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Mathematical Modeling for Solar PV Module

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***Abstract*— The two inherent problems in solar technology is low conversion and next one is the presence of highly non-linear I-V characteristics. Therefore the aim of this paper is to increase the efficiency and power output of the system and to reduce external power consumption. So to increase the efficiency it is desire to extract the maximum power from PV module.**

***Keywords*— SPVM, PV Module;**

I. INTRODUCTION

The growing demand for electricity and the recent environmental threats such as global warming has led to need for new source of energy that is cheaper and clean with less carbon emission. The increasing prices of oil and decreasing level of oil has made solar energy most suitable as energy source. Among all renewable energy resources PV energy has drawn attention due clean, need little maintenance and having no noise. Earth receives 174 pet watts of incoming solar radiation at the upper atmosphere. The total solar energy absorbed by earth's atmosphere, ocean and land masses is 3,850,000EJ per year. Solar energy is used in many applications such as solar heater, solar cooker, crop drying etc. the solar energy is harvest by human since ancient times. To harvest solar energy, the most common way is to use the PV panel which will receive photon energy from sun and convert it into electricity.

The photovoltaic effect was first demonstrated by Edmond Becquerel. The PV system has two main drawbacks high capital cost and low efficiency. The conversion efficiency drops by about 0.38 % per ◦C increase in panel temperature [2]. Energy produced by PV module is dependent on environmental condition such as temperature and solar insolation [6]. For given solar insolation and temperature there is only one maximum peak point (MPP) at which PV module delivers the maximum power. Hence, in order to extract maximum power and to increase the utilization efficiency of the module it is necessary to operate it at MPP [1]. To achieve this, there are different methods to extract maximum power has developed such as perturb and observe (P&O) and incremental conductance. P&O is the simple and cost of implementation is low but they are not accurate enough [5], while the incremental conductance algorithm has high complexity but it can track the rapidly changing environmental condition with high accuracy.

II. SIMULINK MODEL OF PV ARRAY

Solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. The energy can be directly converted to electricity through photovoltaic effect, low voltage generated in a PV cell (around 0.5V), several PV cells are connected in series and in parallel to form a PV module for desired output. Performance evaluation shows a solar panel can generate output power above of its rated value for only six hours of a day from 9.00 am to 3.00 pm [3].

An ideal cell is modeled by a current source in parallel with a diode. However no solar cell behave as an ideal and thereby shunt and series resistances are added to the model as shown in the equivalent model of solar cell. R_S is the intrinsic series resistance whose value is very small. R_P is the equivalent shunt resistance which has a very high value. Energy available from the solar cells is not in uniform throughout the day, it arbitrarily varies according to environmental conditions like temperature, intensity of radiation and partial shading effects [5].

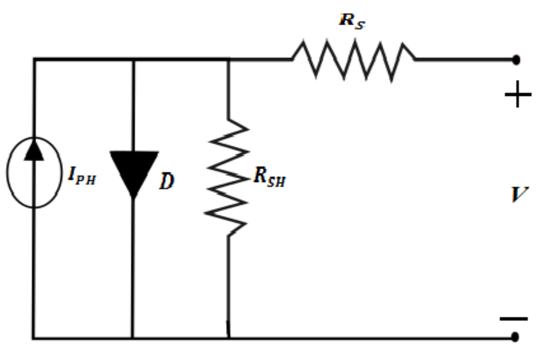

Figure 1: Equivalent model of solar cell

Applying Kirchoff's law to the node where I_{ph}, diode, R_p and R_s meet, we get

$$(I_{PH} - I_d - I)R_{SH} = V + IR_S$$

But

$$I_d = I_0\left(e^{\frac{V+IR_S}{\frac{nkT}{q}}} - 1\right)$$

Replacing I_d we obtain

$$I = I_{PH} - I_0\left(e^{\frac{V+IR_S}{\frac{nkT}{q}}} - 1\right) - \frac{V+IR_S}{R_{SH}}$$

Where,
I_{PH}-Light-generated current or photocurrent,
I_0-cell saturation of dark current,
Electron charge q = 1.6 ×10-19C
Boltzmann's constant k= 1.38 ×10−23J/K,
T-cell's working temperature,
A -is an ideal factor,
R_{SH}- is a shunt resistance, and
R_S-is a series resistance.

