

# Simulation of Photovoltaic Systems using Maximum Power Point Tracking Algorithm

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**ABSTRACT:** This paper presents the Modelling and simulation of Solar Photovoltaic Cell. Solar module temperature, solar radiation and its effects on series resistance are taken into account. This model is based on mathematical equations and is also represented through an equivalent circuit including a photocurrent source, a diode, a series resistor and a shunt resistor. This model allows the prediction of PV cell behaviour under different physical and environmental parameters. In this model, the function of solar temperature and solar radiation can also be used to take out the physical parameters for a given solar photovoltaic cell. The I-V and P-V characteristics are obtained and studied at various temperature values.

**KEYWORDS:** Maximum Power Point Tracking, photovoltaic module, Simulink Model.

## 1. INTRODUCTION

A photovoltaic (PV) system directly converts sunlight into electricity. The basic device of a photovoltaic system is the photovoltaic cell. A photovoltaic energy source is a source of interesting energy. It is renewable, inexhaustible and non-polluting and is used as an energy source in various applications. The photovoltaic module is a group of PV cells in series and parallel. In this generation system represents the conversion unit. An array is the group of photovoltaic modules in series and parallel. A photovoltaic (PV) generator consists of solar cells, connections, protective parts, supports. Solar cells consist of a p-n junction fabricated by thin wafer or layer of semiconductor. An exponential behaviour of a solar cell includes the I-V output characteristic is related to that of a diode. When solar energy strikes a solar cell, that energy is greater than the band gap energy of the semiconductor. The electron-hole pairs are created when the electrons are knocked out from the atoms in the material. These carriers are swept under the influence of the internal electric fields of the p-n junction. The current passed onto load impedance depends upon its value. This current is shunted internally by the intrinsic p-n junction diode. Solar energy is widely available, free of cost, and a sustainable source of energy. The photovoltaic (PV) cell is the device which converts solar energy into electrical energy.

The solar radiation, the temperature of the cell and the voltage produced in the photovoltaic module depends on the obtained energy. A PV device may directly feed small loads available the voltage and current. The PV device is used to require electronic converters to process the electricity. At the load, the electronic converters are used to regulate the voltage and the current and it is mainly used to track the maximum power point of the device.

## II. SOLAR CELL MODELLING

The solar cell is a device that is a parallel combination of current source and diode. The equivalent circuit of PV cell is shown in Fig.1. The photocurrent ( $I_{ph}$ ) is defined as the output of the current source (I) is directly proportional to the light falling on the cell. In parallel with the diode model, leakage current is called the shunt resistance ( $R_{sh}$ ).

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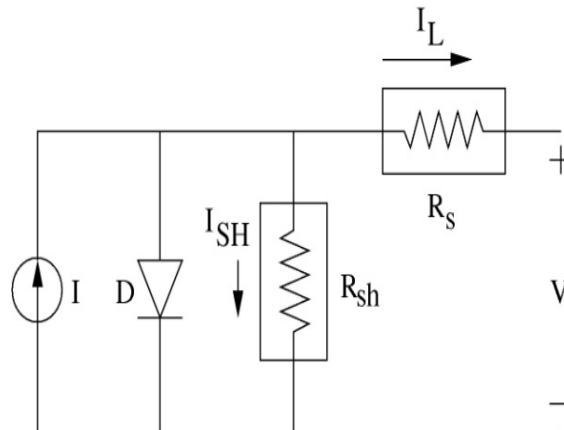


Fig-1 circuit diagram of PV model

To get accurate shape to the power-voltage characteristic from the series resistance ( $R_s$ ). Due to the current flow, the series resistance ( $R_s$ ) represents the internal voltage drop.

The output current of photocell ( $I_L$ ) can be represented as

$$I_L = I - I_0 q \frac{(V + I_L R_s)}{e^{nkT-1}} \quad (1)$$

Where,

- $I$  is the current generated by the incident light
- $I_0$  is the reverse saturation or leakage current of the diode.
- $q$  is the electron charge [ $1.60217646 \times 10^{-19}C$ ].
- $k$  is the Boltzmann constant [ $1.3806503 \times 10^{-23}J/K$ ].
- $T$  [K] is the temperature of the p-n junction.

The output current is simply different from photocurrent and diode current. Generally, the value of  $R_{sh}$  is very high and therefore, it is neglected. The performance of PV cell depends upon ambient temperature and it is modelled through dependence diode current as a function of temperature. The leakage current ( $I_0$ ) of diode also depends upon temperature. The photocurrent ( $I$ ) is strong function of temperature. The dependence of  $I_0$  and photocurrent ( $I$ ) on temperature was included in MATLAB implementation. The modelling equations of  $I$  and  $I_0$  are not included just for the simplicity. The performance of PV cell also depends upon the value of series resistance ( $R_s$ ).

The output power of PV cell is changed by means of environmental factors, such as illumination and temperature. Since the characteristic curve of a solar cell exhibits nonlinear voltage-current characteristics. The maximum power point tracker is involved to match the solar cell power with the environmental factors. There are more algorithms have been developed for tracking the maximum power point solar cell.

