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Matlab Based Modelling of PV Array at Different Irrediation Level Using MPPT Technique

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Abstract - **In this Paper a new Max. Power point tracking algorithm is used for PV array at different irradiation. This algorithm is used to find the max. power point and used the simple mathematical calculation using different mathematical equation. Mat lab is used to modelling of PV array for getting the max. power. This paper conclusion to find the efficiency of is 16.2% of PV array using polycrystalline silicon material.**

Keywords – **Modelling of PV Array, MATLAB, Solar Radiation**.

I. INTRODUCTION

Renewable energy resources will be an increasingly important part of power generation in the new millennium. Besides assisting in the reduction of the emission of greenhouse gases, they add the much- needed flexibility to the energy resource mix by decreasing the dependence on fossil fuels. In other hand, deregulation of the electric utility industry is providing an opportunity for higher penetration and use of distributed resources (DR). Distributed resources are generation sources that can be located at or near loads. PV systems are ideally suited for distributed resource applications. Photovoltaic (PV) systems produce DC electricity when sunlight shines on the PV array, without any emissions. The DC power is converted to AC power with an inverter and can be used to power local loads or fed back to the utility. PV systems consist of a PV generator (cell, module, array), energy storage devices (such as batteries), AC and DC consumers and elements for power conditioning. This article refers about a model for modelling and simulation of PV module based on Shockley diode equation and the result on the basis of Matlab software.

PV generation systems have two major problems which are related to low conversion efficiency of about 9 to 12 % especially in low radiation conditions and that the amount of electric power generated by PV arrays varies continuously with weather conditions. Therefore, considerable research is being carried out to increase the efficiency of the energy produced from PV systems.

For any PV system, there is an one option for increasing its output power by tracking the maximum power point (MPP) of the PV system. The solar cell current-voltage (I-V) characteristic is nonlinear and varies with irradiation and temperature. However, there is a unique point on the I-V and a power-voltage (P-V) curve, called as the MPP, in which at this point the PV system is said to operate at maximum efficiency and produces its maximum power output. The location of the MPP is not known but can be traced by using MPPT methods to maintain the PV array's operating point at its MPP.

II. PV GENERATOR

A photovoltaic PV generator is the whole assembly of solar cells, connections, protective parts, supports etc. In the present modelling, the focus is only on cell/module/array. Solar cells consist of a p-n junction fabricated in a thin wafer or layer of semiconductor (usually silicon). In the dark, the I-V output characteristic of a solar cell has an exponential characteristic similar to that of a diode. When solar energy (photons) hits the solar cell, with energy greater than band gap energy of the semiconductor, electrons are knocked loose from the atoms in the material, creating electron-hole pairs. These carriers are swept apart under the influence of the internal electric fields of the p-n junction and create a current proportional to the incident radiation. When the cell is short circuited, this current flows in the external circuit. When open circuited, this current is shunted internally by the intrinsic p-n junction diode.

A. Modelling the Solar Cell

Thus the simplest equivalent circuit of a solar cell is a current source in parallel with a diode. The output of the current source is directly proportional to the light falling on the cell (photocurrent I_{ph}). During darkness, the solar cell is not an active device. It works as a diode.

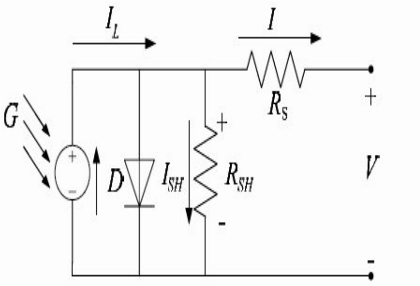

Fig.1. Equivalent circuit of PV panel

III. MATLAB MODEL OF THE PV MODULE

The any polycrystalline silicon module was chosen for modelling, due is well-suited to traditional applications of photovoltaic's . There are 60 array connected in series and 4 connected in parallel polycrystalline silicon cells. The key specifications are shown in Table 1.

