

# Design and Simulation of Photovoltaic System in Matlab using Simulink

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**Abstract:-** In recent year the solar power energy is the economical and independent of power grid connected power supplies plays important role in developing country such as India ,Pakistan, Bangladesh etc. In developed country it is very useful because it is connected with power grid. But in developing country the government not supply power to the rural area through power grid. So in this case independent solar power is very useful. In this paper we design and simulate the photovoltaic system using matlab simulink. The step by step designing is explained and the output data is analysed. After analysis of the it is found that the solar power system is very useful and economical if we consider it for long time (about 20 year).

**Keywords:-**Solar Cell, Matlab, Solar PV system, Photovoltaic Energy, PV array

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## 1. Introduction

The regular research from the past decades on photovoltaic energy as energy sources in various applications has increasing day to day. It is renewable, clean and sustainable energy which make it suitable to use as an alternative energy sources. The power user customer and Government focus has shifted towards obtaining energy from renewable resources rather than from finite sources of fuels and coals. Photovoltaic model consists of number of photovoltaic cell that are connected in series and parallel used to generate electricity from soar energy. Solar PV system can be fund ranging from a few hundred watts to MW Capacity. This means that solar power energy system can provide energy solution for individual houses to small scale industries. India or developing country ,places where grid connection is not possible or not till date supply energy from grid make use of PV system with the backup batteries which can also provide electricity in night time when sunlight is not available. The modelling and simulation of photovoltaic module helps in better understanding in terms of the behaviours and characteristics. The behaviour of photovoltaic module varies in environmental condition.[1-10]

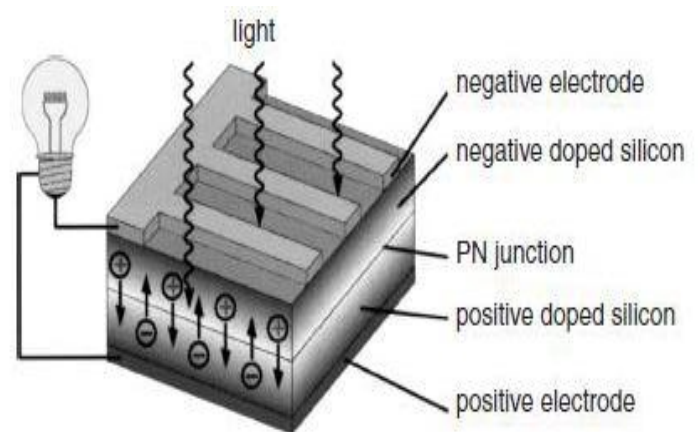
## 2. Methodology

### 2.1 Solar system

The most abundant fuel source in the area of renewable energy is the sun. Solar panels produce electricity through individual photovoltaic cells. This form of energy collection is viable in regions of the world where the sunlight is plentiful, and can be used in isolated regions or on houses to supplement the rising cost of electricity from a power grid. To convert the sun's energy, the cells capture photons to create free electrons that flow across the cells to produce usable current (Penick & Louk 2007). The efficiency of the panel is determined by the semiconductor material that the cells are made from as well as the process used to construct the cells.[1-3]

