MODELING AND SIMULATION OF PHOTOVOLTAIC MODULE WITH RESPECT TO DIFFERENT SOLAR IRRADIATIONAND TEMPERATURE USING MATLAB/SIMULINK

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ABSTRACT

In this paper we haveperformed the effect of solar irradiation and temperature on photovoltaic (PV) module. Solar radiation never remains constant. It keeps varying throughout the day.This module is developed using basic circuit equation of photovoltaic cell.PV module has non-linear characteristics. In the present study, PV module characteristics curve as power-voltage (P-V) andcurrent-voltage (I-V) characteristics are drawn according to value change of the temperature and solar irradiation using Matlab/Simulink.One diode equivalent circuitwas used to investigate P-V and I-V characteristics.

Keywords: Irradiation, Matlab/Simulink.Photovoltaic Module

I. INTRODUCTION

The Conventional sources of energy are rapidly depleting. Moreover the cost of energy is increasing day by day therefore photovoltaic system is a promising alternative. They are abundant, pollution free, distributed throughout the earth and recyclable so, the demand of solar photovoltaic energy systems has been increasedas they produce electric power without hampering the environment by directly converting the solar radiation into electric power. PV cell are useful in obtaining energy from the sun,since it converts sunlight directly to electricity with very high efficiency of conversion,it provides permanent power output at low operating cost. The rapid development of photovoltaic material technology has reduced the production cost of solar PV modules, generating electricity from a solar cell, solar PV cellsor photovoltaic cells change energy from sun into useful electrical energy using semi-conductor PN junction device. PV cell generates voltage, which varies in the range of 0.5 to 0.8 volts depending upon the cell manufacturing technology used[1].

The limiting factor is,its high installation cost and low conversion efficiency. Therefore our aim is to increase the efficiency and power output of the system. It is also required that constant voltage must be supplied to the load irrespective of the variation in solar irradiance and temperature. PV arrays consist of parallel and series combination of PV cells that are used to generate electrical power depending upon the atmospheric conditions (e.g solar irradiation and temperature).But there are two major problems with PV generation systems. One is the low conversion efficiency of solar energy into electrical power and the other is the nonlinear characteristics of PV array which makes the electrical power generated vary with temperature and solar irradiation [2]. In general there is only one point on P-V and V-I curve called the maximum power point. At this point only PV system operates with maximum efficiency and produces maximum output power. Moreover, the amount of extracted power from a PV system is a function of the PV array voltage and current set point. Due to these reasons stated above, it is crucial to maximize the output electric power available from the PV cell. Actually the solar PV cell has non -linear I-V and P-V characteristics which depend on the irradiance and the operating temperature also in load condition of the cell [3,4]. Patel and Agarwal [5] proposed the MATLAB based modelling, and studied the effects of partial shading on PV array characteristics. PV module characteristics and mathematical modeling[3] which indicate an exponential and nonlinear relation between the output current and voltage of PV module.There arefour different types of generalized MATLAB models toexamine the effect of solar irradiance and cell temperature and to optimize the generalized model[6].

II. PRINCIPLE OF OPERATION

PV Cells are basically made up of a PN junction fabricated in a thin wafer or layer of semiconductor (usually the material used is silicon). When sunlight hits on the cell, the photons are absorbed by the semiconductor atoms, freeing electrons from the negative layer. These free electrons find its path towards the positive layer through an external circuit, resulting in an electric current, flows from the positive layer to the negative layer. PV cells are connected in series to form a PV module. These modules can be interconnected in series and/or parallel to form a PV panel. In case these modules are connected in series, their voltages are added with the same current, when they are connected in parallel, their currents are added while the voltage remains the same [3].

III. MODELLING OF PV CELL

The solar cell is the basic unit of a PV system. Solar Cell or Photovoltaic (PV) cell is a device that is made up of semiconductor materials such as silicon, gallium arsenide and cadmium telluride, etc. that converts sunlight directly into electricity. The voltage of a solar cell does not depend strongly on the solar irradiance but depends primarily on the cell temperature. PV modules can be designed to operate at different voltages by connecting solar cells in series. When solar cells absorb sunlight, free electrons and holes are created at positive/negative junctions. If the positive and negative junctions of solar cell are connected to DC electrical equipment, current is delivered to operate the electrical equipment.

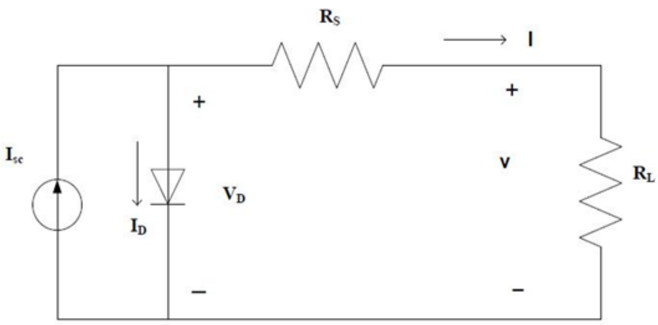
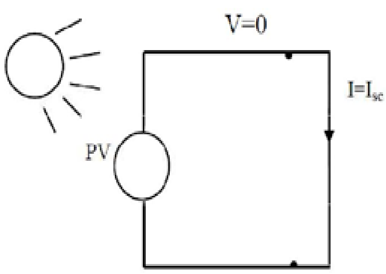


Fig.1 PV Cell with its Equivalent Electric Circuit

The PV model consists of a current source (I_{SC}), a diode (D) and a series resistance (R_S).The significance of "parallel resistance. (R_P), is that the leakage resistance of the cell is very small in a single module and hence the model doesn't include it. The "current source represents the current generated by photons" (I_{PH}), and the output because of this current is "constant under constant temperature and constant incident radiation of light".

