# Comparison of V-I characteristics of two different region on the variation of solar radiation on Matlab Software

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**ABSTRACT:**A solar cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. Solar cells are the building blocks of photovoltaic modules, known as solar panels. There are different parameters on which solar cell efficiency is depend upon i.e Absorption coefficient, wavelength, Band Gap, Material, Fill factor ,voltage open circuit (Voc), short circuit current (Isc). The most important parameter is wavelength of light. Visible light is a very small part of the electromagnetic spectrum, range of energy wavelengths that includes radio waves, light and X-rays. Visible light waves lie between 400 and 700 nanometers. Different region in India have different light intensity as it depends on weather .This paper compares the solar radiation of two regions Faridabad and Srinagar it is important because If wavelength of light is small then it get absorbed fast in the solar cell top region and which lead to create large no of electrons holes pairs due to which current produce is more hence efficiency also get increased. This paper enough to do efforts in this direction. The implementation is done in Matlab on the basis of variation of solar radiation intensity in different region .

**KEYWORDS:**Absorption Coefficient, Current short circuit , Fill factor, Solar cell, Solar radiation, voltage open circuit

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## 1 INTRODUCTION

Solar cell is made up of two words Solar and Cells which convert solar energy into electricity by Photovoltaic device it is a device which generate voltage when exposed to light and its electrical characteristics get change such as current(I),voltage(V),resistance(R).

The photovoltaic effect was discovered by Alexander-Edmond Becquerel in 1839[1]. The first photovoltaic device was built, using a Si PN junction, by Russell Ohl [2] in 1939.Solar cell work on broad wavelength range and wide area devices to absorb more light. Sun is a natural source of light and energy. There are 2 types of reactions take place in Sun:

1) Nuclear Fission 2) Nuclear fusion

we deal in Nuclear Fission in solar cells .

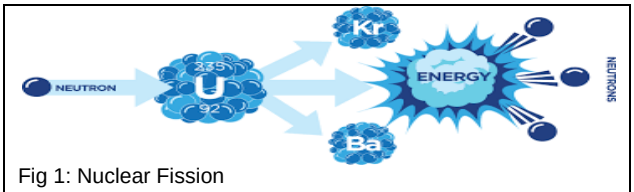


Fig 1: Nuclear Fission

Nuclear fission refers to splitting of electronic nuclei by which energy generated in nuclear power plant .U^92 use in power plant .Nucleus contain positive charge when two nucleus place together equal charges repel each other but they remain in same position due to strong interaction force when neutron strike atom it get split and energy is equal to energy in band holding positive protons together .

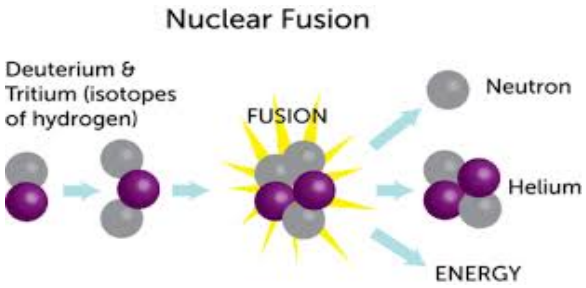


Fig 2: Nuclear fusion

Nuclear fusion refers to the process in which the electronic nuclei amalgamate , it works on small atom .If one tries to force these protons together they repel each other due to coulomb force like fission required force fusion also require force to break fencing when it happens they form 2 new atom .

The operation of a photovoltaic (PV) cell requires three basic attributes:

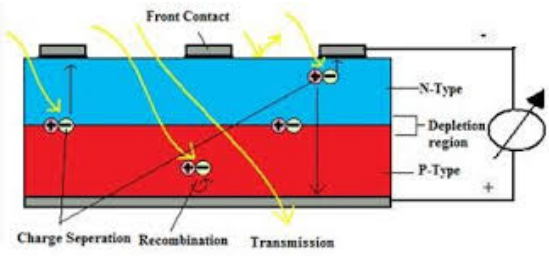


Fig 3: Solar cell modal

The absorption of light from sun directly, leads to generation of electron-hole pairs or excitons.

- The separation of charge carriers of opposite typesi.e electron hole pair.
- The separate extraction of those carriers through wire to an external circuit.[3]

## 2 PARAMETERS OF SOLAR CELLS

**2.1 Short Circuit Current (Isc):**The current flow is maximum when the two terminals are directly connected with each other and the voltage across is zero. Short circuit current impedence is zero. [4] solar cell under illumination(light), If the external circuit is a short circuit then the only current is due to the generated EHPs by the incident light. This is called the photocurrent, denoted by Iph which flows in opposite direction to short circuit current (Isc).

**2.2Open Circuit Voltage (Voc):**When the cell is not connected to any load there is no current flowing and the voltage across the cell reaches its maximum value ,Voc occur when value of resistance is maximum.This is called 'open circuit voltage'.

