Design of Maximum power Tracking System by Automatic Control of Solar Cell Panel to the Sun Direction

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Abstract:

Renewable energy is an area of significant investment and importance for future generations. The basis of this project is to design a new automatic control system for solar panel that tracking maximum power tracking according to the direction of sun ray. This project is an analysis of maximum power that can generate from the solar panel. This project needed to investigate the system parameter that affected the input sun ray to the solar panel. The system parameter that needs to investigate is weather, cell type, number of cells, temperature and the intensity of the sun. The system parameter is important to create the maximum power that can be generated by the design solar panel. In this paper, the main purpose is to design a system which controls the direction of the solar panel base on the sun direction and the main system parameter is the intensity of sun in daily mode. The system uses the motor type for controlling the angle of the solar panel base on the maximum intensity of sun ray**.** The validity of this proposed system achieved the maximum power of 101 Watt compared with the conventional types.

Keywords: Solar cell, Renewable Energy, Polycrystalline, maximum power.

تصميم منظومه سيطره اوتوتيكي لخلايا الطاقة الشمسية باتجاة اشعة الشمس للحصول على اكبر مقدار من الطاقة.

الطاقه المتجدده تعتبر من الفروع الحديثه والاستثمارية المهمه لمستقبل الطاقه. البحث المقدم يقترح تصميم منظومة سيطرة جديدة للخلايا الشمسيه التى باستطاعتها مواكبة حركه الشمس تزامنيا. و تم التطرق للعناصر المهمه التى تتحكم في دوران خلايا الشمس باتجاه اشعة الشمس الساقطة. علاوة الى ذلك تم اضافه عناصر ثانويه لمحاكاه عمل النظام الحقيقي كحالة الطقس , عدد الخلايا , نوع الخلية الشمسية, درجة الحراره, وكمية اشعة الشمس الساقطة. العناصر التى تم تضمينها تعتبر مهمه للحصول على اكبر مقدارمن الطاقة الكهربائيه المتولدة من خلال هذا التصميم. في هذا البحث تم التطرق ايضا على نظام السيطره لمواكبه حركة الخلايا الشمسيه تزامنيا مع حركه واتجاه الشمس باستخدام ماطور احادي الطور لليسطره على زوايه انحراف الخلايا الشمسية تزامنيا مع حركه اكبر كمية لاشعة الشمس الساقطة. ان موثوقيه المنظومة المقترحه حققت مقدار طاقه قدره 101 واط مقارنه بالنماذج االاخرى.

الكلمات المفتاحية:: خلايا شمسية, اكبر من الطاقة, الطاقه المتجدده,

1. Introduction

Nowadays, the electrical system is widely used in the world. Consuming of electrical energy is increasing from day to day with the growing demand for electrical users that follows the massive jump of new technology in electrical component. The electrical consumption in South Asia increases 20% from 1980 to 2012 because the demand of the electrical user rapidly increases. [1-3].

For Example, in Malaysia, the greatest power plant generation of electricity currently use is a thermal power plant and hydroelectric power plant supported by TNB Company. Thermal power plants can cause much affection for our environment. The burning of coal for thermal power plant that release carbon dioxide and methane gases that can affect the greenhouse effect for the environment. The hydroelectric is a one of green energy, but it can’t accommodate the demand of users today. The hydroelectric limited the production of electricity that can’t increase easily. The service and maintenance of turbine fan of hydroelectric also need high cost to make sure the turbine is working every time. Based on the above listed challenges, the proposed based on a solar panel system can help to solve this problem. The solar energy is reliable resources that can be a cost-effective contingency [4]. Solar panel system also can provide virtually power system without affecting the environment problem because it is secure and save green energy [5]. The maintenance cost of solar panel is less than the hydroelectric that need more workers to maintain the process is running smoothly [6]. But, the installation of solar panel needs high cost to get the higher wattage compare to another power plant like hydroelectric and combustion of coal. The designing of the maximum power, solar panel can solve a little bit installation cost. By designing the system, it can save the space and cost forget the high output electrical wattage of solar panel. The remainder of this manuscript is organized as follows: Section two presents the Solar Panel Model. Section Three focuses on the scheme of the proposed system, and Section Four concludes the paper.

