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PV SOLAR PANEL PERFORMANCE IN IRAQ USING MATLAB

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ABSTRACT: - Baghdad is the capital city of Iraq and located at 33° 20’ 19" North latitude and 44° 23’38" East longititude. In this paper, a MATLAB model is investigated to simulate the characteristics output of a photovoltaic solar module with respect to changes in operating temperature and solar irradiance. The model is able to predict the output current and output voltage, as well as the output power. The results show that the current, voltage and output power of PV-collector increase by 80%, 17.5%, and 85.5%, respectively when the solar irradiance increases from 200 to 1000 W/m^2, but the current almost unchanged and the voltage and output power decrease by 9% and 18.5% respectively when the operating temperature changes from 25 ^{o}C to 45 ^{o}C.
Keywords: photovoltaic solar, Voltage, Current, Irradiance.

1-INTRODUCTION:

In recent years, extensive research has been carried out an experimental and theoretical analysis on the performance of PV solar collector. Edouard and Donatien (1) proposed a simple method of modeling and simulation of photovoltaic panels using MATLAB software package to determine the characteristic of PV panel. The influence of different values of solar radiation at different temperatures concerning performance of PV cells was studied. The proposed model was found to be better and accurate for any irradiance and temperature variations. The model results show that the I-V, P-V and P-I characteristics of a solar cell/module are highly dependent on the solar irradiance values. A simulink simulators for photovoltic solar collector was proposed by Alsayid (2) to take inconsideration the effect of sunlight irradiance and cell temperature on the output current and power characteristic The simulation model makes use of the two-diode model basic circuit equations of PV solar cell, taking the effect of sunlight irradiance and cell temperature into consideration on the output current I-V characteristic and output power P-V characteristic. As reported in (3), the maximum power angle of the PV collector is further able to find and track the point of maximum power throughout the day. Matlab-Simulink proposed by (4) to study the effect of irradance, temperature and surface conditions on the behavior of the PV-module under partial shading conditions. The results showed that the output power of the photovoltic module can be reduced dramatically under these conditions. As reported in (5), a unique step-by-step procedure for the simulation of photovoltaic modules with Matlab / Simulink were presented. One-diode equivalent circuit was employed in order to investigate I-V and P-V characteristics of a typical 36 W solar module. The main objective of this paper is to investigate a MATLAB model for simulating the characteristics output of a photovoltaic solar module with respect to changes in operating temperature and solar irradiance in Iraq.

2- BASIC EQUATIONS OF SOLAR CELL

Photovoltaic module is formed by connecting many solar cells in series and parallel as shown in Figure 1. At a fixed temperature and solar radiation, the I-V characteristic of the model is given by:

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

Where I_{ph} , I_d and I_{sh} are the light-generated current, the diode current and the current through the shunt resistance respectivelly [6].

$$I_{ph} = \left[I_{SC} + K_i\left(T - T_r\right)\right]\frac{S}{S_r} \qquad (2)$$

Where:

I_{SC} and Ki, are short-circuit current, and cell‘s short-circuit current temperature coefficient, respectively. T and T_r are the cell operating and the cell‘s reference temperatures, S and Sr are the solar and the reference solar radiation (1000 W/m^2);

$$I_d = I_o\left[\exp\left(\frac{V_d}{nkT/q}\right) - 1\right] = I_o\left[\exp\left(\frac{V_d}{V_t}\right) - 1\right] \qquad (3)$$

Where :

$$V_t = \frac{nKT}{q} \qquad (4)$$

Where:

I_0:Dark saturation current (A), n:Ideality factor, q:Electron charge (1.602×10^{-19} C), V_d:Diode voltage (Volt), V_t:Thermal junction voltage (mV)

And the saturation current of the solar photovoltaic cell can be expressed as:

$$I_o = I_{o,r}\left(\frac{T}{T_r}\right)^2 \exp\left[\frac{q E_g}{nK}\left(\frac{1}{T_r} - \frac{1}{T}\right)\right] \qquad (5)$$

$$T_r = \left(T_{r1} - 32\right) + 273 \qquad (6)$$

Where :

Eg: Band gap energy of the semiconductor (eV), $I_{o,r}$: Cell’s short circuit current (2.10-5 A) at Standard Test Condition (AM=1.5, T=25 ^{o}C, S=1000 W/m^2), K:Boltzmann’s constant (1.38×10^{-23} J/K), T:Cell working temperature (^{o}C), T_r: Cell’s reference temperature (^{o}C), T_{r1}: Cell’s reference temperature (40 ^{o}C)

