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ISSN (Online): 2455-7838

SJIF Impact Factor (2017): 5.705

EPRA International Journal of

# Research & Development (IJRD)

Monthly Peer Reviewed & Indexed  
International Online Journal

Volume: 3, Issue:8, August 2018



Published By :  
EPRA Journals

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## MODELLING AND SIMULATION OF V-I AND P-V CHARACTERISTICS OF A SOLAR CELL UNDER VARIOUS IRRADIATIONS

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### ABSTRACT

Now a day's solar energy became a vital part of the renewable energy source. The use of solar power increasing day by day beyond the imagination. So, it is necessary to know a idea about the solar cell design as it the basic need for a solar energy. In design of a solar cell, V-I and P-V charatertics play a major role as they decide the capacity of the solar cell to deliver the energy. In this paper, charactertics of V-I and P-V of the solar cell is designed and step by step procedure for obtaining the charactertics is explained. In this paper, these charactertics are plotted by taking different irradiations to the solar cell. This circuit is modelled and simulated in matlab-2016b version with the help of block diagram environment known as Simulink.

**KEY WORDS:** Solar cell, PS constant, Simulink to PS converter, Solver configuration, Voltage and Current sensor.

### 1. INTRODUCTION

Solar cells and photodetectors are devices that convert an optical input into current. A solar cell is an example of a photovoltaic device, i.e., a device that generates voltage when exposed to light. The photovoltaic effect was discovered by Alexander-Edmond Becquerel in 1839, in a junction formed between an electrode (platinum) and an electrolyte (silver chloride). The first photovoltaic device was built, using a Si pn junction, by Russell Ohl in 1939. The functioning of a solar cell is similar to the photodiode (photodetector). It is a photodiode that is

unbiased and connected to a load (impedance). There are three qualitative differences between a solar cell and photodetector.

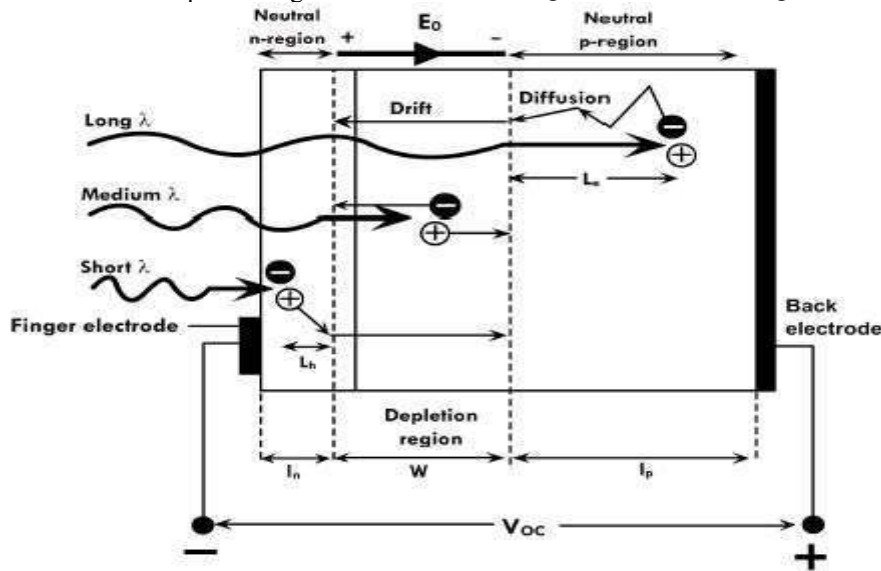
1. A photodiode works on a narrow range of wavelength while solar cells need to work over a broad spectral range (solar spectrum).
2. Solar cells are typically wide area devices to maximize exposure.
3. In photodiodes the metric is quantum efficiency, which defines the signal to noise ratio, while for solar cells, it is the power conversion efficiency, which is the power

delivered per incident solar energy. Usually, solar cells and the external load they are connected to are designed to maximize the delivered power.