2. Solar Panel Model

A solar cell is modeled as a current source with a diode and represented as an equivalent circuit as shown in Figure 1.

The parameter's value of solar cell like diode, resistor and current will change the output power of I-V curve.

The model of solar panel is obtained by connecting of solar cells in series and parallel. The interconnection of solar panel is shown in Figure 2, which shows how the output power is produce depends on the designing of connection of solar cell. The output power that will produce for each type of connection in solar panel will differ. The selection of connection optimization is necessary to obtain the maximum power that can be generated by solar panel

2.1 System Design

The derived equations represented a mathematical analysis for calculating the maximum output power (P_{max}) from the solar panel model. The basic equation is mainly based on previously published articles [7-8].

$$I = Ipv - Io\left(e^{bV} - 1\right) \quad (1)$$

$$Ipv = 2.54\sin[\tfrac{\pi}{12}(t-6)] \quad (2)$$

$$P = IV \quad (3)$$

$$P = (Ipv - Io(e^{bV} - 1))(V) \quad (4)$$

$$\frac{dP}{dV} = \left(Ipv - Io\left(e^{bV} - 1\right)\right) - \left(Iobe^{bV} - 1\right)(V) = Ipv + Io - Ioe^{bV}(1 + bV) \quad (5)$$

$$Ipv + Io - Ioe^{bV}(1 + bV) = 0 \quad (6)$$

Let,

$$b = \frac{1}{2}, \qquad Io = 4.1 \times 10^{-5}$$

Then,

$$\frac{2.54}{4.1 \times 10^{-5}} \sin\left[\frac{\pi}{12(t-6)}\right] = e^{\frac{V}{2}}\left(1 + \frac{V}{2}\right) - 1 \quad (7)$$

Final equation is,

$$Pmax = \left(\left[2.54\sin\frac{\pi}{12}(tmax - 6)\right] - Io\left(e^{\frac{Vmax}{2}} - 1\right)\right)Vmax \quad (8)$$

Where, I, V, t and b represent the voltage, current, time and solar sale absorption constant, respectively.

Figure 3-4 shows the detailed of the project schematic diagram for the system. A couple of solar panels are installed in the single control motor. The motor is controlled from the main control station in order to move a solar panel as a function of sun direction. The motor is automatically operated in daytime only.

3.1 System Performance

3.2 Ideal Photovoltaic Cell Array

The Figure 5 shows the simulation of ideal photovoltaic cell in a standard condition. The input signal of the simulation is constant that are 25 °C of temperature and 1k W/m^2 of Irradiation. The signal is in optimum condition to get the maximum power from the photovoltaic cell.

The parameter that need to change in solar cell are short circuit current (Iscn), Open circuit voltage (Vocn), Maximum Current (Imp), and the Maximum Voltage (Vmp) to get the maximum power that can be generated by solar cell.

Figure 6-7 show the result for I-V and P-V graph of ideal solar cell. The curve explains the value of the maximum power of the solar panel. The graph shows that the maximum power that generated is 1000 W during maximum voltage at 90 V. The result is for ideal solar cell value that can be controlled by changing the parameter of the solar cell. The changing of the parameter may affect the value of output power of solar panel.

3.3 Simulation Model

For the designed simulation, the 100 of cell is combining to be a solar panel. The simple circuit of the simulation is shown in Figure 8 below. The simulation of the system is comparing the output power of solar panel from different input concentration of sun that called irradiation. The input irradiation is entering to the system from 0 to 1000 W/m^2. Then, it will connect to the Simulink-PS Converter to convert the unit less Simulink input Irradiation to a physical signal. The physical signals directly connect to the input Ir for solar panel. The output from the 100 panel block diagram is connected to the current sensor and voltage sensor. The function of the current sensor is directly converted the output signal from the current measured to the physical signal proportional to the current. Then, the voltage signal is quite similar to the current sensor but its change the voltage measured signal. From these two sensors, the output power can calculate by product of the signal from current and voltage sensor. The value of current (I), voltage (V), and power (P) is export to the MATLAB by using a workspace block diagram.