Band gap energy

$$E_g = E_{go} - \frac{\alpha T^2}{T + \beta} \qquad (7)$$

$$V_{sh} = V_d \text{ and } V_d = V + I R_S \qquad (8)$$

$$I_{Sh} = \frac{V_{sh}}{R_{sh}} = \frac{V_d}{R_{sh}} = \frac{V + IR_s}{R_{sh}} \qquad (9)$$

Where:

Eg_0: Band gap energy at T=0K (eV), I: Cell output current (A), I_d: Diode current (A), R_s: Series resistance of cell (Ω), R_{sh}: Shunt resistance of cell (Ω), V: Cell output voltage (Volt), V_d: Diode voltage (Volt), Vsh: Voltage through the shunt resistance (Volt), α, β: Band gap energy parameters of the semiconductor (eV/K2, K).

Then:

$$I = I_{ph} - I_o \left[\exp\left(\frac{V + IR_S}{nKT/q} \right) - 1 \right] - \frac{V + IR_s}{R_{sh}} \quad (10)$$

The capability of overall PV systems will increase when the cells configure in series and parallel features. In this case, the relationship between the output current and output voltage is given by [7]:

$$I_{ph,\,final} = N_P I_{ph} \quad (11)$$

$$I_{o,\,final} = N_P I_o \quad (12)$$

$$n_{final} = N_S n \quad (13)$$

$$R_{S,\,final} = \frac{N_S}{N_p} R_S \quad (14)$$

Where:

$I_{0,final}$: Final value of I0 (A), $I_{ph,final}$: Final value of Iph (A), I_{ph}: Light-generated current or photocurrent (A), n_{final}: Final value of ideality factor, N_p, N_s : Number of parallel and series cells respectivelly, $R_{s,final}$: Final value of Rs (Ω), R_s:Series resistance of cell (Ω). A non-linear mathematical equation draws the relationship between output voltage and current of PV module as shown in Figure2. For ideal condition ($R_s = 0$) and ($R_{sh} = \infty$), the output current of the solar photovoltaic cell in Equation (10) can be expressed as:

$$I = N_p I_{ph} - N_p I_o \left[\exp\left(\frac{\left(V/N_S \right)}{nKT/q} \right) - 1 \right] \quad (15)$$

The output power of the solar photovoltaic cell can be expressed as P and it is the product of output voltage and output current.

$$P = IV \quad (16)$$

3- SOLVING PROCEDURE

Under given conditions, the characteristics output of PV collectors can be investigated using the above described set of equations. The calculation procedure of the MATLAP program is as follows:

1. Input the known data, such as reference solar irradiance and temperature of cell, number of cells in parallel and series, short circuit voltage and current, band gap energy, and electron charge.
2. Input the varying solar irradiance and temperature vectors [200 400 600 800 1000] W /m^2 at T= 40 ºC and [25 30 35 40 45] ºC at S=800 W/m^2 respectively.
3. Calculate the light generated and diode current and current through the shunt resistance.
4. Calculate the band gap energy and then calculate saturation PV-collector current.
5. Calculate the cell output current.
6. Calculate the cell output voltage and output power.

4- BAGHDAD WEATHER DATA

The weather data of Baghdad were obtained from Jadriah Meteorological Station-2013. In summer, the climate is both hot and dry. The maximum daily temperature varies between 40 to 48 ˚C and the maximum daily radiation is approximately 720 W/m^2. The hourly outdoor temperature and solar radiation in August are shown in Figures 3 and 4. As shown in Figure, A maximum air temperature of 42 ˚C records at 1:00 p.m., while a minimum temperature of 29 ˚C after 9:00 p.m. In other side, the peak value of solar radiation was about 700 W/m^2 at 2:00 pm and then drops to zero at 8:00 p.m.

5- RESULTS AND DISCUSSION

The electrical output characteristics of photovoltaic module are investigated using MATLAB software dependence on the solar radiation and the temperature. Figures 5, 6, and 7 shows the influence of the solar irradiance at constant temperature on the output current, output voltage, and output power of PV-collector. The current and voltage increase as the solar irradiance increase. Due to this, the power increase with increasing the solar irradiance. As shown in figures, increasing solar irradiance from 200 to 1000 W/m^2 will increase output current, output voltage, and output power of collector by 80%, 17.5%, and 85.5% respectively.

