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Photovoltaic Modeling and Effecting of Temperature and Irradiation on I-V and P-V Characteristics

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Abstract

In this paper, a simulation model of China real plant using Matlab/ Simulink is implemented. The regulation of PV panel direction in order to receive the higher irradiance from the sun. PV model relies on math's equation that represented by awarding circuit including a photo-current exporter. The improver model gives the best manner of putting PV array under different types of PV circuit modeling and ecological parameters with solar temperature. A photo-cell china product is used in this article.

List of Symbols

I_{ph} : Photovoltaic output current (A).
I_s : Reverse diode current (A).
I_{sh} : Current of parallel resistance (A).
I_{sc}: Short current (A).
I_{pv} : Output current (A).
V_{pv} : Terminal voltage (V).
V_{ph} : Photovoltaic voltage (V).
I_d : Diode current (A).
V_{oc} : Open circuit voltage (V).
q : Electron charge (1.60217646×10^{-19}C).
K : Boltzmann Fixed (1.3806503×10^{-23}J/K).
T : Temperature of P-N junction (K).
E : Irradiation (W/m^2).
R_s : PV series resistance (Ω).
R_{sh} : PV shunt resistance (Ω)
m : Ideality diode factor.
N_s : No. of series of PV cells.
N_p : No. of parallel PV cells.

INTRODUCTION

PV applications become more suitable for a green and clean energy. It has more benefits than other different types. This type of energy has no infesting**,** no fuel, simple maintenance and no emitting noise [1]. The efficiency of PV panel is low. The relationship between voltage and current for P-N junction in the solar cell is very complex. The light falling on the cell is represented as a mathematical equation. This equation is depended on voltage and current [2]. Solar cell captures low energy of slow-moving electrons.

CHARACTERISTICS

The curve between current and voltage is called I-V characteristics; this curve shows an inverse relation. The PV maximum power is obtained from the area under curve [3]. When voltages of solar cell increase the area will be decrease. I-V curve will be changing when changing the conditions of environmental (irradiance & temperature) and thus the peak point of power curve will also change [4]. Thus the algorithm of MPPT keeps the knee point is given in figure1.

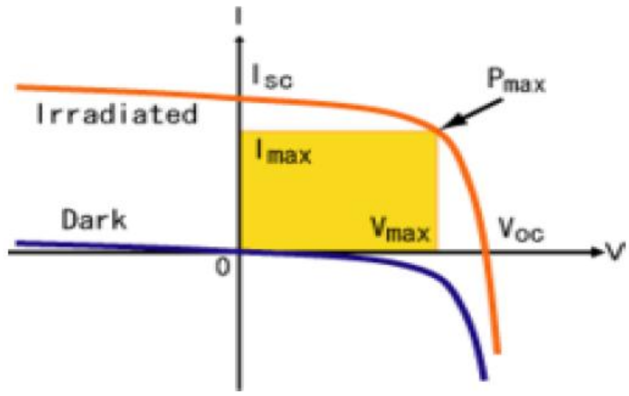


Figure 1. I-V Characteristics of a solar cell under dark and irradiated conditions.

Murky and irradiated properties are shown from above figure, this property are enhanced in from and shift downward with respect to the P-N junction illuminated. From hyperbola curve the max power point can be obtained as defined: (V*I=constant) therefore, if will be tangential to the I-V and P-V properties. Peak point represents the peak values of voltage and current [4]. Under incident illumination level and product these two points will give a one point on the curve represents the maximum electrical power.

Solar PV Cell Mathmatical Equations

The one of many models for representation the PV cell, the general adopted model is single-diode model.

A. Ideal model of PV cell (1M3P)

PV cell has an exponential behavior disposal akin to a diode. The optimal model is shown in figure 2 and consisting from (parallel connection of current source parallel with single diode). Called (1M3P) and has three parameters (I_s, m, I_{ph}) [5].

