

# Comparison of Solar Energy System Tools: A Case Study

Mallikarjuna G D<sup>1</sup>, G.S. Sheshadri<sup>2</sup>

<sup>1</sup>Assistant Professor, Department of Electrical and Electronics Engineering, Tontadarya College of Engineering, Gadag, Karnataka, India

<sup>2</sup>Professor, Department of Electrical and Electronics Engineering, Sri Siddartha Institute of Technology, Tumukuru, Karnataka, India

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**Abstract** - Alternate sources of energy used due to rapid increasing demand and change in climate. Solar energy has been used to generate electrical power due to clean source with wide acceptance and integrated in modern electric grids. Modeling and Simulation of solar power systems is done using MATLAB/Simulink Software. In this paper observation of characteristics of I-V and P-V output curve using both PVSYST\_5 and Simulation tool under different Irradiance and temperature is similar. This study helps to consider MATLAB/Simulink Software for further research work.

**Key Words:** MATLAB/Simulink, PV Modeling, Irradiance, Solar cell.

## 1. INTRODUCTION

Nowadays there is a lot of climatic changes occurs in environment. Solar energy is clean and abundant available source for generation of power [1-3]. Utilization of this energy will reduce the weather polluting risk. Demand of power is increasing day by day. Photovoltaic energy will meet the demand. Performance characteristic of solar module is modeled using the basic equation [4-6].

Many software are present to analyze the module under varying climatic conditions [7-8]. In this paper as a case study, author used PVSYST\_5 software and MATLAB/Simulink Software to validate tool for research. Flow chart of Photo voltaic generation is explained by using equivalent solar cell circuit. Step by step modeling is done to get the required output and compared with PVsyst\_5 software for validation. Paper show the performance characteristic of I-V and P-V curve for different Irradiance and temperature for both tools.

## Nomenclature

- $I_{ph}$  Photo-current (A).
- $I_{sc}$  Short circuit current.
- $k_i$  Short circuit current of cell at 25oC and 1000 W/m<sup>2</sup>, 0.003.
- $T$  Operating Temperature (K).
- $T_n$  Nominal Temperature, 298 K.

- $G$  Solar Irradiation (W/m<sup>2</sup>).
- $q$  Electron Charge, 1.6\*10<sup>-19</sup> C.
- $V_{oc}$  Open circuit voltage (V).
- $n$  Ideality factor of the diode, 1.3.
- $K$  Boltzmann's constant, 1.38\*10<sup>-23</sup>J/K.
- $E_{g0}$  Band gap energy of the semiconductor, 1.1eV.
- $N_s$  Number of cells connected in series.
- $N_p$  Number of PV modules connected in parallel.
- $R_s$  Series resistance, 2.366 Ω.
- $R_{sh}$  Shunt resistance, 1100Ω.

## 2. METHODOLOGY

### 2.1. PV Module Modeling:

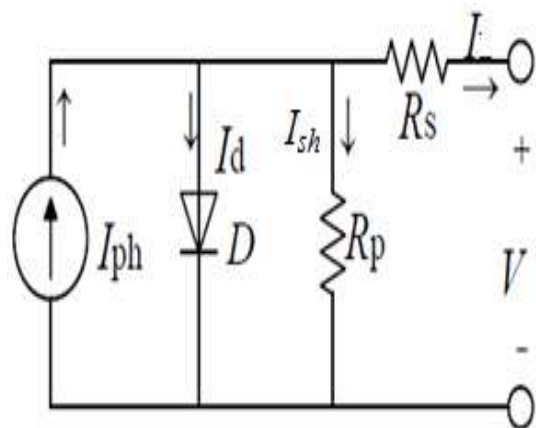


Fig. 1: Solar Energy Generation circuit [1].

The circuit of solar energy generation is shown in Fig. 1. The above circuit gives the solar module equations for the energy power generation. Photon is generated when light fall on panel. The electrical specifications of I-V curve and P-V curve of solar module depends on the varying weather condition. The values of voltage and current of solar module is influenced by the ambient temperature and solar

irradiance of the selected location. The DC energy is connected to converters. Converters convert direct current to alternating current and connected to grid.

