Objective: Study photovoltaic effects and efficiency for the given solar cell.

Theory: Solar cell is one of the most common photoelectric devices in use today because of its widespread use as solar panels for the generation of clean electric power with no pollution. The working of a solar cell depends upon its photovoltaic effect, hence a solar cell also known as photo voltaic cell. A solar cell is basically a semiconductor p-n junction device without any biasing. It is formed by joining p-type (high concentration of hole or deficiency of electron) and n-type (high concentration of electron) semiconductor material. At the junction excess electrons from n type try to diffuse top side and vice-versa. Movement of electron to the p-side exposes positive ion cores in n-side, while movement of holes to the n-side exposes negative ion cores in the p-side. This results in an electric field at the junction and forming the depletion region. When sunlight falls on the solar cell, photon with energy greater than band gap of semiconductor are absorbed by the cell and generate electron-hole pair. These migrate respectively to n and p side of the p-n junction due to electrostatic force of the field across the junction. In this way a potential difference is established between two sides are connected by an external circuit, current starts flowing from positive to negative terminal of the solar cell.

Solar Cell I-V characteristics

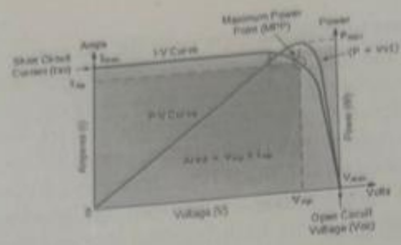
From these characteristics various parameters of the solar cell can be determined, such as: short-circuit current (ISC), the open-circuit voltage (VOC), the fill factors (FF) and the efficiency. The rating of a solar panel depends on these parameters.

The **short-circuit current** is the current through the solar cell when the voltage across the solar cell is zero (i.e., when the solar cell is short circuited). is due to the generation and collection of light-generated carriers. For an ideal solar cell at most moderate resistive loss mechanisms, the short-circuit current and the light-generated current are identical. Therefore, the short circuit current is the largest current which may be drawn from the solar cell.

The **open-circuit voltage**, VOC, is the maximum voltage available from a solar cell, and this occurs at zero current. The open-circuit voltage corresponds to the amount of forward bias on the solar cell due to the bias of the solar cell junction with the light-generated current.

The **"Fill factor"**, more commonly known by its abbreviation "FF", is a parameter which, in conjunction with Voc and Isc, determines the maximum power from a solar cell. The FF is defined as the ratio of the maximum power from the solar cell to the product of Voc and Isc. Graphically, the FF is a measure of the "squareness" of the solar cell and is also the area of the largest rectangle which will fit in the IV curve as shown in Fig. 3.

The **Efficiency** is the most commonly used parameter to compare the performance of one solar cell to another. Efficiency is defined as the ratio of energy output from the solar cell to input energy from the sun. In addition to reflecting the performance of the solar cell itself, the efficiency depends on the spectrum and intensity of the incident sunlight and the temperature of the solar cell.



The power delivered by solar cell or panel is product of its output current and voltage (I×V). With the solar cell open-circuited that is not connected to any load the current will be at its minimum (zero) and the voltage across the cell is maximum its V_{oc}. At the other extreme when the solar cell is short circuited the voltage across the cell is minimum but current flowing out of the cell reaches its maximum its I_{sc}. There is one particular combination of current and voltage for which the cell generates maximum electrical power and this is shown at top right area of the rectangle. This is maximum power point.
The product of open circuit voltage V_{oc} and short circuit current I_{sc} is known as ideal power.

$$\text{Ideal power} = V_{oc} \times I_{sc}$$

The maximum useful power is the area of the largest rectangle that can be formed under the V-I curve. If V_m and I_m are the values of voltage and current under this condition, then

$$\text{Maximum useful power} = V_m \times I_m$$

The ratio of maximum useful power to the ideal power is called the fill factor

$$\text{Fill factor} = \frac{V_m \times I_m}{V_{oc} \times I_{sc}}$$

Procedure:

- Switch ON the set-up, Switch ON the light source is facing the solar panel.
- Choose the solar cell sensor on the panel.
- Set the illumination level to 4 and read the voltage on the voltmeter with the loading potentiometer turned extreme left. The current meter will show circuit current.
- Now slowly turn the potentiometer clockwise. A current will be seen on the meter. This is the loading condition.
- Measure voltage and current for various settings and continue till the current reading is zero. This is the open circuit condition.
- Any further clockwise turn of the potentiometer will apply voltages higher than the solar cell voltage and shift its operation to the photodiode condition.

Observations:

Sr. No.	Voltage(V)	Current(mA)	Power(W)	Eq. R(kohm)
1.				
2.				
3.				
4.				
5.				

6.				

Graphs:

- Plot graph between solar cell current and voltage.
- Plot graph between power output and voltage.