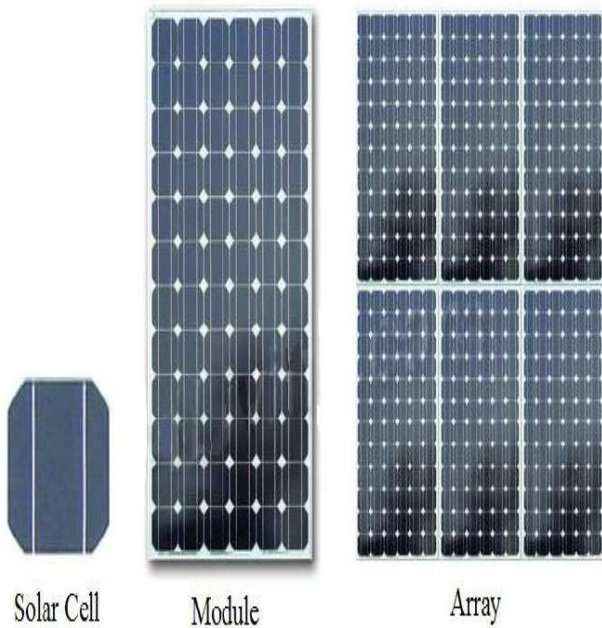
### 2.2 Photovoltaic Energy

Photovoltaic (PV) cells are made by semiconductor technology to convert solar light energy into electrical energy in the form of Direct Current (DC). The most preferable semiconductor material for manufacturing a PV cell is silicon. PV cell consists of a junction of *p* and *n*-doped silicon. A schematic diagram of the cross section view of solar cell (Hille et al 1995) is as shown in Figure(1) When the sun light strikes the junction, the energy in the photons is converted into electrical energy. Since the PV cells do not have any movable parts a longer life with less maintenance can be achieved.



Figure(1) Principle of generating electricity from sunlight

One of the major drawbacks of the PV conversion system is its huge capital cost and its poor efficiency only in the range of 13% to 16%. But the induction of new technologies in the manufacturing of solar cell, the production cost is reduced significantly. To generate more power, a group of cells called as PV modules or PV array as shown in Figure 1.3 (Mohammad. H. Rashid 2007) can be connected in series or in parallel to generate more power.[1-4]



Figure(2) Structure of solar cell, module and array  
 The generated DC power can be used directly to a DC load or it can be inverted into Alternating Current (AC) power to supply a AC load or utility grid.

**2.3 Equation and parameters of PV system.**

The basic equation from the theory of semiconductors that mathematically describes the I–V characteristic of the ideal PV cell is

$$I = I_{pv, cell} - I_{0, cell} \left[ \exp\left(\frac{qV}{\alpha KT}\right) - 1 \right] \quad (1)$$

The basic equation 1 of the elementary PV cell does not represent the I–V characteristic of a practical PV array. Cells connected in parallel increase the current and cells connected in series provide greater output voltages. Practical arrays are composed of several connected PV cells and the observation of the characteristics at the terminals of the PV array requires the inclusion of additional parameters to the basic which is mention in equation 2 as follow

$$I = I_{pv} - I_0 \left[ \exp\left(\frac{v + R_s I}{v_t \alpha}\right) - 1 \right] - \frac{v + R_s I}{R_p} \quad (2)$$

All PV array datasheets bring basically the nominal open-circuit voltage ( $V_{oc, n}$ ), the nominal short-circuit current ( $I_{sc, n}$ ), the voltage at the MPP ( $V_{mp}$ ), the current at the MPP ( $I_{mp}$ ), the open-circuit voltage/temperature coefficient ( $K_V$ ), the short circuit current/temperature coefficient ( $K_I$ ), and the maximum experimental peak output power ( $P_{max, e}$ ). This information is always provided with reference to the nominal condition or standard test conditions (STC’s) of temperature and solar irradiation. The practical PV device has a series resistance  $R_s$  whose influence is stronger when the device operates in the voltage source region and a

parallel resistance  $R_p$  with stronger influence in the current source region of operation. The assumption  $I_{sc} \sim I_{pv}$  is generally used in the modelling of PV devices because in practical devices the series resistance is low and the parallel resistance is high. The diode saturation current is given by

$$I_0 = \frac{I_{sc, n} + k_I \Delta T}{\exp\left(\frac{V_x, n + k_V \Delta T}{\alpha V_t}\right) - 1} \quad (3)$$

The saturation current  $I_0$  is strongly dependent on the temperature so that the net effect of the temperature is the linear variation of the open-circuit voltage according to the practical voltage/temperature coefficient. The equation of the PV current is given in equation 4 .

$$I_{pv} = (I_{pv, n} + k_I \Delta T) \frac{G}{G_n} \quad (4)$$

The relation between  $R_s$  and  $R_p$ , the only unknowns of inequation 2 may be found by making  $P_{max, m} = P_{max, e}$  and solving the resulting equation for  $R_s$  is given in equation 5 and 6.

