A Study of Different Characteristics of Solar PV Array for Grid Connected System

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***Abstract*:** Over and above one billion people around the world lack access to grid electricity. Over the last few years, prices solar panel system is decrease dramatically leading to more affordable solar electric systems. The characteristic of PV solar systems is a requisite to get a good performance of systems under different circumstances. The characteristic allows the simulation of PV systems under different temperatures and irradiances level. The solar array for a PV array depends upon the unknown parameters, sometimes, they depends of atmospheric conditions. In this paper a developed mathematical model in MATLAB/ Simulink environment of solar PV array system and plot a different characteristics like Io - Vo, Po-Vo and Po- Io of solar array PV System.

Keywords— Solar PV modeling, Solar cell characteristics, PV systems, MATLAB/ Simulink

I. Introduction:

Energy requirements of the customers achieve through the conventional power plant (TPS,HEPS,NPS) grid has become obsolete to meet the utilities. Further awareness of customers about green technologies, environment concerns and depletion of the stock of fossil fuel has forced the planners and grid designers to explore the various renewable energy sources and alternative sources. PV-module and wind power generators, now, have become the standard renewable sources of electrical energy generation. PV Modules, which convert the solar light photon energy of to electrical energy. PV Modules is one of the best renewable energy and environmental friendly solar energy source. The main purposes of PV-modules generate DC-voltage [1-6]. Recently, PV array systems have been used in several electric power applications. Despite of the high initial cost and low efficiency, PV system has small operation and maintenance costs as it is a stationary source of energy fabricated from semiconductor material. Compared with the oil prices, the solar energy is a feasible energy supply with great long-term benefits. PV cell is considered the fundamental power conversion unit of a PV-based power system [1-6]. Solar insulation, temperature, and output voltage of PV are the essential factors that affect the output characteristics of a PV cell. Since the PV has a nonlinear current-voltage (*I-V*) characteristic, it is vital to model the PV unit for MPPT (maximum power point tracking) in PV- based power systems [1-5].The characteristic of PV solar systems is a requisite to get an good performance of systems under different circumstances. The characteristic allows the simulation of PV systems under different temperatures and irradiances level. The solar models for a PV module depends upon the unknown parameters, sometimes, they depends of atmospheric Conditions. Therefore, the characterization and simulation of PV modules using models is important to determine the performance. The utility of distributed generation projects allows the integration of PV systems. The performance of PV systems depends on the I-V (current-voltage) curve of each cell and the corresponding IV (current-voltage) curve of the module. The inverter used to get a DC into an AC and MPPT (maximum power point tracker) to get maximum power from the module. The appropriate simulation allows the most efficient design or even a method to evaluate the performance of constructed projects. According to different parameters including costs

There are three generations of PV technologies. The first generation system (I) is depend on semiconductors materials as crystalline silicon. The production of crystalline had decreased during the last years [7]. The second generation (II) of PV technologies is based on the solar cells of thin films made of Cadmium-Telluride (CdTe), Cu (In,Ga) [8] which requires less material. So, the cost is lower than first generation technologies, however, the efficiency is around 10%. The ultimate PV technologies, also known as third generation (III) corresponds to hybrid cells, it means, the cells are made of a combination of organic and inorganic materials [9]. The PV models developed so far describe output characteristics

with solar insulations and cell temperature as input parameters whereas in this paper cell temperature is determined by taking into account ambient temperature, solar insulation and wind speed [10-11].

This paper proposes a study of different characteristic of solar PV System. Section II deals with the solar system hierarchy. These equations are implemented for simulation purpose. Mathematical equivalent circuit for photovoltaic array is illustrating in section no. III and in Section no. IV simulation of system and output of solar PV system is given. Finally, Section no. V gives the conclusion.

II. PV System Hierarchy

PV Cell

As shown in Fig. 1, PV cell is a semiconductor P-N junction-based photo diode. The main purpose of semiconductor photodiode generates electrical power when convert to light .Various semiconductor materials used to PV cells. But in PV cell mono-crystalline silicon and poly- crystalline silicon material are the most commonly used [12- 14].