After running the simulation in Simulink MATLAB, the output data will export to the MATLAB to plotting the graphs. The graph is to analyze the relationship between current, voltage, and power to the change of input irradiation.

The simulation results obtained Fig.9 presents the increasing of output power under the changing of irradiance. From the graph above, the maximum power can be defined during the input irradiance is at the optimum value. The maximum power that can be generated from the simulation is 160.9 W.

4. System Performance with difference type of Solar cell

The first step for the mathematical analysis of solar panel is defining the parameter that need to calculate in the formula. The value of each parameter depends on the data sheet of Monocrystalline type solar module SPM-100M and Polycrystalline type solar module SPM-20M. Table 1 and Table 2 shows the list of parameter from the datasheets given. Moreover, other solar cell system parameters are based on the previously published articles in [9-11].

Based on the various system parameters listed in Table 1 and Table 2, the parameter value is set as a constant value for the mathematical analysis. This result of mathematical analysis is evaluated by comparing the difference in temperature value. Table 3 shows the value of difference of for evaluating the output power of solar panel. Two types of solar panel are comparing the result by changing the temperature.

4.1 Performance of Monocrystalline solar panel type.

The Figure 10 shows the results of Current and voltage for monocrystalline solar panel type. The graph represents the value of voltage is decreasing under high temperature. To archive the maximum voltage that can generate is maintain the solar panel under lower temperature. The value of current for the monocrystalline solar panel is around 5.6A to 6A under the difference of temperature. The current a little bit increasing when the temperature is increased.

The Figure 11 shows the relationship between power and voltage from the monocrystalline solar panel type. The graph above proves that the maximum power can be achieved by decreasing the value of temperature. The maximum power that can generate is 101 W at 10 °C, 95 W at 25 °C, 87 W at 45 °C and 74 W at 75°C.

4.2 Performance of Polycrystalline solar panel.

Figure 12 represents the I-V curve for polycrystalline type solar panel. The output voltage of this solar panel is similar to the monocrystalline solar panel. But, from the graph below the output current of this solar panel type is smaller compared to the monocrystalline solar panel. The result shows the output current only 1 A to 1.5 A.

Finally, Figure 13 depicts the graph of P-V curve of polycrystalline type solar panel is plotted. The graph shows that the power is decreasing under the high temperature. The graph shows the Maximum power from this solar panel type is lower than monocrystalline type. The maximum power from this solar panel is shown in Figure 4.15 below. The maximum power is 19.2 W at 10 °C, 19.0 W at 25 °C, 18.4 W at 45 °C and 17 W at 75 °C. The ratio of the output power and temperature is lower compared to the monocrystalline solar panel type.

5. Conclusion

In this paper, a new model of dual solar cell is designed to compare the output power result with different parameters. The result shows the relationship between maximum output power with the difference irradiance or concentration of sun. The simulation represents the design of maximum power, solar panel system according to the sun direction to achieve the first step towards real time enviournment. The solar panel must be in optimum irradiation to achieve maximum power from solar panel. The solar panel must be controlled perpendicularly directly according sun direction to get the optimum of irradiation. Otherwise, the shadowing effect will occur if the solar panel system at fixed condition. The cloudy and rainy weather also gives the negative impact to the generation of maximum power. The mathematical analysis of the maximum power solar panel is implemented in MATLAB programming by comparing the two different types of solar panel datasheet. From the result, the effect of temperature for the monocrytalline type and the polycrystalline type of solar panel can be analyzed. The result shows the polycrystalline solar panel more efficient compare with the monocrystalline solar panel.