$$P_{max, e} = V_{mp} \left\{ I_{pv} - I_0 \left[ \exp\left(\frac{q V_{mp} + R_s I_{mp}}{K_T \alpha N_s}\right) - 1 \right] - \frac{V_{mp} + R_s I_{mp}}{R_s} \right\} = P_{max, m} \dots \dots \dots (5)$$

$$n \frac{V_{mp} + I_{mp} R_s}{\left\{ I_{mp} I_{pv} - V_{mp} I_0 \exp\left(\frac{V_{mp} + I_{mp} R_s q}{N_s \alpha K_T}\right) + V_{mp} I_0 - P_{max, e} \right\}} \quad (6)$$

$$I_{pv, n} = \frac{R_p + R_s}{R_p} I_{sc, n} \quad (7)$$

The initial value of  $R_s$  may be zero. The initial value of  $R_p$  may be given by

$$R_{p, min} = \frac{V_{mp}}{I_{sc, n} - I_{mp}} - \frac{V_{oc, n} - V_{mp}}{I_{mp}} \quad (8)$$

Equation 8 determines the minimum value of  $R_p$ , which is the slope of the line segment between the short-circuit and the maximum-power remarkable points. Although  $R_p$  is still unknown, it surely is greater than  $R_{p, min}$  and this is a good initial guess.[5-13]

**2.4 Deigning of Solar Panel**

**2.4.1 The mathematical model or circuit model of an ideal photovoltaic module is shown in below figure (3).**

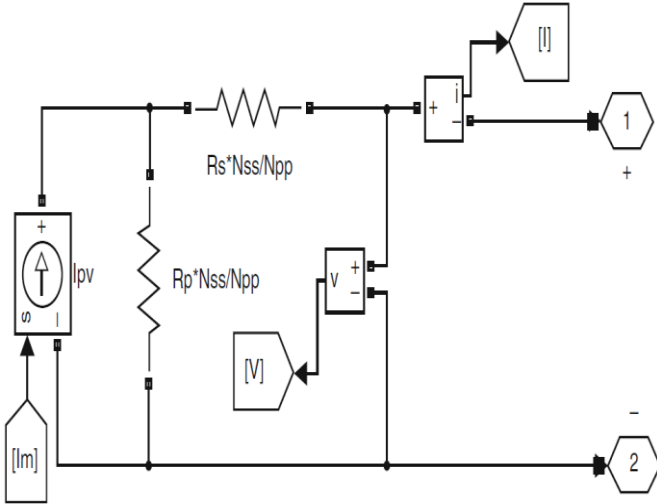


Figure (3) Basic SIMULINK model of equivalent PV module

**2.4.2 The simulink model for calculation of  $I_m = I_{pv} - I_d(N_{ss} \times N_{pp} \text{ modules})$  is shown in figure(4)**

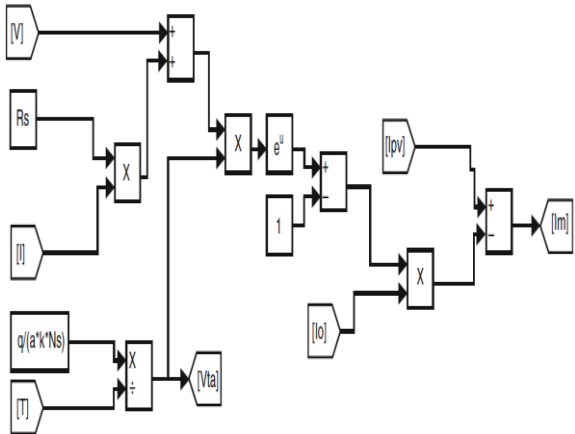
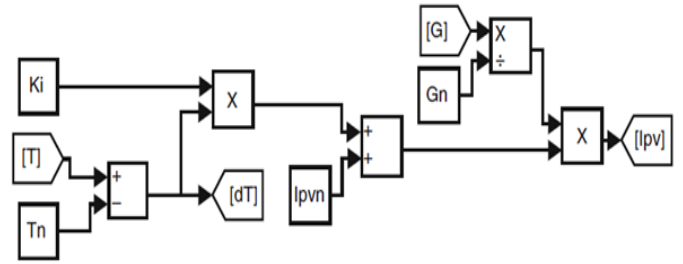