### III. MPPT ALGORITHM

An MPPT is defined as an electronic device that operates the PV panel and it delivers all the power it can produce. The power generated by the panel is considerably affected by variations in irradiation, temperature and panel voltage,

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revealing a non-linear characteristic for that reason an MPPT algorithm to track changes and extract the maximum power from the PV solar panel.

Under certain conditions, the MPPT algorithm that included in charge controllers used for extracting maximum available power from PV module. The maximum power point or peak power voltage is defined as the voltage at which PV module can produce maximum power. PV modules have relatively low conversion efficiency; hence, controlling maximum power point tracking for the solar array is essential. A PV depends on the operating voltage of the array by means of that the amount of power generated. By solar insolation and temperature, a maximum power point (MPP) varies.

The PV cell output is limited by both the cell current and the cell voltage. From the *I-V* curve, it can only produce a power with any combinations of current and voltage. The cell current is proportional to the irradiance. The maximum power is produced by the open circuit voltage and short circuit current.

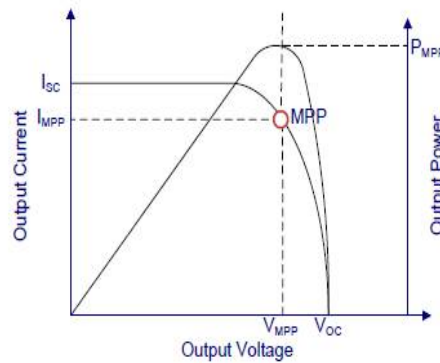


Fig.2. I-V and P-V characteristics

$$I = I_{sc} - I_0 \left\{ \exp \left[ \frac{q(V + R_s I)}{nkT_k} \right] - 1 \right\} - \frac{(V + R_s I)}{R_{sh}} \quad (2)$$

Where,

$$I_{sc} = I_d + I \quad (3)$$

### 3.1 Flowchart of Mppt Algorithm:

The MPPT design method is based on the regulation of the PV array output voltage or current. From the PV array output characteristics, the reference voltage or current signal which is either derived or constant. A variation on this method is directly use the dc/dc converter duty cycle as a control parameter and force the derivative  $dP / dD$  to zero.

Where,

P is the PV array output power and D is the duty cycle. Thus only one control loop is required.

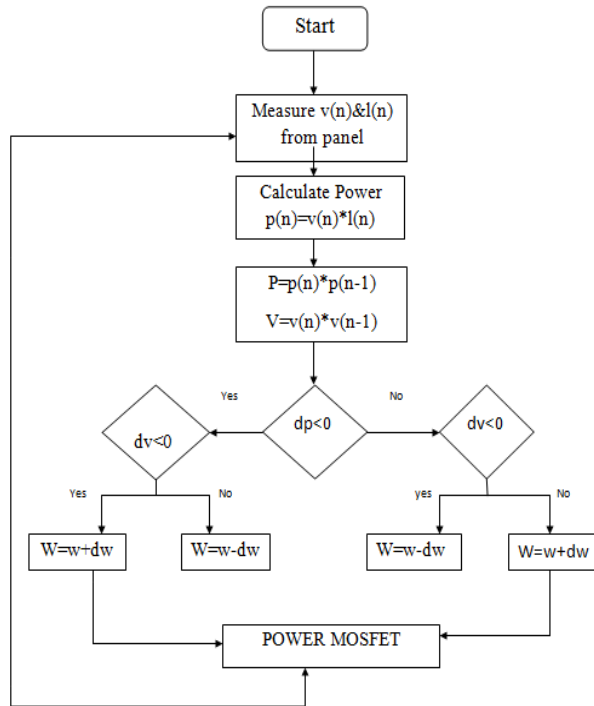


Fig .3. Flowchart of MPPT Algorithm

There are three methods in MPPT algorithm. Most commonly used MPPT algorithm is the perturb and observe method. In this method, due to a small amount  $dW$ , the duty cycle of the PWM to the MOSFET that separates the panel and battery. Consider a small amount  $dW$  has increased, the panel voltage and current are measured and the corresponding change in Power  $dP$  is observed. If the change in power is positive, then the direction of perturb is correct and continue to perturb in the same direction. If the change in power is negative, the direction of perturb is reversed and the process continues. The main aim of an algorithm is always to ascend the power curve in order to achieve the maximum power output from the PV cell. Hence, we always make the solar panel to operate at a point that delivers maximum power. If MPPT system is not implement the load connected to the panel is always constant, and it cannot operate at maximum power point. So, it will not trap the maximum power available from the panel.

#### IV. SIMULATION RESULTS

Figure 4 shows, during the different irradiation condition, the simulation of I-V and P-V characteristics of a photovoltaic cell. The maximum power is obtained by using the open circuit voltage and short circuit current. PV modules still have relatively low conversion efficiency; therefore, controlling maximum power point tracking (MPPT) for the solar array is essential in a PV system. The amount of power generated by a PV depends on the operating voltage of the array. A PV's maximum power point (MPP) varies with solar insulation and temperature.

