Design of Solar PV

J.M.Nimavat
M.Tech (Power System)
Arya College of Engineering &I.T, Jaipur

***Abstract* - One of the major concerns in the power sector is the day-to-day increasing power demand but the unavailability of enough resources to meet the power demand using the conventional energy sources. Solar Photovoltaic (PV) is a technology that converts sunlight directly into electrical energy. When the entire array does not receive uniform insolation under partial shaded conditions affect the power output of solar system. This paper presents Design of solar PV as DER (Distributed Energy resources) and its mathematical modeling and its P-V and I-V characteristics and compared with MSX60 PV module under various temperature levels.**

I. INTRODUCTION

Solar Photovoltaic (PV) is a technology that converts sunlight directly into electrical energy. The output is direct current. The major components of a PV system comprise a PV array, a battery storage unit, an inverter and a charge controller. Previous work that developed solar PV models included the following publications [1-3].Modeling techniques of PV panels are classified into two types: numerical techniques and analytical techniques. The former required iterative processes and mathematical tools to solve the implicit exponential equation associated with diode and photovoltaic devices. The latter involved more simplified significant errors. A very good numerical technique was published in [4] that predicted performance of a solar photovoltaic generator in various operating conditions. Many subsequent publications had also followed this similar method [5]. Accurate analytical methods for the extraction of solar cell model parameters were proposed in [6].Along these same lines, Analytical techniques to determine parameters of solar cells were proposed in.

II. DESIGN OF SOLAR PV AS DER

A technology that converts sunlight directly in to electrical energy is called solar photovoltaic (PV) .Direct current is the output of the solar cell and the major component of solar photovoltaic system consists of PV array, a battery storage unit, an inverter and a charge controller. The number of PV cells together forms PV modules, which further interconnected in series and parallel manner to form PV arrays in desired voltage and current output levels.

A. Model Description

The model of a solar photovoltaic (PV) generator was developed in the Matlab/Simulink environment. It was designed such that standard electrical characteristics of solar cells, as well as temperature and solar irradiation were used as inputs. The standard electrical characteristics used as inputs to the model included: open-circuit voltage (Voc), number of cells connected in series (Ns), short-circuit current (Isc), number of cells connected in parallel (Np), maximum module power (Pmax), temperature coefficient of open-circuit voltage and temperature coefficient of short-circuit current. These parameters could be obtained from a manufacturer’s datasheet. Additional inputs to the model were cell temperature and solar irradiation, which could be obtained from historical data. Model outputs were PV outputs, including voltage and current,at the maximum power point.

III. MATHEMATICAL MODELLING

The equivalent circuit of a photovoltaic cell is represented by a constant current source (Iph) connected with a diode and a series resistance (Rs, cell), as shown in Fig.1

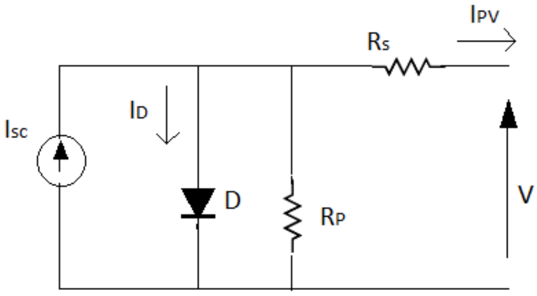

Fig.1..Equivalent circuit of a solar cell

The ideal photovoltaic module consists of a single diode connected in parallel with a light generated current source (Isc) as shown in Fig.5.1. The equation for the output current is given by

$$I = I_{SC} - I_D \qquad (1)$$

Where,

$$I_D = I_{SCref}\left\{\exp\left(\frac{qV_{oc}}{kAT}\right) - 1\right\}$$

Here,

$q = 1.6 * 10^{-19}$ (Electronic charge)
Voc-open circuit voltage k-is the Boltzmann constant (1.38 x 10-23 J/k).
The light current depends on both irradiance and temperature. It is measured at some reference conditions.
Thus,

$I_{sc} = [I_{SCref} + K_i(T_K - T_{ref})] * {}^{\sigma}/_{1000}$ (2)