**1.1 Solar Cell Working Principle: -**

A simple solar cell is a pn junction diode. The schematic of the device is shown in figure 1. The n region is heavily doped and thin so that the light can penetrate through it easily. The p region is lightly doped so that most of the depletion region lies in the

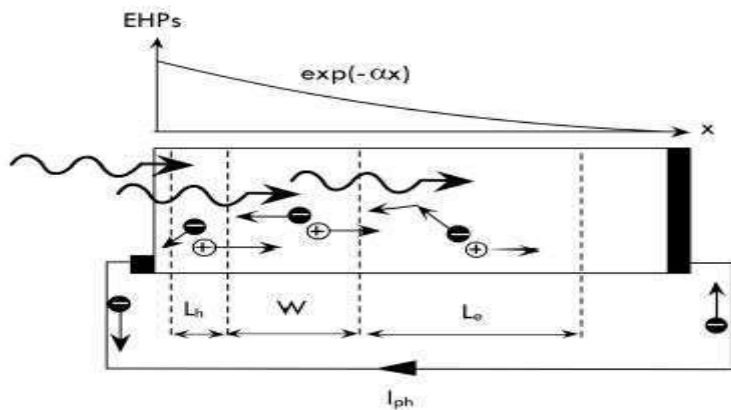
p side. The penetration depends on the wave-length and the absorption coefficient increases as the wavelength decreases. Electron hole pairs (EHPs) are mainly created in the depletion region and due to the built-in potential and electric field, electrons move to the n region and the holes to the p region. When an external load is applied, the excess electrons travel through the load to recombine with the excess holes. Electrons and holes are also generated with the p and n regions, as seen from figure 1.



**Figure :1 Principle of operation of pn junction solar cell**

The shorter wavelengths (higher absorption coefficient) are absorbed in the n region and the longer wavelengths are absorbed in the bulk of the p region. Some of the EHPs generated in these regions can also contribute to the current. Typically, these are EHPs that are generated within the minority carrier diffusion length,  $L_e$  for electrons in the p side and  $L_h$

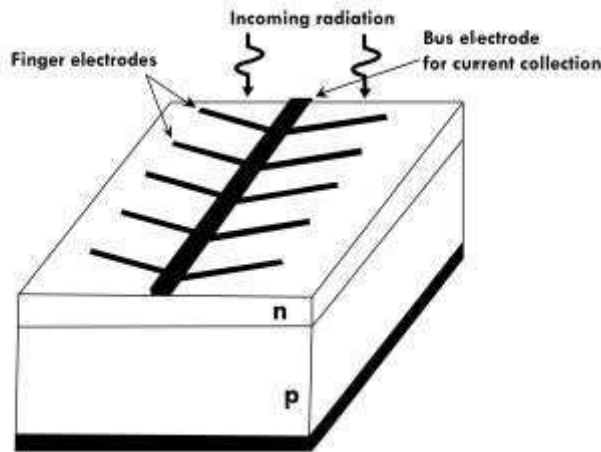
for holes in then side. Carriers produced in this region can also diffuse into the depletion region and contribute to the current. Thus, the total width of the region that contributes to the solar cell current is  $Wd + L_e + L_h$ , where  $Wd$  is the depletion width which is shown in figure 2.



**Figure 2: Photo generated carriers in a solar cell due to absorption of light.**

The carriers are extracted by metal electrodes on either side. A finger electrode is used on the top to make the electrical contact, so that there

is sufficient surface for the light to penetrate. The arrangement of the top electrode is shown in figure 3.

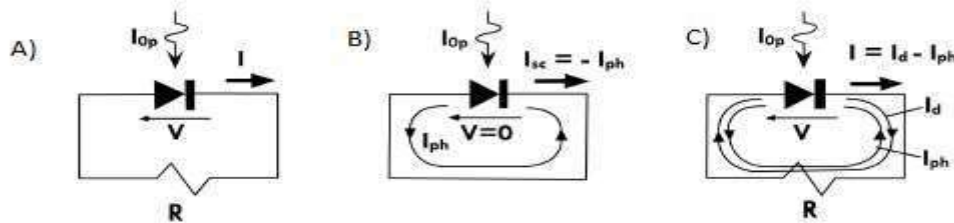


**Figure 3: Finger electrodes on a pn junction solar cell**

**1.2 Solar Cell I-V Characteristics:**

The I-V characteristics depend on the intensity of the incident radiation and also the operating point (external load) of the cell. The I-V