2.1. Mathematical Equation:

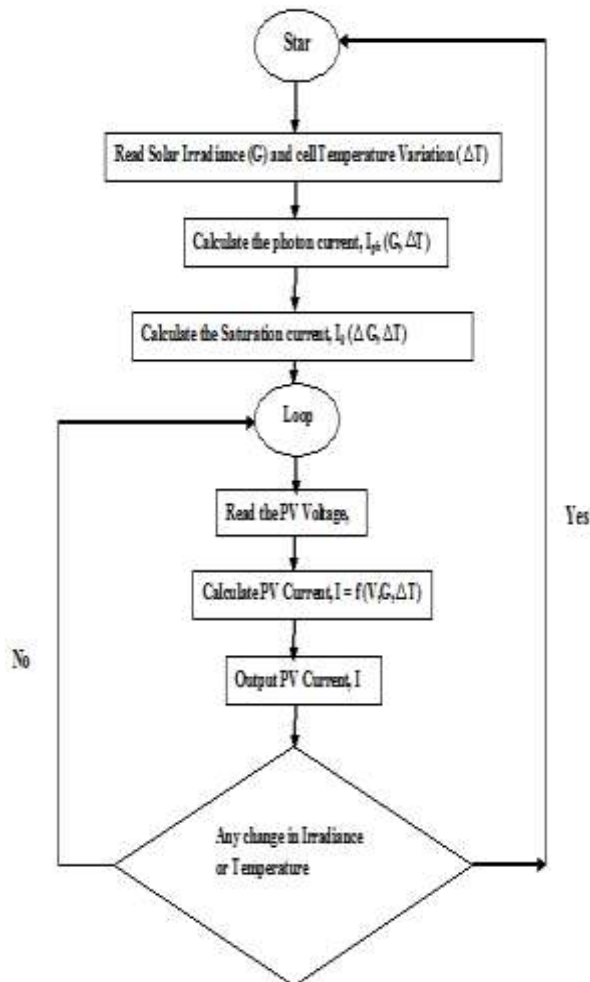


Fig. 2: Flow chart of PV calculations.

Fig. 2 gives the detail procedure to model and calculation of current, voltage and power of the solar energy using equation 1 to 5.

Photon current:

$$I_{ph} = [I_{sc} + k_i (T - 298)](G/1000) \tag{1}$$

Reverse Saturation current:

$$I_{rs} = \frac{I_{sc}}{e^{\frac{q \cdot V_{oc}}{n \cdot N_s \cdot K \cdot T} - 1}} \tag{2}$$

Saturation current:

$$I_0 = I_{rs} (T/T_n)^3 \exp \left[ \frac{q \cdot E_{go} \cdot (\frac{1}{T_n} - \frac{1}{T})}{n \cdot K} \right] \tag{3}$$

Shunt resistor Current:

$$I_{sh} = \left[ \frac{V + I \cdot R_{sh}}{R_{sh}} \right] \tag{4}$$

Solar output current:

$$I = I_{ph} - I_0 \cdot \left[ \exp \left[ \frac{q(V + I \cdot R_{sh})}{n \cdot K \cdot N_s \cdot T} \right] - 1 \right] - I_{sh} \tag{5}$$

Table 1: Parameters of GES-6P10 Model.

Rated power	10.0 W
Voltage at Maximum power (V <sub>mp</sub> )	17.40 V
Current at Maximum power (I <sub>mp</sub> )	0.58 A
Open circuit voltage (V <sub>oc</sub> )	21.6 V
Short circuit current (I <sub>sc</sub> )	0.65 A
Total number of cells in series (N <sub>s</sub> )	36
Total number of cells in parallel (N <sub>p</sub> )	1

The PV Syst\_5, GESolar, 10W, 15V, Si-poly, model software parameter shown in table 2.

3. Simulation Model

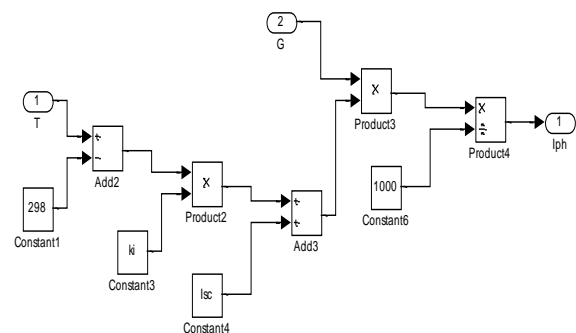


Fig. 3: Matlab/Simulink model of photon current.

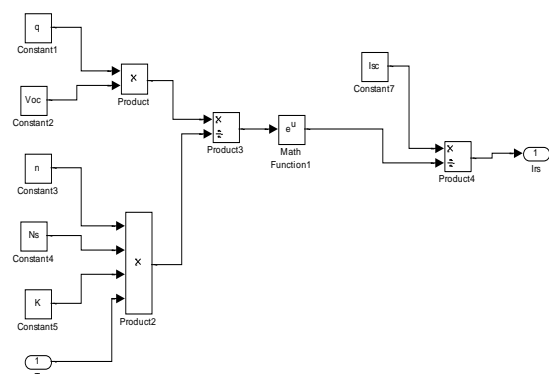


Fig. 4: Matlab/simulink model of reverse saturation current.