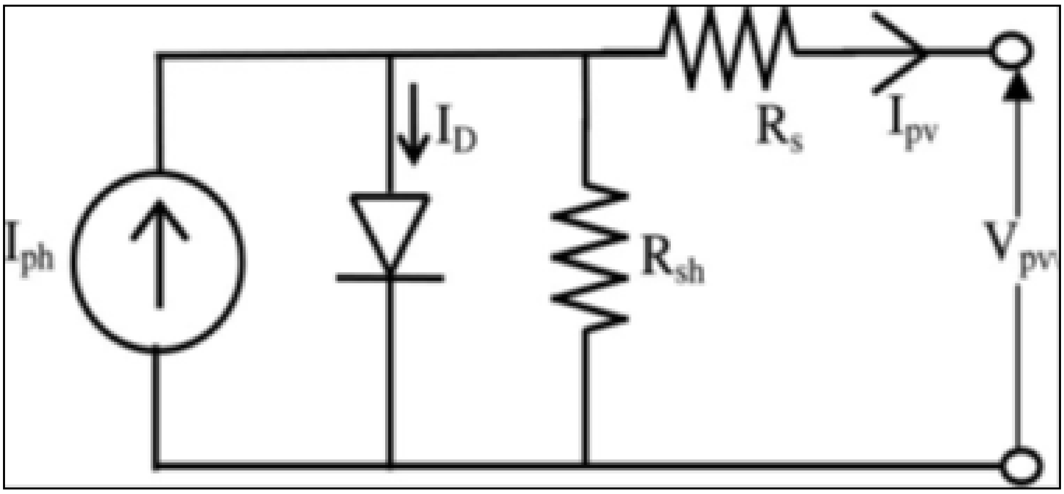

Figure 1: Equivalent Circuit of Solar Cell [3].

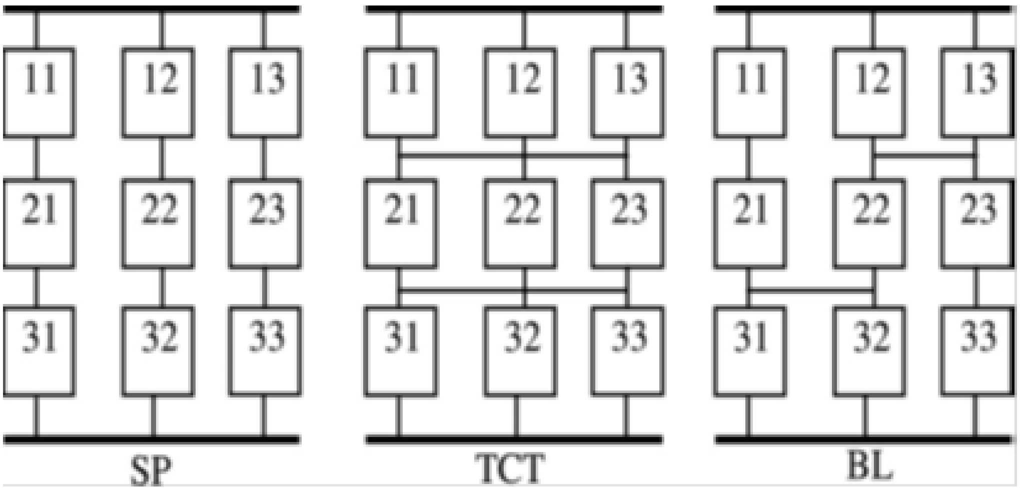

Figure 2: Series and Parallel connection of Solar Cell in a Solar Panel. [3]

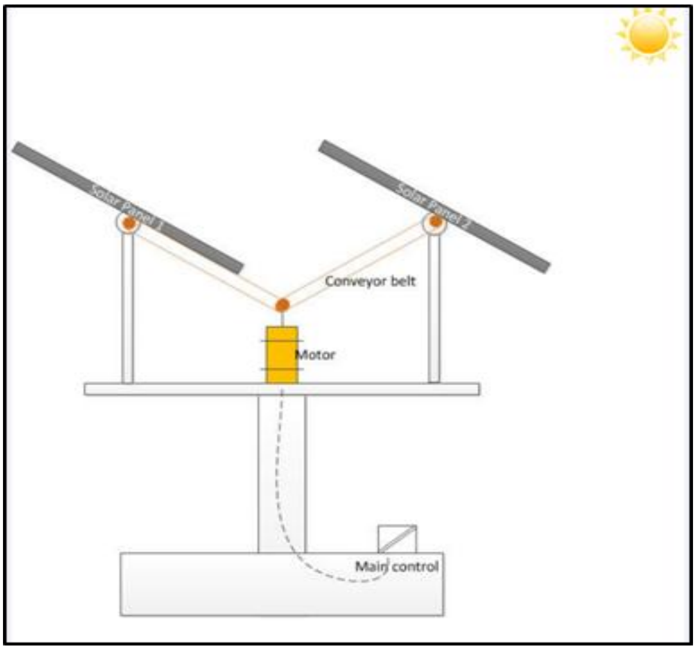

Figure 3: Proposed Design of Dual Solar Panel.