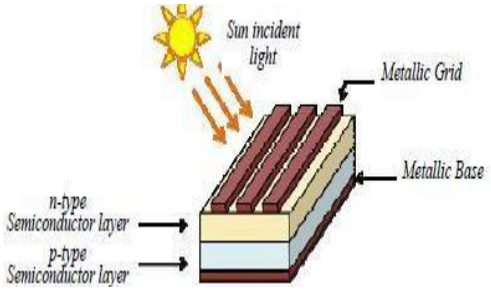

Figure 1.Basic PV cell structure

PV Module

PV Module the power produced by a single PV cell is not enough for general use. There for, no. of solar cell connected in series gives the higher voltage and no. of solar cell connected in parallel gives the higher current can be obtained consequently higher power. Generally, a combination of series and parallel connection of PV cells is known as a module. Mostly, modules consist of 36 or 72 cells. The modules consist of transparent front side, Compress PV cells, and back side. In PV cell front face material is usually made by low-iron and tempered glass. PV module efficiency is less than a PV cell due to the fact that various solar irradiations is reflected by the glass cover and frame shadowing [12-14].

PV array

Fig.2.show the circuit diagram of solar photovoltaic array. As we know that ,PV module is define as number of solar cell connected in series or parallel is known as solar PV module .PV array is define as number of solar module connected in series or parallel is known as solar photovoltaic array .A single solar module doesn't produce sufficient power for industrial and commercial purpose. For large amount of power required number of solar module connected in series or parallel. Solar module connected in series and parallel it gives an increase the voltage and current. Connecting several modules in series gives a string where several strings in parallel is an array. [12-14].

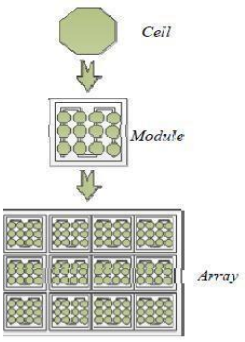

Figure.2.PV Hierarchy

PV Cell operation

In Fig. 3.show the principle of operation of a Solar PV cell is based on the principle of photoelectric effect. Photoelectric effect defined as a phenomenon in which an electron gets emit from the conduction band as a consequence of the consumption of sunlight of the certain wavelength by a material either metallic, non-metallic, solids, liquids or gases [12]. In a solar PV cell when sunlight strikes its surface a few Part of the solar energy is absorbed in the Semiconductor material. Suppose the absorbed energy is large than the band gap energy of the semiconductor, the electron from the valence band rise to the conduction band. By this, pairs of hole-electron are created in the illuminated region of the semiconductor. The electrons is compose in the conduction band are now free to move. These free PV charetertices electrons are forced to move in a particular direction by the action of the electric field presented in the PV cells. These flowing electrons constitute current and can be drawn for outer use by connecting a metal plate on top and bottom of PV cells. Current and voltage (created because of its built-in electric field) generate electric power [12-14].

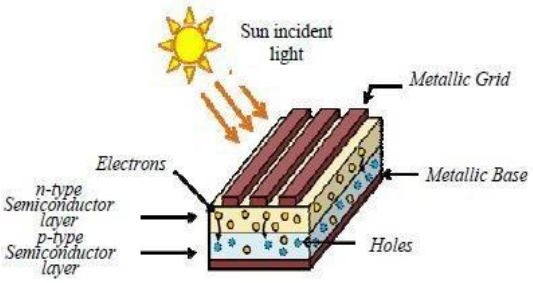

Figure.3. Operation of solar PV cell

2.5.P-V and I-V charetertices

Solar module Power-current (P-V) and current-voltage (I-V) curve are depend upon number of solar cell in series and parallel .Solar cell operate

Constant current source ⟶ operating voltages are low values

Constant voltage source ⟶ operating current are low values shown in fig4.

