Modeling and Simulation of Solar Cell Depending on Temperature and Light Intensity

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ABSTRACT

Capture the solar energy and convert it to the useable form is the challenge of energy society.Solar cell is one of the relevant solutions for conversion of solar energy. But due to different loss factor and burdening of environment at different place the efficiency of solar cell is very much less. And on the other hand silicon is the promising and well known material for getting low cost and better performance solar cell. Also further study is going on for making more efficient solar cell. In this paper the modeling of solar cell using Matlab and QUCS software has done and environmental effect like temperature and light intensity has been discussed.

Keywords: solar cell; Solar panel ; temperature effect ; series resistance; shunt resistance; efficiency of solar cell

1. INTRODUCTION

Day-by-day the energy demand is increasing and thus the need for a renewable source that will not harm the environment are of prime importance. Yet majority of the energy requirements is satisfied by fossil fuels but by the use of photovoltaic systems could help in supplying the energy demands. Solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be of greater importance.

About 3.8x1024 joule of solar radiation is absorbed by earth and atmosphere per year. The energy radiated by the sun on a bright sunny day is 4 to 7 wt/m2 [1]. But it is seen that under test condition solar cell of 20\% efficiency with a 100 cm2 surface area would produce 20 Wt [2]. Commercial solar cells range from 10% to about 20% [3].

The efficiency limit of solar cell which is related different loss factor describe by William Shockley and Hans J. Queisser which is well known as Shockley-Queisser limit [4]. Different methods have been introduced to overcome the Shockley-Queisser limit, such as adding impurities to high band-gap semiconductors [5] or by stacking several PN junctions with decreasing band-gaps, creating a multi-junction Solar Cell [3]. In this paper the main parameter are temperature and light intensity. From the two parameters solar cell performance is described.

2. MODELING AND SIMULATION:

In solar cell main parameters are effect of recombination, series resistance, shunt resistance, and different surface parameters those are responsible for reduction of solar sell efficiency. The simplest model of solar cell is shown in fig. 1. In this paper first mathematical modeling is being described and it is solved by Matlab [6]. First Cell temperature is calculated from eq. 1. Reverse saturated current is calculated from eq. 2 which is related to cell temperature.

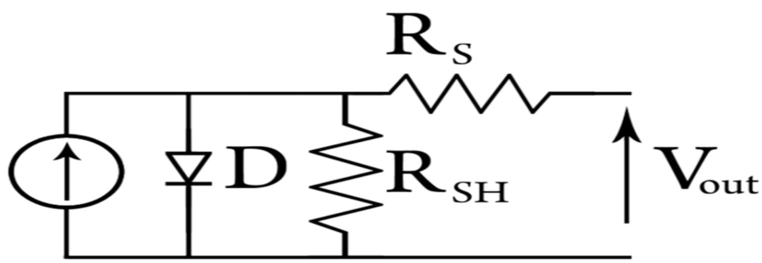

Fig. 1. Circuit representation of solar cell

Where A= Ideality factor ,q= Charge of 1 electron [Coulomb] ,k=Boltzmann constant [J/K] ,Eg= Band gap energy [eV] ,Io= Reverse saturation current at Tr [A] ,Isc= Short circuit current generated at Tr [A], ki= Temperature coefficient of short circuit current [A/K] ,ns= Number of cells connected in series ,np= Number of cells connected in parallel ,Rs= Internal series resistance of a cell [Ohm] ,Rp= Internal parallel resistance of a cell [Ohm] ,Tr=Reference temperature [K] ,NOCT=nominal operating cell temperature, G=Insolation (kW/m^2) ,Ta= ambient temperature(^{o}K).