When the resistance of the load is varied and thus the current produced is measured. I-V curve passes through two points: Short-circuit current (I_{SC})": when the two terminals are short –circuited the current produced in that situation is called "Short-circuit current. Open-circuit voltage (V_{OC})": is the voltage across the two terminals under open-circuit conditions is called "Open Circuit voltage



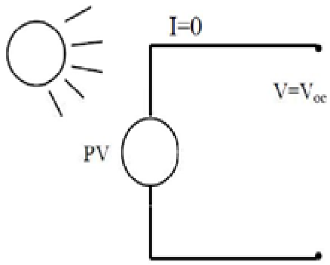


Fig 2(a). Short circuit current **Fig2(b). Open circuit Voltage**

The current-voltage relationship of a PV cell is given as:-

$$I = I_{SC} - I_D \text{.......................................} (2.1)$$

$$I_D = I_S[e^{\frac{qV_D}{nKT}} - 1] \text{.......................................} (2.2)$$

Where, I = output current (A) q = electron charge (1.6x 10^{-19}C)

I_{SC}= short circuit current (A) k = Boltzmann's constant (1.381x10^{-23} J/K)

I_S = reverse saturation current (A) T = junction temperature (K)

VD = voltage (V) across the diode n = diode ideality factor (1~2)

IV. BASIC FUNCTIONAL MATLAB-SIMULINK MODULE OF THE PHOTOVOLTAIC MODEL

The basic model used for solar PV cell is designed in MATLAB-SIMULINK environment as shown in figure 3. A circuit based simulation model for a PV cell for the estimation of the I-V characteristic curves of photovoltaic panel with respect to changes on environmental parameters (temperature and irradiance).

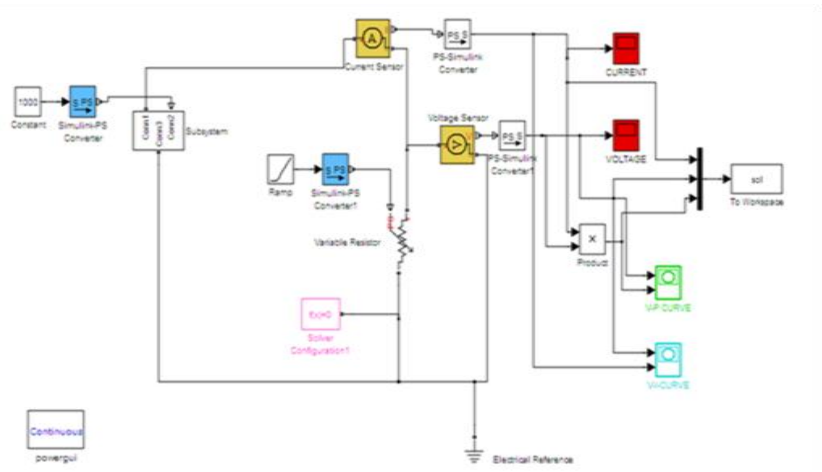
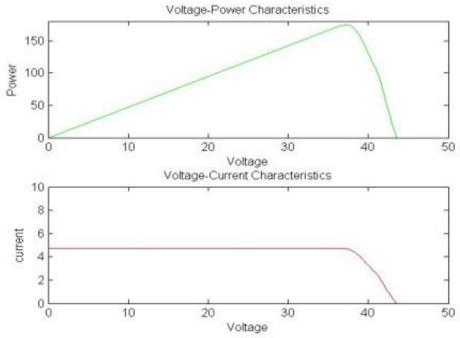


Fig 3.Functional Matlab-Simulink Module of the Photovoltaic Model

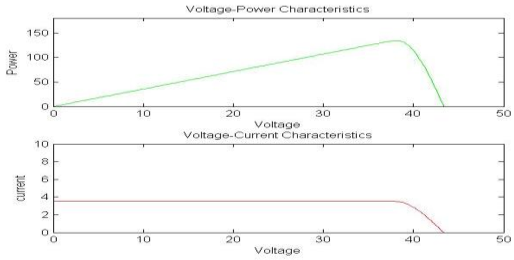
V. ARIABLE IRRADIANCE

The simulation of solar photovoltaic system is carried out using MATLAB/Simulink and the characteristics between various parameters are plotted.