Figures 8, 9, and 10 show the influence of the operating temperature at constant solar irradiance on the PV-collector electrical characteristic. When the temperature changes from 25 ^{o}C to 45 ^{o}C, the output current almost unchanged while the output voltage decreases significantly nearly by 9% and the output power decreases drastically by 18.5%.

6- CONCLUSIONS

A simple MATLAB program used for investigating the characteristics output of a photovoltaic solar module with respect to changes in a solar irradiance and temperature. The model is able to predict the output current and voltage, as well as the power output. From the analysis of the program results, the following conclusions can be summarized:

- When the solar irradiance increases from 200 to 1000 W/m^2, output current, output voltage, and output power of collector increase by 80%, 17.5%, and 85.5% respectively.
- When the operating temperature changes from 25 ^{o}C to 45 ^{o}C, the current output almost unchanged while the output current, output voltage, and output power decrease by 9% and 18.5% respectively.

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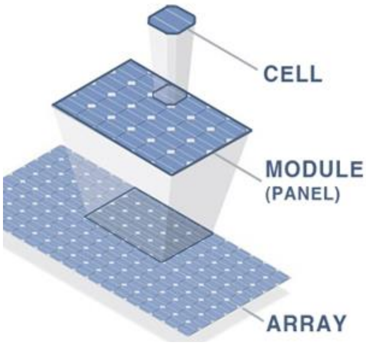

Figure (1): Photovoltaic cell, module and array.

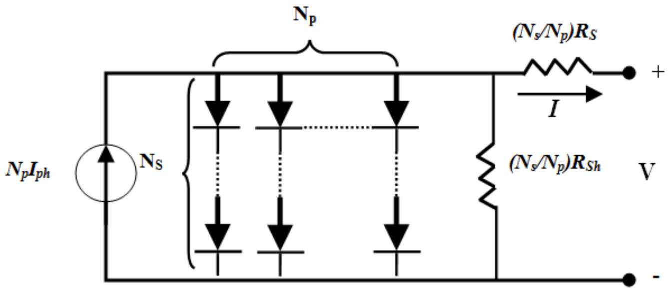

Figure (2): Equivalent circuit model of PV array.

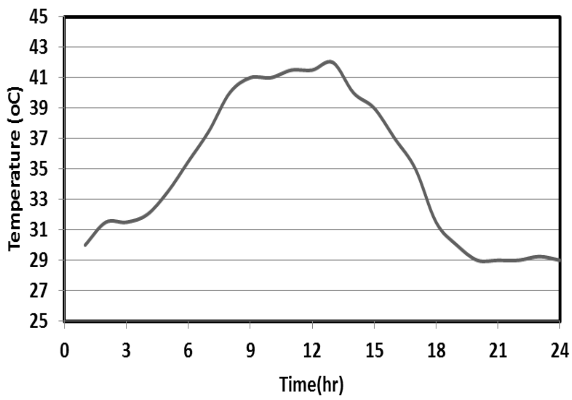

Figure (3): Hourly profiles of outdoor air temperature on August days in Baghdad.

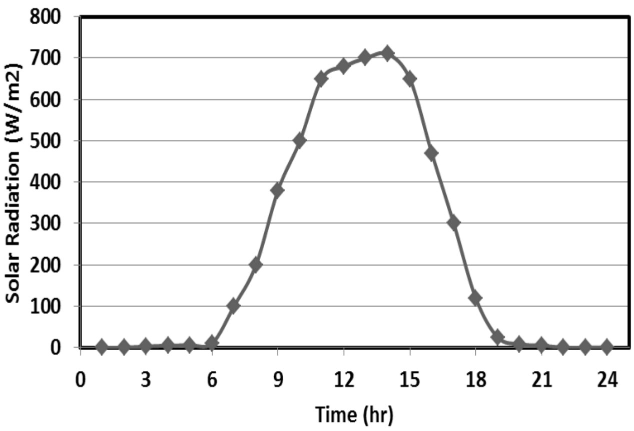

Figure (4): Hourly profiles of solar radiation on August days in Baghdad.