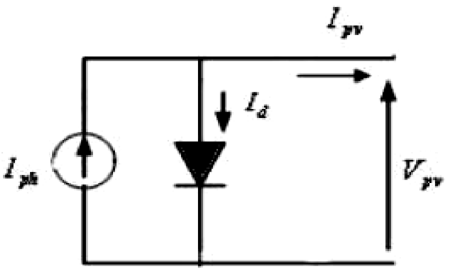


Fig.2 Ideal single diode model (1M3P)

Applying Kirchhoff law:

$$I_{pv} = I_{ph} - I_d \quad \text{............(1)}$$

While, $I_d = I_s\left(\frac{qV_{pv}}{e^{mKT}} - 1\right)$

Then,

$$I_{pv} = I_{ph} - I_s\left(\frac{qV_{pv}}{e^{mKT}} - 1\right) \quad \text{............(2)}$$

I_{sc} and V_{oc} are depicted as:

$$I_{sc} = I_{pv} = I_{ph} \quad \text{............(3)}$$

For $V_{PV} = 0$

$$V_{pv} = V_{oc} = \frac{mkT}{q}\ln\left(1 + \frac{I_{sc}}{I_s}\right) \quad \text{............(4)}$$

where $I_{Pv} = 0$,

$$P = V_{pv}\left[I_{sc} - I_s\left(e^{\frac{qV_{pv}}{mKT}} - 1\right)\right] \quad \text{............(5)}$$

B. Solar Cell With Series Resistance(1M4P)

The second type of PV model has four parameters (R_s, I_s, m, I_{ph}) as shown in figure 3.

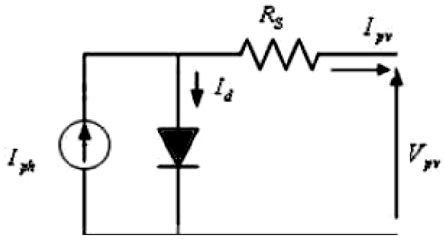


Fig 3 Second type of PV model (1M4P)

Where,

$$I_d = I_s\left(e^{\frac{q(V_{pv}+R_sI_{pv})}{mkT}} - 1\right) \quad \text{............(6)}$$

And,

$$I_{pv} = I_{ph} - I_s\left(e^{\frac{q(V_{pv}+R_sI_{pv})}{mkT}} - 1\right) \quad \text{............(7)}$$

This model concludes the equation recurrent in order to find the voltage value at positive value of current.

C. Solar Cell With Series And Shunt Resistance (1M5P)

The third type of PV model has five parameters (R_{sh}, I_{sh}, R_s, m, I_{ph}) the equivalent circuit is depicted in figure 4 [5].

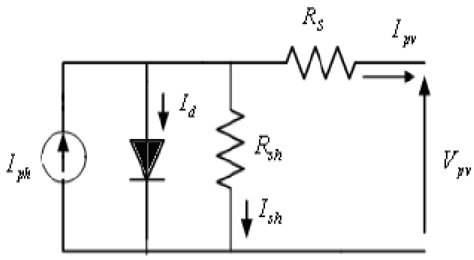


Fig. 4 Third type of PV model (1M5P)

Applying Kirchhoff law:

$$I_{ph} = I_{ph} - I_d - I_{sh} \quad \text{............(8)}$$

Where,

$$I_d = I_s\left(e^{\frac{q(V_{pv}-R_sI_{pv})}{mkT}} - 1\right) \quad \text{............(9)}$$

$$I_{sh} = \frac{V_{pv} + R_s I_{pv}}{R_{sh}} \qquad \ldots\ldots\ldots\ldots (10)$$

And

$$I_{pv} = I_{ph} - I_s\left(e^{\frac{q(V_{pv} - R_s I_{pv})}{mkT}} - 1\right) - \frac{V_{pv} + R_s I_{pv}}{R_{sh}} \qquad \ldots\ldots\ldots (11)$$

Real Solar Plant Model

The real model of Dan yang, china (Solar plan) with size 15MW is shown in figure 5.

Figure 5. Solar power plant.

The (Phono Solar Cell) module specification is given in table 1.

Table.1 Electrical parameters of (phono-cell).