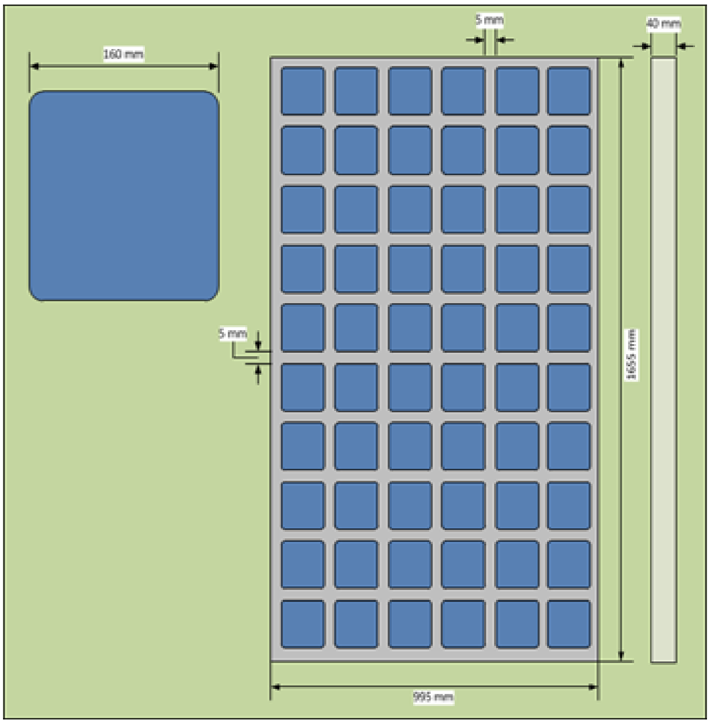

Figure 4: Dimension of Solar Panel Design

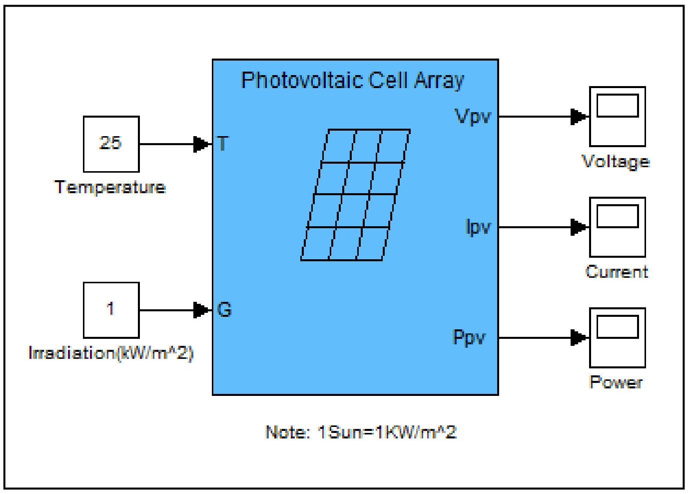

Figure 5: Simulation of Ideal Photovoltaic cell Array.

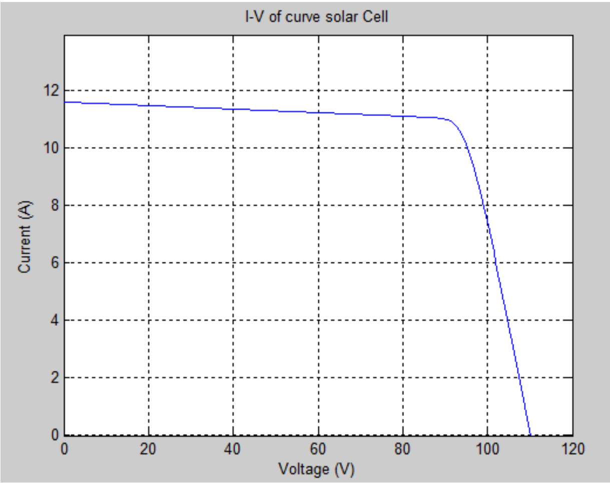

Figure 6: Ideal Solar cell I-V Graph.