The model of the PV module was implemented using a Matlab program. The model parameters are evaluated during execution using the equations listed on the previous section. The program, calculate the current *I*, using typical electrical parameter of the module (I_{SC}, V_{OC}), and the variables Voltage, Irradiation (*G*), and Temperature (*T*).

Table 1

Typical Electrical characteristic of PV model

Parameter	Variables	Value
Maximum power	P_m	349Watt.
Maximum Voltage	V_m	26.2 volt
Maximum Current	I_m	13.35 Amp
Short Circuit Currrent	Isc	15 Amp
Open Circuit Voltage	Voc	34 volt
Temperature coefficient of Short circuit voltage		(0.0065±.015)%/ °C
Temperature coefficient of Open circuit voltage		-(80±10)mv/°C
Temperature coefficient of power		
NOCT^2	P_m	-(0.5±.005)%/ °C

Notes:

(1) The data are based on measurements made in a solar simulator at Standard Test Conditions (STC), which are:
- Illumination of 1 kW/m^2 (1 sun) at spectral distribution of AM 1.5;
- Cell temperature of 28°C or as otherwise specified (on curves).

(2) Under most climatic conditions, the cells in a module operate hotter than the ambient temperature. NOCT (Nominal Operating Cell Temperature) is an indicator of this temperature differential, and is the cell temperature under Standard Operating Conditions: ambient temperature of 20°C, solar irradiation of 0.8 kW/m^2, and wind speed of 1 m/s.

In an ideal cell $R_s = R_{sh} = 0$, which is a relatively common assumption. For this paper, a model of moderate complexity was used. The net current of the cell is the difference of the photocurrent, I_L and the normal diode current I_0:

The model included temperature dependence of the photo-current I_L and the saturation current of the diode I_0.

$$I = I_L - I_0\left(e^{\frac{q(V+IRs)}{nKT}} - 1\right) \qquad (1)$$

$$I_L = I_L(T_1) + K_0\ (T - T_1) \qquad (2)$$

$$I_L(T_1) = I_{SC}\ \ (T_{1,NOM})\frac{G}{G_{NOM}} \qquad (3)$$

$$K_0 = \frac{I_{SC}\ \ (T_2) - I_{SC}\ \ (T_1)}{(T_2\ )} \qquad (4)$$

$$I_0 = I_0(T_1) * \left(\frac{T}{T_1}\right)^{\frac{n}{3}} e^{\frac{qV_q\ (T_1)}{nk\left(\frac{1}{T}-\frac{1}{T_2}\right)}} \qquad (5)$$

$$I_0(T_1) = \frac{I_{SC}\ \ (T_1)}{\left(e^{\frac{qV_{OC}(T_1)}{nKT_1}} - 1\right)} \qquad (6)$$

A series resistance R_s was included which defined as

$$R_S = -\frac{dV}{dI_{V_{OC}}} - \frac{1}{X_V} \qquad (7)$$

$$X_V = I_0(T_1)\frac{q}{nkT_1}e^{\frac{qV_{OC}\ (T_1)}{nkT_1}} - \frac{1}{X_V} \qquad (8)$$

The shunt resistance R_{sh} is neglected. A single shunt diode was used with the diode quality factor set to achieve the best curve match. This model is a simplified version of the two diode model presented by "Gow" and "Manning".The circuit diagram for the solar cell is shown in Figure 1.

B. Current-Voltage I-V Curve for a solar Cell

A typical I-V characteristic of the solar cell for a certain ambient irradiation *G* and a certain fixed cell temperature *T*, is shown in Fig 2.

For a resistive load, the load characteristic is a straight line with scope *I/V*=1/*R*. It should be pointed out that the power delivered to the load depends on the value of the resistance only.

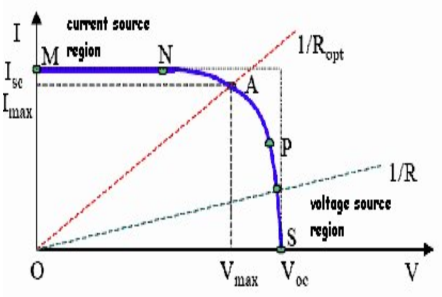

Fig.2. A typical current-voltage I-V curve for a solar cell.