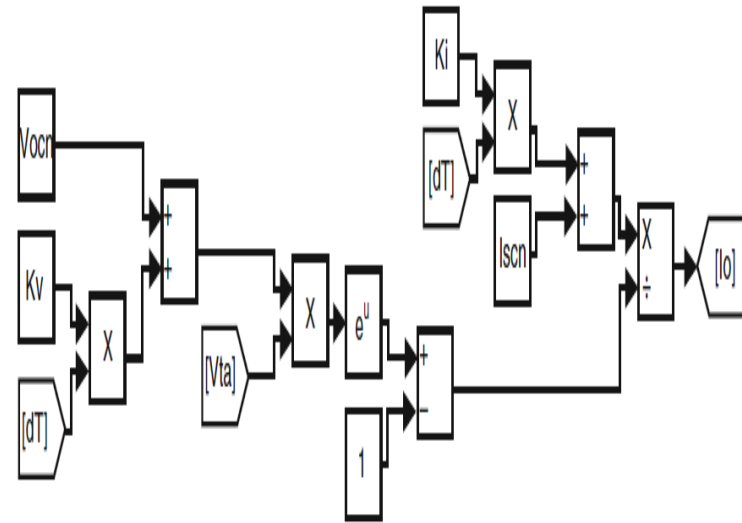
Figure (4) The simulink model for calculation of  $I_m = I_{pv} - I_d(N_{ss} \times N_{pp} \text{ modules})$

**2.4.3 The Simulink model for the calculation of  $I_{pv}$  (single module) is shown in figure(5)**



Figure(5) The simulink model for the calculation of  $I_{pv}$  (single module)

**2.4.4 The simulink model for the calculation of  $I_o$ (single module) is shown in figure(6)**



Figure(6) The simulink model for the calculation of  $I_o$ (single module)