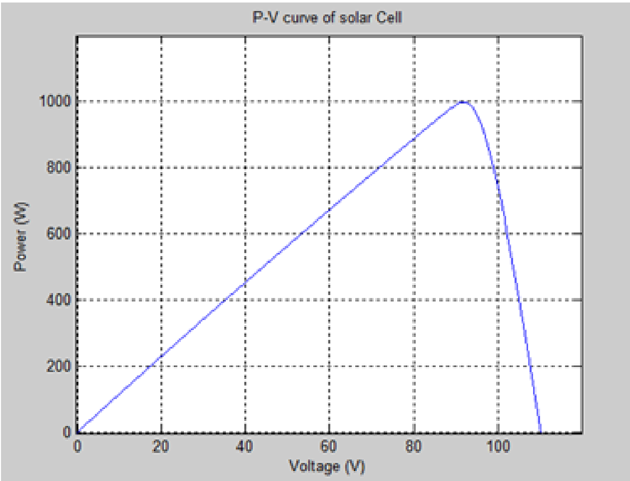

Figure 7: Ideal Solar cell P-V graph

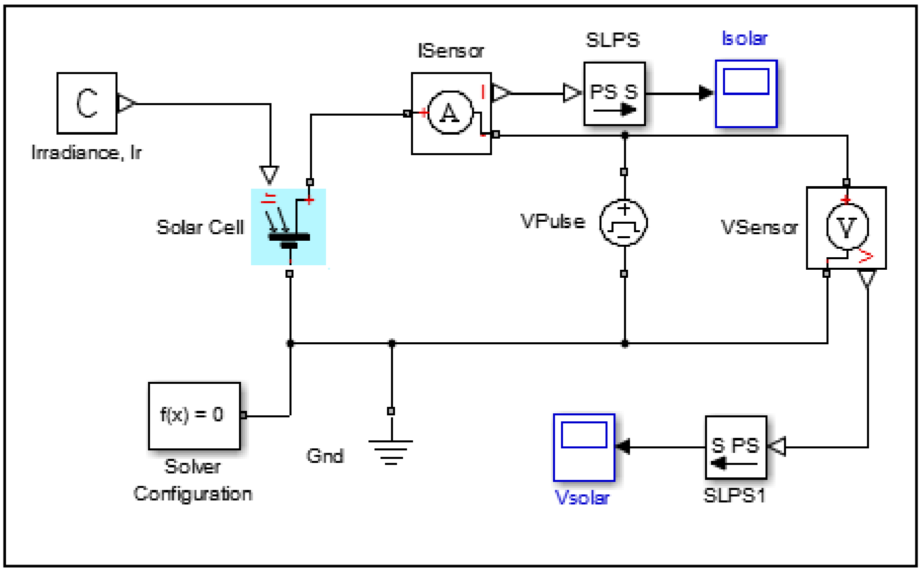

Figure 8: Simulation of Solar Panel System.

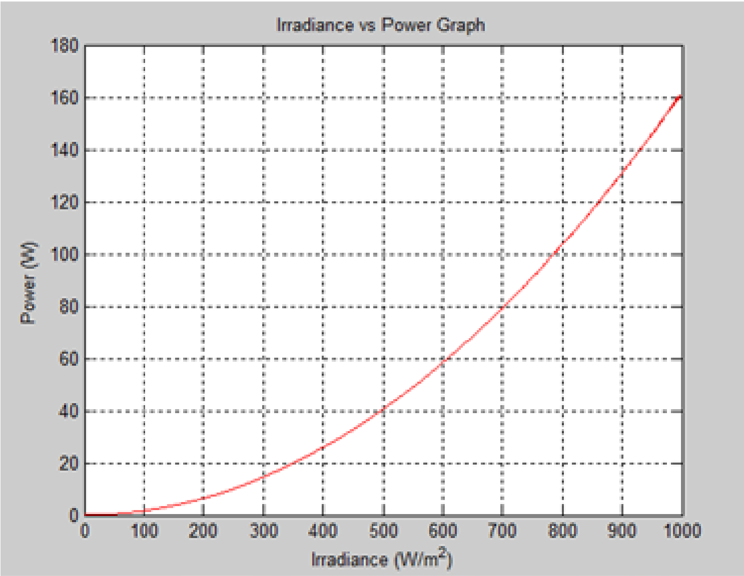

Figure 9: The simulation output Power over Irradiance Graph

Table1: Parameters of SPM100-M Monocrystalline type solar panel.

