

PSPICE MODEL OF THE PV PANEL

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Abstract

This paper provides theoretical studies of photovoltaic and modeling techniques using equivalent electric circuits. The use of equivalent circuits makes it possible to investigate the characteristics of a PV cell. The method used here is implemented in orcad pspice program. The same modeling technique is also applicable for modeling a PV module. Details are also given of methods of measuring the panel parameters I_{sc} , R_s and I_s . Several techniques are described to create new components (PV), in the orcad-pspice simulator library that can be directly called by their equivalent circuits.

Index term key words: PV, PSPICE, Hierarchical block.

1-Introduction

The conventional energy sources, obtained from our environment, tend to exhaust with relative rapidly due to its irrational utilization by the humanity. This uncontrolled extraction of the natural energies, certainly will lead the harmony of our ecological system to the instability. It is important to point out, that if it occurs the recuperation of this system will be practically impossible. An a consequence of this possibility, the apprehension for a diminution of the petroleum sources, natural gas and natural resources of coal has been intensified. For this reason, the effort to find new sources of energy, to permit reduction in the utilization of the natural resources of fuel, became a challenge for all scientific and technological areas in the world, and especially for the electrical engineering area.[1].

Within this content, the solar energy appears as an important alternative to the increase of the energetic consumption of the planet, once that, the quantity of the energy from the sun that arrives on the earth surface in a day is ten times more than the total energy consumed for all the people of our planet during a year. Now due to the cost of manufactured the pv panel in our country and to denote the researcher a chance to operate in this field this research is presented. In practice we simulate the pv panel within the orcad pspice simulator based on which returns in the framework of Greg waldo[2], intusoft

newsletter issue 78[3] and A. Aziz [4]. Details are also given of methods of measuring the panel parameters I_{sc} , R_s and I_s .

2-Panel Parameters Calculation

The entire cell is represented according to the pv model in fig. 1. The current generator (I_L) provides a short circuit current which is a function of the solar irradiation (P_{var}) according to an equation determined by the characteristics $I(V)$ provided by the manufacturer:[4].

$$I_{sc} = a \cdot P_{var} - b \dots\dots\dots(1)$$

Where, a and b are constants which depend on PV cells.

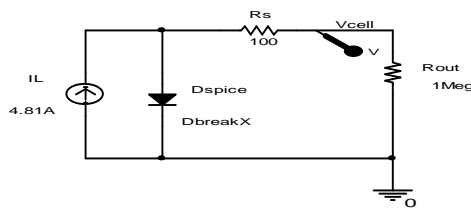


Fig.(1) : The circuit diagram used to determine I_s .

Figure 1: The circuit diagram used to determine I_s .

Eq. (1) is similar to the final (I-V) equation of the output PV cell with some

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modification, V equal zero under short circuit current condition and become:[5][6].

$$I_{sc} = I_L - I_s \left[\exp\left(\frac{I_{sc} \cdot R_s}{V_t}\right) - 1 \right]$$

Where $V_t = \frac{KT}{e}$

By comparing eq. 1 and eq. 2

$$b = I_s \left[\exp\left(\frac{I_{sc} \cdot R_s}{V_t}\right) - 1 \right]$$

From the practical results obtained by A.Aziz et.al[4], it can be derived that the current crossing a cell could be described according to illumination P var(W / m^2):

$$I_{sc}(A) = 0.00481 \cdot P \text{ var} - 0.0125$$

It should be noted that the test standard conditions (TSC) are defined by irradiance power (P var) $1000W / m^2$ at $25^\circ C$ Therefore, $I_L = 4.81A$.

