Analysis the Performance of Silicon Solar Cell Parameters with the Ambient Temperature using Fuzzy Logic

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Abstract

In this paper, the fuzzy logic technique is used to obtain the optimal value for the main parameters of silicon solar cell in different temperatures. The important parameters to perform the solar cell is, short circuit current (I_{sc}), open circuit voltage (V_{oc}), fill factor (F.F) and efficiency (η_m). The experimental results for this method show to obtain on the maximum value of conversion efficiency when the values of T is low , I_{sc} is high , V_{oc} is low ,P_{in} is low, Temp is low Then I_m is high, V_m is low, P_m is high, F.F is high, Eff. is high &R_{cell} is low.

Keywords: fuzzy logic technique, solar cell, indoor and outdoor parameters, temperature effect.

1. Introduction

Solar energy is an unlimited source of energy which is clean, abundant and extremely available. Solar cell by converting solar energy into the electrical power makes using this energy possible. Output power of solar cell is nonlinear and time varying Depending on environmental conditions such as light intensity and temperature it will be changed. Serial and/or parallel cells generate photovoltaic (PV). So if PV produces high power on grid-connected and doesn't have optimal performance it may cause losing power which is costly. In this paper we tracked maximum power of PV array to place performance point of PV panel in its maximum power [1].

Renewable energy becomes an essential source for many applications in the last four decades. It is difficult to supply electrical energy to small applications in remote areas from the utility grid or from small generators. Stand alone photovoltaic (PV) systems are the best solutions in many small electrical energy demand applications such as communication systems, water pumping and low power appliances in rural area [2][3]. The maximum operating point of solar Photovoltaic (PV) panels changes with environmental conditions. Many

methods have been proposed to locate and track the maximum power point (MPP) of PV cells. The difficulties that face these methods are the rapid changes in solar radiation and the variety in cell temperature which affects the MPP setting [4].

Solar irradiation, ambient temperature and wind speed are the main environmental factors that affect PV systems. I_{sc}, V_{oc}, V_{max} and MPP current (Imax) are the main characteristics that specify the I-V and PV curves of PV panels [5][6][7]. I-V curve characteristics and cell junction temperature of PV panels is adjusted due to any changes in environmental conditions.

MPP changes due to irradiance level and cell junction temperature. Ambient temperature with current flows in PV cell increase the cell junction temperature. The temperature of cell junction is the main factor that reduces the maximum power output of PV panel. Fig. (1) shows how the I-V curves and power curves change with PV cell junction temperature. The operating voltage on I-V curves depends on load type and load value, [5].

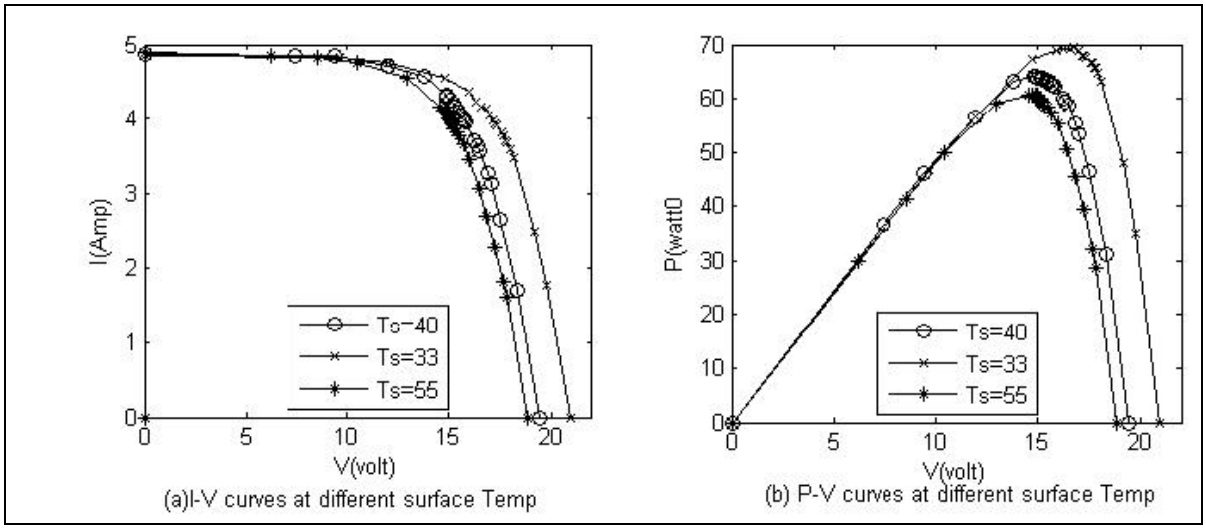

Fig. (1) a I-V curves at different surface temperature.
b P-V curves at different surface temperature.