Parameters	Values
Maximum Power, P_{max}	20 W
Maximum Power Voltage, V_{mp}	18.32 V
Maximum Power Current, I_{mp}	1.09 A
Open-circuit Voltage, V_{oc}	22.06 V
Short-circuit Current, I_{sc}	1.17 A
Series Fuse Rating	10 A
NOTC	47 °C

Table 2: Parameters of SPM020-P polycrystalline type solar panel

Parameters	Values
Maximum Power, P_{max}	20 W
Maximum Power Voltage, V_{mp}	18.32 V
Maximum Power Current, I_{mp}	1.09 A
Open-circuit Voltage, V_{oc}	22.06 V
Short-circuit Current, I_{sc}	1.17 A
Series Fuse Rating	10 A
NOTC	47 °C

Table 3: Table of Changing Temperature with Maximum Irradiation of Sun.

Irradiation of Sun (W/m^2)	Temperature (°C)
1000	10
1000	25
1000	45
1000	75

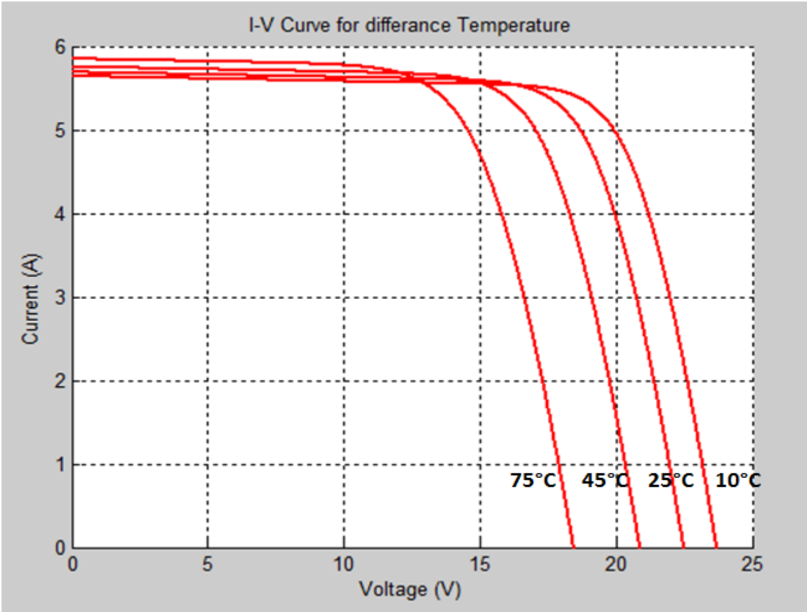

Figure 10: I-V Curve of Monocrystalline SPM100-M Model

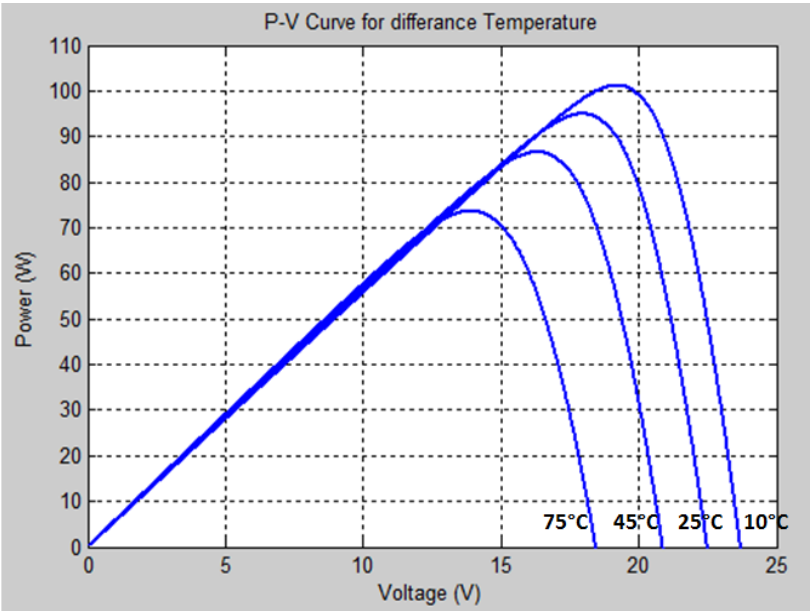

Figure 11: P-V Curve of Monocrystalline SPM100-M Model.