It is possible to simulate a column of PV cell and a panel in the orcad-pspice if the parameters I_L, I_s, R_s for a single cell are calculated. The value of I_L (for single cell) is determined from eq.(2). In order to determine I_s the circuit shown in fig. 1 is used, Dspice is a diode whose parameter I_s (saturation current) that is calculated from simulation under open circuit voltage condition $V = Voc$. In order to eliminate the voltage drop across R_s , the PV cell terminal is connected to high resistance (R_{out}). From Dc simulation result shown in Fig. (2) ($I_s = 436.96pA$) at $Voc = 0.602V$ (open circuit voltage for single cell).

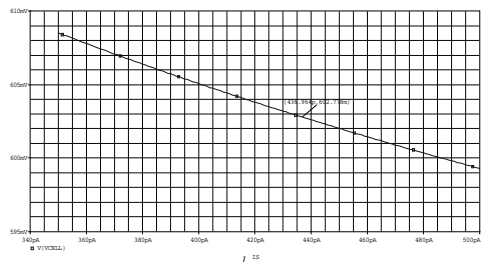


Fig.(2) : The voltage cell as a function of the saturation current I_s .

According to the electrical characteristics of the tested panel SP75 in (Table (1)) and under standard test conditions the optimum load equal to 0.1069Ω . Dbreak (the pspice model of the diode) is built according to the results from Fig. (2) ($I_s = 436.96pA$, $N = 1$, $R_s = 0.001\Omega$, $XTI = 3$, $IKF = 0A$, $EG = 1.11V$, $Cjo = 1pF$, $M = 0.3333$, $VJ = 0.75V$, $Fc = 0.5$, $ISR = 0.1pA$, $NR = 2$, $BV = 100V$, $IBV = 0.0001A$). The last parameter R_s is represented as R_{val} in Fig.(3) and simulated under optimum load resistance $R_p(max)$. From Dc analysis results shown in Fig.(4) $R_s = 13.95m\Omega$.

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Table (1)
The electric characteristics of SP75 PV panel under TSC.

Maximal power	75w
Optimal voltage	17V
Optimal current	4.41A
Open circuit voltage	21.7V
Short circuit current	4.8A

(5)

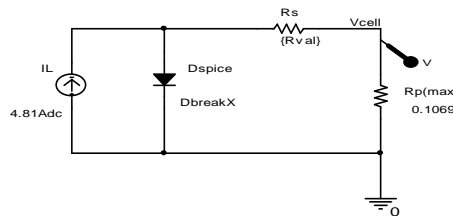


Fig.(3) : The circuit diagram used to determine R_s .

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Fig.(4) : The voltage cell as a function of internal resistance R_s .

Now it is possible to define the PV panel (SP75) by associating 36 elementary cells in series as shown in Fig.(5). Observe that the value of internal resistance R_s for whole model is the sum of the internal resistance of the entire cell; also it could be calculated in the same manner as in Fig.(4). In both methods R_s equal to 500.946 mΩ as shown in Fig.(6).

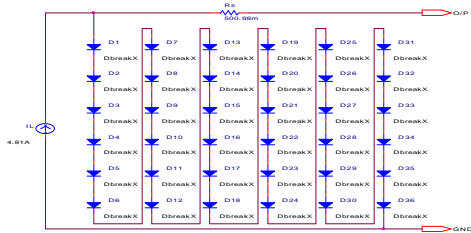


Fig.(5) : The electrical circuit of the pv model.

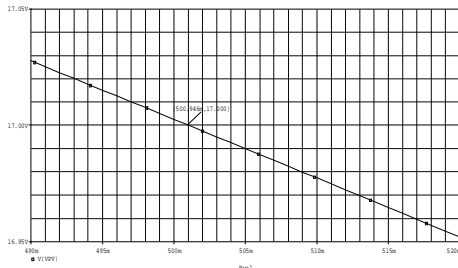


Fig.(6) : The output voltage panel $V(PV)$ as a function of the internal resistance R_s .