Here,
Isc - Photocurrent in (A) which is the light generated current at the nominal condition (25oC and 1000W/m2).
Ki- is the short-circuit current/temperature coefficient at I_{SCref}(0.0017A/K)
T_k, T_{ref} – are the actual and reference temperature in K.
The equation that describes the I-V characteristic of the circuit in Fig.5.1 is given by

$$I_{SC} - I_D - \frac{V_D}{R_P} - I_{PV} = 0 \quad (3)$$

Thus,

$$I_{PV} = I_{SC} - I_D - \frac{V_D}{R_P}$$

Rp- parallel resistance
Rs- series resistance
And the reverse saturation current is given by

$$I_{rs} = I_{SCref}\left\{\exp\left(\frac{qV_{oc}}{N_S kAT}\right) - 1\right\} \quad (4)$$

Ns- Number of cells in series (36)
Np-number of cells in parallel (1)
A- the diode ideality factor
The module saturation current varies with the cell temperature which is given by;

$$I_o = I_{rs}\left[\left({}^{T}/_{T_{ref}}\right)^3 * \left({}^{1}/_{T_{ref}} - {}^{1}/_{T}\right)\right] \quad (5)$$

The basic equation that describes the current output of the photovoltaic (PV) module of the single-diode model is as given by.

$$I_{PV} = N_P I_S - N_S I_O\left\{\exp\left(\frac{q(V_{PV}+I_{PV})}{N_S AKT}\right) - 1\right\} - V_{PV} + \left(\frac{I_{PV}R_S}{R_p}\right) \quad (6)$$

IV. Result and Discussion

A. I-V.characteristics-varying irradiance constant temperature

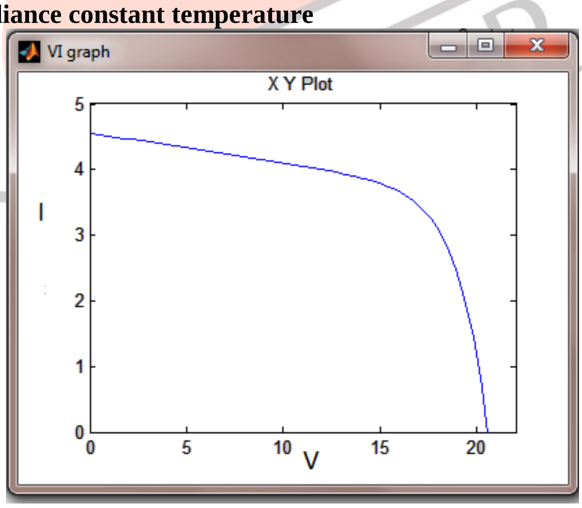

Fig:2.I-V characteristic - at irradiance 1000 - constant temperature (25 =c)

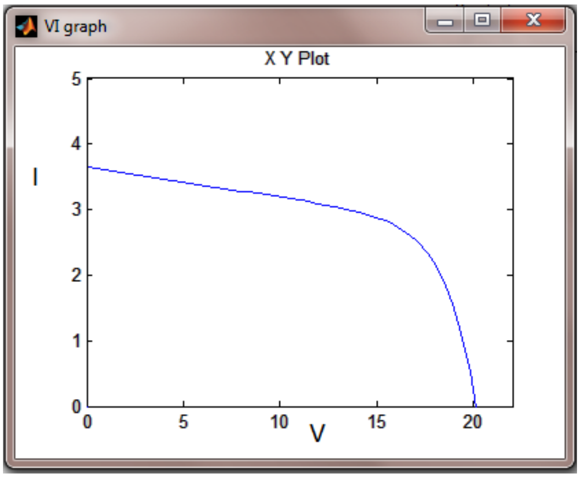

Fig.3.I-V characteristic- at irradiance=800 - constant temperature (25 c)

