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Modeling of Photovoltaic Array using MATLAB

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Abstract **- The non-renewable energies such as petroleum, natural gas and coal are present in very small amount due to which large number of challenges is created. The non-renewable energy resources also causes environmental pollution about which people have to think. The reduction of these resources and rising demand of the people for energy shows that there is need to find ways to reduce the use of these fossils fuel. Now our technologies are improved which help us to solve our energy crises. The best solution of this entire problem is the renewable energy resources. In this paper we will discuss about the modeling of PV array. I-V and P-V characteristics are also obtained for the model of PV array under different conditions of irradiance and Temperature.**

Keywords—MATLAB/Simulink

I. INTRODUCTION

The non-renewable energies such as petroleum, natural gas and coal are present in very small amount due to which large number of challenges is created for the population of the country and the world. The reduction of these resources and rising demand of the people for energy shows that there is need to find ways to reduce the use of these fossils fuel but it is not possible because of the use of these energies in everything like cooking, transportation and many more. If we increase the cost of energy it is directly related to the reduction of use of the non-renewable resources but some economical and political factors are also linked with this. The demand for these types of energies is continuously increasing which require thinking about the alternatives to develop energy. The non-renewable energy resources also causes environmental pollution about which people have to think. The gas release from the vehicles polluted the water that we drink and also polluted the air that we breathe. The effect of the storms, flood, droughts and the rising level of sea all these are the result of global warming and are also caused by the pollution. Now our technologies are improved which help us to solve our energy crisis. The best solution of this entire problem is the renewable energy resources.

A photovoltaic cell (PV cell) is a specialized semiconductor diode that converts visible light into direct current (DC) Due to the low voltage of an individual solar cell (typically ca. 0.5V), several cells are wired in series to form a module. A photovoltaic array (or solar array) is a linked collection of solar panels. The modules in a PV array are usually first connected in series to obtain the desired voltage; the individual strings are then connected in parallel to allow the system to produce more current .The operation of PV cell is described from a PN junction.

II. MODELING OF PV ARRAY

The fundamental parameters related to solar cell are short circuit current (Isc), open circuit voltage (Voc), maximum power point (MPP), efficiency of solar cell and fill factor.
Short Circuit Current is the current corresponds to the short circuit condition when the impedance is low and it is calculated when the voltage equals to zero.
Open Circuit Voltage is the voltage when the open circuit occurs and there is no current passing through the cell. . The open circuit voltage can be expressed as:

$$V_{oc} = \frac{AkT_c}{q} \ln\left(\frac{I_{pv}}{I_s}\right)$$

Maximum Power Point is the operating point at which the power is maximum across the load.

$$P_m = V_m * \mathrm{I}_m$$

Where Vm is maximum voltage and Im is the maximum current.
The fill factor, abbreviated FF, is a parameter which defines the quality of the solar cell. Fill factor is defined as the ratio of the maximum power from the solar cell to the product of Open Circuit Voltage Voc and Short-Circuit Typical fill factors range from 0.5 to 0.82. The fill factor diminishes as the cell temperature is increased.

$$FF = \frac{P_m}{V_{oc} * I_{sc}}$$

The equivalent circuit of solar cell comprised of a current source connected in anti-parallel with the diode, series resistance and shunt resistance is shown in figure.1, the output current of solar cell:

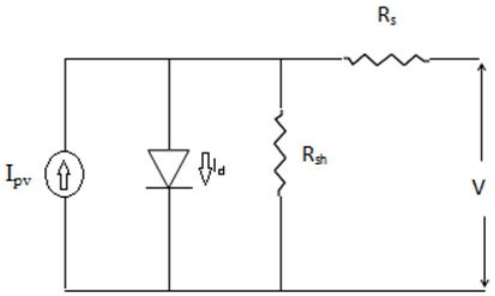

Fig.1 Equivalent circuit of solar cell

$$I = I_{pv} - I_d$$

Ipv is the photovoltaic current and Id is the diode current. Where

$$Id = Is\{\exp(\frac{q}{AkTc}) - 1\}$$

Here, Is is the diode saturation current is the electron charge (1.60×10^{-19}°C), A is the ideality constant, k is the Boltzmann constant (1.38×10^{-23}J/K), Tc operating temperature.