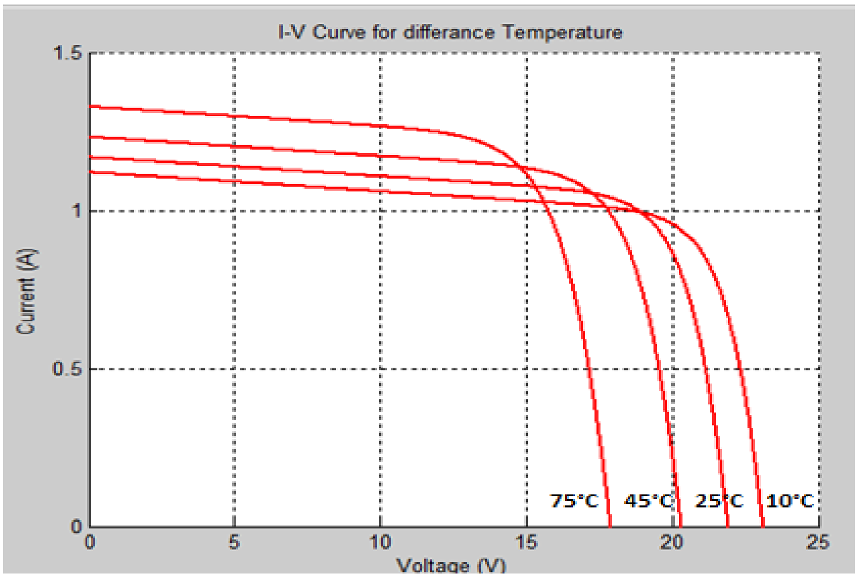

Figure 12: I-V Curve of Polycrystalline SPM020-P Model.

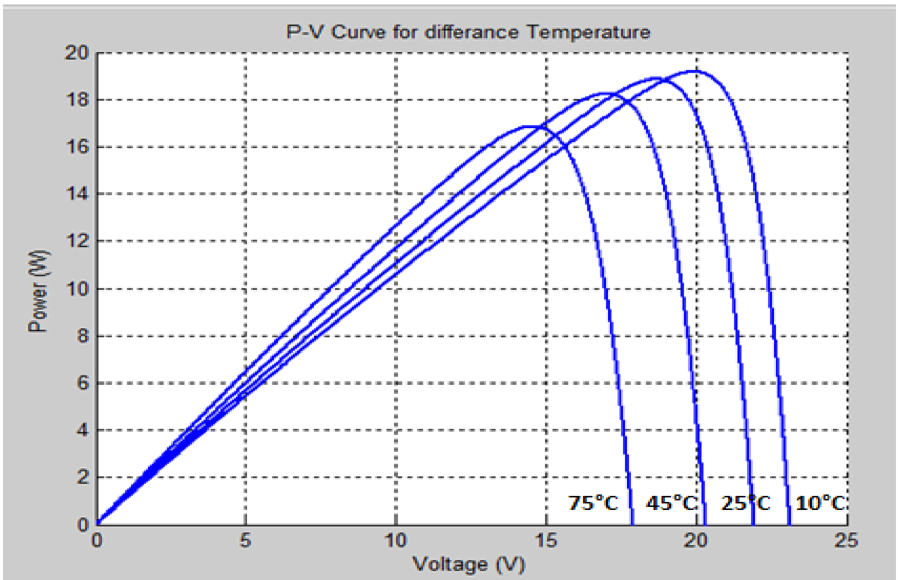

Figure 13: P-V Curve of Polycrystalline SPM020-P Model

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