Exp-06 ME-383

Determination of efficiency, [redacted] of a solar cell

Theory:-

Basically solar cell is a p-n junction device formed by diffusion or epitaxy. The p-n junction solar cell is shown in fig.1 and its equivalent circuit is shown in fig.2.Now consider the band diagram of a p-n junction in dark and under illumination as shown in fig. 3(a) and fig. 3(b) respectively. In the dark, drift of thermally generated minority carriers across the junction constitutes the reverse saturation current. At zero bias it is exactly balanced by a small flow of majority carriers in the opposite direction, resulting in zero net current. Under forward bias, the net direction is from p-side to n-side. If the junction is illuminated by photons with $h\nu \geq \epsilon_g$,additional electron-hole pairs are created with a generation rate G($cm^{-3}.sec^{-1}$).Then, number of holes created per second within a diffusion length on the n-side is AL_hG, where A is the area of diode. Similarly the number of electrons created per second within a diffusion length on the p-side is AL_eG.Thus thetotal photo generated current,I_{ph},due to the drift of these carriers across the junction is given by

$$I_{ph} = qAG(L_h + L_e)$$

This current is directed from the n-side to p-side and is opposed to the main diode current from p-side to n-side. Therefore,for the illuminated diode,

$$I = qA\left(\frac{L_h}{Le} + \frac{L_e}{\tau_e} n_{PO}\right)\left(e^{qv/K_BT} - 1\right) - qAG(L_h + L_e)$$

Thus, the current is lowered by an amount proportional to the generation rate, as shown in fig 4. Note that generation and the recombination effects within the depletion region are neglected.

Let us consider the two cases of the short circuited and open circuited diode. For the short-circuited diode, V=0, and

$$I_{SC} = I_{ph} = -qAG(L_h + L_e)$$

For open circuited diode, I = 0, and

$$V = V_{OC} = \frac{k_BT}{q}\ln\left[\frac{L_h + Le}{\left(\frac{L_h}{Le}\right)p_{NO} + \left(\frac{L_e}{\tau_e}\right)n_{PO}}G + 1\right]$$

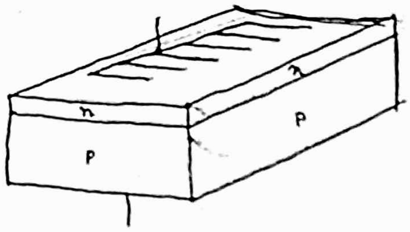
which is equivalent to [redacted]

$$V_{oc}=\frac{k_BT}{q}\ln[\frac{I_{ph}}{Is}+1]$$

or, $V_{oc}\sim\frac{k_BT}{q}\ln[\frac{I_{ph}}{Is}]$

Therefore under illumination the junction acts as a power source. The output power is given by the eqn.

$$P = IV = I_sV(\,e^{qv/K_BT}-1) - I_{ph}V$$



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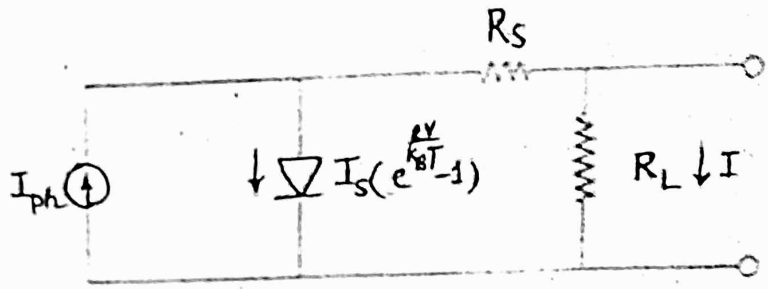

