TO STUDY THE CHARACTERISTICS OF SOLAR CELL

OBJECT

To study the characteristics of solar cell, the following studies can be carried out.

1. Illumination Characteristics.
2. Current Voltage Characteristics.
3. Power Load Characteristics.
4. Area Characteristics.
5. Spectral Characteristics.

OPTIONAL

1. Distance Vs Open Circuit Voltage.
2. Distance Vs Short Circuit Current.
3. Measurement of Short Circuit Current (I_{ESC}) with biasing the solar cell and compare it with the theoretical value obtained from current voltage characteristics curves.

THEORY:

Solar cells are basically solid-state devices. It is basically a p-n junction, which converts sunlight (solar energy) into electrical energy through a three-step process:

1. **Generation of carrier pairs (electron hole pairs)**
2. **Separation of electrons and holes**
3. **Collection of separated carriers**

The details of each of the three processes are beyond the scope of this manual. Pl see text books.

When a solar cell is illuminated, the photons incidents on the cell generate electrons-hole pairs. By diffusion in the material the electron and holes reach the junction. At the junction the barrier field separates the positive and negative charges carriers. Under the action of the electric field, the electrons (minority carriers) from p region are swept into n region. Similarly, the holes from n region are swept into p region. It leads to an increase in the number of holes on the p side and of the electrons on the n side of the junction. The accumulation of charges on the two sides of the junction produces an emf, which is called a photo emf. The photo emf is known as open circuit voltage. It is proportional to the illumination (mW/cm^2 or $lumen/cm^2$) and on the size of the illuminated area. When an external circuit is connected across the solar cell terminals, the minority carriers return to their original sides through the external circuit, causing the current to flow through the circuit. Thus the solar cell behaves as a battery with n side as the negative terminal and p side as positive terminal. The photo emf or voltage can be measured with a voltmeter. The process of generation of photovoltaic voltage is shown in Fig.

(1) The conversion of optical energy is known as photovoltaic effect. Hence a solar cell is also called a photovoltaic cell.

All solar cell materials used till date are semiconductors in crystalline or amorphous forms. A common characteristic of these materials is that they posses a band gap i.e. a discontinuity or rather a range of forbidden values in the energy spectrum. Mostly, solar cells are fabricated from silicon single crystals; Silicon is not transparent for visible light. Therefore, the surface layer of the cell, which is of p type, is made extremely thin to enable maximum light to penetrate the junction. It is desired the absorption of light takes place at the junction region such that the generated electron holes pairs can be separated by the junction fields before they are lost by recombination. To enhance the transmission of the light into the material an anti reflection coating is given over p type layer. Thin metallic films vacuum deposited suitably on both the sides of the cell act as electrodes. An open circuit voltage of peak value of 0.6 V is generated by a solar cell. Silicon wafer of 1"dia to 4"dia are used too fabricate solar cells. In order to enhance the total voltage and current out put, a number of P-n junction are formed on a wafer, using a mesh type or finger like electrode structure. To increase power output, solar cells are arrayed into a series chain or parallel chain and are interconnected. Such an arrangement is called a solar panel. In normal use single solar cell is rarely used, as its output is very low.

(i) **Illumination Characteristic**

The Illumination Characteristic of a solar cell is shown in the Fig. (2). It is seen that the current through the solar cell increases as the intensity of the light falling on the solar cell increases.

(ii) **Current Voltage Characteristic**

The out put characteristic (current voltage characteristics) of a solar cell is shown in the Fig. (3) it is seen that in the open circuit, the out put voltage of the cell is $\approx$ 0.6 V and the current is zero. If the panel is short circuited, the current is maximum while the output voltage of the cell becomes zero. In both the cases, the output power is zero. It is seen from the curve that the voltage varies depending on the current drawn.

(iii) **Power Load Characteristics**

To derive maximum power from the panel, an appropriate load is to be connected across it. The value of the load that allows the cell to give maximum output power is obtained by drawing a power load characteristics, as shown in the Fig. (4). It is seen that a load other than $(R_L)_{max}$ will produce less power.

(iv) **Area Characteristics:**

The power delivered is proportional to the surface area of the solar panel exposed to the light. It is governed by the relation,

$$P = K A$$

Where, P is the total power available

A is the area of the Cell

K is a constant.

The dependence of P on A is shown in the Fig. (5)

PROCEDURE

(a) Illumination Characteristics

1. Make the circuit as shown in fig. 7. A 100 W lamp is arranged over the solar cell such that the light falls on it at normal. The intensity control is kept at its minimum say at 50 volts and the lamp is switched on.
2. Adjust the resistance box at zero ohm (i.e. both the knobs marked X10 and X100 ohm must be set at off position) note the short circuit current and make table as shown below.
3. Increase the intensity of the lamp in steps say 100, 150, 200 volts and note the corresponding current for each setting of the voltage, record these readings in the table.