From the flowchart in fig. 2 first put the value v=0 to calculate short circuit current. After that from eq 3. And eq 4.

```
Tc=((NOCT-20)*G/0.8)+(Ta)-----------2
Is=(Ior*((Tc)/Tr)^3)*exp(((q*Eg)/(k*A))*((1/Tr)-(1/Tc)))--------2
F1=(I)*(1+(Rst/Rsht))-It+(np*Is*exp(P*((V/ns)+I*Rst))+(V/(ns*Rsht)))
                                                  ------------------3
Fdash=(1+(Rs/Rsh))+np*P*Rs*Is*exp(P*((V/ns)+I*Rs))--------4
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Total current and power is calculated. The total current must be not equals to photo generating current. Then the process is finished. If the total current is equals to photo generating current then go for the 2nd iteration. The model also created by using QUCS software and effect of temperature and light intensity is analyzed (shown in Fig. 3).

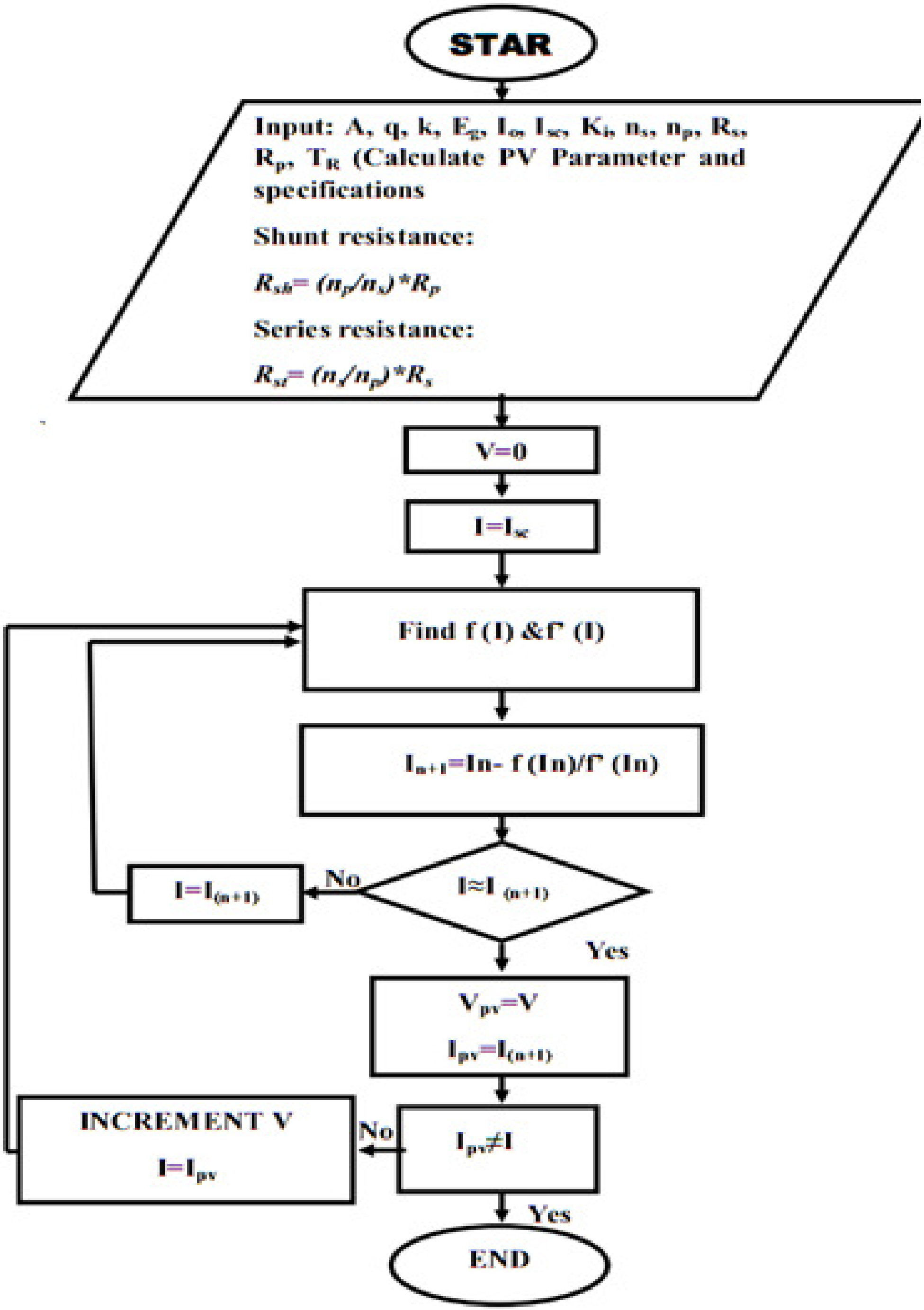

Fig. 2. Flowchart of solar panel simulation

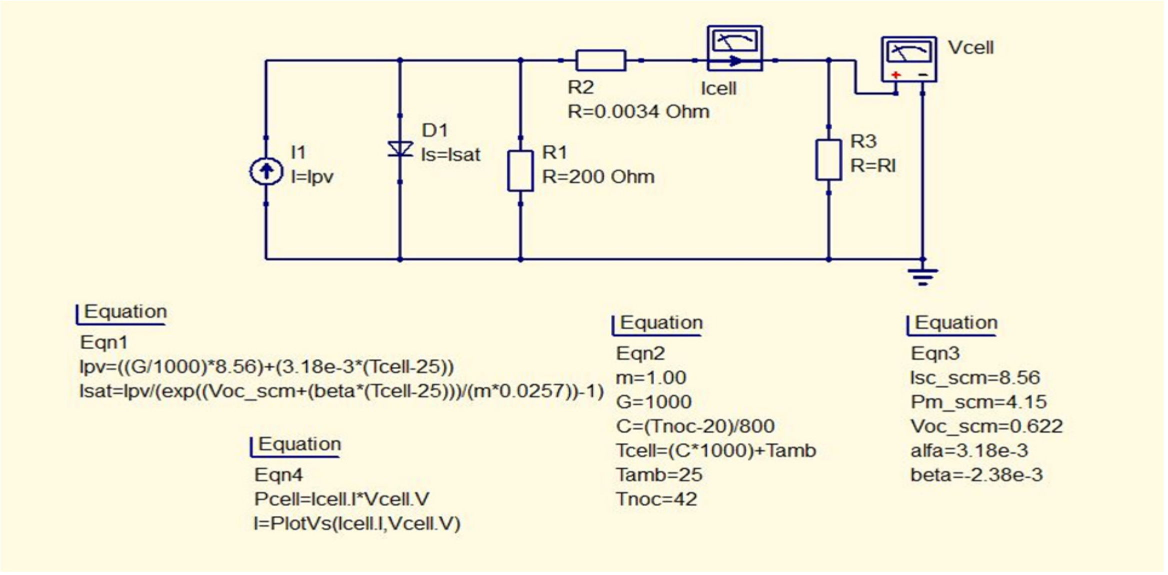

Fig. 3. Schematic diagram of solar cell using QUCS

3. RESULT AND DISCUSSIONS

From the Matlab modeling the temperature parameter is varied with respect to voltage and it is seen that (fig. 4) that temperature increases and the open circuited voltage decreases. As the voltage of solar cell decreases the power also decreases which is shown in fig.5.

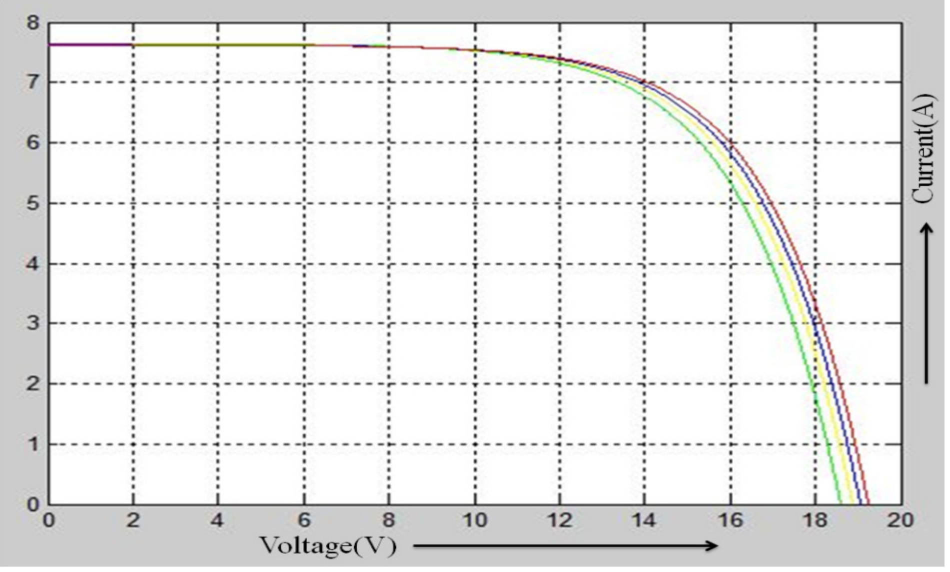

Fig. 4. Voltage Vs Current using Matlab

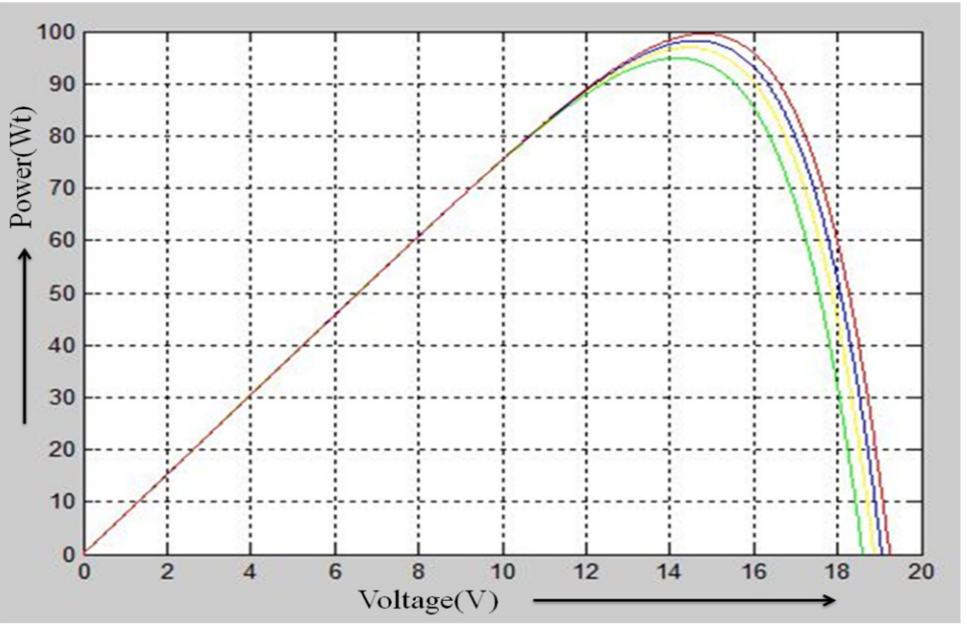

Fig. 5. Voltage Vs power using Matlab

From the model using QUCS software temperature and light intensity has been analyzed. By simulating the solar model the perfect solar voltage and current result is optimized (shown in fig. 