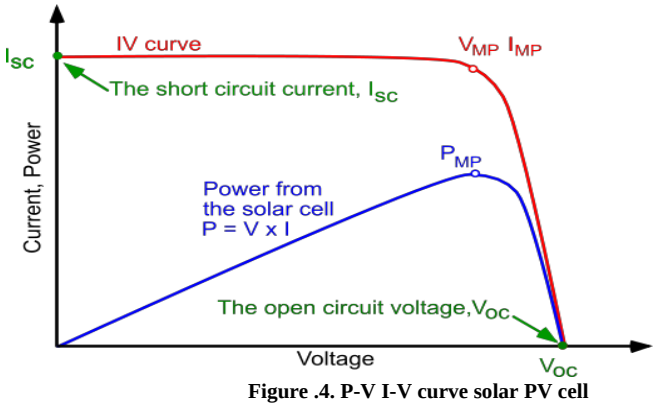

Figure .4. P-V I-V curve solar PV cell

2.6. Effect of varying the solar irradiance

Simulated the effect of different values of solar irradiance varying between 100–1000 W/m2 on the V–I photovoltaic characteristic and versus maximum output PV generator power under constant temperature 25 °C as seen in Fig. 5. The results reveal that short circuit current “Isc” linearly increases with increasing solar irradiance, and the maximum generator power increases with increasing the solar irradiance level.[32]

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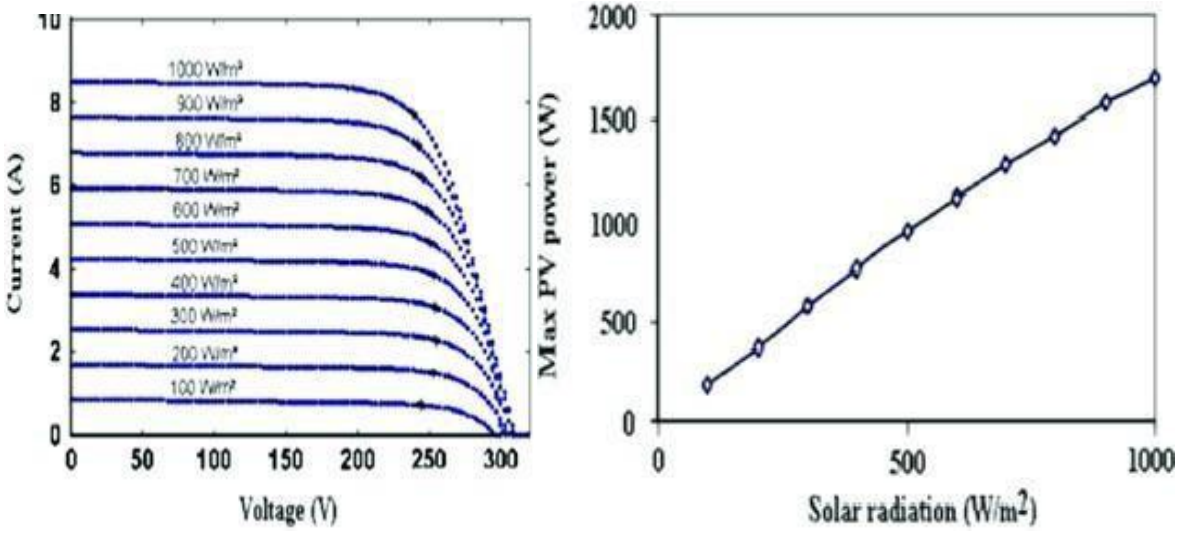

Figure .5. Effect of varying the solar irradiance on (V–I) PV characteristics and maximum generated power under constant temperature

III. Mathematical model of solar PV array

Figure 6. Show the equivalent circuit of a photovoltaic cell and Figure 7. Show the equiv. Circuit of a photovoltaic module .In figure the current (I) source Iph represents the solar cell photocurrent and Rsh and Rs are show the shunt and series resistances of the solar cell respectively. Normally in solar system, the value of shunt Resistance (Rsh) is very large. The value of Series resistance (R_S) is small [20].Practically, A group of solar cells in larger units called PV modules and many no of solar modules are connected in parallel or series is known as photovoltaic arrays .The photovoltaic system generate electricity