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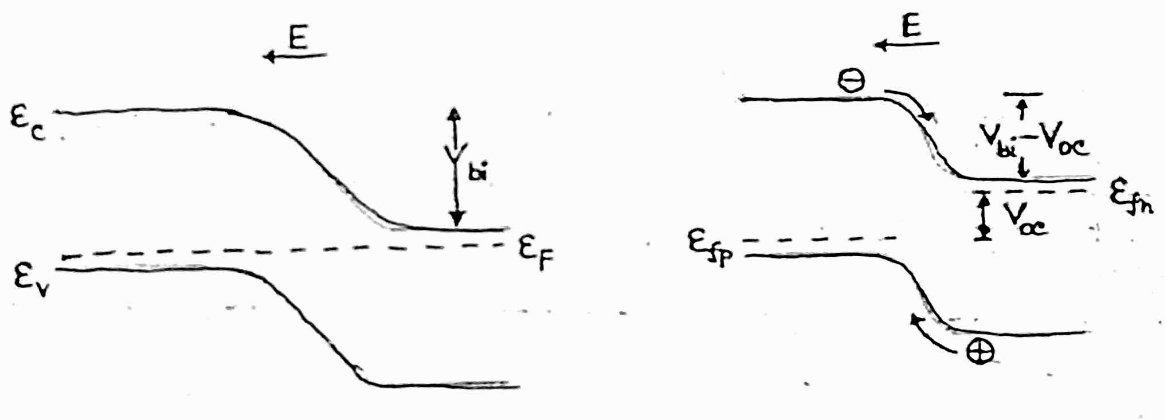
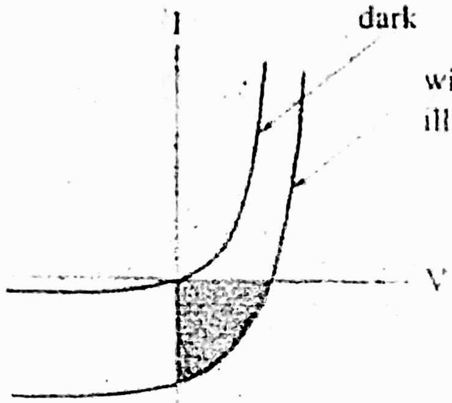


(a) Dark.

(b) Under illumination

3



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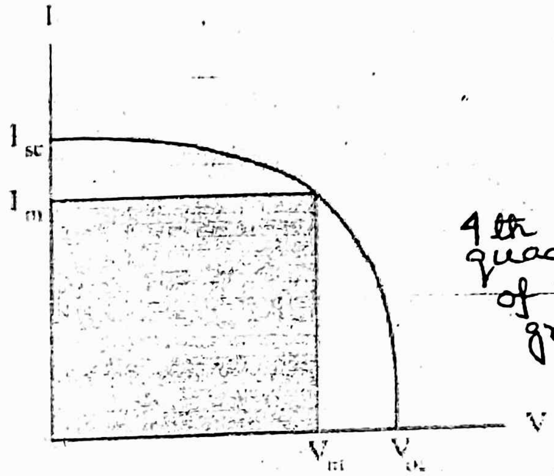

4 th quadrant of I-V graph.

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We define the quantities I_m and V_m, (shown in figure 5 in the fourth quadrant), as the current and voltage, respectively, for maximum power output $P_{max} = V_{max} \cdot I_{max}$.