From figure 1 equation of the current

$$I = Ipv - Id - Irsh$$

$$I = Ipv - Is\{\exp(\frac{q}{AkTcNs}V + IRs) - 1\} - \frac{V + IRs}{Rsh}$$

Here, Ns is the number of cells in series, Rs is the series resistance and Rsh is the shunt resistance.

The photovoltaic current of the solar cell is mainly depends on the solar irradiation level and its working temperature, which is expressed as

$$Ipv = [Isc + Ki(Tc - Tr)].G$$

G is the irradiance (W/m2). The diode saturation current of the cell varies with the cell temperature, which is expressed as

$$Is = Irs(\frac{Tc}{Tr})^3 \exp[\frac{qEg}{Ak}(\frac{1}{Tc} - \frac{1}{Tr})]$$

Irs is the reverse saturation current, Tr is the reference temperature and Eg is the band gap (for silicon 1.1 ev)

The reverse saturation current of a cell Irs is

$$Irs = \frac{Isc}{\exp(\frac{q}{AkTcNs}Voc) - 1}$$

For PV array number of module may connect in series or in parallel. Equation for PV array

$$I = I_{pv}N_{pp} - I_sN_{pp}\left[\exp\left(\frac{q}{AkT_cN_sN_{ss}}(V + R_s\left(\frac{N_{ss}}{N_{pp}}\right)I)\right) - 1\right] - \frac{V + R_s\left(\frac{N_{ss}}{N_{pp}}\right)I}{R_{sh}\left(\frac{N_{ss}}{N_{pp}}\right)}$$

N_{pp} is number of module connected in parallel and N_{ss} is number of module connected in series. Block developed using above equation in MATLAB/Simulink for the PV module is shown in figure2 and the I-V characteristic, P-V characteristics is shown in figure 3,4,5 and 6