However, if the load *R* is small, the cell operates in the region *M-N* of the curve (Fig 2), where the cell behave as a constant current source, almost equal to the short circuit current. On the other hand, if the load *R* is large, the cell operates on the regions *P-S* of the curve, the cell behaves more as a constant voltage source, almost equal to the open-circuit voltage.

A real solar cell can be characterized by the following fundamental parameters, which are also sketched in Fig. 2.

- *Short circuit current:* $I_{sh} = I_{ph}$. It is the greatest value of the current generated by a cell. It is produce by the short circuit conditions: $V = 0$.
- *Open circuit voltage* correspond to the voltage drop across the diode (p-n junction), when it is transverse by the photocurrent I_{ph} (namely $I_L = I_{ph}$), namely when the generated currents is $I = 0$. It reflects the voltage of the cell in the night and it can be mathematically expressed as:

$$V_{oc} = \frac{nkT}{q}\ln\left(\frac{I_L}{I_0}\right) = V_t \ln\left(\frac{I_L}{I_0}\right) \qquad (9)$$

Where

$V_t = \frac{mkT}{q}$ is known as thermal voltage and T is the absolute cell temperature.

- *Maximum power point* is the operating point $A(V_{max}, I_{max})$ in Fig 2, at which the power dissipated in the resistive load is maximum: $P_{max} = V_{max}I_{max}$.
- *Maximum efficiency* is the ratio between the maximum power and the incident light power.

$$\eta = \frac{P_{max}}{P_{in}} = \frac{V_{max} * I_{max}}{AG_a}$$

=(26.1*13.35/2.15*1000)*100

= 16.2% (10)

Where G_a is the Max.ambient irradiation=1000 w/sq.cm and A is the cell area=2.15.

- *Fill factor* is the ratio of the maximum power that can be delivered to the load and he product of *Isc* and V_{OC}:

$$FF = \frac{P_{max}}{V_{oc}I_{sc}} = \frac{I_{max}V_{max}}{V_{oc}I_{sc}} \qquad (11)$$

The fill factor can be measure by the real *I-V* characteristic. It's valued higher than 0.7 for good cells. The fill factor diminishes as the cell temperature is increased.

A program that simulates the V-I characteristics curves of solar panel on Matlab based

```
clc;
clear all;
close all;
T=28+273 ;
Tr1=40 ;% Reference temperature in degree Fahrenheit
Tr=((Tr1-32)*(5/9)+273); % Reference temperature in Kelvin
S=[100 80 60 40 20] ;% Solar radiation in mW/sq.cm
ki=0.00023; % in A/K
Iscr=3.75; % SC Current at ref. temp. in A
Irr=0.000021 ;% in A
k=1.38065*10^(-23); % Boltzmann constant
q=1.6022*10^(-19); % charge of an electron
A=2.15 ;
Eg0=1.166 ;
alpha=0.473 ;
beta=636 ;
Eg=Eg0-(alpha*T*T)/(T+beta)*q; % band gap energy of semiconductor used
Np=4 ;
Ns=60 ;
V0=[0:1:300] ;
for i=1:5;
Iph=(Iscr+ki*(T-Tr))*((S(i))/100) ;
Irs=Irr*((T/Tr)^3)*exp(q*Eg/(k*A)*((1/Tr)-(1/T))) ;
I0 =Np*Iph-Np*Irs*(exp(q/(k*T*A) *V0/Ns)-1)
P0 = V0.*I0;
figure(1);
plot(V0,I0)
axis([0 50 0 25]);
xlabel('Voltage in volt');
ylabel('Current in amp');
hold on;
figure(2);
plot(V0,P0);
axis([0 50 0 400]);
xlabel('Voltage in volt');
ylabel('Power in watt');
hold on;
figure(3)
plot(I0,P0);
axis([0 20 0 400]);
xlabel('Current in amp');
ylabel('Power in watt');
hold on;
end
```