**2.4.5 The proposed PV module is sown in figure (7.)**

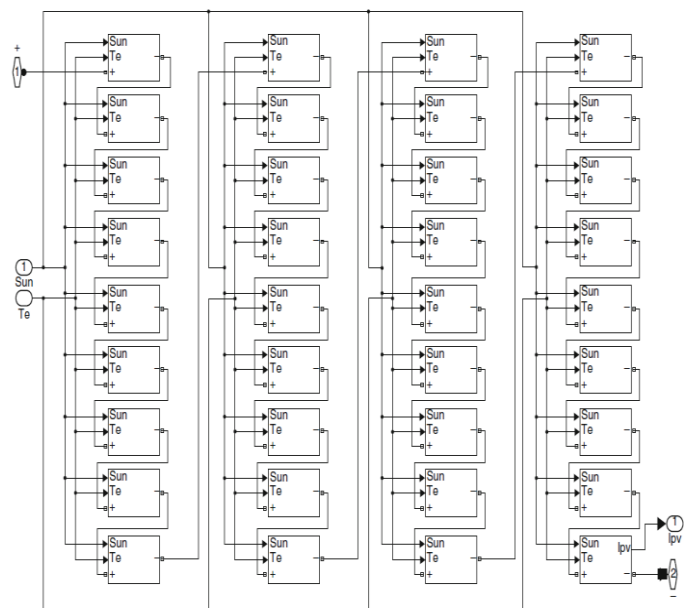


Figure (7) Proposed PV module SIMULINK

2.4.6 The proposed PV array simulink model is shown in below figure 8

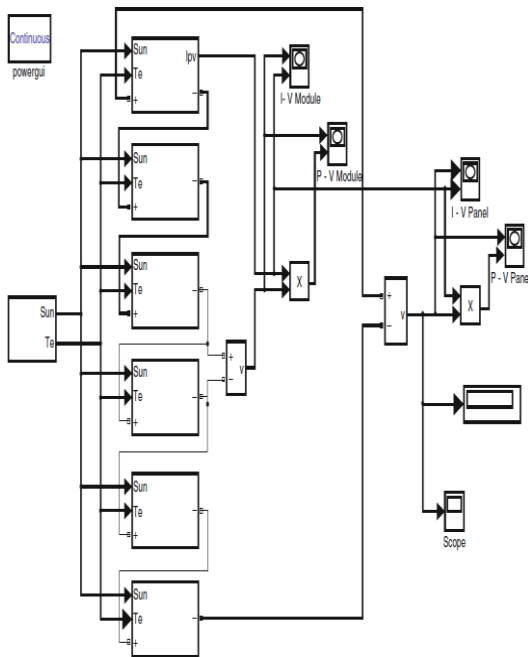


Figure (8) Proposed PV array simulink model

### 3. Simulation Results

#### 3.1. Simulation of PV Module

PV module is modelled by using Matlab Simulink. After the simulation of proposed PV model in matlab for different values of parameter we have find the result shown in figure 9 ,10,11,12 Simulation results for the proposed PV module based on P-V and I-V characteristics under different solar radiations are shown in Figure 9 & 10. Simulation results for the proposed PV module based on P-V and I-V characteristics for different values of cell temperatures are shown in Figure 11 & 12.