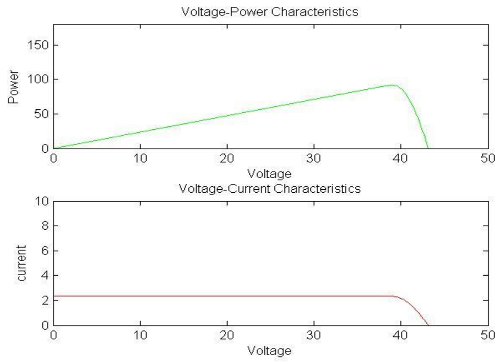
1. For 1000 watts/m^2 irradiance, 25^0C Temp, power-voltage and current-voltage curves are plotted.



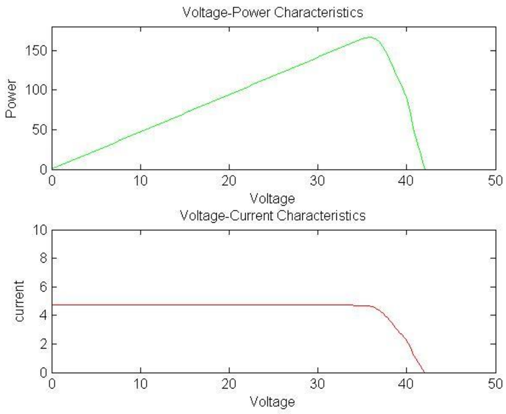
2. For 750 watts/m^2 irradiance, 25^0C Temp, power-voltage and current-voltagecurves are plotted.



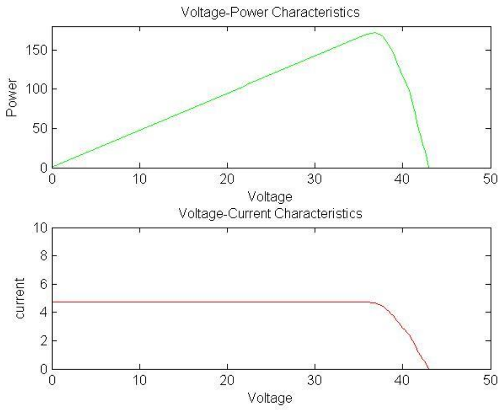
3. For 500 watts/m^2 irradiance, 25^0C Temp, power-voltage and current-voltage curves are plotted



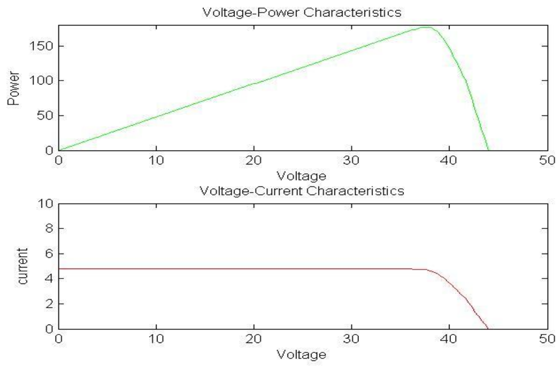
4. For 1000 watts/m^2 irradiance, 10^0C Temp, power-voltage and current-voltage curves are plotted



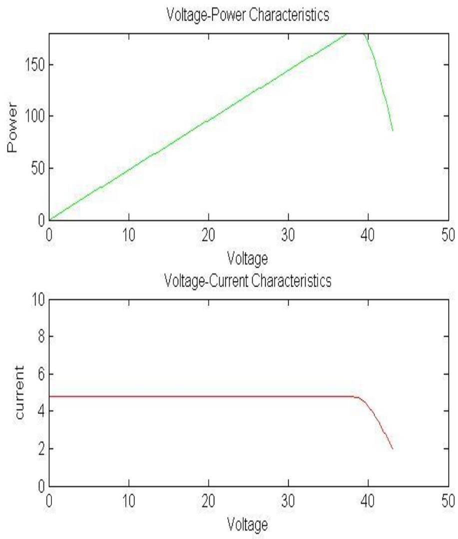
5. For 1000 watts/m^2 irradiance, 20^{0}C Temp, power-voltage and current-voltage curves are plotted



6. For 1000 watts/m^2 irradiance, 30^{0}C Temp, power-voltage and current-voltage curves are plotted



7. For 1000 watts/m^2 irradiance, 40^{0}C Temp, power-voltage and current-voltage curves are plotted



V. CONCLUSION

This paper present detail of modelling and simulation of photovoltaic module(system) suitable to different solar irradiation and temperature using Matlab/Simulink. The effects of temperature and solar irradiance have been considered in the modeling. The developed model has been simulated and validated using Matlab/Simulink for different cells and panels connected in series and parallel. This makes the proposed model very useful for MATLAB/Simulink to model a PV module. The experimental results exhibited a good agreement with the simulation results. This paper provides comparably better accuracy of the, I-V and P-V characteristics of PV module and the effect of change of temperature and insolation levels on these characteristics then the other formulated model. The study is useful to serve as the basicmodel to carry out the further studies in the field of PV modeling. The present, PV module can be used to determine all the necessary parameters under different conditions of irradiance and temperature and then to obtain the I-V and P-V characteristics.

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