Phono Solar		
Module Type PS240M — 20/U		
Rated Power at STC	(Wp)	240 W
Tolerance		±3%
Rated Power Voltage	(Vm)	30.0 V
Rated Power Current	(Im)	8.00 A
Open Circuit Voltage	(Voc)	37.6 V
Short Circuit Current	(Isc)	8.45 A
Nominal Operation Cell Temp	(NOCT)	45°C±2°C
Maximum Fuse Rating		15 A
Application Class		A
All Technical Data at STC: AM1.5 E=1000W/m² Tc=25°C		
Maximum System Voltage		1000V DC
Wind Resistance		5400 Pa
Weight		20 Kg
Dimension		1640 x 992 x 45 mm

The model circuit of Dan yang china plant is given in figure 6.

Modeling Simulation

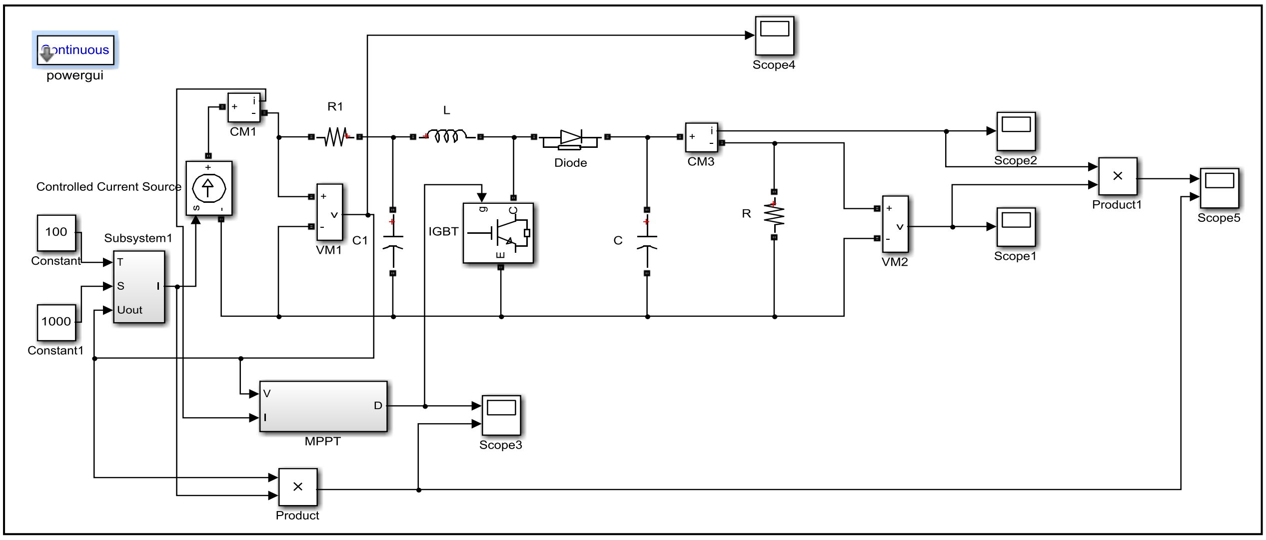
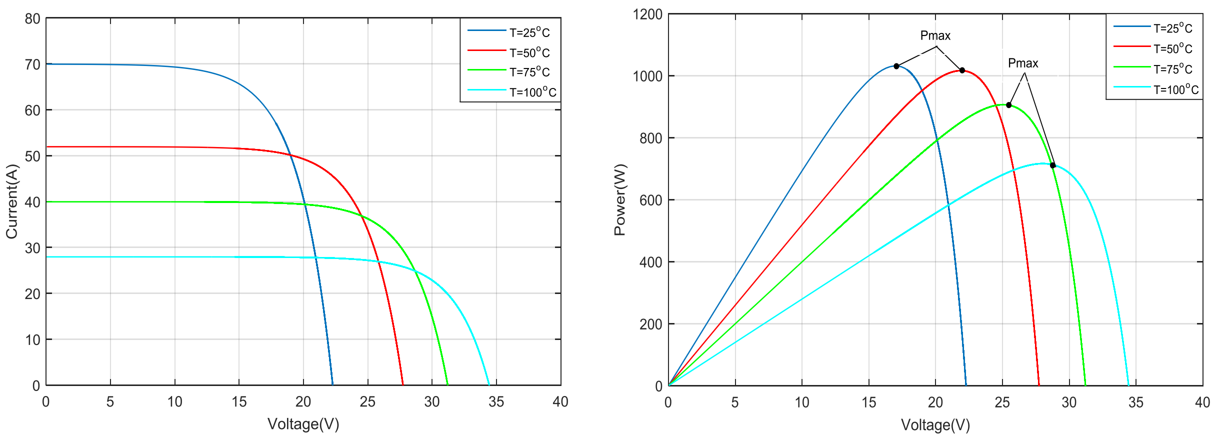


