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MATLAB/Simulink Model of Solar PV Module

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Abstract*—*This paper presents the simulation and modeling of a PV Panel using the software platform MATLAB/Simulink. Basically, the purpose of making a model is solved only when we start getting the I-V & PV characteristics for various values of solar irradiance. Any solar system configuration consists of a required number of solar photovoltaic cells connected in series or in parallel to obtain the required voltage output. Furthermore these cells connected in parallel increases the current and cells connected in series help provide greater output voltages. And now the practical arrays are composed of several connected PV cells to get the desired output voltages and currents.

1. INTRODUCTION

As we know that day by day, there are increasing concerns about fossil fuel deficiency, due to which the oil prices are going very high while the major concerns are global warming and damage to environment and ecosystem. For all of these problems, there is only a way out and that is to develop alternative energy resources with high efficiency and low emission. Hovering over all the options of renewable energy resources, the energy through the photovoltaic is considered to be the best because of its availability, free of cost available sunlight and it is a pollution free resource keeping in view disadvantage that is it is available only during a specific time span of the day and high capital fabrication cost and low conversion efficiency.

It is a known fact that the PV Cells have a task of conversion of solar energy into DC electrical energy. There are various kinds of Photovoltaics which are monocrystalline, polycrystalline and amorphous silicon. Major thrust of the day is to work on efficiency and cost. Whereas, the efficiency of a Solar Photovoltaic is the ability of the material to absorb the light energy photon over a large range of the band gap. More the efficiency, more the number of electrons move into the conduction band and so more conduction to the electrical load is available. Typically, PV cells

produce low power and so several cells are connected together to form modules and panels for higher power applications.

By doing the process of modeling, computer simulation of a real system can be successfully done as it is based on a theoretical analysis of the various physical processes occurring in the system and all factors influencing these processes are taken up. For doing any kind of modeling first of all mathematical models describing the system characteristics are formulated and translated into computer codes. There are many models of Photovoltaic cells out of which the most common model used to predict energy production in photovoltaic cell modeling is the single diode circuit model that represents the electrical behavior of the pn-junction.

2. SINGLE DIODE MODEL OF A SOLAR CELL

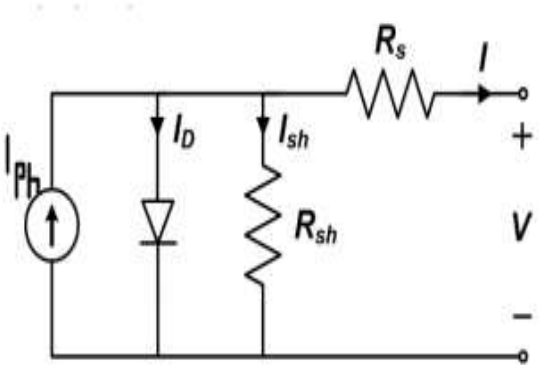

Figure 1: Equivalent Circuit of a Solar cell

Where in the above figure, R_s is series resistance of PN junction cell and R_{sh} is shunt resistance which is inversely in relation with leakage current to the ground.

The equations for the single diode model have been given below:-

Output terminal current I is

$$I = I_{ph} - (I_d + I_{sh})$$

Voltage current characteristic equation:

$$I = Iph - Io(\exp\frac{q.(V + IRs)}{N.K.T} - 1) - \frac{(V + IRs)}{Rsh}$$

Where,

Iph is light-generated current or photocurrent,

Io is cell saturation of dark current,

q = 1.6 $\times 10^{-19}$C is electron charge,

k = 1.38 $\times 10^{-23}$J/K is a Boltzmann's constant,

T is cell working temperature,

N is ideal factor,

Rsh is shunt resistance,

Rs is series resistance.

Dependence of Photo current on the solar irradiance and cell's temperature, is described as

$$Iph = (Iscr + Ki * (Ic + 273.15 - Tr)) * G$$

Where,

I_{scr} is cell short current at a 250°C & 1kW/m^2,

K_i is cell short circuit current temperature coefficient,

T_r is cell's reference temperature,

G is solar irradiance in kW/m^2

Cell saturation current varies with cell temperature, like following

$$Io = I_{oR} * (\frac{Tc}{T_{ref}})^3 * \exp(\frac{q * Eg(\frac{1}{Tref} - \frac{1}{Tc})}{K.N})$$

$$Tc = ((NOCT - 20) * \frac{G}{0.8}) + (Ta)$$

Where,

I_{OR} is cell reverse saturation current at reference temperature and solar irradiance,

NOCT is nominal operating cell temperature,

E_g is band gap energy of the semiconductor used in the cell.

The ideality factor N depend on PV technologies.