Table 2 : Parameter Used In Matlab Code

PARAMETERS	VALUES
Np	4
Ns	60
Iscr	3.75 A
Tr1	40 ^{0}C
K_i	0.00023 A/^{0}K
Irr	0.000021 A
K	0.000021 A
q	1.6022* 10^-19 ^{0}C
A	2.15
Eg_0	1.66 eV
α	4.73* 10^-4 eV/^{0}K
β	636 ^{0}K

IV SIMULATION RESULT ON MATLAB

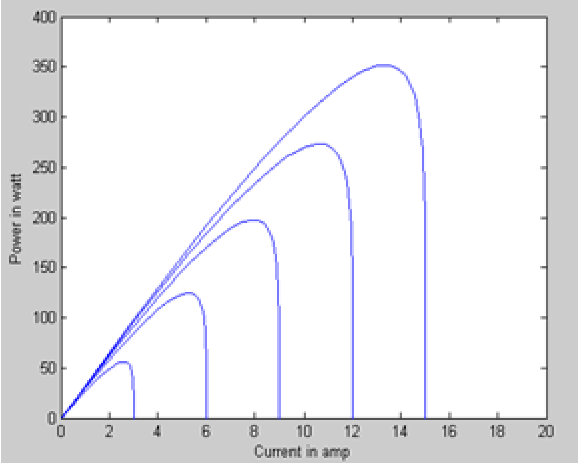

Fig.3. P-I curves obtained at 28 ^{0}C for various irradiance levels

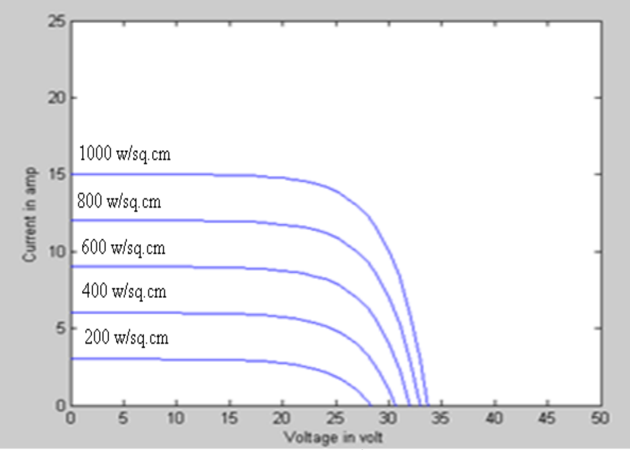

Fig.4. I-V curves obtained at 28 ^{0}C for various irradiance levels

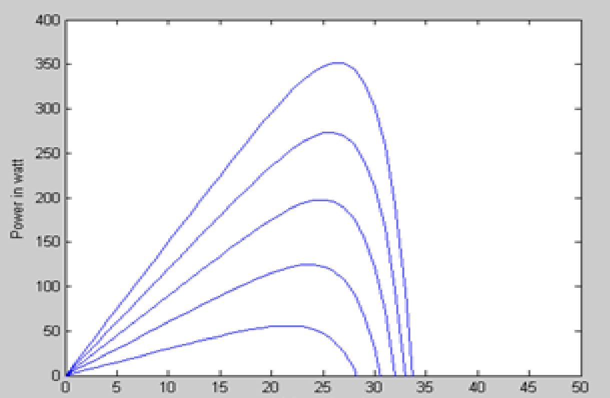

Fig.5. P -V curves obtained at 28^{0}C for various irradiance levels

V. CONCLUSION

An accurate PV module is presented and demonstrated in Matlab for a typical 349 W solar panel. Given solar insulation and temperature, the model calculates the current for a given voltage. The results from the Matlab model show excellent correspondence to manufacturer’s published curves. Finally the model development was used to show the effect of insulation, temperature, ideality factor and series resistances.

This paper is the first step to develop a complete solar photovoltaic power electronic conversion system in simulation. The final objective is develops a general model to simulate the electrical behavior of the PV systems in a grid-connected application.

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