Development of Photovoltaic module in MATLAB/SIMULINK

Nikate Swapnali C.
PG Student
Dept. of Electrical Engineering
Govt. College of Engineering
Karad, India

V. B. Waghmare
Professor (H.O.D)
Dept. of Electrical Engineering
Govt. College of Engineering
Karad, India

ABSTRACT
Paper based on the development of photovoltaic module in MATLAB/Simulink software, the module is designed with the help icon in Simulink block libraries. PV model are easily simulated it analyzing conjunction with power electronics for a MPPT. Sunlight irradiance and cell temperature are effects on tracking peak power. A simulation result shows the output current and power characteristics of proposed PV model.

Keywords
Photovoltaic cell, model, Mathematical equations of PV,PV characteristic, MATLAB/Simulink.

1. INTRODUCTION
Rapidly reduction in conventional energy sources. Alternately use Renewable energy, it is harvested from the natural resources like solar, wind, tidal, geothermal heat etc. Main advantage is present on life-long for utilization & free from pollution. Energy getting from the solar widely available & free of cost. Photovoltaics generates solar energy into the electrical energy depends on solar irradiation & temperature [1]-[2]. PV cells combined with series or parallel produces module, interconnection of modules forms array. To obtaining large panel output voltage by series cell connected. In parallel connecting cell gives large in current. PV system abundant, pollution free, distributed throughout the earth andrecyclable. But its installation cost high & low conversion efficiency. Therefore to increases an efficiency & system output power. So PV module coupled with DC-DC converter& controlled by MPPT.

Their several MPPT methods for different applications. PV system efficiency improved by MPPT, it is an electronic system that varies the electrical operating point of the modules so that module able to deliver maximum available power [3]. Algorithm reduces PV system cost as well as the number of PV panel required to achieve the desired output power.

This paper is to presents behavior & functions of a PV device. Basic equations & PV characteristic's PV system designed in the MATLAB-Simulation platform are discussed. Simulation results shows I-V curve &P-V curve for change in irradiations.

2. PHOTOVOLTAIC CELL
Basically, PV cell developed by a semiconductor diode whose p–n junction is exposed to light. P-N junction made with different types of semiconductor materials which reduces the cost. P-N junction of cell consists of P-type & N-type layer. Potential barrier is form at the junction which prevent the motion of electrons & holes. In depletion layer electron-hole pair generated at the light incidence on surface PV cell and Charges will be generated. This phenomenon based on semiconductor material [4] as well as incident light wavelength. The rate of developing electric carriers depends

upon flux of incident light & absorption capacity of the semiconductor.

An absorption capacity decided by the semi-conductor bandgap, reflectance of the cell surface, the electronic mobility, recombination rate, temperature etc. PV cell fails to generate voltage or current as photons energies less than the bandgap. Charge collected at the terminals of the solar cell. If terminal of cell is connected with external load, electrons flow through it which is cause of current in the circuit. Solar cell is a current source for connected external circuit.
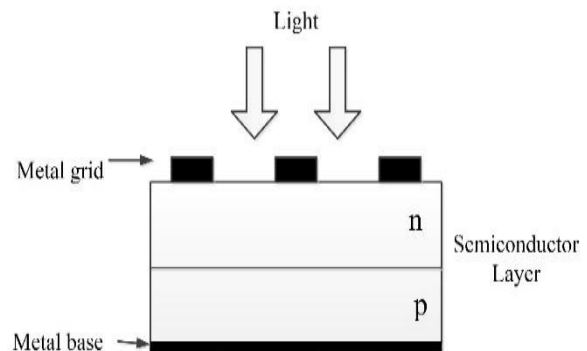

Fig 1: Basic PV cell structure

3. MATHEMATICAL MODELING OF PV
PV module generated electrical energy depends on the solar insolation, temperature. Physical model & output PV characteristic of Solar cell are easy access to mathematical model. The behavior of PV characteristic is similar to diode characteristics. PV module characteristics has in nonlinear nature. Photocurrent generated by movement of electron-holes in PV cell which is act as current sources and represented in I_{Ph}. Photocurrent proportional to the solar irradiation so that Photocurrent increases with increasing irradiation of solar. This current (I_{Ph}) continue to flow without externally applied voltage this current known as short circuit current (I_{SC}). Module consist of number of PV cells are interconnected in form of series or parallel into single unite. In order to obtaining Power from solar.