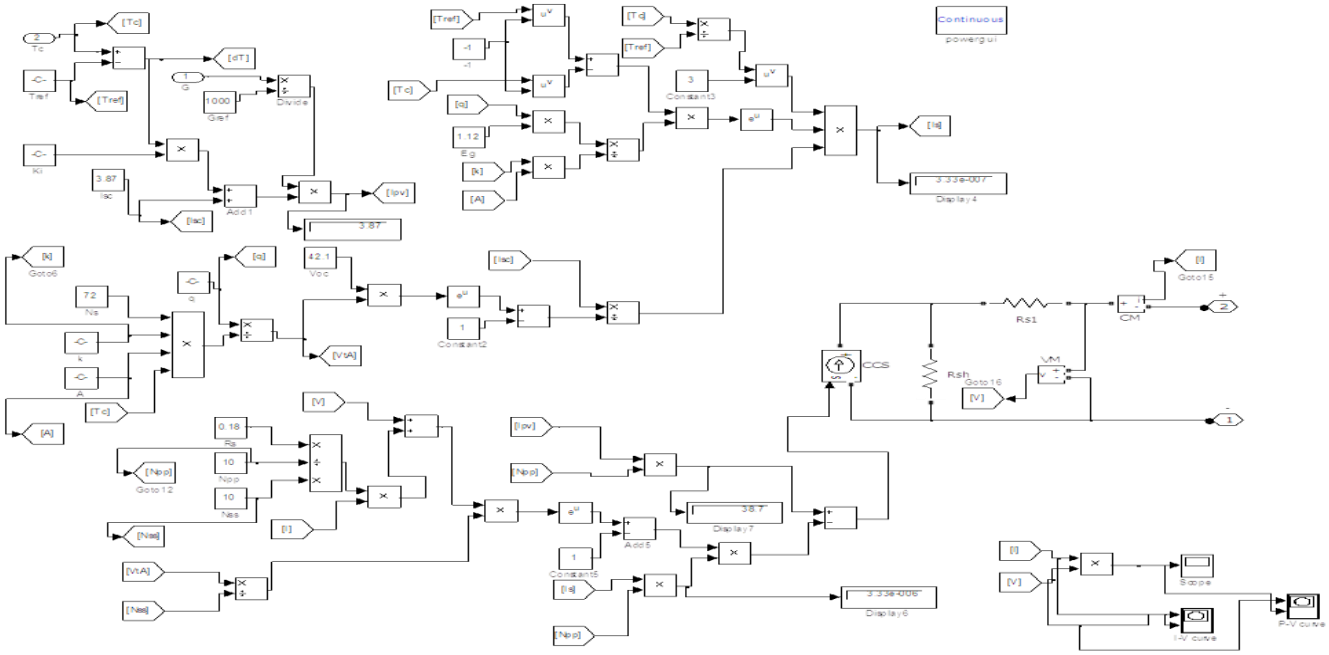

Fig 2 Simulink Model of PV Array

III. SIMULATION RESULTS

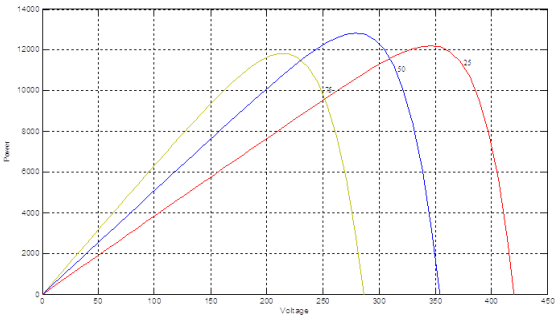

Fig.3P-V curve of PV array at different temperature

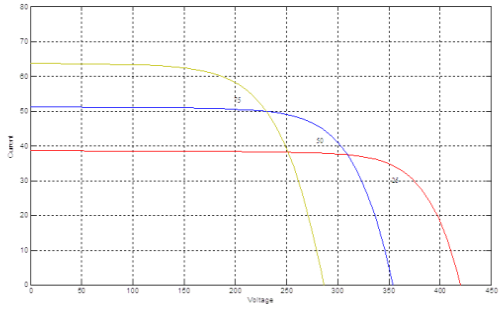

Fig.4 I-V curve of PV array at different temperature

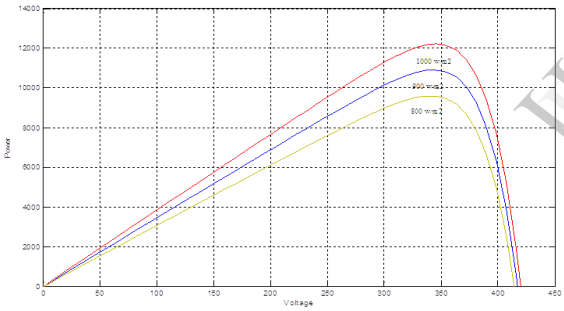

Fig 5 P-V curve of PV array at different irradiance

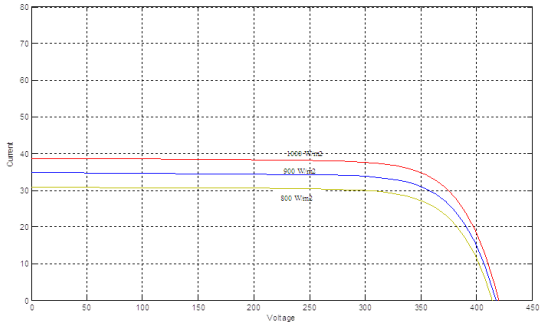

Fig 6 I-V curve of PV array at different irradiance

IV. CONCLUSION

In this paper we have obtained the simulation model of PV array using MATLAB/Simulink blocks. The I-V and P-V characteristics is obtained using simulation model of PV array under different condition of irradiance and temperature. From the obtained graph we will easily find the maximum output under different condition.

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