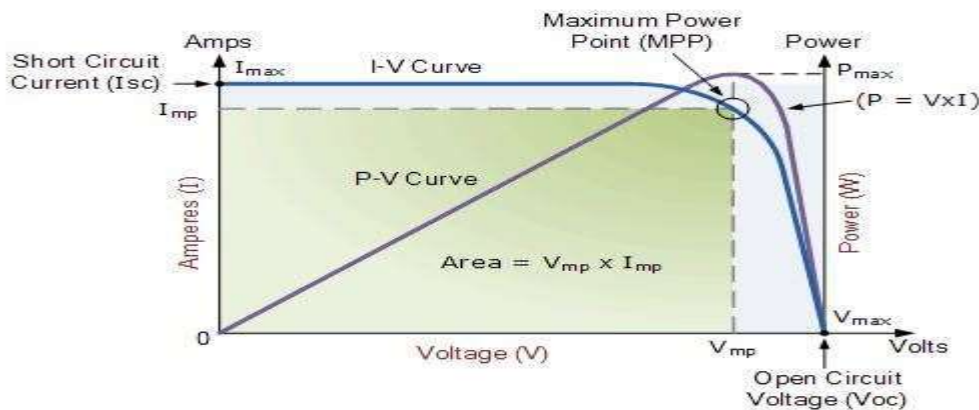
characteristics is calculated by taking the equivalent circuit. Consider a pn junction solar cell under illumination as shown in figure 4.



**Figure 4.A) PN junction solar cell under illumination with an external load B) Equivalent circuit without any external load C) equivalent circuit with an external load**

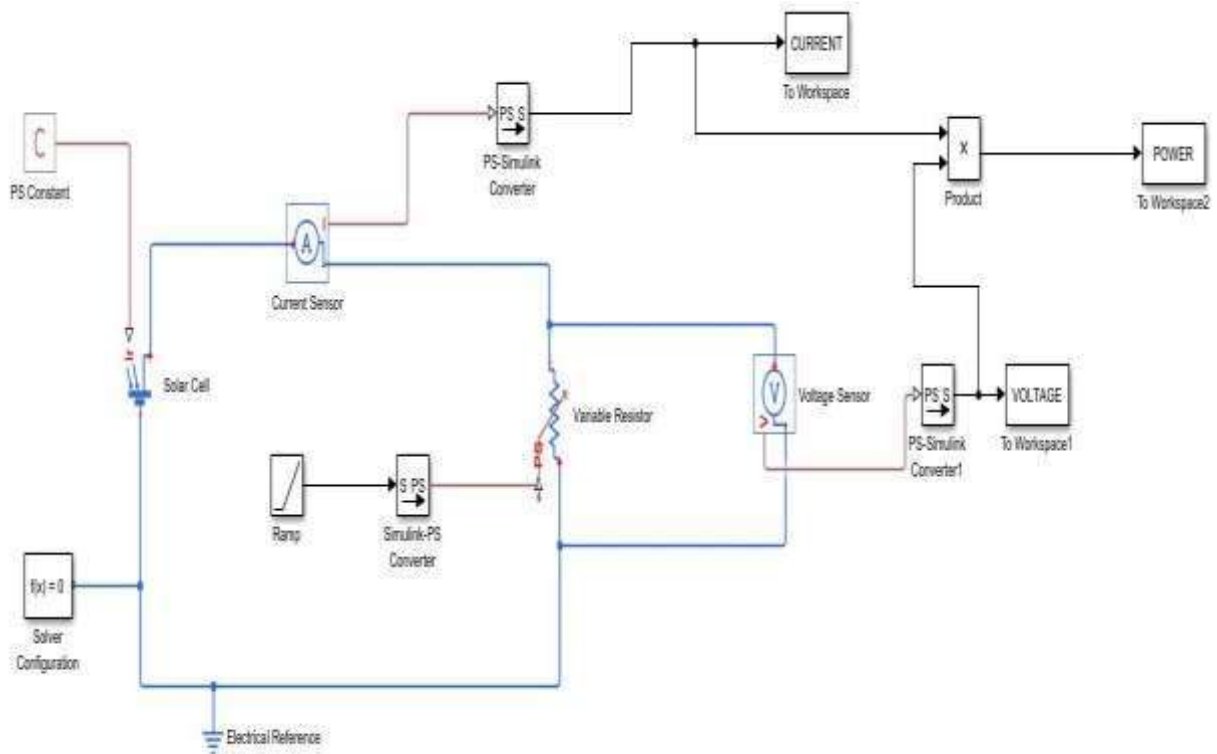
The illumination causes a photo current to flow applied the potential drop across it creates a forward bias through the external circuit. When an external load is current, that opposes the photocurrent.