A PV array is a group of several PV modules which are electrically connected in series or parallel circuits to generate the required current or voltage. The equivalent circuit for the solar module arranged in parallel and series is shown in Fig.

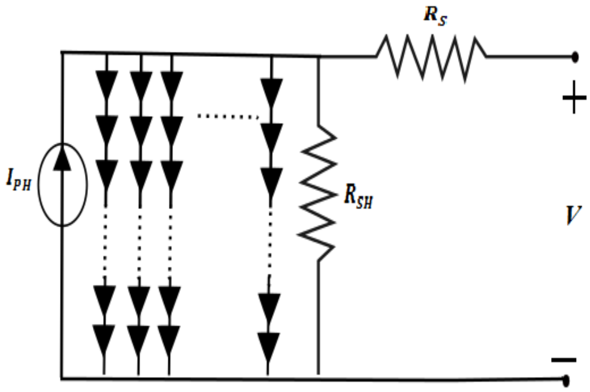

Figure 2: Equivalent circuit for the solar module.

The terminal equation for the current and voltage of the array is given by:-

$$I = N_P I_{PH} - N_P I_S \left[e^{\frac{\frac{q\left(\frac{V}{N_S}+IR_S\right)}{N_P}}{KT_CA}} - 1 \right] - \frac{\frac{N_P V}{N_S} + IR_S}{R_{SH}}$$

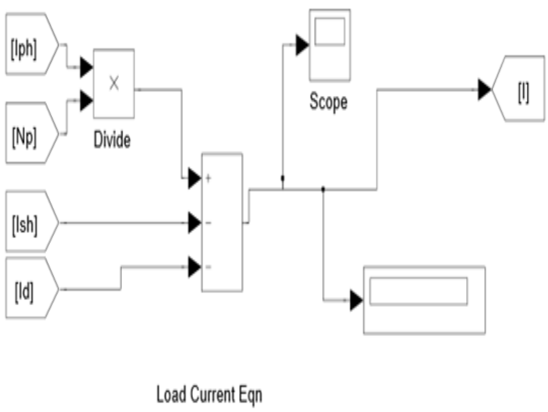

Figure 3: Simulink model for load current equation.

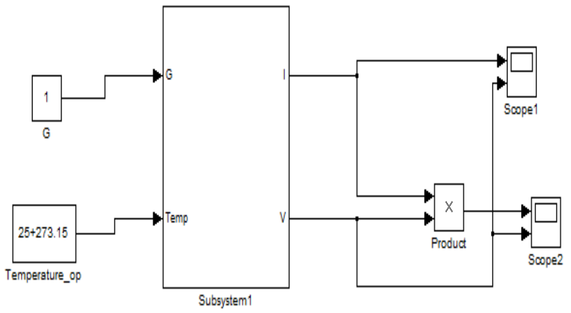

Figure 4: Simulink model of PV array module.

III. SIMULATION RESULT OF PV ARRAY

Effect of temperature on IV and PV characteristics:

Since increase in temperature increases reverse saturation, the total output current and hence, the output power decreases. The conversion efficiency drops by about 0.38 % per ◦C increase in panel temperature [2]

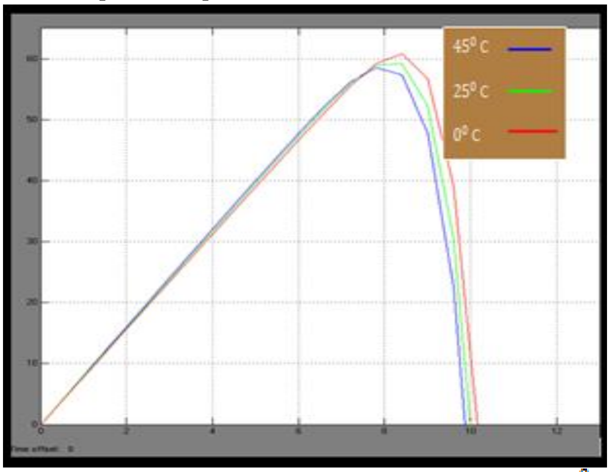

Figure 5: Effect of temperature on P-V curve at insolation 1w/m^2.