2. Fuzzy logic Technique

Fuzzy logic is a form of many-valued logic or probabilistic logic; it deals with reasoning that is approximate rather than fixed and exact. In contrast with traditional logic theory, where binary sets have two-valued logic: true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false [8]. Furthermore, when linguistic variables are used, these degrees may be managed

by specific functions. Fuzzy logic began with the 1965 proposal of fuzzy set theory by Lotfi Zadeh [9][10]. Fuzzy logic has been applied to many fields, from control theory to artificial intelligence. The nature of inaccurate things in life where a problem that sometimes these things can be neglected to facilitate the analysis steps, fuzzy logic theory is able to solve these problems. Fuzzy logic is a form of algebra employing a range of values from "true" to "false" that is used in decision-making with imprecise data, as in artificial intelligence systems. Fuzzy Logic is basically a multi-valued logic that allows intermediate values to be defined between conventional evaluations like yes/no, true/false, black/white, etc. Notions like rather warm or pretty cold can be formulated mathematically and processed by computers. In this way an attempt is made to apply amore human-like way of thinking in the programming of computers. Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth - truth values between "completely true" and "completely false". It was introduced by Dr. Lotfi Zadeh of U.C. Berkeley in the 1960's. The basic idea In this theory start a so-called degree of membership of each variable is undefined. Apply include organic (graded member ship) where each element in the description (Universe of discourse) (U) indicates member (membership) arranges and sets of "0" (non-member) to "1" (full member), which represents the degree to which the element is joined to a group (Fuzzy logic set) [10], [11]. Thus, the membership function (μ) that make the item (X_i) in the field Description (U) to the real number in the specified period (0.1) and that the real number representing the degree of membership for the element Xi proportion to the group of fuzzy logic T (Fuzzy set) fuzzy logic set T Can be written as follows

$T = \mu T(X_1) / X_1 + \mu T(X_2) / X_2 + \ldots\ldots\ldots \mu T(X_n) / X_n \ldots$ (1)

or $T = \sum_{i=1}^{n} \mu(X_i / X_i)$, i= 1,2,3 ..... n…(2)

Photovoltaic (PV) offers many advantages such as incurring no fuel costs, not being polluting and requiring little maintenance. The PV arrays produce electric power directly from sun light. The relationship between output voltage and current of the solar cell at varying light intensity and temperature is very important. At same irradiation and temperature, there is a unique point located at the knee of the I-V curve that is called maximum power point (MPP). In a solar cell operating under the normal conditions, even a small derivation of 1% from the optimum power transfer condition can cause a loss of output power by nearly 10% [1]. For increase efficiency of PV we need to track MPP.

3. Experimental Details

According to the data in table (1,2), this data of the silicon solar cell parameters

(100 cm^2 Area) indoor and outdoor obtained from [12]. Now, we used the fuzzy logic technique to obtain on the optimal values of these parameters.

Table (1) indoor measurements of the silicon solar cell parameters.

Time (H)	I_{sc} (mA)	V_{oc} (mV)	I_m (mA)	V_m(mV)	P_m (W)	Pin (W/m^2)	F.F	η_m %	R_{cell} (ohm)	T cell (^oC)
10	0.47	0.45	0.41	0.342	0.14022	10	0.663	1.4022	0.834	40
14	0.65	0.45	0.49	0.35	0.1715	10	0.5863	0.7149	0.714	60

Table (2) outdoor measurements of the silicon solar cell parameters.