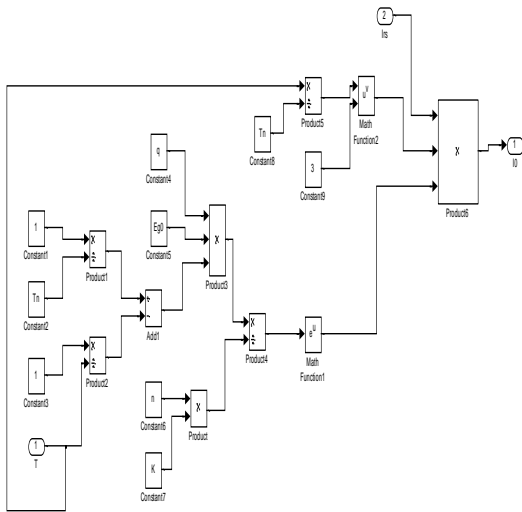


Fig. 5: Matlab/simulink model of Saturation current.

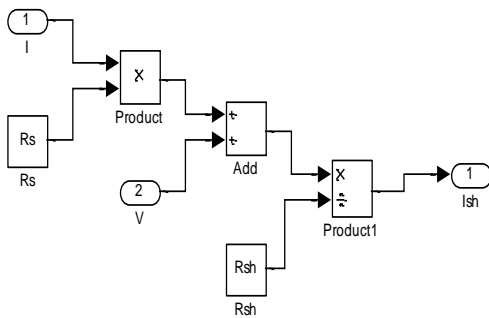


Fig. 6: Matlab/simulink model of Shunt current.

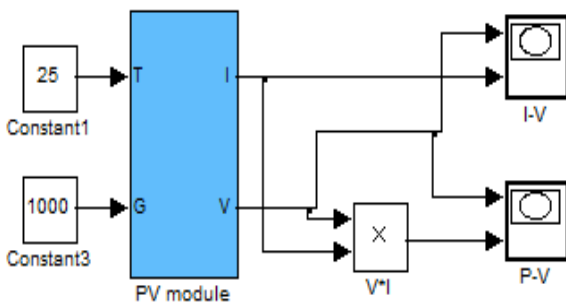


Fig. 7: Matlab/Simulink Photo voltaic module.

Fig. 3 and Fig. 4 show the model of photon and saturation current respectively. Fig. 5 and Fig. 6 show the model of reverse saturation and shunt current. PV module is modeled shown in Fig. 7.

#### 4. Results and Discussions

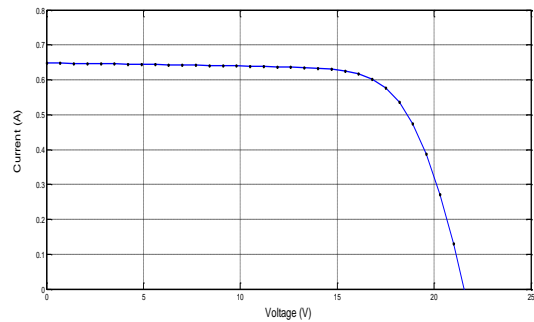


Fig. 8: Simulated I-V Characteristic,  $G = 1000 \text{ W/m}^2$ ,  $T = 25^\circ\text{C}$

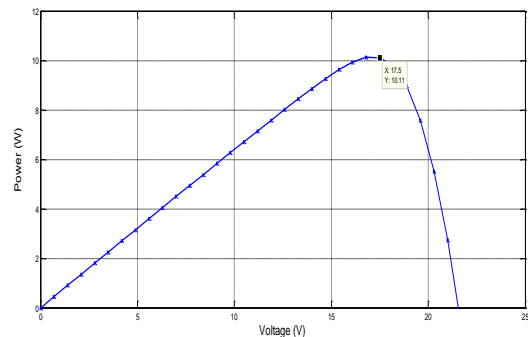


Fig. 9: Simulated P-V Characteristic,  $G = 1000 \text{ W/m}^2$ ,  $T = 25^\circ\text{C}$

Fig. 8 and Fig. 9 show the simulated I-V and P-V characteristic curves at  $1000 \text{ W/m}^2$  and  $25^\circ\text{C}$  temperature.