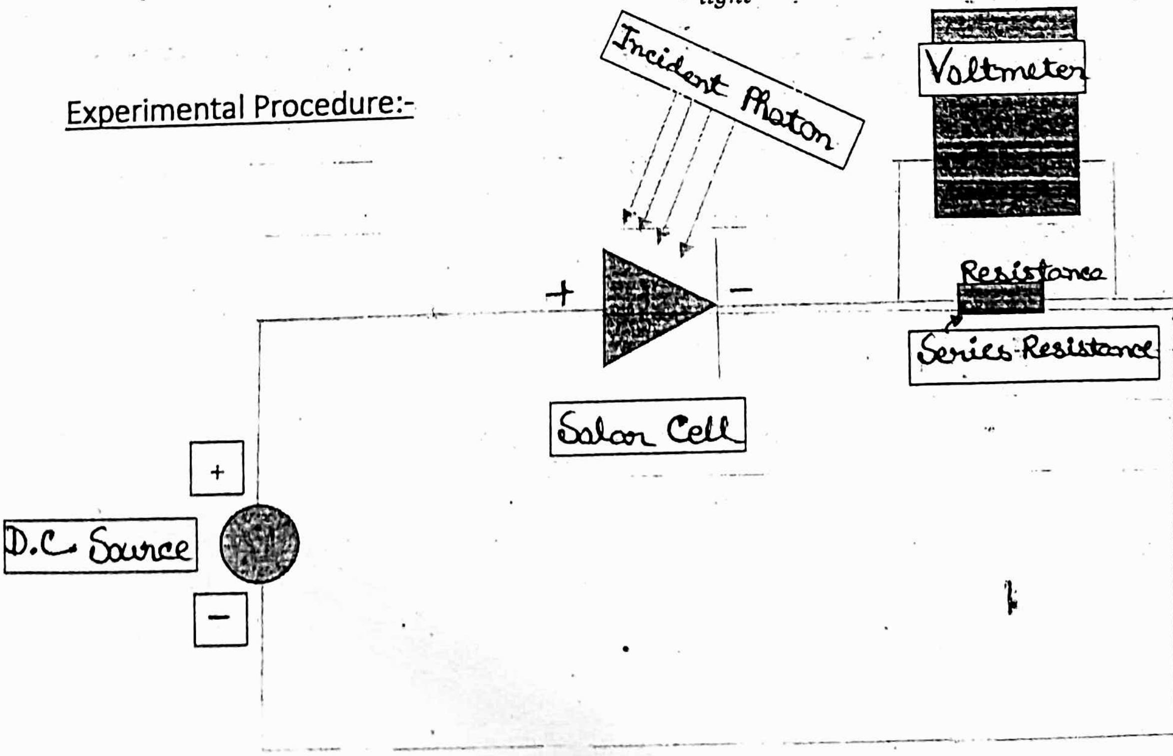
Now, we define the quantity Fill Factor as,

$$F.F. = \frac{P_{max}}{I_{sc} \cdot V_{oc}} = \frac{V_{max} \cdot I_{max}}{I_{sc} \cdot V_{oc}}$$

Also, Power Conversion efficiency (PCE) is,

$$PCE = = \frac{I_{sc} \cdot V_{oc} \; X \; F.F.}{P_{light}}$$

Experimental Procedure:-



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1. At first do the circuit connection as shown in figure.
2. Then cover up the solar cell completely so that no light can reach inside it.
3. Then take the data for dark current i.e. take the data for I-V characteristics keeping the light off.
4. Now take data for I-V characteristic curve by removing the cover and keeping the light on. You can take data for different intensity of light.
5. Data must be taken in both cases in forward bias condition and resolution of at least 0.5 V of input voltage.
6. Draw the I-V characteristic curves.
7. Calculate P_{max}, F.F. & PCE.