Time (H)	I_{sc} (mA)	V_{oc} (mV)	I_m (mA)	V_m (mV)	P_m (W)	Pin (W/m^2)	F.F	η_m %	R_{cell} (ohm)	T cell (^oC)
6	0.65	0.441	0.59	0.341	0.20119	10	0.7019	2.012	0.676	5.8
7	0.63	0.452	0.57	0.352	0.20064	15	0.7046	1.3376	0.717	10.6
8	0.61	0.473	0.55	0.373	0.20515	20	0.711	1.0257	0.775	15.7
9	0.52	0.485	0.46	0.385	0.1771	25	0.7022	0.7084	0.933	20.6
10	0.43	0.514	0.37	0.414	0.15318	30	0.6931	0.5106	1.195	27
11	0.37	0.535	0.31	0.435	0.13485	32.5	0.6812	0.4149	1.446	38.6
12	0.36	0.543	0.36	0.443	0.15948	35	0.8158	0.4556	1.508	42.5
13	0.35	0.567	0.29	0.467	0.13543	37.5	0.6824	0.3611	1.62	48.4
14	0.343	0.582	0.283	0.482	0.136406	40	0.6833	0.341	1.696	55.7
15	0.301	0.611	0.241	0.511	0.123151	36	0.6696	0.3421	2.029	60.6
16	0.26	0.622	0.2	0.522	0.1044	35	0.6456	0.2983	2.392	70
17	0.21	0.631	0.15	0.531	0.0797	32.5	0.6011	0.2451	3.004	65.3
18	0.14	0.635	0.08	0.535	0.0428	30	0.4814	0.1427	4.36	40.2

The relation between the voltage and current, open circuit voltage vs. maximum output power illustrated in Fig. (2).

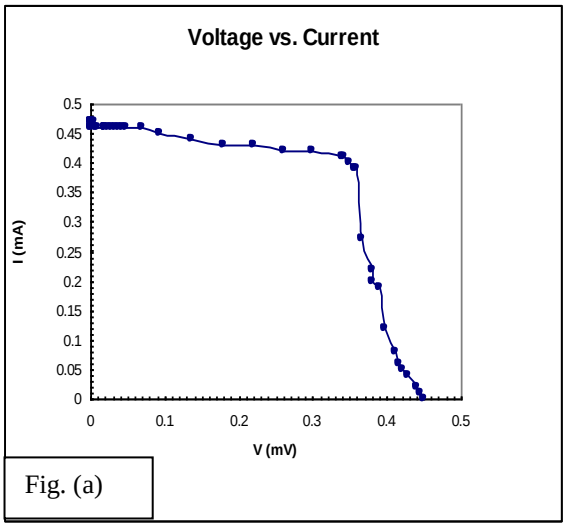

Fig. (a)

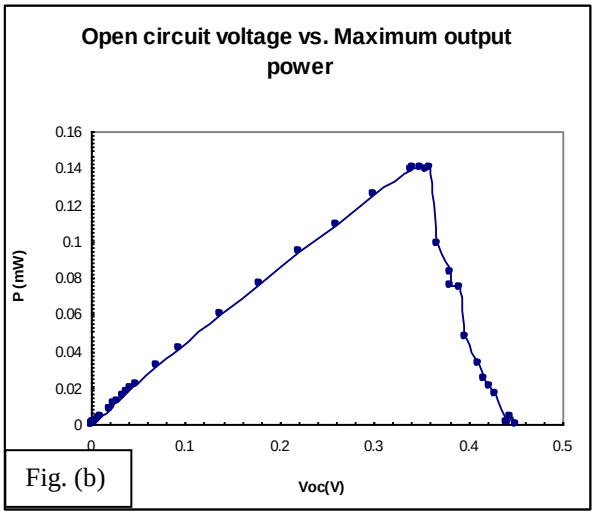

Fig. (b)

Fig. (2) a. voltage vs. current. b. open-circuit voltage vs. maximum power.

fuzzy logic technique is used to analyze the flow load through the selection function (member ship) (type of trigonometric key name (solar cell) and include this function five different values for the input of the first representing (time) , second represents the input (I_{sc}) , third input represents the (V_{oc}), fourth

represents input power (P_{in}) and fifth represents input (temp)all these values were obtained from indoor and outdoor laboratory testing of a solar cell type single crystal silicon (100 cm^2 Area) and This function calculates of one value represents the output and by using these following steps