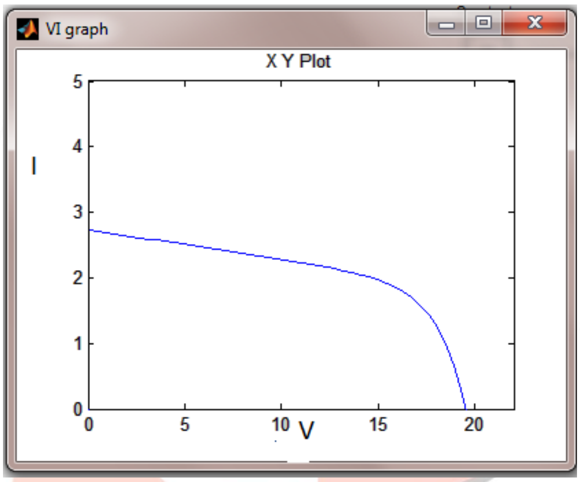

Fig.4.I-V characteristic- at irradiance=600 - constant temperature (25 c)

B. P-V characteristic- irradiance varying constant temperature

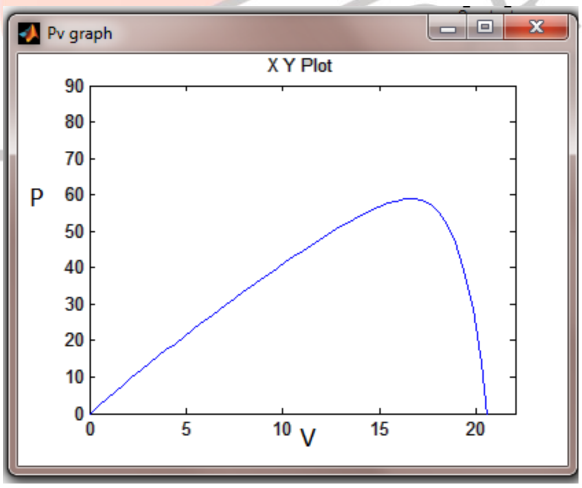

Fig.5.P-V characteristic- at irradiance=1000 – constant temperature (25 c)

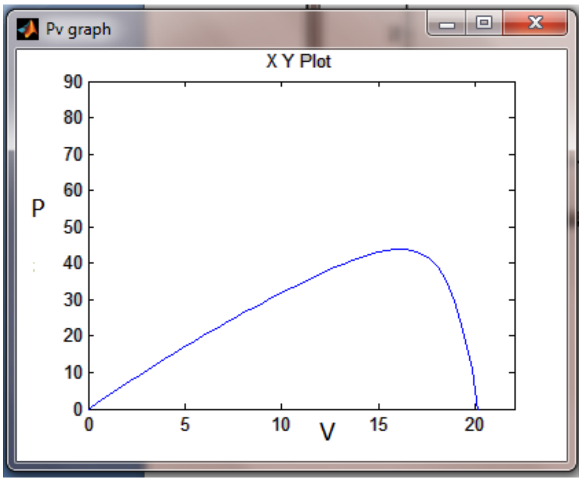

Fig.6. P-V characteristic- at irradiance=800 - constant temperature (25 c)

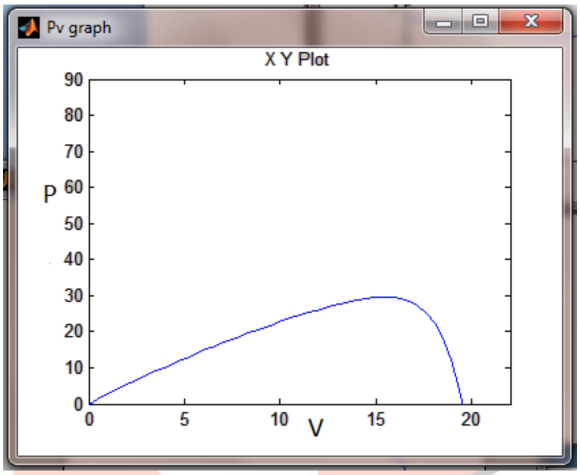

Fig.7. P-V characteristic- at irradiance=600 – constant temperature (25 c)

C. Comparison of P-V and I-V characteristic developed with MSX60 PV module

Fig.7.18 and Fig.7.19 are the P-V and I-V characteristic developed and the Fig.7.20shows the MSX60 I-V and P-V characteristics under various temperature levels [7] and the results are matching.