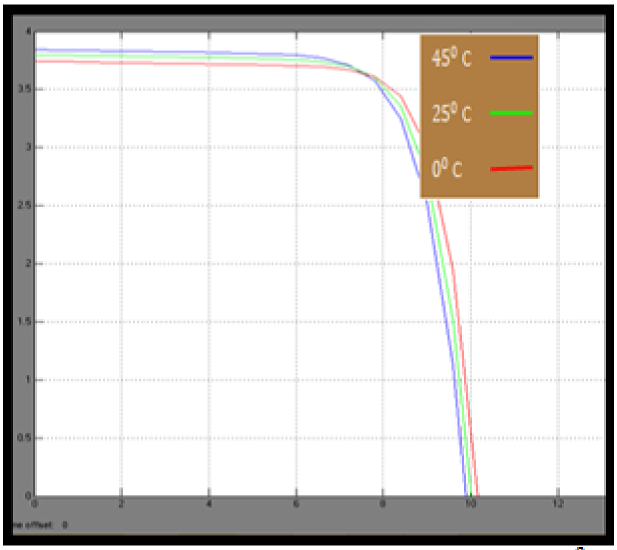

Figure 6: Effect of temperature on I-V curve at insolation 1w/m^2.

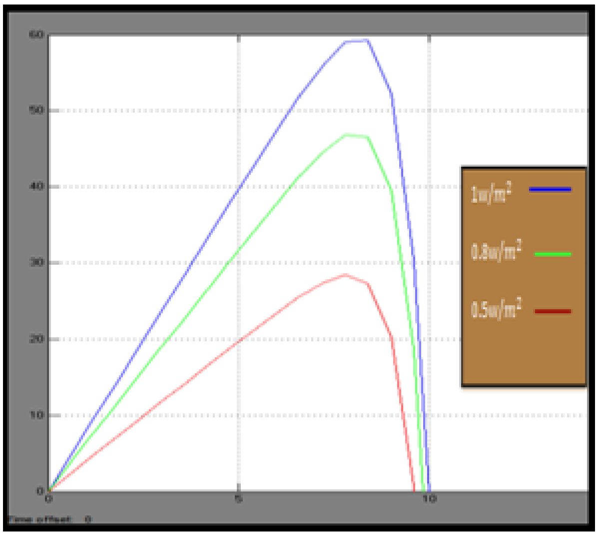

Figure 7: Effect of solar insolation on P-V curve at temperature 25^0.

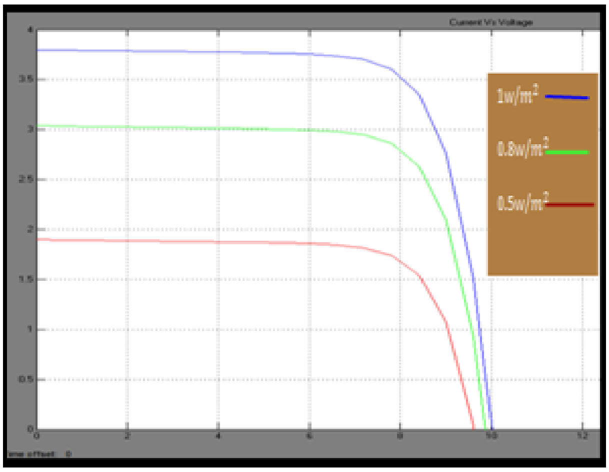

Figure 8: Effect of solar insolation on I-V curve at temperature 25^0.

CONCLUSION

We have done the simulation of solar panel and observe that the characteristics of solar panel are non-linear. Effect of solar insolation on IV and PV characteristics the output current and the power increases with the increase of irradiance. This is due to the fact that increase in irradiance increases the light-generated photo current

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