An equivalent circuit of photovoltaic cell given in Fig.2. It consist of current source is I_{Ph}, diode current (I_d), shunt resistance (R_{Sh}), & series resistance (R_S)
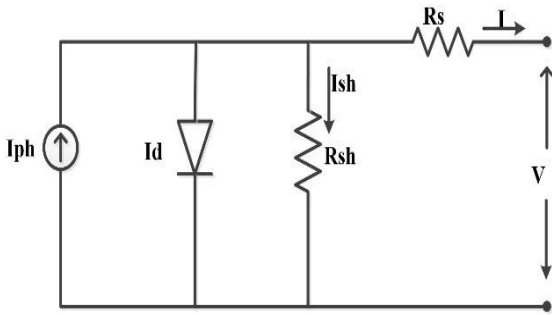
Fig 2: Equivalent circuit of PV cell

The Mathematical equations [5]-[7] described I-V characteristics of PV cell. Given as by applying Kirchhoff law at node. The load current I is obtained as

$$I = I_{Ph} - I_d - I_{sh} \qquad (1)$$

The diode current (I_d) is given by the Shockley equation

$$I_d = I_o \left[\exp\left(\frac{q(V+IR_S)}{\alpha KT_c} \right) - 1 \right] \qquad (2)$$

Where,

I = load current (A)

V = output voltage (V)

I_d = diode current(A)

I_{Ph} = The light generating current in PV Module (A)

I_o = The saturation diode current [A];

I_{scr}= PV module short circuit current at 25∘c & 1000w/m^2

E_{go}= band gap for silicon 1.1ev

α= identity factor 1.6

Rs= The series resistance of the cell [Ω];

R_{sh}= shunt resistance of the cell which is large.

Ki =short circuit current temperature co-efficient at (I_{scr}=0.0017A/∘c)

q =electric charge (1.602*10^-19C)

K = the Boltzmann's constant (1.381*10^-23K);

Tc = the module temperature [K].

Thermal voltage is V_t

$$V_t = N_s * K * \alpha * T * q \qquad (3)$$

By substituting (2) in (1), the following equation is obtained, which represents the I-V module characteristics curve under temperature conditions.

$$I = I_{Ph} - I_o \left[\exp\left(\frac{q(V+IR_S)}{\alpha KT_c} \right) - 1 \right] - \frac{(V+IR_S)}{R_p} \qquad (4)$$

A typical PV cell generated 0.6 V approximately, while they are interconnected in series (N_S)and parallel (N_p) Form to produce enough high power. The output current PV module is

$$I = N_p I_{Ph} - N_p I_o \left[exp\left(\frac{q\left(\frac{V}{N_S} + \frac{IR_S}{N_P} \right)}{\alpha KT_c} \right) - 1 \right] - \frac{\left(\frac{V}{N_S} + \frac{IR_S}{N_P} \right)}{R_p} \qquad (5)$$

For a PV module, the series resistance becomes small & shunt resistance approached infinity value so it becomes open

hence no current flow in R_{Sh}. The mathematical equation of model can be described as

$$I = N_p I_{Ph} - N_p I_o \left[exp\left(\frac{q\left(\frac{V}{N_S} + \frac{IR_S}{N_P} \right)}{\alpha KT_c} \right) - 1 \right] \qquad (6)$$

3.1 Effect of Varying Solar Irradiation & Temperature

$$I_{ph} = [I_{sc} + Ki(T - 298)] \frac{G}{1000} \qquad (7)$$

It is difficult to get an analytical solution for the specific irradiance & temperature. Therefore $I_{Ph} \gg I_0$ an ignoring the small diode & ground leakage current under short circuit terminal. So the short circuit current I_{SC} is approximately equal to the Photocurrent, i.e.

$$I_{ph} = I_{sc}$$

Module saturated current (I_0)

$$I_0 = I_{rs} \left[\frac{T}{298} \right]^3 exp \left[\frac{qE_{go}}{AK} \left[\frac{1}{298} - \frac{1}{T} \right] \right] \qquad (8)$$