6) It is seen in fig. 7 that when the voltage is high (or open circuit voltage) at that time current is minimum (or zero) and when current (short ckt. current) is maximum the voltage is minimum Which is ideal for solar cell.

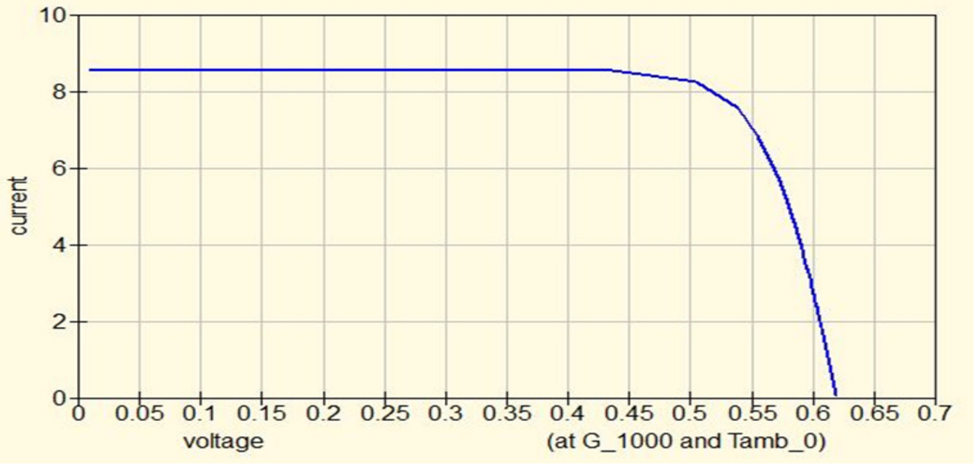

Fig. 6. Voltage Vs Current using QUCS

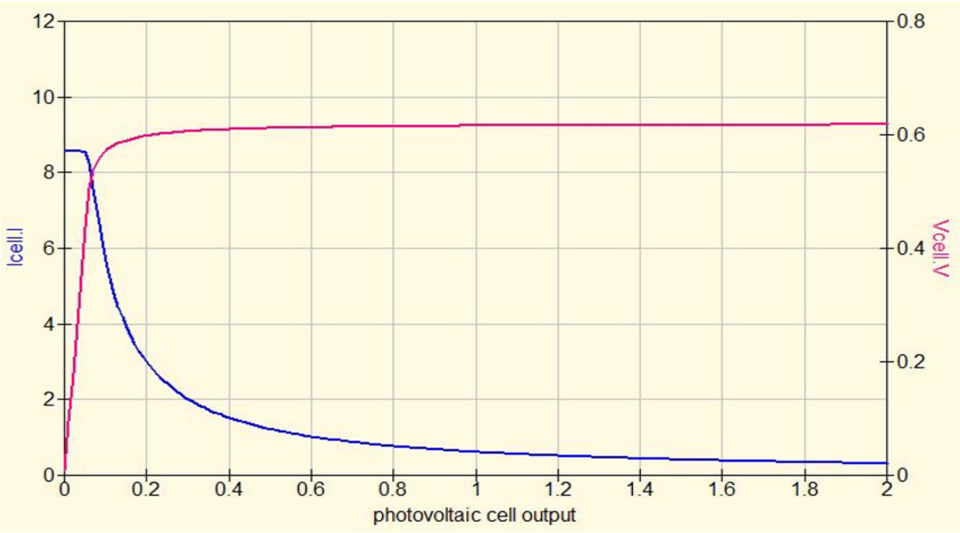

Fig. 7. Changing of cell current and cell voltage

And by changing the environment temperature from 25 oC to 35 oC the voltage and power is plotted where due to increase in temperature the voltage decreases as result power decreases (shown in fig. 8). Another most important parameter is light intensity because due bad environment shadowing effect increased as a result light intensity changes. Depending on light intensity main parameter is current as light intensity decreases the current also decreases and as a result power of solar cell decreases (shown in fig. 9).

