Study on Photovoltaic Energy and Characteristics of Photovoltaic Arrays.

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ABSTRACT:

This study paper helps us understand photovoltaic materials and the characteristics that help design photovoltaic arrays. Photovoltaic materials are components which convert light energy into electrical energy by the phenomenon of photoelectric effect. These components are usually semiconductors. The characteristics used in modeling and circuit design are helpful to circuit designers who need an easy, time saving, point to point, and user friendly method of modeling for use in analysis of photovoltaic systems through various simulation softwares. The data used, in the modeling process to analyse the nonlinear current-voltage characteristics, is provided by commercial array data sheets. The paper will shed light on the working of photovoltaic arrays and the basic characteristics of PV solar cells.

1. Introduction

Photoelectric effect is the property of a substance in which, when light is incident on a substance, electrons get excited, leave their location, and thereby induces a flow of charge within the substance, in this case the substance is a photovoltaic cell (or solar cell). A photovoltaic panel (or solar panel) is a bundled, connect assembly of typically 6x10 photovoltaic solar cells. Photovoltaic arrays are a combination of photovoltaic panels and modules which are arranged so as to generate enough electricity to provide sufficient power as per requirement.

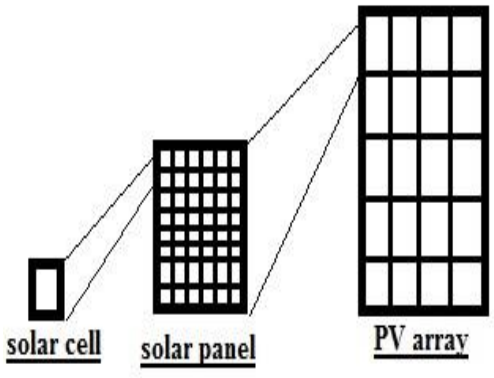


Figure 1. Exploded view of a PV array.

These PV arrays are used widely over many areas such as in satellites, space stations,

rooftop solar PV-systems, solar vehicles etc. Moreover, PV systems convert light directly into electricity and shouldn't be confused with other technologies, such as concentrated solar power or solar thermal, used for heating and cooling. Some advantages and disadvantages of solar energy are as follows:

Advantages:

1. Renewable Energy Source

2. Reduces Electricity Bills

3. Diverse Applications

4. Low Maintenance Costs

Disadvantages:

1. Cost

2. Weather Dependent

3. Storage is Expensive

4. Uses a Lot of Space

Total completed global solar capacity reached 301 gigawatts (GW) in 2016, and the total installed capacity of India, as per Mar 2017 is 320 GW. Which implies if all the PV solar panels in the world were to power our country, it will not be sufficient. This helps us realise that we have to show interest in using solar energy efficiently. Thus there is a lot of scope for developments in this field.

2.1. Working of PV cells.

A solar cell or a PV cell is more or less a diode in which the P-N junction is affected by the sunlight. The PV cells are made out of different semiconductor materials employing different methods, but the most popular ones available are made up of silicon as of now.

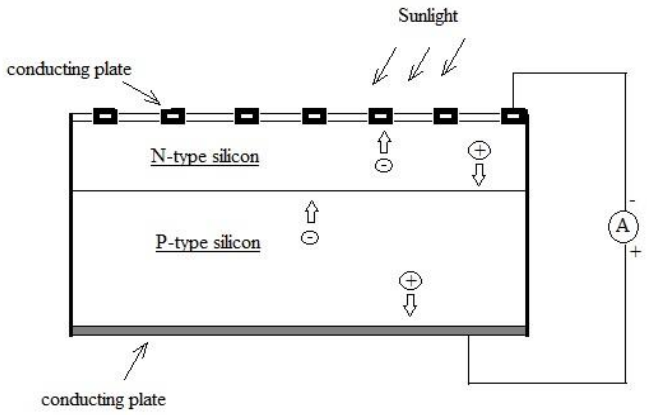


Figure 2. Basic layout of a solar cell.

Due to the photoelectric effect, the electrons in the solar cell which are affected by the sunlight, receive enough energy to jump into the conduction band from the valence band. This happens when the solar energy absorbed by the electron is greater than the band gap energy of the semiconductor.