3. PV CELL *MODELLING*

The Simulation of a PV module has been performed in MATLAB/Simulink. Parameters of physical solar blocks are defined by short circuit current and open circuit voltage preset values Modeling task has been performed in MATLAB/Simulink library to create a solar array. Series and parallel connections of PV modules are prepared from solar cell blocks taken from simulink- library. Solar module has series connection of 36 PV cells. Hence there are 36 cells in series.

Table 1: Specification Of The Simulated Module

Parameter	Value
Maximum power, Pm	50W
Voltage at Maximum Power, Vmp	17.44V
Current at Maximum Power, Imp	2.86A
Short circuit current Isc	3.11A
Open circuit voltage Voc	21.8V
Number of cell in Series-Ns	36
Number of cell in Parallel-Np	1

The performance evaluation of solar cell is under the standard test condition (STC), the irradiance is normalized to 1000W/m^2, and the cell temperature is defined as 25 °C.

A model of the same has been implemented in MATLAB/Simulink Software which is given below.

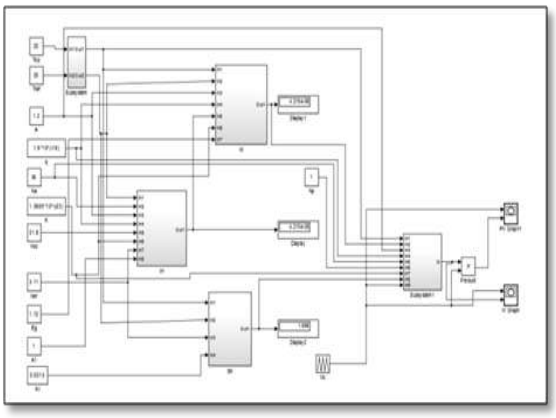

Figure 2: Solar PV Module made in Simulink

4. SIMULATION RESULTS

We can see that at an average output power of a Solar Panel under study is seeing a trend to be around 50Watts most of the time. The same has been shown in the following figure which is a snapshot of the Output Power versus time plot obtained from the Simulink Model.

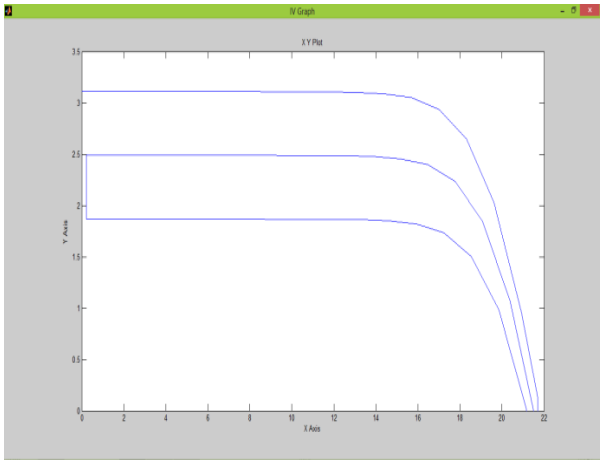

Figure 3: Solar PV Output Current Versus Voltage Plot

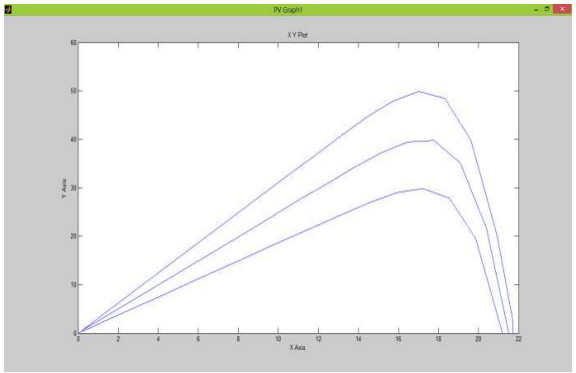

Figure 4: Solar PV Output Power Versus Voltage Plot for various irradiances

5. CONCLUSION

The generalized model of PV cell and module has been presented in MATLAB/ Simulink. Different irradiance levels have a great effect on the Power Output of the PV Module. This model and is expected to show the behavior of solar cell and module. Tools used for simulation are required for developing and handling mathematical simulations to analyze the behavior of PV Systems. Due to simulation, the study of new systems like power converters, inverters etc., for reducing cost and time can be effectively done. In this paper, a study on the single diode model has been done. This task of appropriate modeling of the solar cells can help do a lot of work in the area of MPPT even under varying atmospheric conditions.

In this paper, a PV array has been modeled in MATLAB/Simulink. A generalized mathematical description of a PV array has been followed in order to model PV array. This study will be further spread forward for Maximum Power Point Tracking algorithms in focus of grid connected PV system in future research area.

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