**2.3 Fill Factor (FF):**It measure the quality of the solar cell. It is calculated by comparing the maximum power (Pmax) to the theoretical power ($P_T$) it can be calculated by product of short circuit current and open circuit voltage. For a good panel FF must lie between 0.7 to 0.8 while for bad panel it may be 0.4 [4]

$$fillfactor = \frac{vm*\mathrm{Im}}{Voc*Isc}$$

**2.4 Efficiency(η):**Efficiency is defined as ratio of output from solar cell to input from sun

$$\eta = \frac{vm*\mathrm{Im}}{pin} = \frac{Voc*Isc*ff}{pin}$$

Vm=maximum voltage ,Im =maximum current, Isc=short circuit current, ff=fill factor ,Voc= open circuit voltage.

The efficiency is most commonly used parameter to compare the performance of one solar cell to another depend on solar spectrum, intensity of sunlight and the temperature of solar cell ,fill factor.[5]

**2.5 Solar Irradiance /(solar radiation) :** It ismeasured perpendicular to the incoming sunlight. It is a measure of the solar power over all wavelengths per unit area incident on the Earth's .

**2.6 Absorption of light:**When the energy of a photon is equal to or greater than the band gap of the any material, the photon is absorbed by the material and by gaining energy electron jump from valance band to conduction band.

**Case1:** $E_{ph} < E_G$ Photon with energy $E_{ph}$ less than the band gap energy $E_G$ interact weakly with the semiconductor, passing through it as if it were transparent.
**Case 2:** $E_{ph} = E_G$ it have enough energy to create an electron hole pair and are efficiently absorbed.

***Case3:*** $E_{ph} > E_G$ Photons with energy much greater than the band gap are strongly absorbed. However, for photovoltaic applications, the photon energy greater than the band gap is wasted .Bandgap (EG) vary according to material for silicon bandgap is 1.1ev and for germanium 2ev.[6]

**2.7 Absorption Coefficient:**Absorption coefficients vary according to different material with higher absorption coefficients more readily absorb photons, which excite electrons into the

conduction band from valance band. Absorption coefficient determines how far into a material light of a particular wavelength can penetrate before it is absorbed. If a material with a low absorption coefficient, light is poorly absorbed, and if the material is thin enough, it will appear transparent to that wavelength. [7]The absorption coefficient, $\alpha$, is related to the extinction coefficient, $k$, by the following formula:

$$\alpha = \frac{4K\Pi}{\lambda}$$

where $\lambda$ is the wavelength.

If $\lambda$ is in nm, multiply by $10^7$ to get the absorption coefficient in the units of $cm^{-1}$.

**2.8 Absorption depth:**The absorption depth is inversely proportional of the absorption coefficient, and describes how deeply light penetrates into a semiconductor before being absorbed by material. Higher energy light is of a shorter wavelength and has a shorter absorption depth than lower energy light which is not as readily absorbed and has a greater absorption depth. It affects aspects of solar cell design, such as the thickness of the semiconductor material.[8]

**2.9 Generation rate:** The generation of an electron-hole pair can be calculated at any location within the solar cell at any wavelength of light or for the entire standard solar spectrum when light fall on semiconductor. Generation is the greatest at the surface of the material, where the majority of the light is absorbed. The generation rate gives the number of electrons generated at each point in the device due to the absorption of photons. Generation is an important parameter in solar cell operation as it lead to production of current.[9]

## 3 PROBLEM DEFINATION

Visible light waves vary between 400 and 700 nanometers, although the sun's spectrum also includes shorter ultraviolet waves and longer waves of infrared. [10]
The silicon atoms in a photovoltaic cell absorb energy from light wavelengths that lie in range of the visible spectrum. Light causes the charges to move, producing an electric current. Materials containing different impurities change the wavelengths at which the cell responds in different ways.

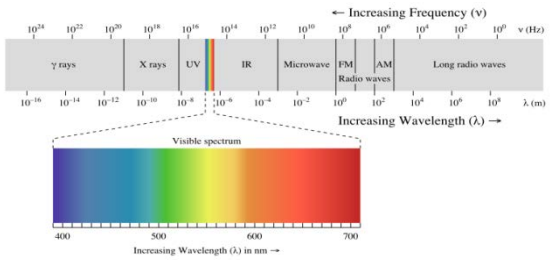


Fig 4: Electromagnetic spectrum

The photovoltaic cell doesn't convert all the light even if it is at the right wavelength. Some of the energy becomes heat, and some reflects off the cell surface lead to loss.
As solar radiation vary according to the regions because of weather it has a great effect on efficiency of the solar cell and other parameters. As a colder region intensity or photons falling on solar cell will be less than the hotter region therefore current produce is more in hotter than colder region .Comparison is done between two region
Faridabad is the largest city in the north Indian state of Haryana in Faridabad district. It is a leading industrial centre.(hotter region)Solar radiation calculated is 523w/cm2.
Srinagar is the largest city and the summer capital of the Indian state of Jammu and Kashmir. Solar radiation calculated us 481 w/cm2.

Energy is inversely proportional to wavelength given by-

$E = hc/\lambda$ where $\lambda$ =wavelength, h=Plank's constant ,c=velocity of light

If energy of incident light is more then wavelength is less due to which the light get absorbed in the top most region of solar cell and generate more electron hole pair and hence after the separation of hole pairs as electron jump from valance band to conduction band it leads to generating of electricity.

