,cell} - I_{0,cell} \left[ \exp \left( \frac{qV}{akT} \right) - 1 \right] \quad ...1
\]

The light generated current of the photovoltaic cell depends linearly on the solar irradiation and is also influenced by the temperature is given by

\[
I_{pv} = \left( I_{pv,n} + KI_{I} \Delta T \right) \frac{G}{G_n} \quad ...2
\]

The light generated current of the photovoltaic cell depends linearly on the solar irradiation and is also influenced by the temperature is given by diode saturation current \( I_o \) and its dependence on the temperature may be expressed by

\[
I_0 = I_{0,n} \left( \frac{T_n}{T} \right)^3 \exp \left[ \frac{qE_g}{ak} \left( \frac{1}{T_n} - \frac{1}{T} \right) \right] \quad ...3
\]

where \( E_g \) is the bandgap energy of the semiconductor \( (E_g \approx 1.12 \text{ eV for the polycrystalline Si at } 25 \, ^\circ \text{C}) \), and \( I_{0,n} \) is the nominal saturation current. \( V_t = NskT/q \) is the thermal voltage of the array with Ns cells connected in series. \( I_{o,n} \) is the nominal saturation current, with \( V_{t,n} \) being the thermal voltage of Ns series- cells at the nominal temperature \( T_n \)

\[
I_{0,n} = \frac{I_{sc,n}}{\exp \left( \frac{V_{oc,n}}{aV_{t,n}} \right) - 1} \quad ...4
\]

Maximum experimental power from datasheet

\[
P_{max,e} = V_{mp} \left\{ I_{pv} - I_0 \left[ \exp \left( \frac{q}{kT} \frac{V_{mp} + R_s I_{mp}}{aN_s} \right) - 1 \right] - \frac{V_{mp} + R_s I_{mp}}{R_p} \right\} \quad ...5
\]
For any value of $R_s$ there will be a value of $R_p$ that makes the mathematical I-V curve cross the experimental $(V_{mp}, I_{mp})$ point.

$$R_p = V_{mp} \left( \frac{R_{s} + R_p}{R_{s}} \right) \left( V_{mp} I_{mp} - V_{mp} I_{mp} \exp \left( \frac{V_{mp} + I_{mp} R_p}{N_a} \frac{q}{kT} \right) + V_{mp} I_{mp} - P_{max} \right)$$

**P-V Array equivalent circuit block model using Matlab/Simulink**

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**Simulation Results**

The output of a model is evaluated with a typical

**Parameters of the KC200GT solar array at 25°C, 1.5AM, 1000W/m²**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
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<tr>
<td>$I_{mp}$</td>
<td>7.61A</td>
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<tr>
<td>$V_{mp}$</td>
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<tr>
<td>$P_{max,e}$</td>
<td>200.143W</td>
</tr>
<tr>
<td>$I_{sc}$</td>
<td>8.21A</td>
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<tr>
<td>$V_{oc}$</td>
<td>32.9V</td>
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<tr>
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<td>-0.123 v/k</td>
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<tr>
<td>$K_I$</td>
<td>0.0032 A/k</td>
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<tr>
<td>$N_s$</td>
<td>54</td>
</tr>
</tbody>
</table>

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**TABLE I**

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**Fig. d - Matlab model of P-V system**

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**Fig. e - Subsystem of Photovoltaic Array Model**

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**Fig. f - Dc bus voltage**

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**Fig. g - Simulated Current and voltage curve of KC200GT at 25°C and 1000 W/m²**
Result Analysis-

The maximum output power form the array under the stated conditions (1000 W/m² and 25°C) should have been 200W.

Conclusion-

This paper introduces a simulation model for photovoltaic system to be used in matlab/simulink. The model is simulated connecting a three phase inverter showing that the generated dc voltage can be converted to ac and interfaced to ac load as well as ac utility grid system. Therefore the model proposed here can be considered as a part of distributed power generation systems.

References-


Pedro Rosas, “Dynamic Influences of Wind Power on the Power System”, Ph.D. Thesis, ØRsted-DTU, Section of Electrical power