1- Choose the appropriate weight for the group overall (Universe of discourse), which includes the variables that used in fuzzy logic which is short-circuit current (I_{sc}), open-circuit voltage (V_{oc}) , temperature (Temp) and the incident power density (P_{in}).

$$+L \leq X \leq -L$$

Where the (+L,- L) represent upper and lower limits for the group overall (U) of the variables which were as follows:

Time	$0 \leq T \leq 20$
Current	$0 \leq I_{sc} \leq 0.8$
Voltages	$0 \leq V_{oc} \leq 1$
Temperature	$0 \leq Temp \leq 90$
Incident power density	$0 \leq P_{in} \leq 50$

Selection of variables that represent the short-circuit current, open-circuit voltage and so on for the rest of the variables and let three variables(membership) was selected triangular type for not more accurate in distinguishing uncertain values and inaccurate, as described shapes is shown in Fig. (3).

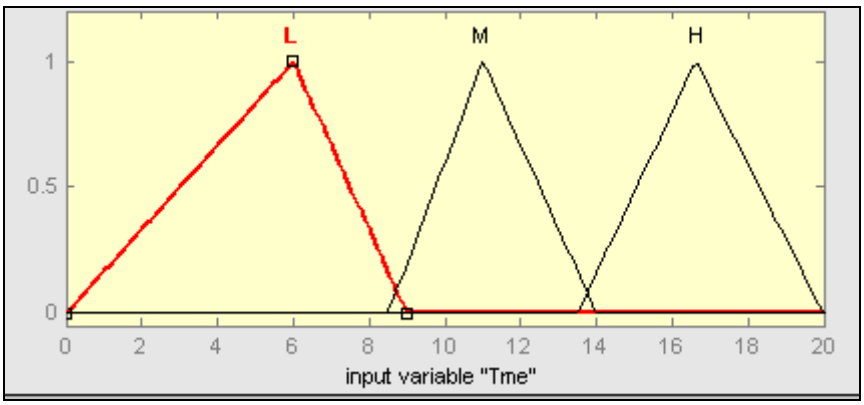

Fig. (3) Membership function of the Time T.

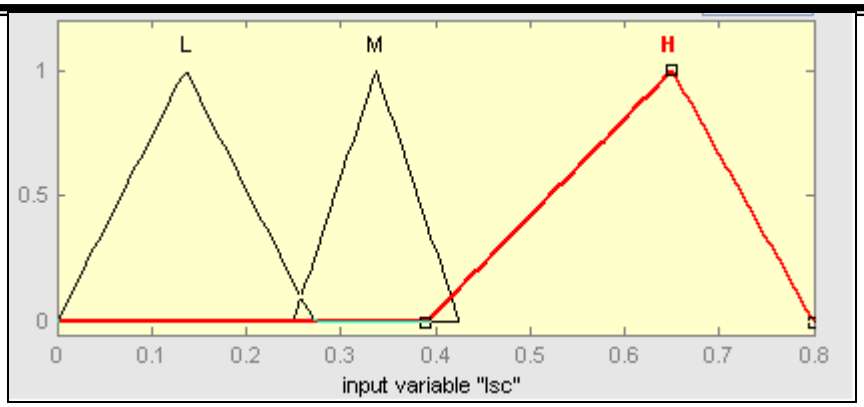

Fig. (4) Membership function of short-circuit current I_{sc}.