Note: Intensity is taken as proportional to the A.C. voltage given to the lamp

a. Plot a graph between Current and the Intensity.

Table – 1

S.No.	Intensity (volts)	Current (mA)
1.		
2.		
3.		

(b) Current Voltage Characteristics

1. The intensity of the lamp is kept at the minimum say 100 V. disconnect the load resistance (i.e. R.B. is at infinity) and note the open circuit voltage.
2. Adjust the resistance box (R.B.) at zero ohm (i.e. both the knob of the resistance box marked X10 and X100 ohm must be set at off position) and note the short circuit current.
3. Set the load dial at 100 ohms. Note the corresponding voltage and current make the table as shown below and record these readings in the table. Vary the load in steps up to 1100 ohms and note the corresponding voltage and current for each setting of the load in table
4. The intensity of the lamp is increased say 150 V. The load is again varied from 100 to 1100 ohms and note the corresponding voltage and the currents, record the value in the table. The open circuit voltage and the short circuit current are also determined and recorded.
5. The intensity of the lamp is set at 200 V, and repeat step 4. Record these readings in the table.
6. Plot a graph for Current Vs Voltage.

Table – 2

S.No.	R_L Ohms	Intensity, I_1		Intensity, I_2		Intensity, I_3	
		Voltage(V)	Current(mA)	Voltage(V)	Current(mA)	Voltage(V)	Current(mA)
1.	100						
2.	200						
3.	….						

(c) Power Load Characteristics

1. Using the sets of the reading obtained in the table 2 above, calculate the output power of the cell. Make table as shown below and record the readings in the table.
2. Plot a graph for Power Vs Load. Measure the value of the optimum load that draws maximum power from the cell.

Table – 3

S.No.	R_L Ohms	Intensity, I_1 = 100 V	Intensity, I_2 = 150 V	Intensity, I_3 = 200 V
		Power mW	**Power mW**	**Power mW**
1.	100			
2.	200			
3.	….			

(d) Area Characteristics:

1. Set the intensity of the lamp at a convenient level say 200V. Adjust the load at the optimum value.
2. Place the chopper plate having different slot areas, in front of the solar cell in the grove provided.
3. Adjust one of the slot say 16 mm^2 over the solar cell; it reduces the surface area, which is illuminated. The voltage and the current readings are noted in the table. Note the corresponding voltage and current readings make table as shown below and record the readings in the table.
4. Adjust the other slots say 36, 64, 100, 144 mm^2 over the solar cell and note the corresponding current and voltage for each slot area and record the readings in the table.
5. Plot a graph for Power Vs Area. Measure the slope of the curve.

Table – 4

S.No.	Slot Area mm^2	Voltage, V volts	Current, I amp	Power P = VI mW
1.				
2.				
3.				
4.				