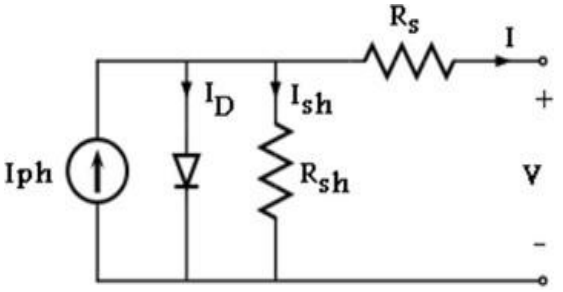

Figure..6.PV cell equivalent circuit [16]

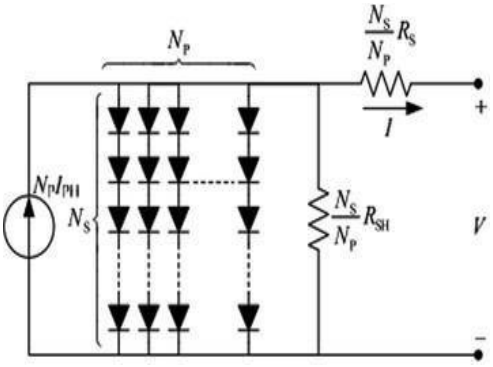

Figure.7. Equiv. Circuit of a photovoltaic Module [16]

Following equitation show the V-I chart. of solar cell [16- 17]

Equation of Solar photo -current Iph is

Iph=[I_sc+K_i(T-298)*Ir/1000] (1)

Hence, Iph: solar photocurrent in Amp.; I_sc: solar S.C current in Amp. ; K_i: S.C current (i) of solar cell at 25 °C and 1000 watt per meter square ; T: temperature (operating) in (Kelvin); Ir: solar irradiation in watt per meter square.

Equation of Solar reverse saturation current I_{rs}

$I\_rs=I\_sc/[\exp qV0C/NS*k*n*T\ ]-1$ (2)

Where, q: Electron charge the value of q is 1.6×10^{-19}C; Voc: O.C voltage in volt; Ns: No. of solar cells connected in series; n: the diode ideality factor; k: Boltzmann constant= 1.3805×10^{-23} J/K.

Equation of solar module saturation current I0 varies with the solar cell temp. is given by:

$I0=I_{rs}\ (T/T_r)\ ^{\wedge}3 \exp[(q*Ego)/n*k\ ((1/T)-(1/Tr)\ ]$ (3)

Here, T_r: nominal temperature of solar = 298.15 k; Eg0: semiconductor device energy band gap = 1.1 ev;

The equation of current output of PV module is:

$I=[Np*I\_ph-Np*Io]*[\exp((V/Ns+I*Rs/Np)/(n*Vt))-1]-I_{sh}$ (4)

With

$Vt=(k*T)/q$ (5)

$Ish=((V*NP)/(N_S+ I*Rs))/Rsh$ (6)

Hence: NP: No. Of solar cell connected in parallel; R_S: resistance in series in ohm (Ω); R_{Sh}: shunt resistance in ohm (Ω); V_t: thermal voltage diode in volt (V).

IV. Simulation Result

The values of parameters used in developing the MATLAB code for solar PV array have been table below [18-29].

Table I-: Parameter Used In Matlab Code

Parameters	Values
NP	3
NS	50
Eg0	1.66 eV
Iscr	3.75 A
K	1.38065 * 10-23 J/0K
Tr1	40 0C
Irr	0.000021 A
q	1.6022* 10-19 C
α	4.73* 10^-4 eV/K
Ki	0.00023 A/K
β	636 K
A	2.15

MATLAB code

Refer table no.1 and develop MATLAB code and MATLAB M.-File and plot Plot Vo & Io , V0&P0 and I0&P0 curve for solar PV system.

MATLAB simulation Result

1. I-V curve

The curve obtained by varying the solar insulation and temperatures which are fed into the PV array model have been plotted as shown below: [18-29].