## 4 MATLAB CODE

INTENSITY 523W/CM2 (FARIDABAD) AND 433W/CM2(SRIGNAGAR)

```
close  all;
clear all;
clc ;
T=302;
Tr1=40;
Tr =298;
S=[433 523];
ki=0.000023;
Iscr=3.75;
Irr=0.000021;
k=1.38065*10^(-23);
q=1.6022*10^(-19);
VT=25;
A=2.15;
Eg=1.21;
 V0=[0:1:300];
for i=1:2
Iph=(Iscr+ki*(T-Tr))*((S(i))/100);
Irs=Irr*((T/Tr)^3)*exp(q*Eg/(k*A)*((1/Tr)-(1/T)));
I0=Iph-Irs*(exp (V0)/(VT*A)-1);
P0 = V0.*I0;
figure (1)
plot (V0,I0);
axis ([0 20 0 50]);
grid  on
Xlabel ('Voltage open circuit (voc)in volt');
Ylabel ('Short circuit Current(Isc)in amp');
Title ('Isc VS voc curve');
hold  on;
figure (2)
plot (V0,P0);
axis ([0 20 0 400]);
Xlabel ('Voltage in volt');
Ylabel ('Power in watt');
Title ('Power vs Voltage curve');
hold  on;
grid on
figure (3)
plot (V0,I0,V0,P0);
axis ([0 20 0 400]);
Xlabel ('Voltage &Voc in volt');
Ylabel ('Power in watt &isc in ampere');
 Title ('Pmax curve');
hold on;
grid on
figure (4)
plot (I0,P0);
axis ([0 20 0 100]);
xlabel ('Current in amp');
ylabel ('Power in watt');
title('Power vs Current');
hold on;
grid on
end
```

## 5 RESULTS

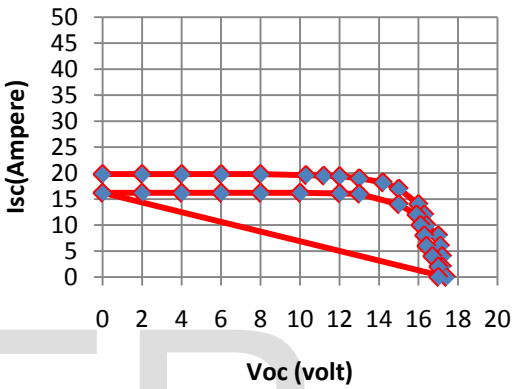


Fig5: VocvsIsc top curve-Faridabad radiation lower curve – Srinagar radiation gives maximum current Imax

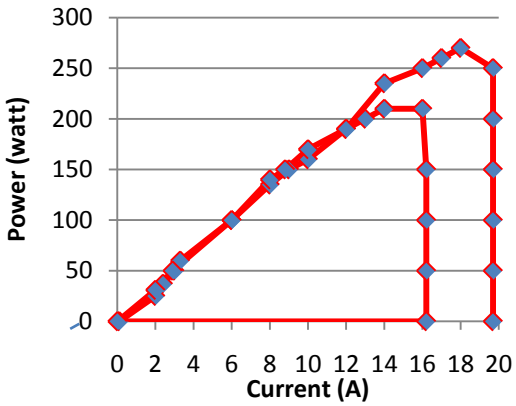


Fig 6: Power vs Current top curve –Faridabad lower-Srinagar

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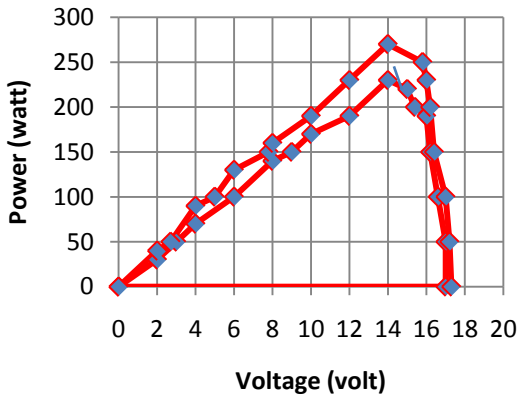


Fig 7: Power vs voltage give maximum voltage Vmax

## 6 SIMULATION SETUP PARAMETERS

Table 1: Parameters value for different region solar cell

| PARAMETERS | SRINAGAR | FARIDABAD |
|---|---|---|
| Voc | 17 | 17.2 |
| Isc | 15.2 | 19.8 |
| Vm | 15.2 | 15 |
| Im | 14.1 | 18 |
| Pmax | 214.3 | 270 |
| FF | 0.81 | 0.79 |
| Efficiency | 49% | 51% |

## 7 CONCLUSION

The proposed model take solar radiation intensity as input and output the I-V ,P-V and P-I curve for Faridabad and Srinagar region under no loss. The efficiency of Faridabad solar cell is more than Srinagar as light intensity is more in hotter region than colder. This model can be used for the analysis in the field of solar photovoltaic conversion system and MPPT technologies.

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