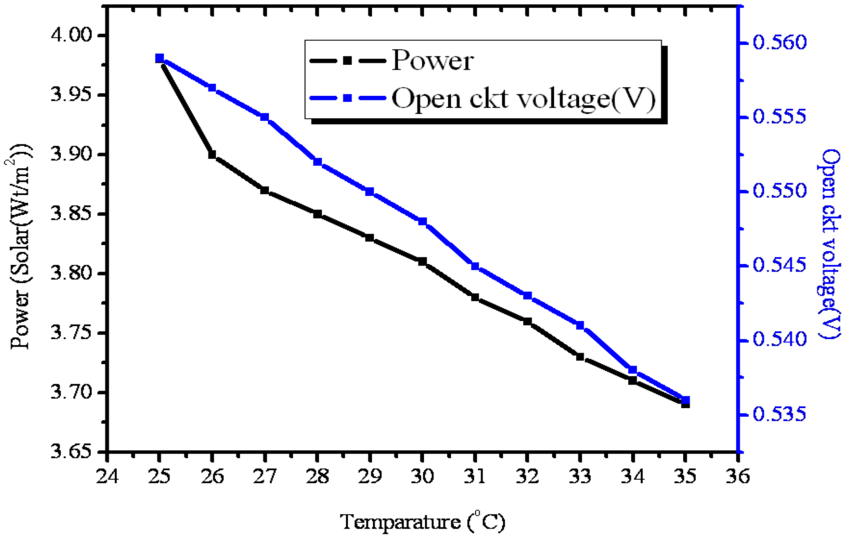

Fig. 8. Temperature effect in solar cell

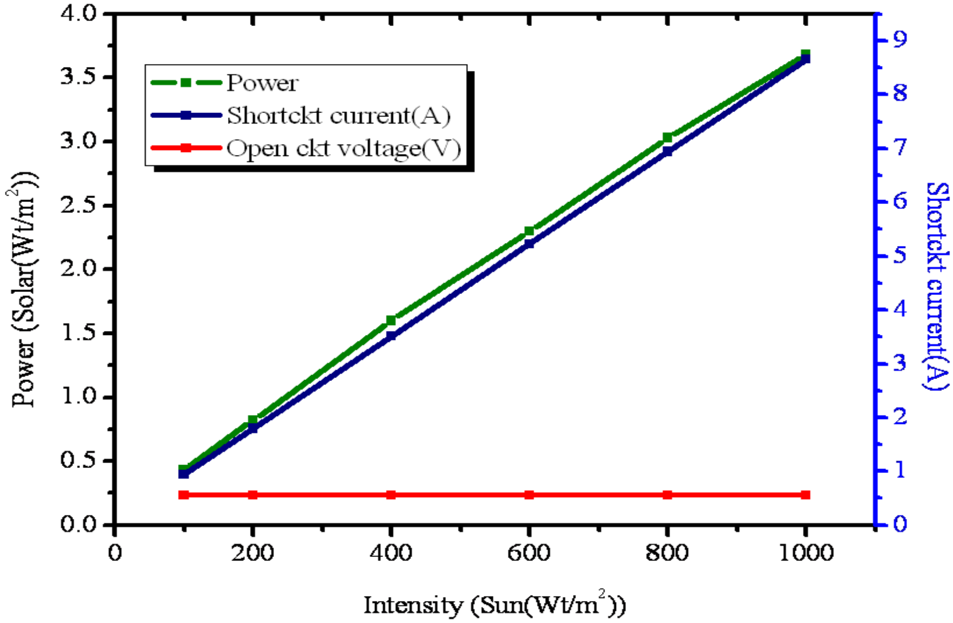

Fig. 9. Light intensity effect in solar cell

4. CONCLUSION

Environment is one of the most effect medium for reduction of solar cell efficiency. First depending on temperature solar cell performance decreases. Temperature may damage the solar cell. Increases in temperature reduce the band gap of a semiconductor, thereby effecting most of the semiconductor material parameters.

The decrease in the band gap of a semiconductor with increasing temperature can be viewed as increasing the energy of the electrons in the material. Lower energy is therefore needed to break the bond. In the bond model of a semiconductor band gap, reduction in the bond energy also reduces the band gap. Therefore increasing the temperature reduces the band gap [7]. The changing light intensity incident on a solar cell and effects on cell parameters as the short-circuit current, the open-circuit voltage, the FF, the efficiency and the impact of series and shunt resistances. A PV module designed to operate under 1 sun conditions is called a "flat plate" module while those using concentrated sunlight are called "concentrators"[7].

5. ACKNOWLEDGMENT

We would like to say thank to our parents because without their support and bless, we never reach this position. After that we also want to say thanks to all of our friends who helped us on writing this review paper and Jadavpur University for supporting software.

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