Open circuit voltage V_{OC} is obtained by assuming the output current is zero. V_{OC} at reference temperature and ignoring the shunt leakage current, the reverse saturation current at the reference temperature can be approximately obtain as

$$I_{rs} = \frac{Isc}{[exp\ (Vd/Vt) - 1]} \qquad (9)$$

3.2 Design PV Model in Simulation

A modeling of PV cell in MATLAB SIMULINK with the help of equations (4), (5) and (7)-(9). The system consist of subsystem block, which contains functional block for (8) and (9). These functional blocks are connected to form the final model of photovoltaic system. The effect on V-I & P-V characteristics of PV system with different values of solar irradiation is shown in Fig.8. The curves of show the dynamic behavior of solar module.
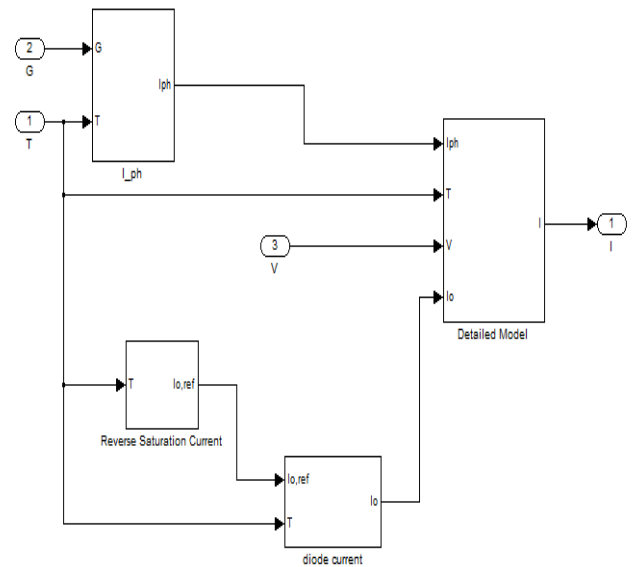

Fig 3: Subsystem of PV system

The PV system are generated in simulation by Mathematical equation of Photon current (II_{Ph}), diode current, reverse

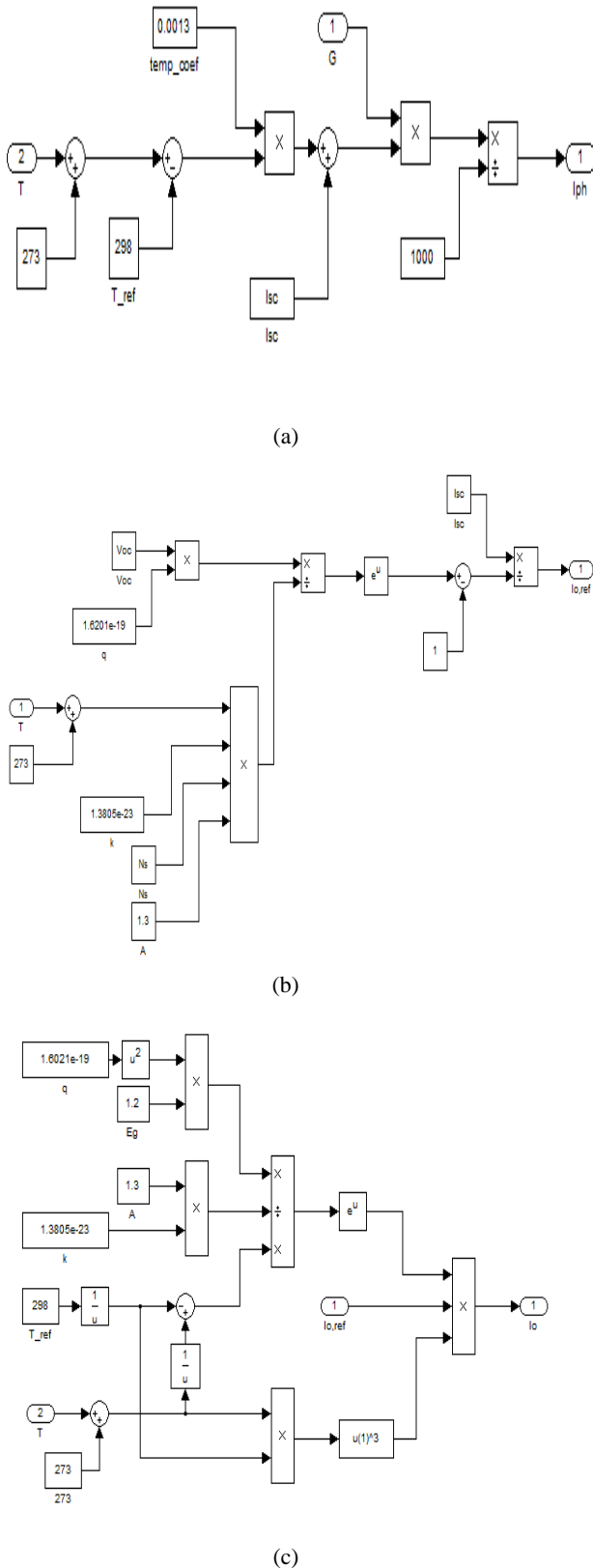saturation current. These Mathematical equations are represented in simulation. As in shown Fig.4.