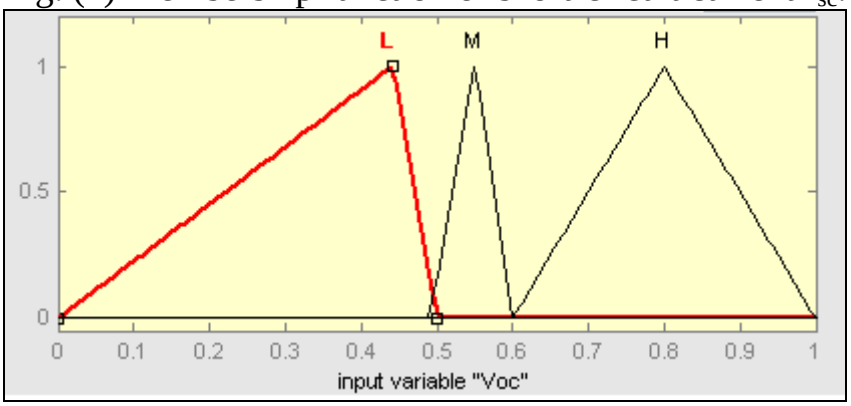

Fig. (5) Membership function of open circuit voltage V_{oc}

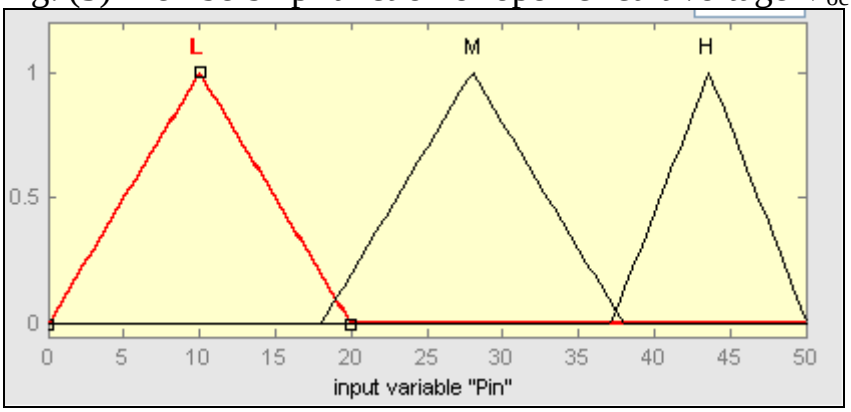

Fig. (6) Membership function of incident power density P_{in}

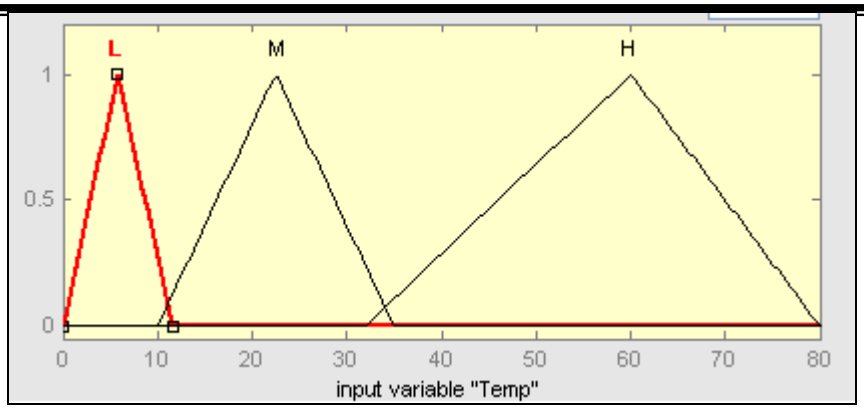

Fig. (7) Membership function of Temperature Temp.

Figures (3-7) Membership function of inputs in fuzzy logic technique.

2- Selection rules are appropriate and possible to get it through the accounts that were obtained laboratory measurements (indoor and outdoor) and have the form of these as shown in the equation including three variables for each of the current (I_{sc}) and voltage (V_{oc}) and therefore there are (25) law, as shown
[IF T is low & I_{sc} is high & V_{oc} is low &P_{in} is low& Temp is low Then I_m is high &V_m is low & P_m is high &F.F is high & Eff. is high &R_{cell} is low]

3- Defuzzucation process where we get the value of one to distinguish and detect the uncertain and inaccurate values and show it naturally. Here, represents the value of output as shown in Fig. (8).

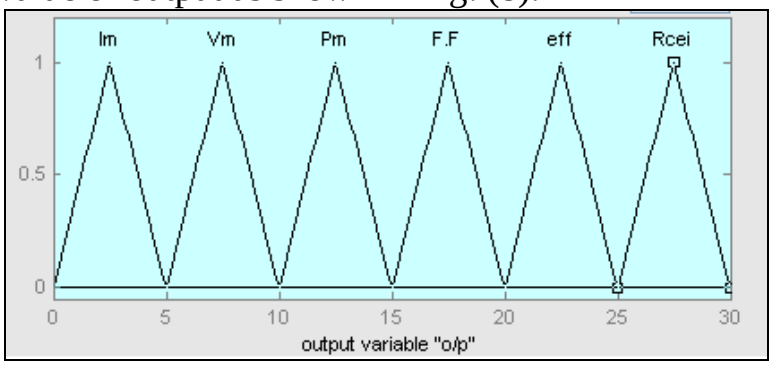

Fig. (8) output variables parameters of solar cell.