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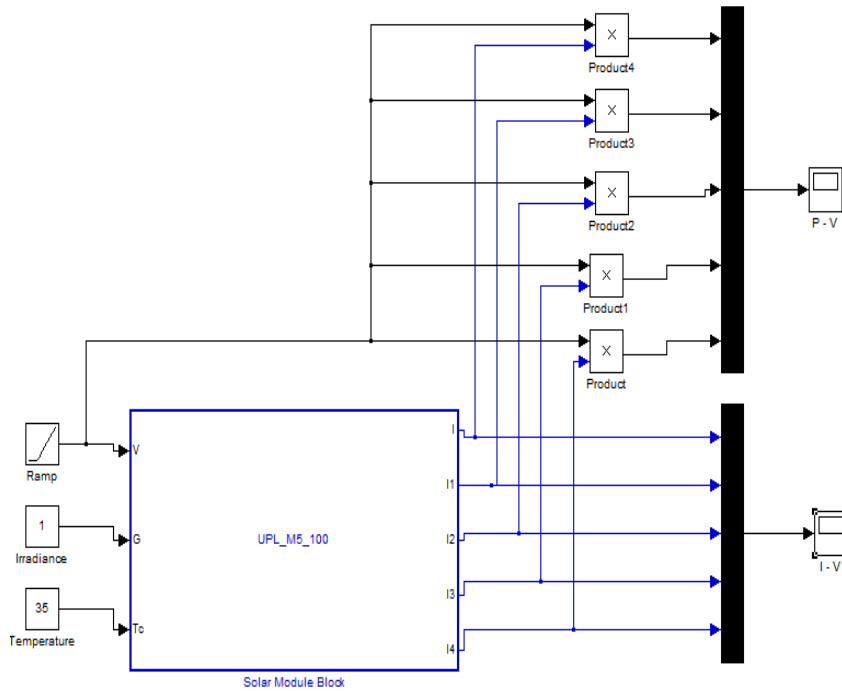


Fig 4.Simulation of Solar Panel

Table 1: Waveform Parameter values of P-V Characteristics

COLOUR INDICATION	POWER	VOLTAGE
DARK BLUE	140W/m <sup>2</sup>	43
GREEN	120 W/m <sup>2</sup>	44
RED	100 W/m <sup>2</sup>	46
SKY BLUE	80 W/m <sup>2</sup>	47
PINK	60 W/m <sup>2</sup>	48

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Table 1: Waveform Parameter values of I-V Characteristics

COLOUR INDICATION	CURRENT	VOLTAGE
DARK BLUE	4.6	43
GREEN	3.9	44
RED	3.3	46
SKY BLUE	2.6	47
PINK	1.9	48

Figure 5 shows the P-V characteristics, the power value decreased from 140W/m<sup>2</sup> and the voltage value increased from 43Volts.

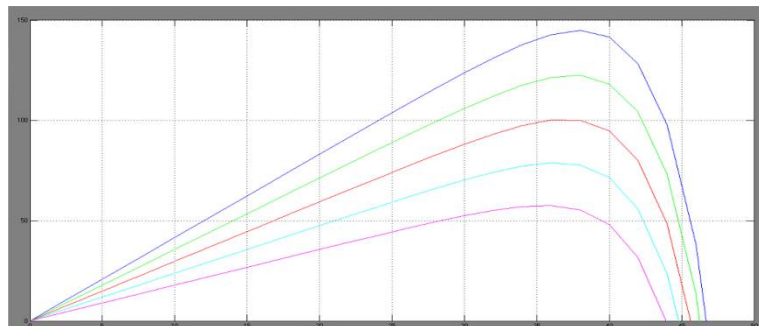


Fig 5. P-V characteristics

Figure 5 shows the I-V characteristics, the current value decreased from 4.6 Ampere and the voltage value increased from 43Volts.

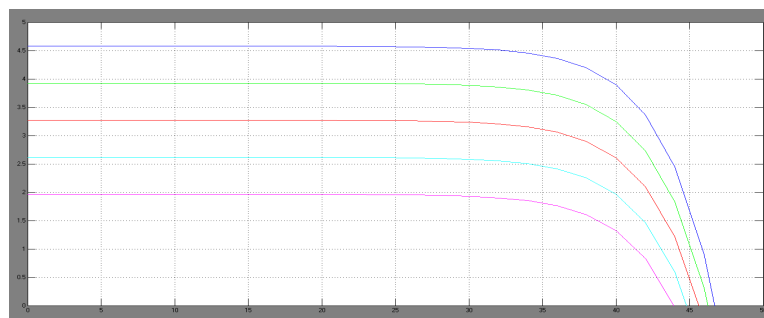


Fig 6.I-V Characteristics

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## V. CONCLUSION

In this paper, we presented simulation of PV cell and its array using MATLAB based setup. The simulation setup can be used to study the effect of variation in temperature value. The value of short circuit current was found to increase with increase in temperature whereas the open circuit voltage was observed to decrease with increase in temperature. The maximum power as well as the voltage at which peak power was observed to increase with increase in temperature. The simulated model was demonstrated as an excellent and flexible environment for studying various PV solar cells operating under different of irradiance and temperature.

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