3.Simulation Results

The model described in the previous paragraph has been implemented in the orcad-pspice. This model has been verified and used to find the optimal operation. Fig.(7) shows the current-voltage curve, obtained from the simulation (Dc analysis) of the PV model. The optimal load replaced by R_{break} to get all value of I and V. The simulated model shows 21.7V open circuit voltage and 4.8A short circuit current at 25C° with 1000W/m² solar irradiation.

Fig.(7) : The (I – V) characteristics of the pv panel under TSC.

Next, the following Figs. (8) and (9) depict the results of the simulation at different temperature and irradiation respectively.

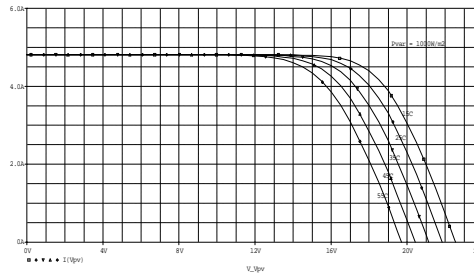


Fig.(8) : The (I – V) characteristics of the pv model at different temperature and constant irradiation.

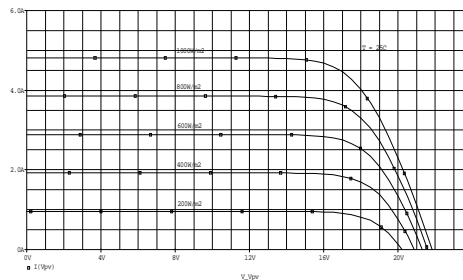


Fig.(9) : The (I – V) characteristics of the panel at different irradiancies and constant temperature $T=25C$.

The power vs. voltage plot is described on Fig. (10). It reveals that the amount of power produced by the PV model varies greatly depending on its operating condition. It is important to operate the system at the maximum power point of PV model in order to exploit the maximum power from the model ($P = 75.953W$ at $V = 17V$).

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Fig.(12) : The (P-V) characteristics of the pv model at different irradiances and constant temperature $T = 25C$.

Fig.(10) : The (P-V) characteristics of the SP75 under TSC.

The location of the maximum power point in the P-V plane is not known beforehand and always changes dynamically dependence on irradiance and temperature. Fig. (11) shows the P-V curve at the irradiance value but with a higher temperature and Fig.(12) shows the P-V curve under decreasing irradiance at a constant temperature ($25C^{\circ}$). There are observable shift where the maximum power point occurred. All the result are similar to the real characteristics; therefore its can be concluded that the simple pspice model of PV used here is valid.

4. Hierarchical Block

The model which explained previously is very large so to minimize it an integrated part (hierarchical block) has been built as shown in Fig.(13).

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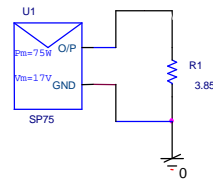


Fig.(13) : The hierarchical block .

The results obtained from this integrated part (Figs. 14, 15, 16, 17) and previous sections are compatible. Therefore, the hierarchical block is used to define the PV panel model as integrated part into special library. This part will be called from that library to simulate the (I-V) and a (P-V) characteristic of the PV model, as well as this part is used as a source of energy to the power circuits.

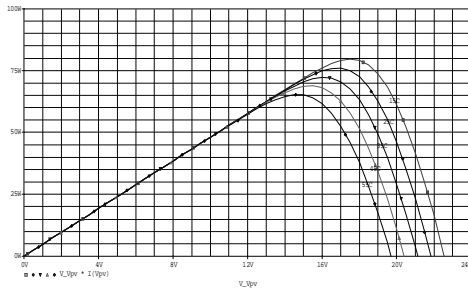


Fig.(11) : The (P-V) characteristics of the pv model at different temperatures and constant irradiation $1000W/m^2$.