The total characteristics of solar cell is shown in figure 5.



**Figure 5: V-I and P-V Characteristics of a Solar Cell**

## 2. CIRCUIT MODELLING



**Figure :6 Simulink model of the solar cell for P-V and V-I characteristics**

### Blocks used to simulate the model:

**PS constant:** This gives the physical constant value to the solar cell. By using this block we generate different types of irradianations required for the solar cell.

**Solver Configuration:** For a circuit model connected by a physical network solver configuration block specifies the solver parameters for the simulation.

**Simulink –PS converter:** This block is used when we take the components of Simulink module and we have to convert in to power system module as we are using the power system modules at one place and we also use PS-Simulink Converter as shown in the above Simulink diagram.

(Ramp: Simulink model), (variable resistor, current sensor, voltage sensor: Simulink model)

**Voltage Sensor:** This block is used to define the voltage of the solar cell.

**Current Sensor:** This block is used to define the voltage of the solar cell.

**Workspace:** This block is used to define the variables to the command window.

**Solver configuration:** This block is used to initialize the system at one function  $f(x)=0$ .

### 2.1 Procedure for modelling of P-V and V-I curve:

Step 1: With the matlab2016b version open Simulink window.

Step 2: Go to library browser get the components used in the Simulink diagram.

Step 3: connect the Simulink diagram as per the figure 5.

Step 4: By using PC constant inject the different irradianations constant. In this paper the irradiation constant is 1000,900,800,700 are given.

Step 5: For every Irradiation Constant the variable names of sensors (voltage, current, power) are named as voltage1, current 1 and power 1. Similarly, like repeat this step for remaining 3 irradianations (900,800,700) constants.

Step 6: After the step 5, plot the two characteristics by using the command window using the below execution.

Step7: `plot(voltage1,current1,voltage2,current2,voltage3,current3,voltage4,current4)`

`xlabel('voltage')`  
`ylabel('current')`  
`title('V-I characteristics of solar cell')`

Step8: `plot(voltage1,power1,voltage2,power2,voltage3,power3,voltage4,power4)`

`xlabel('voltage')`  
`ylabel('current')`  
`title('P-V characteristics of solar cell')`

Step9: V-I and P-V characteristics are plotted.