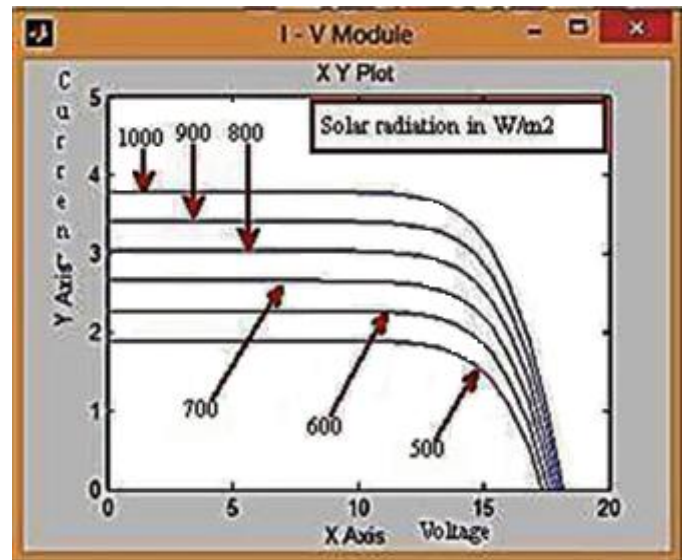


Figure (9) I – V characteristics of PV module

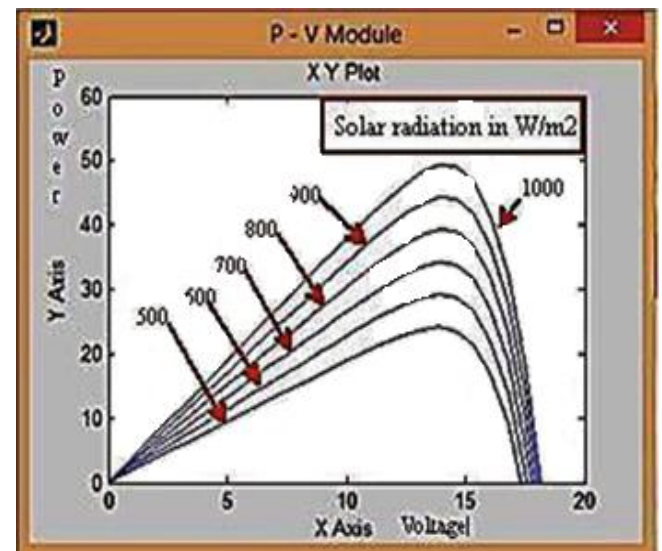
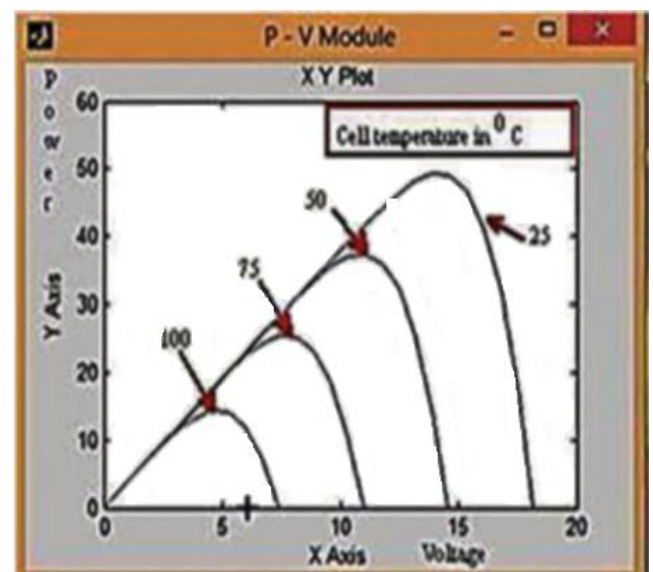
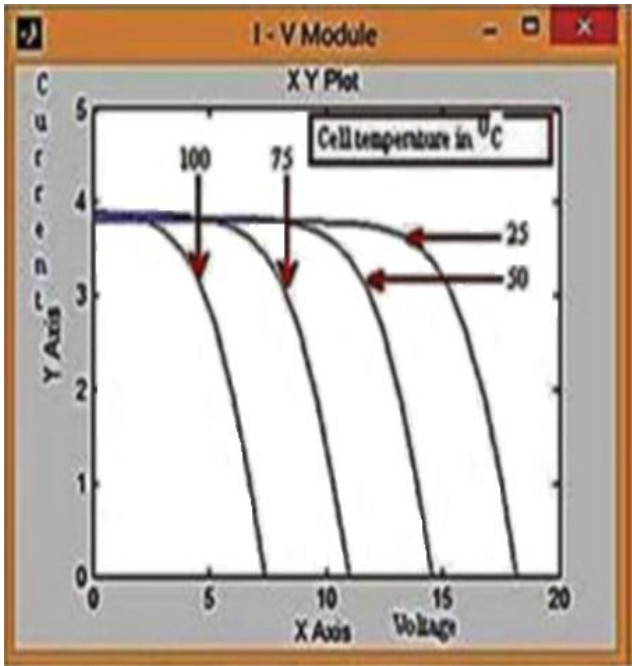


Figure (10) P – V characteristics of PV module



Figure(11) P – V characteristics of PV module

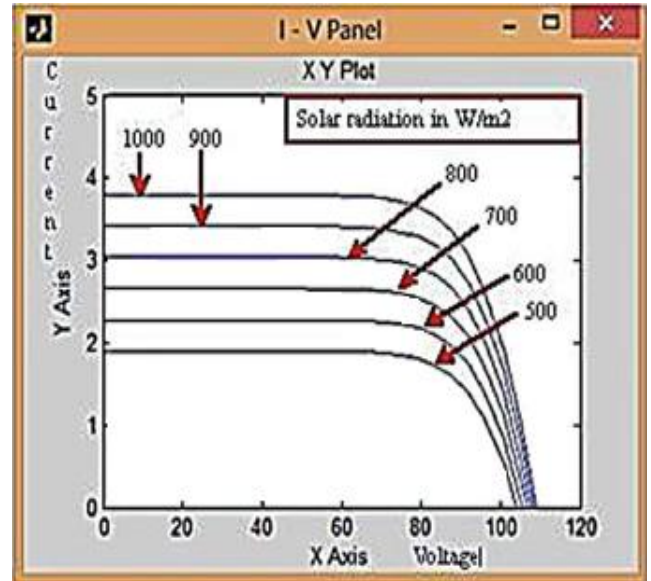




Figure(12) I – V characteristics of PV module

### 3.2. Simulation of PV Array

An array of 6 PV modules has been constructed. The PV modules were interconnected in series. The PV array model was simulated similarly to the model of the PV module and the results obtained are shown in Figure 13,14,15 & 16