Experimental Data:-

Data without light (for dark current):-

VOLTAGE (V in Volt)	VOLTAGE (V_1 in Volt)	CURRENT (I in mA) $I = V_1/R$

Data with light :-

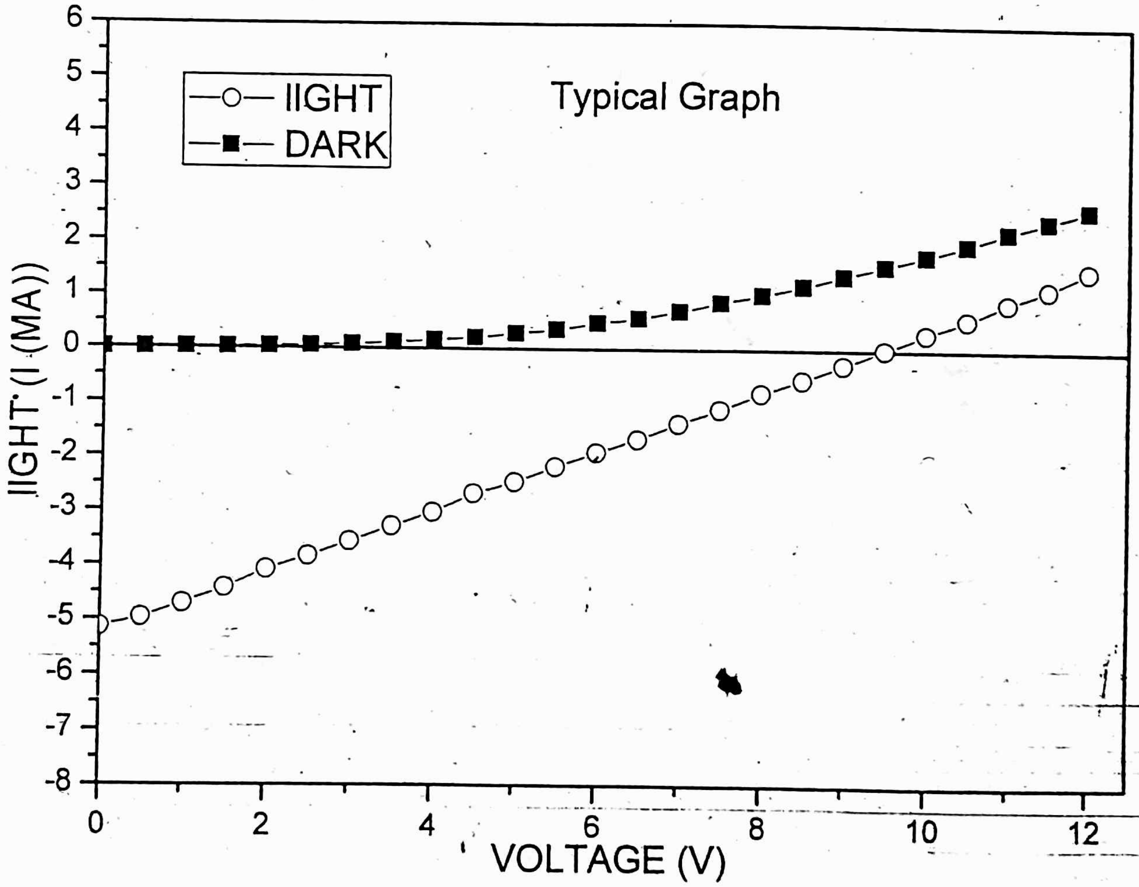
VOLTAGE (V in Volt)	VOLTAGE (V_1 in Volt)	CURRENT (I in mA) $I = V_1/R$

Calculations:-

Discussions:-

Typical Data

	A(X)	B(Y)	C(Y)
ong Name	VOLTAGE	IIGHT	DARK
Units	V	I (MA)	
Comments			
1	0	-5.13889	0
2	0.5	-4.96667	0.00389
3	1	-4.71111	0.01056
4	1.5	-4.42778	0.02111
5	2	-4.08889	0.03833
6	2.5	-3.84444	0.05667
7	3	-3.56667	0.08167
8	3.5	-3.28889	0.11167
9	4	-3.03333	0.16
10	4.5	-2.67778	0.21222
11	5	-2.46667	0.29
12	5.5	-2.17778	0.36889
13	6	-1.91667	0.48833
14	6.5	-1.66667	0.57889
15	7	-1.37222	0.71389
16	7.5	-1.11111	0.87833
17	8	-0.8	1.02833
18	8.5	-0.55556	1.18889
19	9	-0.27778	1.37778
20	9.5	0.01111	1.57222
21	10	0.30556	1.75556
22	10.5	0.57222	1.96667
23	11	0.88333	2.2
24	11.5	1.14444	2.40556
25	12	1.48889	2.62222



Typical Graph
IIGHT
DARK
IIGHT (I (MA))
VOLTAGE (V)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
0
2
4
6
8
10
12