4. Results and Disscussion

The output results of the solar cell parameters using fuzzy logic technique that used to detect and distinguish the uncertain and inaccurate values, and confirmed in normal values, we obtain the optimal results as shown in Figures (9-16)

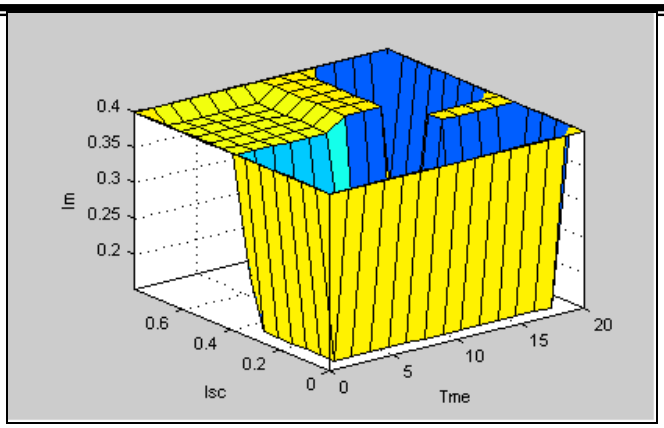

Fig. (9) value of Maximum short circuit current (I_{sc})

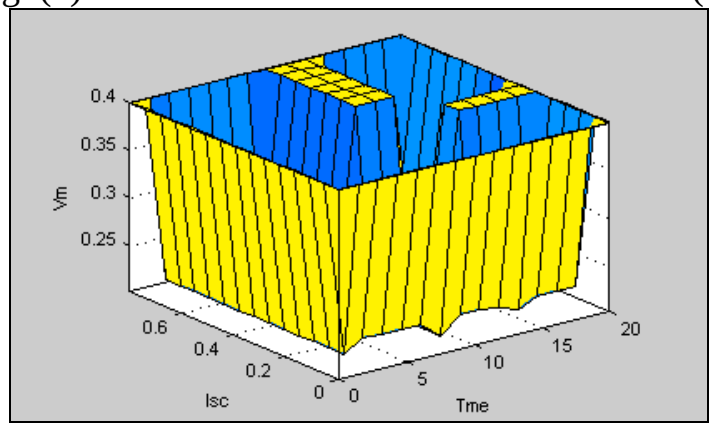

Fig. (10) value of Maximum open-circuit voltage V_{oc}

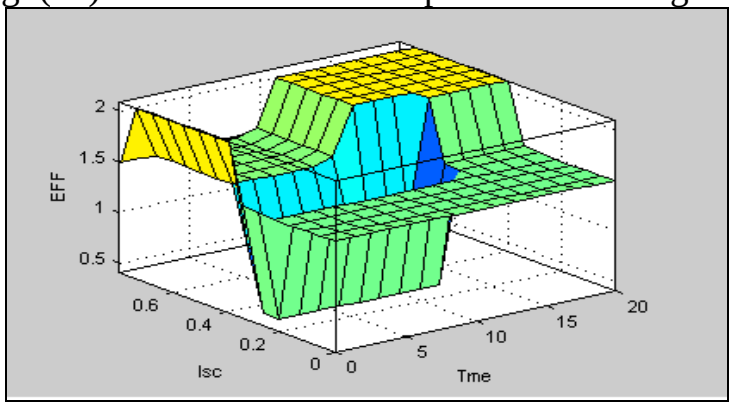

Fig. (11) value of Maximum conversion efficiency eff_m.