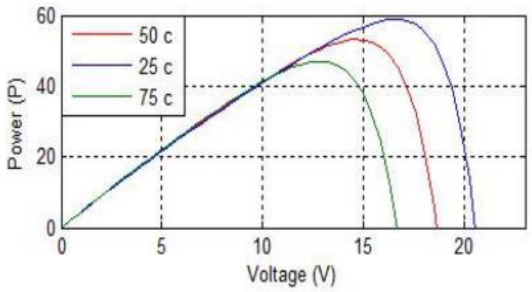

Fig. 8: P-V characteristics of PV module developed

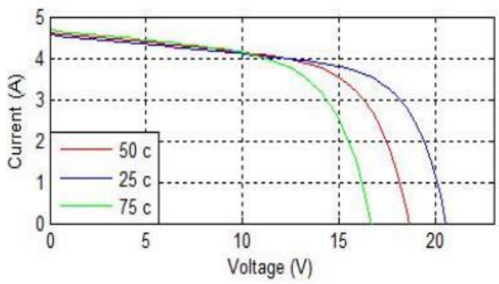

Fig. 9: V-I characteristics of PV module developed

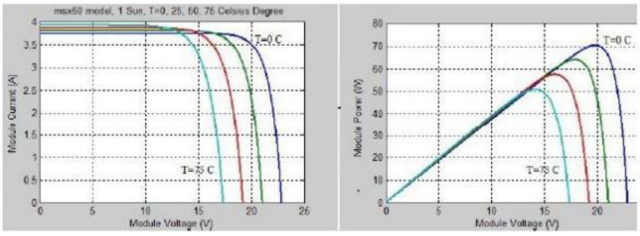

Fig. 10: MSX60 I-V and P-V characteristics under various temperature levels[7]

V. CONCLUSION

From Fig.2, Fig.3 and Fig.4 it is very clear that at constant temperature, the change in solar irradiation will change the solar photo voltaic current. That is when the solar irradiation increases the solar photo voltaic current produced also increases and if irradiation reduces current also reduce. From Fig., Fig.6 and Fig.7 it is very clear that at constant temperature, the change in solar irradiation will change the output power of solar cell. That is when the solar irradiation increases the solar photo voltaic power also increases and if irradiation reduces power also reduces From Fig.8 and Fig.9 it is very clear that at constant solar irradiation, the change in temperature will change the output voltage of solar cell. That is when the temperature increases the solar output voltage reduces and if temperature reduces output voltage increases. From Fig.8, Fig.9 and Fig.10 it is very clear that at constant solar irradiation, the change in temperature will change the output power and voltage of solar cell. That is when the temperature increases the solar output power and voltage reduces and if temperature reduces output power and voltage increases.

REFERENCES

[1] G. Dzimano, "Modeling of photovoltaic systems," The Ohio State University, 2008.

[2] S. Rahman and M. Pipattanasomporn, "Modeling and Simulation of a DG-IntegratedIntelligent Microgrid," DTIC Document2010.

[3] J. A. Gow, "Modelling, simulation and control of photovoltaic converter systems,"© JAGow, 1998

[4] S. Thanakodi, "Modeling and simulation of grid connected photovoltaic system using Matlab/Simulink," Universitiy Teknologi Malaysia, Faculty of Electrical Engineering, 2009.

[5] H.-C. Chang, *et al.*, "A novel electric energy management strategy applied in hybrid PV system,"*International Symposium on Power Electronics Electrical Drives Automation and Motion (SPEEDAM)*, ,pp. 1393-1397, 2010.

[6] A. Grasso, *et al.*, "MPPT charge regulator for photovoltaic stand-alone dual battery systems," *Electrical engineering research report,* vol. 1, 2009.

[7] G. Walker, "Evaluating MPPT converter topologies using a MATLAB PV model," *Journal of Electrical & Electronics Engineering, Australia*, vol. 21, p. 49, 2001.