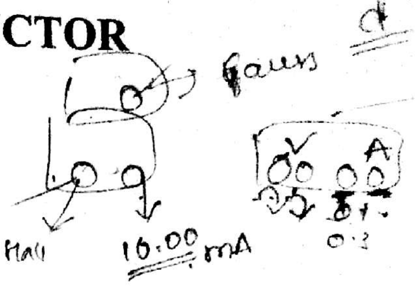
ENERGY GAP OF A SEMICONDUCTOR



AIM:

To determine the forbidden energy gap (E_g) of a given semiconductor.

APPARATUS:

Semiconductor (P-n junction diode in reverse bias, Si or Ge), voltmeter, ammeter and 0-100°C thermometer.

PRINCIPLE & FORMULA:

The energy gap (E_g) of a material is defined as the minimum amount of energy required for an electron to get excited from the top of the valance band to the bottom of the conduction band. The energy gap for metals is zero since the valance band and conduction band overlap each other where as the energy gap for the insulators is very high. The energy gap for the semiconductors lies between the values for metals and the insulators.

The resistance of a semiconductor varies with the temperature as

$$R = R_o\, e^{\frac{Eg}{2KT}} \qquad \text{-----} \qquad (1)$$

Where R_o is the resistance of the semiconductor at absolute zero,

K is the Boltzman constant and → 1.38×10^{-23}

T is the temperature of the material.

By applying logarithms on both sides of the equation (1), we get

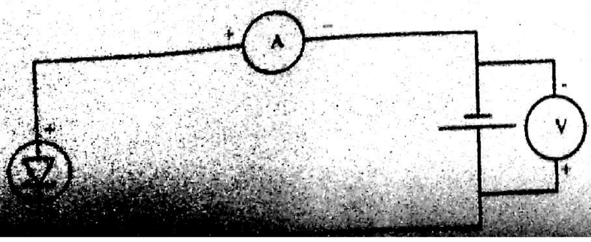
$$\log_{10} R = \log_{10} R_o + \left(\frac{E_g}{2KT}\right) \log_{10}^{e} \qquad \text{-----} \qquad (2)$$

This is a linear equation between $\log_{10}{}^{R}$ and $\frac{1}{T}$ and its slope is obtained from:

$$\text{slope} = E_g \frac{\left(\log_{10}^{e}\right)}{2K}$$

$$E_g = (\text{slope}) \frac{2K}{\log_{10}^{e}}$$

$$E_g = (3.9666 \times 10^{-4} \times \text{slope})\ \text{eV} \qquad \text{-----} \qquad (3)$$



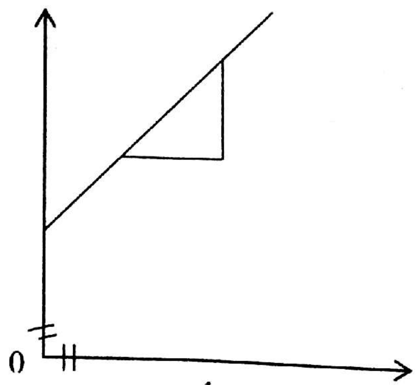
PROCEDURE:

Make the necessary connections. Apply the constant voltage (V) across the semiconductor and switch on the heater, measure the current (I) in μA as the temperature (t) is increasing at regular intervals (say in steps of 5°C) till the temperature reaches 70°C. Switch off the heater and again measure the current in regular intervals while decreasing the temperature till the room temperature is reached. Tabulate the values of current and temperature. Repeat the experiment for two or three different voltages.

GRAPH:

Draw the graph taking $\frac{1}{T}$ on the X-axis and $\log_{10}^{R}$ on the Y-axis. One should get a straight line which does not pass through the origin. Find the slope of the straight line.

$\log_{10}^{R}$



0

$\frac{1}{T}(k^{-1})$

CALCULATIONS:

$E_g = (3.9666 \times 10^{-4} \times \text{slope})$ eV. 13.22×10^{-1}

$= 1.3222$

RESULT:

The energy gap (E_g) of a given semiconductor is found to be 1.3222 eV

PRECAUTIONS:

1. The diode should not touch the heating coil.
2. The temperature and the current should be noted down simultaneously
3. The temperature should come down to room temperature naturally.