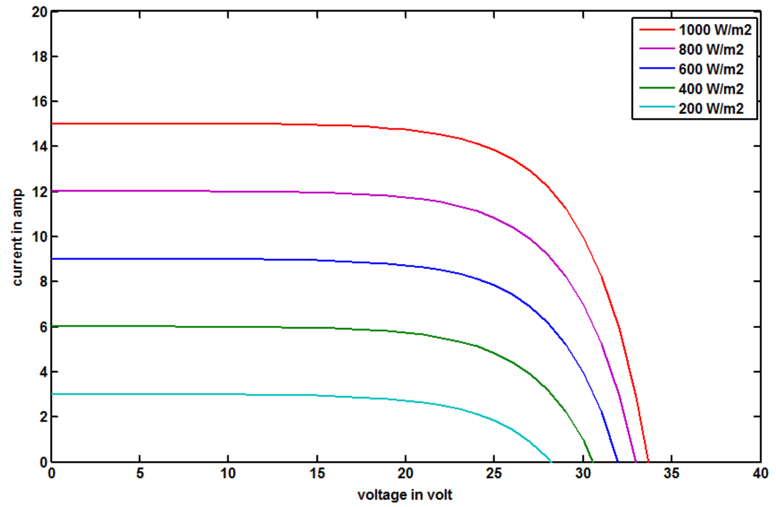

Figure (5): I-V characteristic of PV-collector at constant temperature.

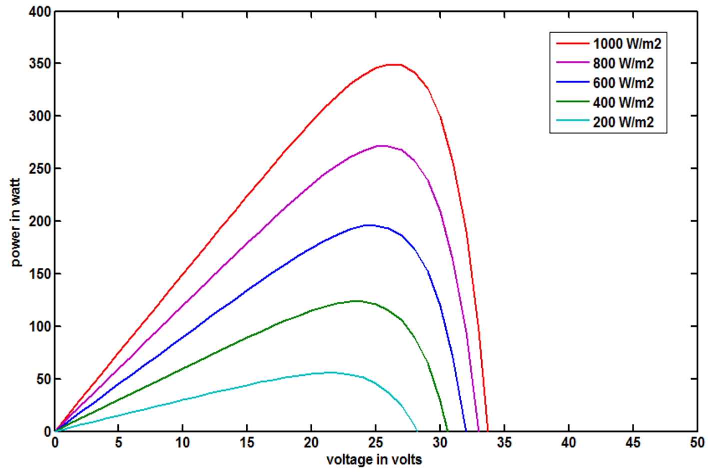

Figure (6): P-V characteristic of PV-collector at constant temperature.

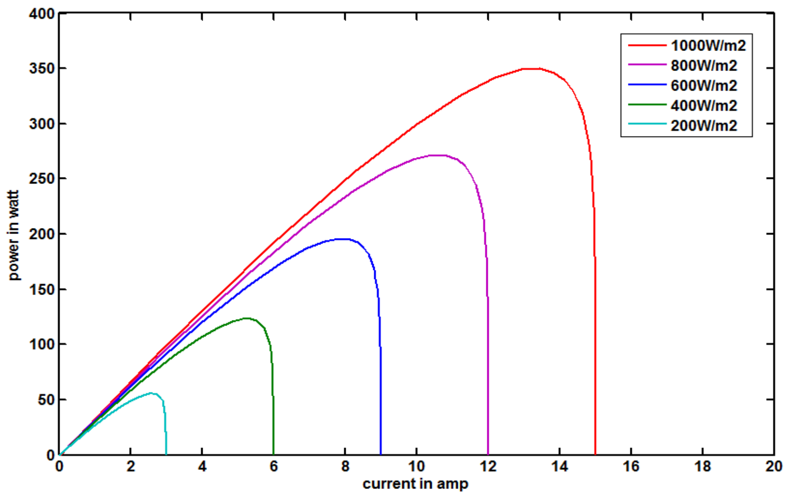

Figure (7): P-I characteristic of PV-collector at constant temperature.

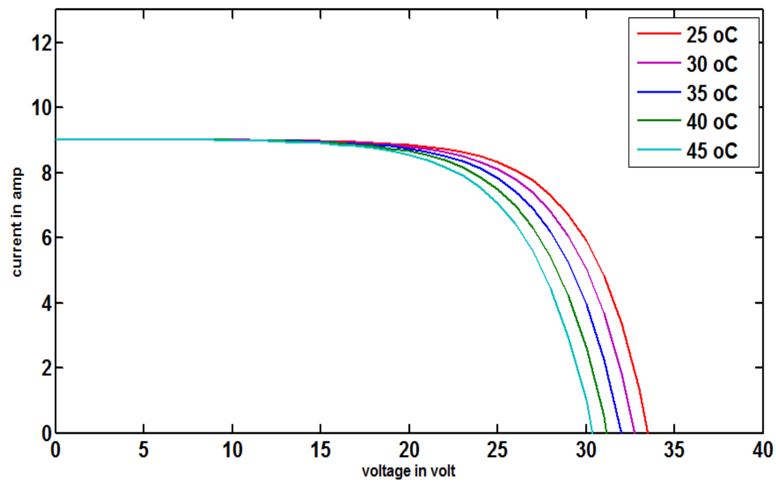

Figure (8): I-V characteristic of PV-collector at constant solar irradiance.