These free electrons are now subjected to move in a direction specified by the electric

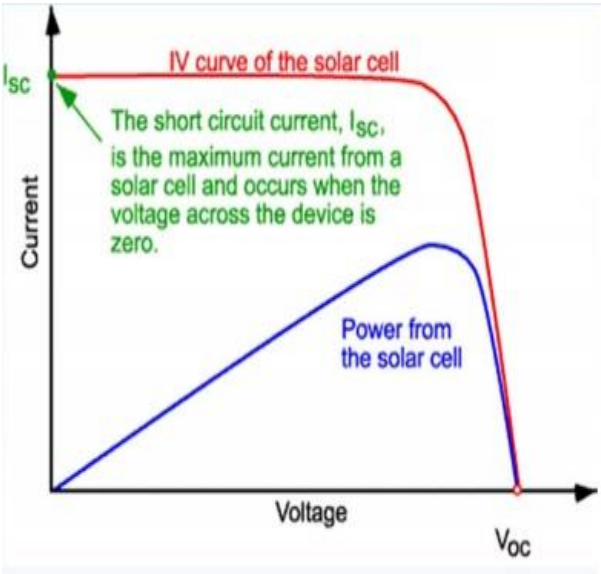
field in the PV cell. When the electrons move, the current and voltage produced can be harvested by suitably placing conductive plates on the cell.

2.2. Characteristics of a solar cell.

There are three basic characteristics of a solar cell. They are: open circuit voltage, short circuit current and maximum power point.

2.2.1. Open circuit voltage.

Open circuit voltage (V_{oc}) is the potential difference available at the solar cell when left open (i.e no current flows) due to the photoelectric effect. The V_{oc} point can be observed in the following current versus voltage graph. The graph below is a general one and does not use specified values.



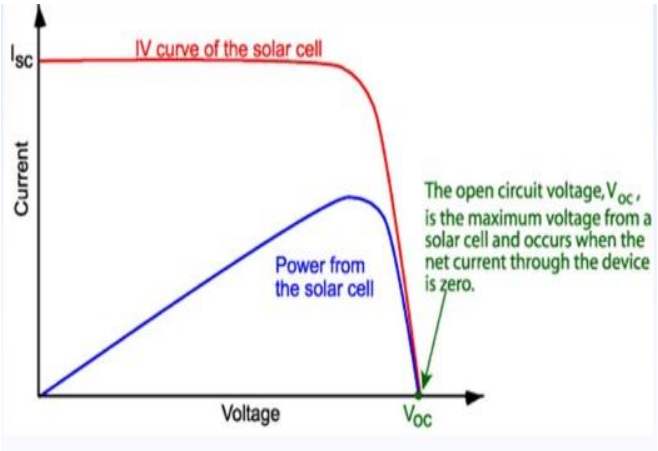


Figure 4. I_{sc} of a solar cell.

2.2.2. Short circuit current.

Short circuit current is the current that flows through the terminals when it is shorted (i.e no voltage across the terminals) due to the photoelectric effect. Similarly, the I_{sc} point can be observed in the following current versus voltage graph. The graph on the right is a general one and does not use specified values.

2.2.3. Maximum power point.

Maximum power point is the point on the graph of current versus voltage in which the power possess the maximum value (i.e the point where the product of current and voltage is maximum, P = V*I). Similarly, the P_m point can be observed in the following current versus voltage graph. The graph below is a general one and does not use specified values. Point B shows values of voltage and current at maximum power point.

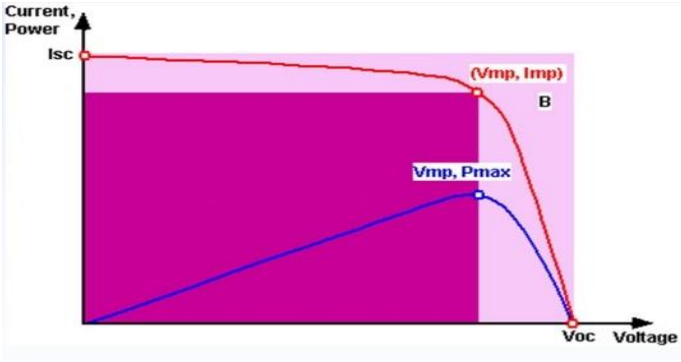


Figure 5. P_{max} of a solar cell.

3. Conclusions

By the definition of photoelectric effect, we can conclude that up to a certain point, as the irradiation of the sun increases, the power generated also increases. From the disadvantages listed, it can be realized that steps such as decreasing the size of the solar cell will help save space, decrease storage expenses and possibly decrease production costs. The graphs show the nonlinearity of the photovoltaic arrays (i.e does not follow ohms law). The current versus voltage graphs show that current is almost constant up to the open circuit voltage.

4. References

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