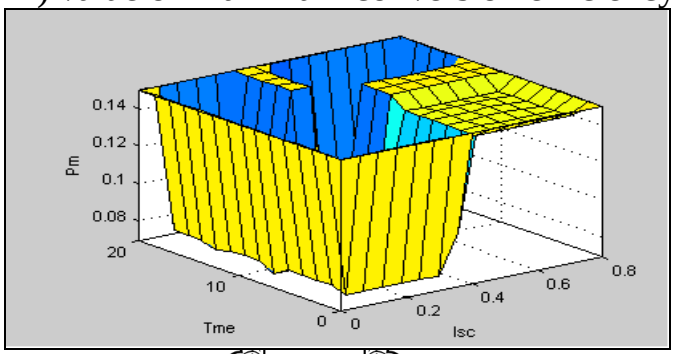

Fig. (12) value of Maximum incident power density P_{in}.

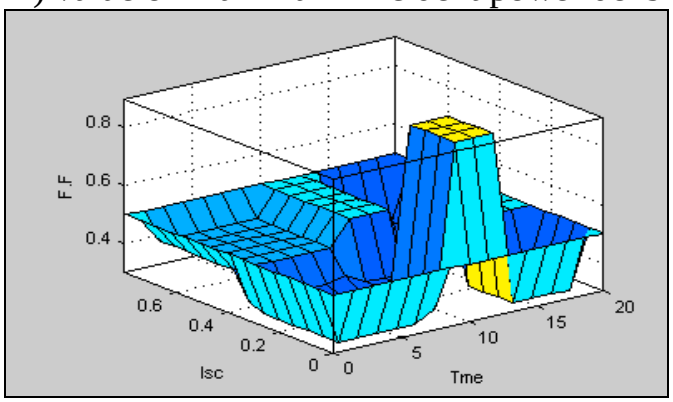

Fig. (13) value of fill factor FF.

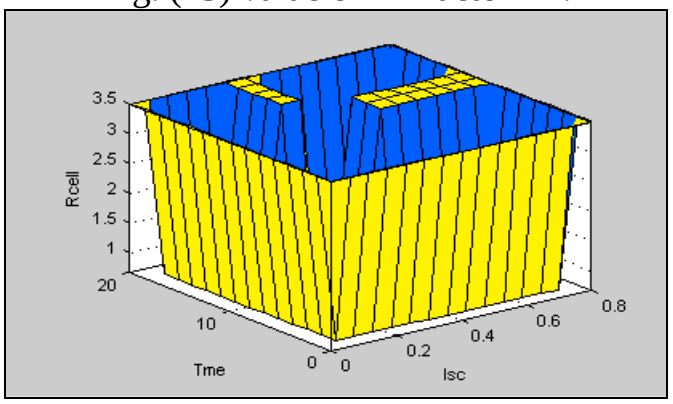

Fig. (14) value of cell resistance R_{cell}

Fig. (9-14) output solar cell parameters in fuzzy logic technique.

Conclusions

You might think that solar cells cope well with increased temperature since they in fact are solar cells. But the truth is that increased temperature can decrease the efficiency of photovoltaic conversion. The most significant is the temperature dependence of the voltage which decreases with increasing temperature. The temperature variation of the current or the fill factor is less pronounced. The voltage decrease of a silicon cell is typically 2.3mV per °C. Thus they are designed to be in good thermal contact with the ambient temperature. Fuzzy logic Technique is the active method to analysis the performance of solar cell parameters which it gave us the optimal and exact value of each parameter for the solar cell with different values of ambient temperatures.

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تحليل اداء معلمات الخلية الشمسية السليكونية مع درجة حرارة الجو باستخدام تقنية المنطق الضبابي

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الجامعة التكنولوجية

الخلاصة

في هذا البحث، تم استخدام تقنية المنطق الضبابي للحصول على القيم المثالية للمعلمات الاساسية المهمة للخلية الشمسية السليكونية في درجات حرارة مختلفة. ان المعلمات المهمة لاداء الخلية الشمسية هي تيار الدائرة المغلقة (I_{sc})، فولتية الدائرة المفتوحة (V_{oc})، معامل المليء (F.F)، وكفاءة التحويل (η). النتائج التجريبية لهذه الطريقة بينت الحصول على اعلى قيمة لكفاءة التحويل عندما تكون قيم كل من درجة الحرارة، فولتية الدائرة المفتوحة، كثافة القدرة الساقطة، ومقاومة الخلية الشمسية واطئة، بينما تكون قيم المعلمات الاخرى اعظم تيار، اعظم قدرة خارجة، تيار الدائرة القصيرة، ومعامل المليء عالية.