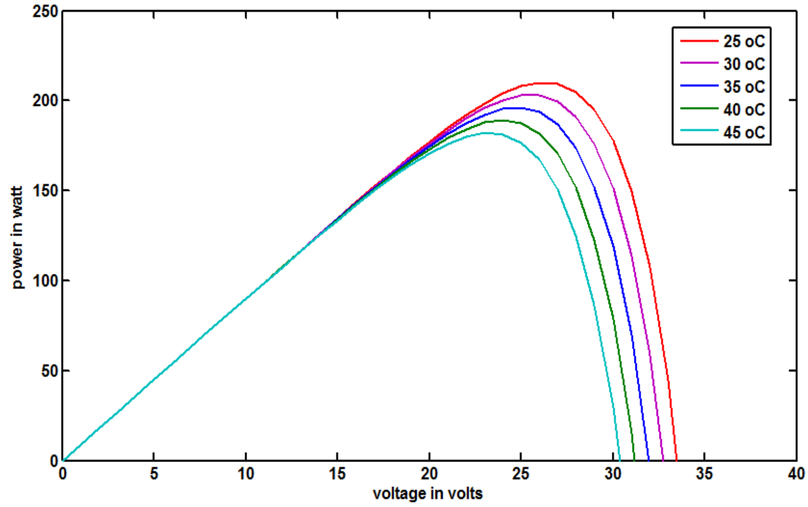

Figure (9): P-V characteristic of PV-collector at constant solar irradiance.

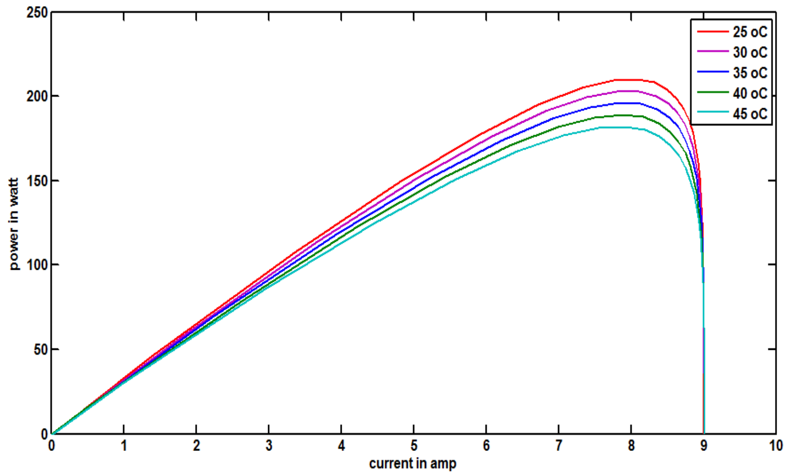

Figure (10): P-I characteristic of PV-collector at constant solar irradiance.

اداء الخلية الشمسية في العراق باستخدام الماتلاب

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الخلاصة:

بغداد عاصمة العراق وتقع على خط **"19 '20 °33** شمالا و **"38'23 °44** شرقا. في هذا البحث تم تحقيق برنامج باستخدام الماتلاب لحل خصائص خلية شمسية طبقا لتغير شدة الاشعاع الشمسي ودرجة الحرارة. البرنامج حقق حساب التيار والفولطية والقدرة الخارجة من الخلية الشمسية. وقد بينت النتائج ان التيار والفولطية والقدرة الخارجة تزداد بنسبة **85.5%** , **17.5%,** **80%** على التوالي في حالة زيادة الاشعاع الشمسي من 200 الى**1000 W/m²** لكن التيار لا يتغير في حالة تغير درجة الحرارة من **25** الى 45 درجة مئوية اما الفولطية والقدرة فسوف تقل بنسبة 9% و 18% على التوالي في حالة زيادة درجة الحرارة من **25** الى 45 درجة مئوية.