14/3

TABLE:

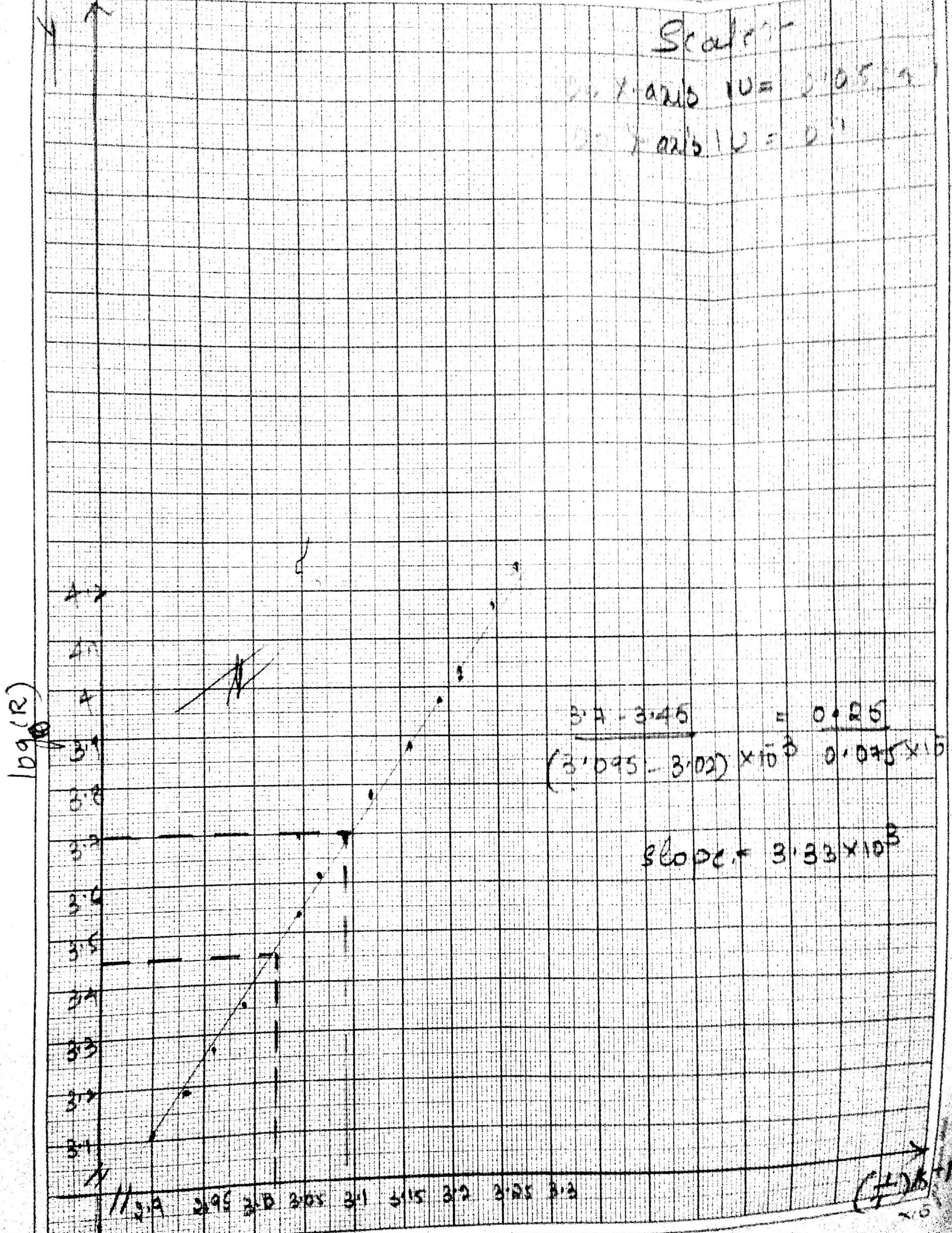
V = 2.00 Volts

S.No.	Temperature t °C	Temperature T°K	Current (μA) While increasing temperature	Current (μA) While decreasing temperature	Mean	Resistance $R = \frac{V}{I}$ in ohms	Resistance $\log_{10}^{R}$	$\frac{1}{T}K^{-1}$
	32	305	97	127	112	17857.14	4.251	3.278×10^{-3}
	35	308	134	133	133.5	14981.61	4.175	3.246×10^{-3}
	38	311	165	153	159	12578.61	4.099	3.215×10^{-3}
	42	314	222	205	213.5	9367.68	3.97	3.184×10^{-3}
	45	317	288	244	266	7518.76	3.876	3.154×10^{-3}
	48	320	352	296	324	6172.83	3.79	3.125×10^{-3}
	51	323	422	358	390	5128.20	3.70	3.095×10^{-3}
	54	326	520	435	477.5	4188.48	3.62	3.067×10^{-3}
	57	329	625	524	574.5	3481.28	3.54	3.039×10^{-3}
	60	332	751	647	699	2861	3.45	3.02×10^{-3}
	63	334	908	819	863.5	2316.15	3.36	2.985×10^{-3}
	66	337	1095	1029	1052	1901.14	3.27	2.958×10^{-3}
					1280	1562.5	3.19	2.932×10^{-3}
	[illegible]	340	1809	1251	1530		[illegible]	2.905×10^{-3}

Scale:-

X-axis 1U = 0.05

Y-axis 1U = 0.1



$$\frac{3.7 - 3.45}{(3.095 - 3.02)\times 10^{3}} = \frac{0.25}{0.075\times 10^{3}}$$

slope = 3.33×10^{3}

WAVELENGTH OF LASER

AIM:

To determine the wavelength of given semiconductor red laser