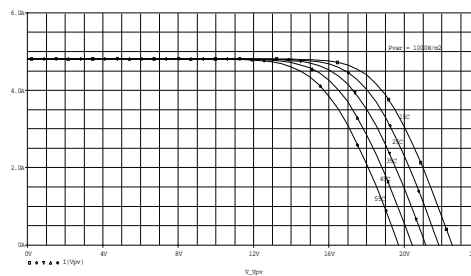
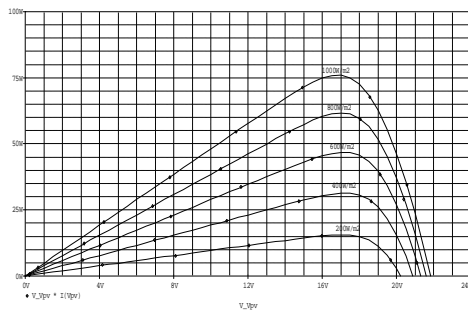


Fig.(14) : The (I-V) characteristics of the Hierarchical Block at different temperatures and constant irradiation $1000W/m^2$.

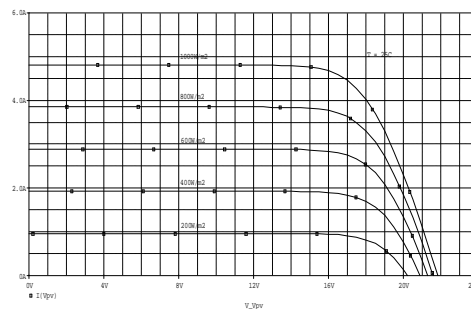


Fig.(15) : The $(I-V)$ characteristics of the Hierarchical Block at different irradiation and constant temperature $T = 25C$.

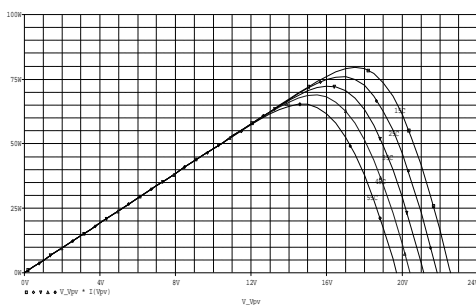


Fig.(16) : The $(P-V)$ characteristics of the hierarchical block at different temperatures and constant irradiation.

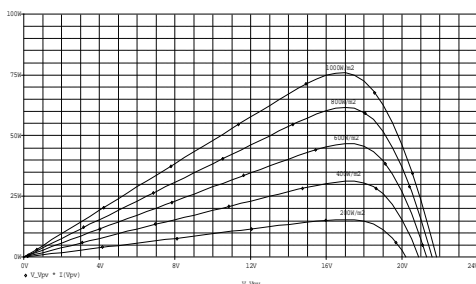


Fig.(17) : The $(P-V)$ characteristics of the hierarchical block at different irradianations and constant temperature $T = 25C$.

5. Conclusion

This research described briefly how a PV panel consists of 36 cell connected in series was created in the ORCAD PSPICE simulator library. Therefore, for a given panel, we can simulate its electric characteristics (voltage-current) by calling directly the panel from the ORCAD PSPICE library. The results show that the PV model using the equivalent circuit in moderate complexity provides good matching with the real PV module. This model can be generalized for any PV panel which it is enough to calculate the

panel parameters (R_s and I_s) and PSPICE model of diode only.

6. References

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الخلاصة

يتناول هذا البحث دراسة نظرية للخلية الشمسية وتقنيات إنشاء موديل لهذه الخلية بأستخدام دائرة كهربائية مكافئة له لتمكين المستخدم من استخدام الدائرة المكافئة في حساب أهم الخواص الكهربائية للخلية الشمسية وتم تحقيق ذلك بأستخدام برنامج التحليل PSPICE. وبنفس التقنية وضع موديل للوح الشمسي. كذلك تفاصيل طرق حساب ثوابت اللوح I_{sh} و R_s , I_s تم إعطاءها أيضاً. تم توضيح أكثر من تقنية لخلق لوح PV في PSPICE كنموذج ليتم أستدعاءه مباشرة.

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