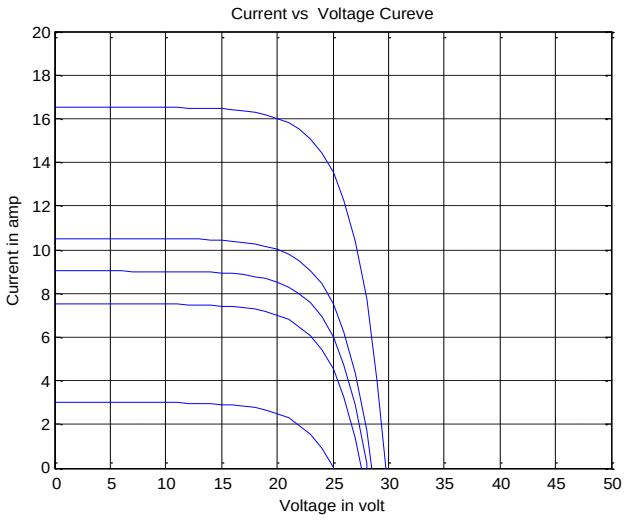

Figure 8. I-V curves obtained at 28^{0}C for various irradiance levels

Form Fig. 8, it can be observed that level solar radiation (at constant temperature at 28^0C) increase .The voltage (V) and current (I) of solar PV array is also increases, hence at more insulation it can be obtained our require voltage level.

2. P-V curve

It can be seen that solar insulation level that increases output power of solar PV array also increases, as shown fig. 9

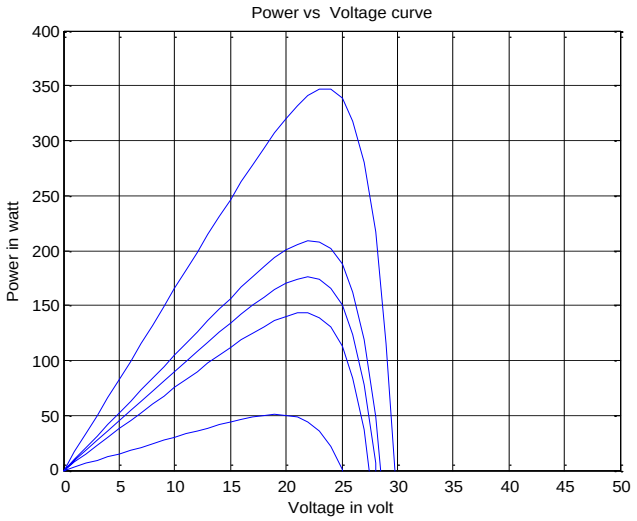

Figure 9. P-V curves obtained at 28^0C for various irradiance levels

3.P-I curve

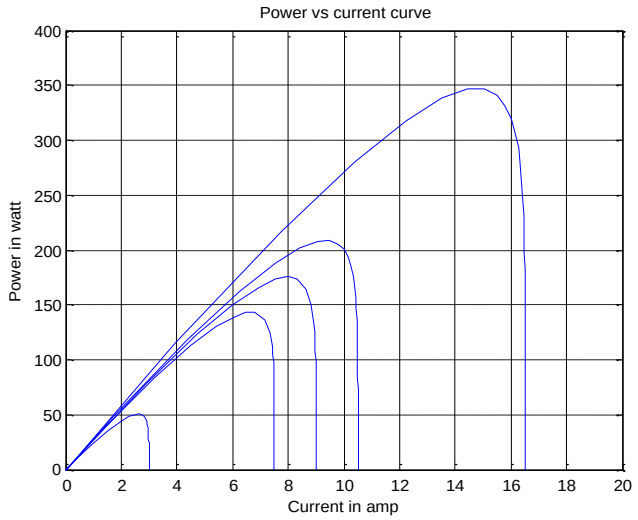

Figure 10 P-I curves obtained at 28^0C for various irradiance levels

As shown in Fig. 10. it can be seen that increasing level of solar radiation ,the current (I) and power (P) output from solar photovoltaic array also increases.

V. Conclusion

The modeling of a solar PV module is basic requirement for understanding of different characteristics of solar PV system. This paper gives a detailed explanation of solar PV module designing and implementation and Plot Vo & Io, Vo& Po and Io& Po characterization for PV system in MATLAB environment (M-File) at different Solar irradiance and temperature.

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