## 2.2 SIMULINK RESULTS:

### 2.2.1 V-I Characteristics of a solar cell: -

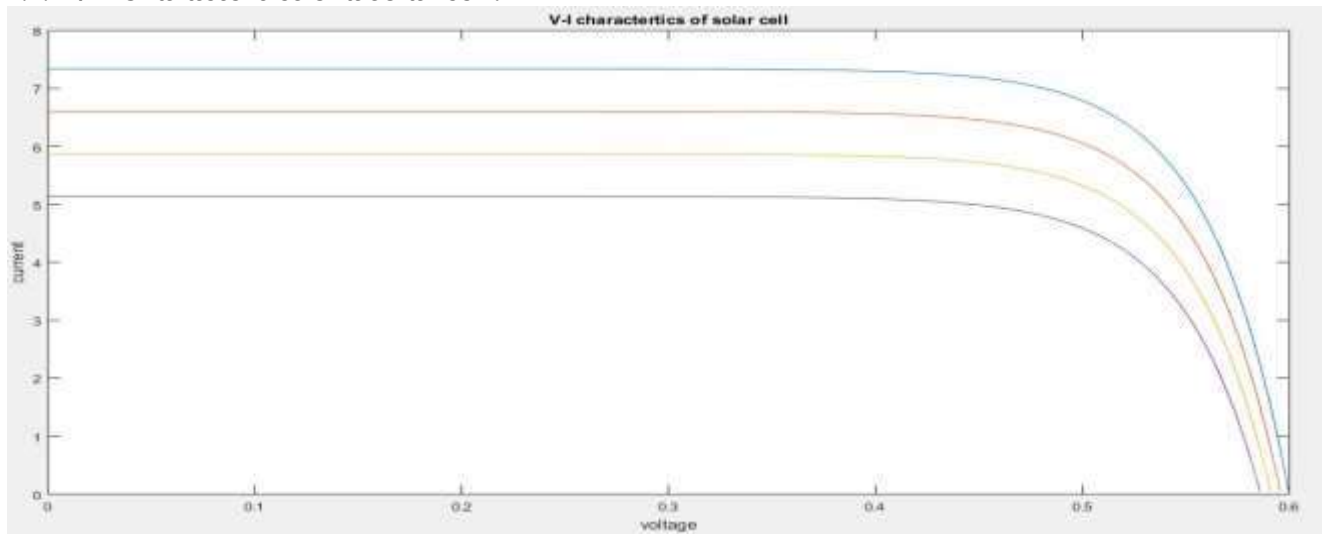


Figure:7 V-I characteristics of solar cell under different irradiances

### 2.2.2 P-V Characteristics Of Solar Cell:

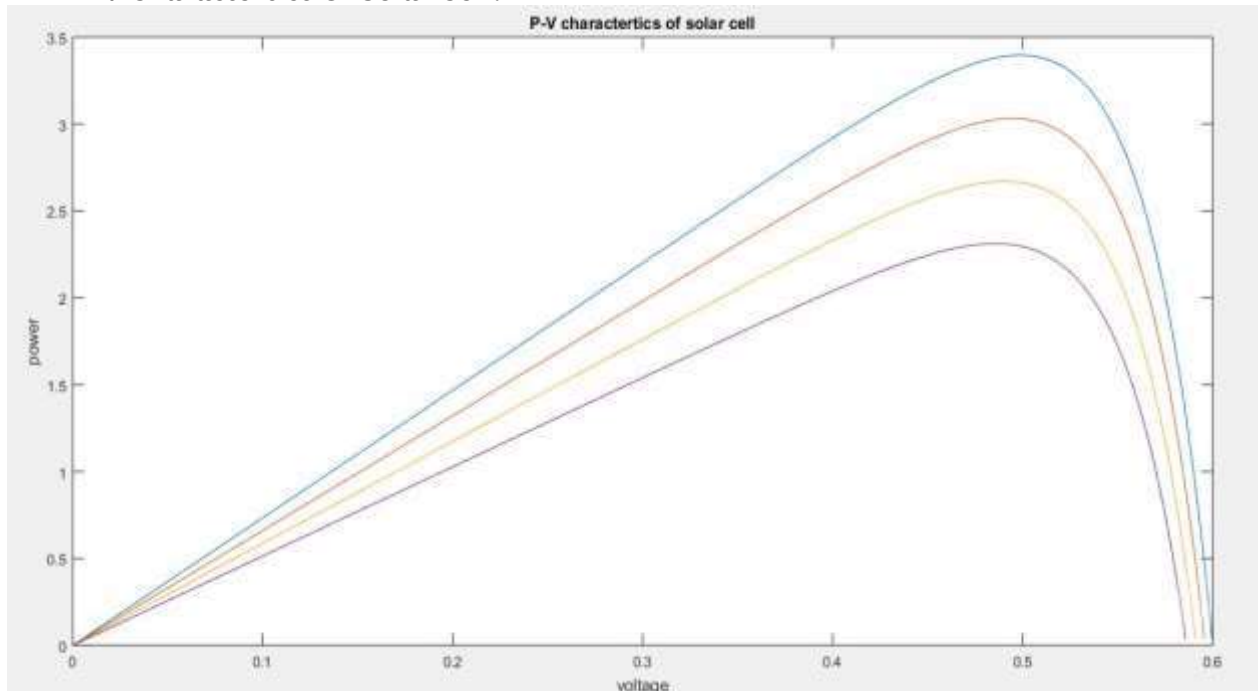


Figure 8: P-V Characteristics of Solar Cell

## 3. CONCLUSION

In this paper by using a PS constant different irradiances level (1000,900,800,700,600) are injected into the solar cell and corresponding values of voltage, current and power are simulated in the workspace which are plotted by the help of command window. By using the different instructions in the command window we plotted (V-I, P-V) characteristics. This total circuit modelling and Simulink output are carried out by the matlab/Simulink 2016b software.

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