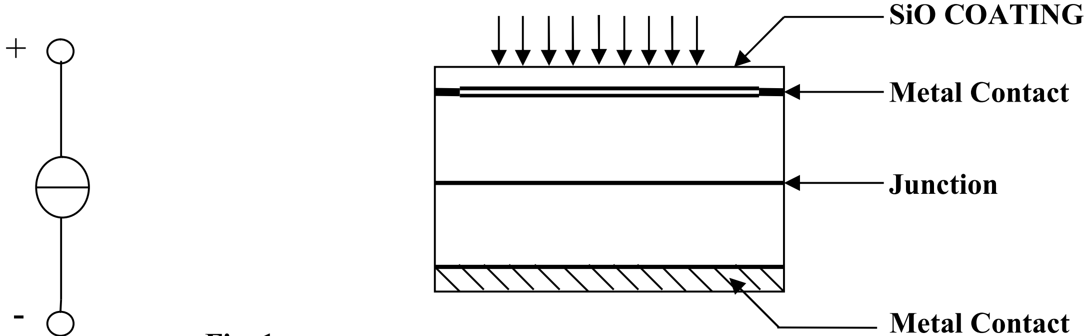

Fig. 1

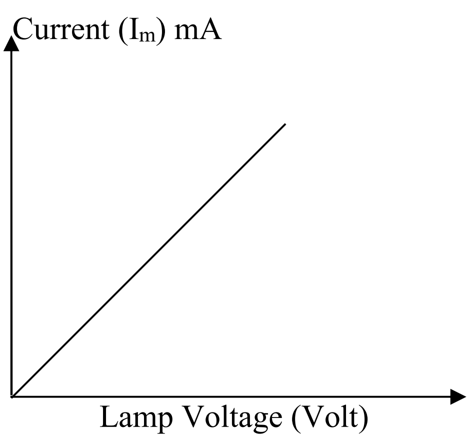

Fig. 2

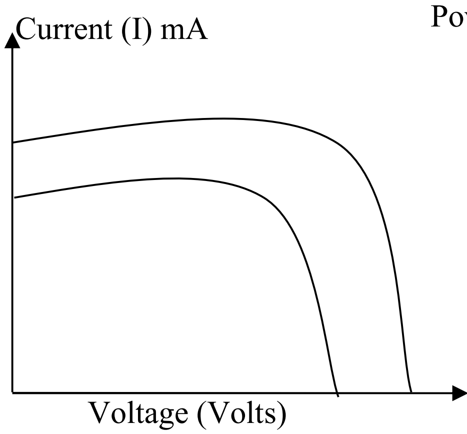

Fig. 3

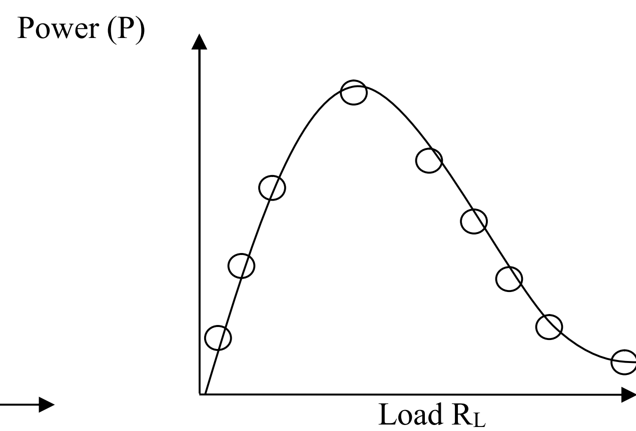

Fig. 4

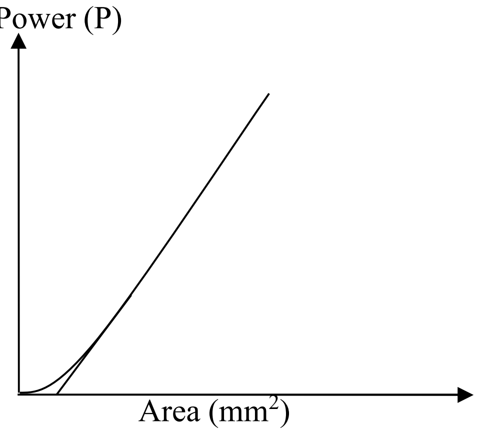

Fig. 5

Fig. 6

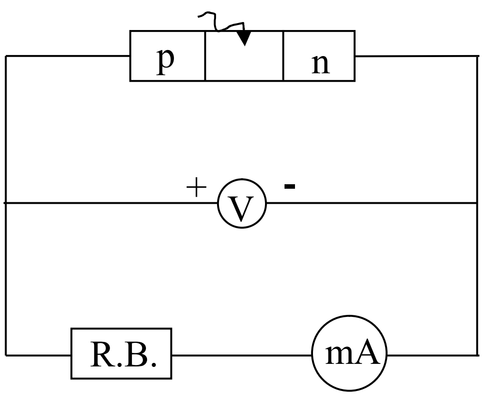

Fig. 7(a)

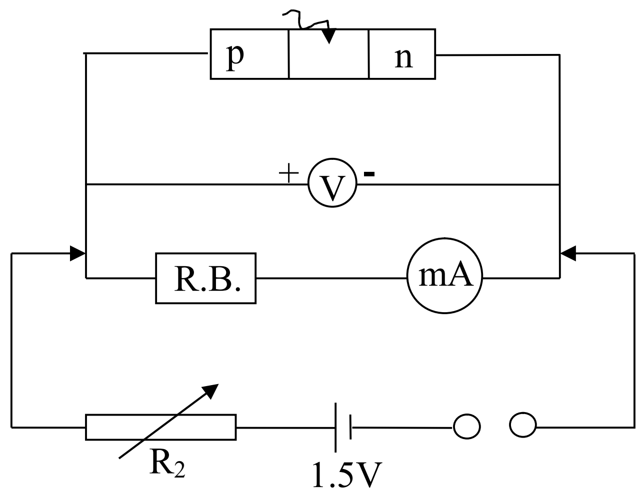

Fig. 7(b)