Figure 6. model of plant.

The physical parameters and environmental effect is discussed here.

1. Influence of Temperature.

The properties of P-V and I-V at immovable irradiation (1000W/m^2) and changeable temperature. When the light was incident with PV, the current will generate and this current increases as the incident light increases slightly while the voltage decrease. The power will increase as temperature decreases shown in figure 7.

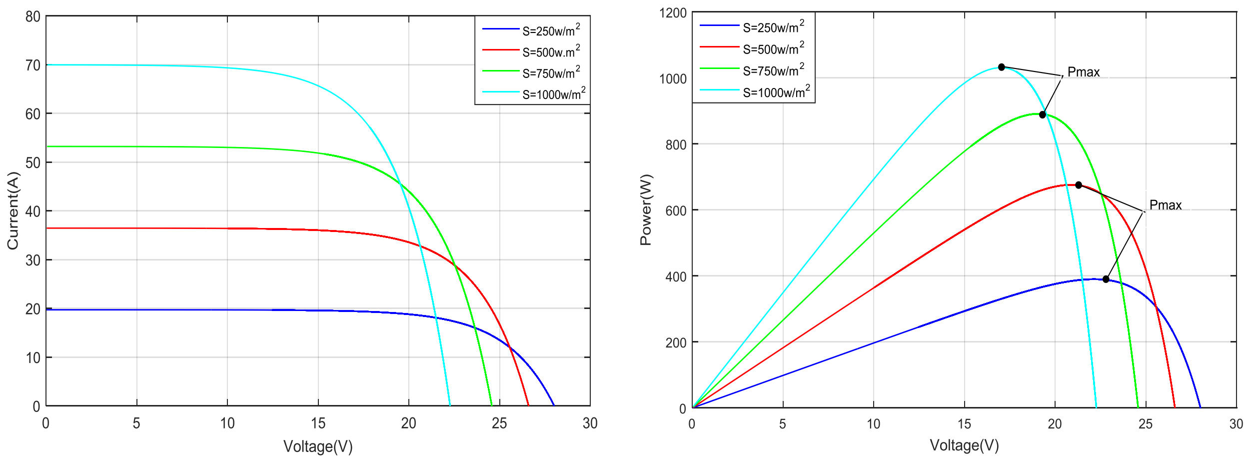


(a) I-V Characteristics. (b) P-V Characteristics.

Figure7. Influence of temperature.

2. Influence of irradiation

Figure 8 illustrate the relationship between P-V and I-V properties at fixed temperature (25°C) and changeable irradiation. From curves, the current increases when the amount of irradiation becomes higher as a result peak power point will obtain.



(a) I-V Characteristics. (b) P-V Characteristics.

Figure 8. Influence of irradiation.

CONCLUSION

The most agreeable model that manage to utilize for studying the electrical action of PV module system for planning object in the power application field:

- PV marched - out power decreased as temperature increased.
- PV marched - out power increased as irradiation increased.
- The simulation result appeared approximately similar to the practical results.
- The highest values of temperatures had negative effect on P-N junction.
- The PV efficiency depending on the fallen light ratio.
- When the temperature increased the PV output power decreased.
- When the irradiation increased the PV output power increased.
- The simulation results appeared approximately similar to the practical results.

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