Figure(14) I – V characteristics of PV array

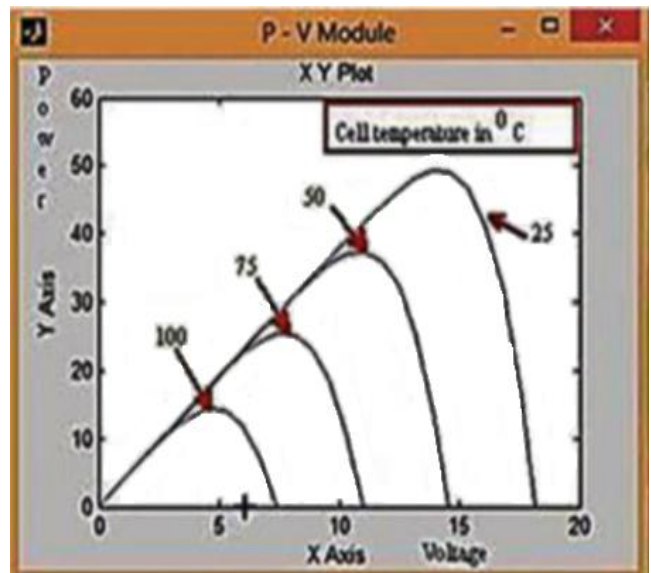
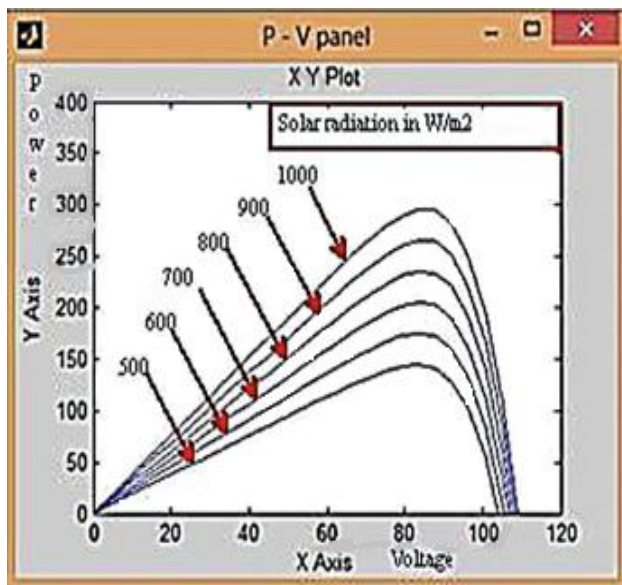


Figure (15) P – V characteristics for PV array



Figure(13) P – V characteristics of PV array

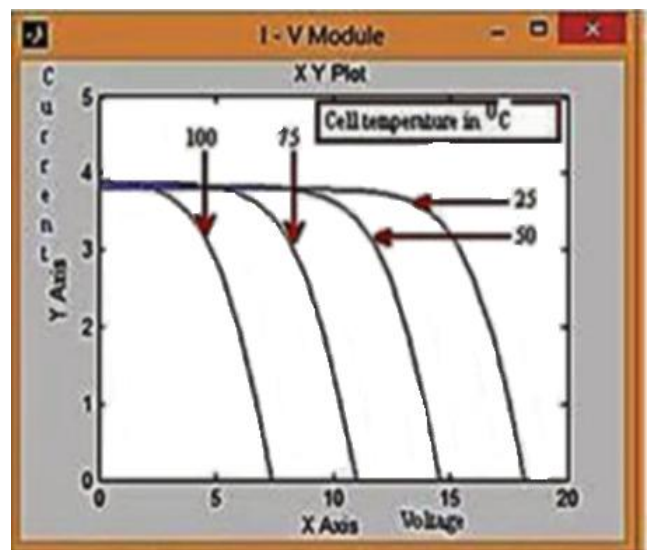


Figure (15) I – V characteristics for PV array

#### 4. Conclusion

Step by step method in modelling PV module was developed using Matlab Simulink and presented. This method also verified by theoretical calculations based on the equations involved for PV module. This paper presents a clear understanding on the behaviour and parameters involved in PV module especially on I-V and P-V characteristics. The result of the simulation shows that the change in different parameter changes the result of I-V and P-V values. Simulation results for the proposed PV module based on P-V and I-V characteristics under different solar radiations and different values of cell temperatures are shown.

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