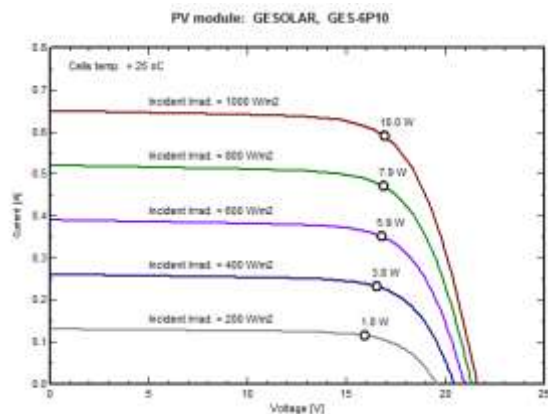


Fig. 10: PVsyst V5.74 Software I-V Curve under different varying irradiance.

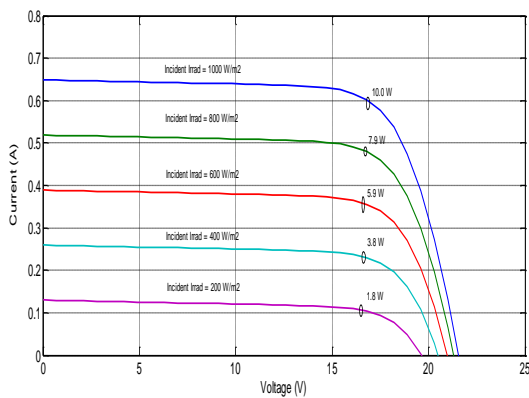


Fig. 11: Simulated I-V Curve under different varying irradiance.

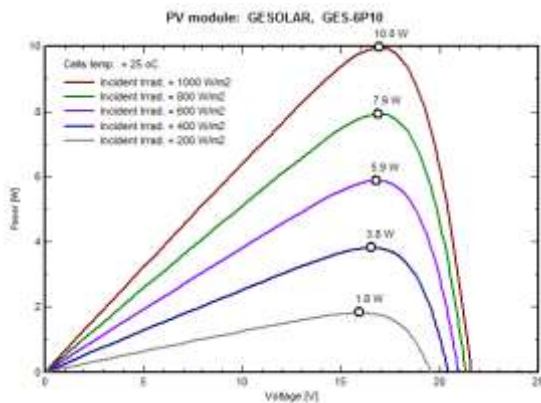


Fig. 12: PVsyst V5.74 Software P-V Curve under different varying irradiance

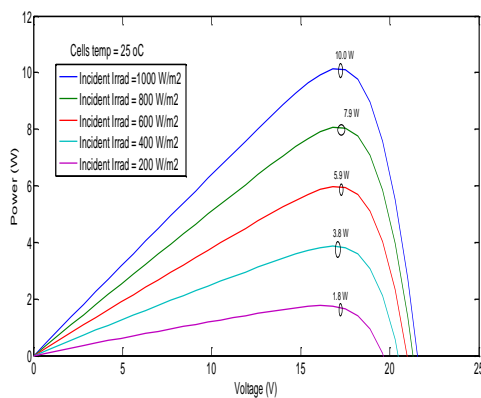


Fig. 13: Simulated P-V Curve under different varying irradiance.

- Validation of current 0.58 A and voltage 17.4 V at maximum power is similar in Fig. 10 and Fig. 11 both tools.
- Fig. 12 and Fig. 13 for varying different irradiance 1000 W/m<sup>2</sup>, and 200 W/m<sup>2</sup>, exactly 10 W and 1.8 W power is obtained in both case which shows the validation of Simulink software for P-V curve is better.

➤ Validation and performance analysis is verified from the result and discussions; hence MATLAB/Simulation is best tool for further research work.

Table 2: Comparison of PVsyst and Simulation Software results.

Software	V <sub>mp</sub> (V)	I <sub>mp</sub> (A)	P(W)
PVsyst	17.4	0.58	10
MATLAB/Simulation	17.4	0.58	10

➤ V<sub>mp</sub> and I<sub>mp</sub> values for 10 W rated power solar panel using PVsyst and Simulation Software results compared shown in table 2.

### 5. Conclusion

PVsyst software directly provides the details of basic data, model parameters and I-V and P-V graphs for 10W GE Solar manufacturing model. The presented work is detailed Modeling and Simulation of 10W PV module at 1000 W/m<sup>2</sup> and 25°C temperature is done. Validations of results are shown by comparing the simulation results with the PVsyst model and it has been observed that both the results are similar to each other. The designed PV module is best to use for further research work.

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