(a)

(b)

(c)

Fig 4: Equations (a) Photon current, (b) Reverse saturation current & (c) Diode current are in simulation.

4. SIMULATION RESULTS

The I-V curve of photovoltaic module shows for different irradiation such as 1000 w/m^2, 800w/m^2, 600 w/m^2, and 400 w/m^2 same as P-V curve of PV system are shown in Fig.5.
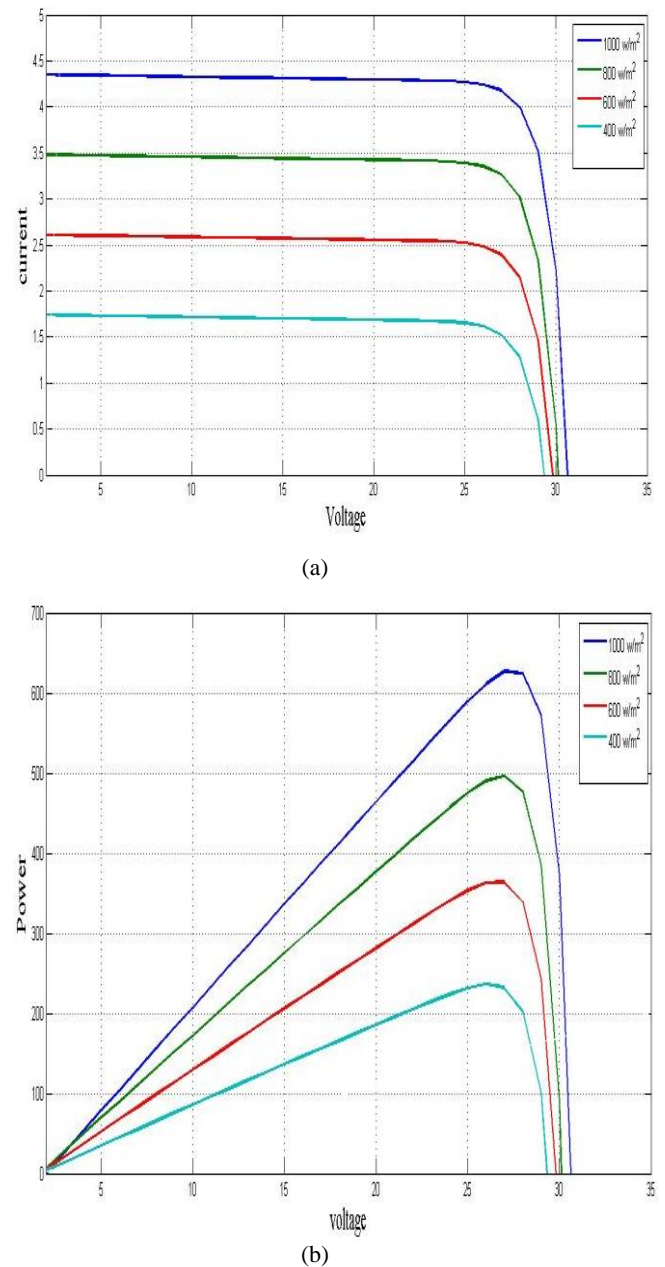

(a)

(b)

Fig5:Characteristics of PV cellas (a) I-V and (b) P-V.

7. CONCLUSION

This paper shows characteristics of PV system for different values of solar irradiations on MATLAB-Simulation software. The results of the characteristics gives effectiveness of PV system in according to changes atmospheric conditions. The output characteristics of Simulink model are similar to the theoretical characteristics.

The simulation results showed that an output current increases with rise in irradiance. This proposed model is easy to understand, simple and user-friendly for study a Photovoltaic design.

8. FUTURE SCOPE

The proposed simulation of PV takes various irradiance and cell temperature as input parameters and outputs the I-V and P-V characteristics having multiple peaks in P-V characteristics. In future simulation is very helpful to design a new hardware of solar PV panel. In manufacturing industry MATLAB/Simulation is very beneficial to design large size solar PV panel at low cost. At starting initial cost of PV panel is very high and less efficiency so less used but in future coal, diesel and petrol price are very high and produce pollution and noise. Solar panel is noiseless, pollution free, life long and less maintenance required.

9. REFERANCES

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