APPARATUS:

Laser source, optical bench, grating device, screen and scale.

PRINCIPLE & FORMULA:

The wavelength of laser light using a grating is given by

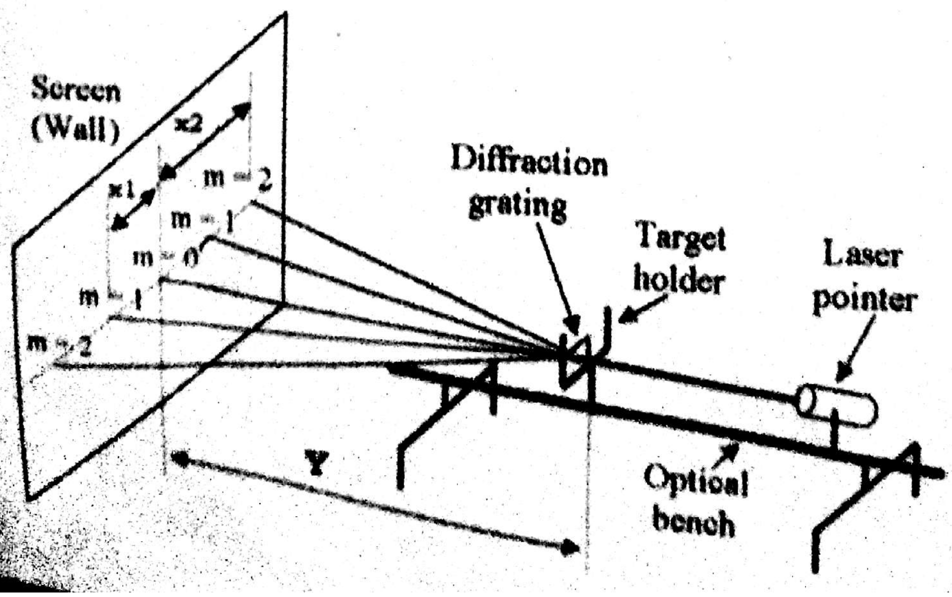
$$\lambda = \frac{\sin\theta}{Nn}$$

Where n = order of diffraction
λ = Wavelength of the laser light (Å)
θ = Diffraction angle
N = Number of lines per cm. on the grating

The radiation given out by the laser is in mutual agreement not only in phase but also in the direction of emission and polarization.

Usually the number of particles N_2 i.e. the population of higher energy level is less than the population N_1 in lower energy level. Making $N_2 > N_1$ i.e. the number of particles N_2 more in higher energy level than the number of particles N_1 in lower energy level, is called as population inversion. It is one of the basic requirements of laser action. The method of rising the particles from lower energy state to higher energy state is called as pumping. Particles can pass from the exited state to a normal state by emitting a light quanta (Photon) not only spontaneously but also when forced to do it, under the effect of another external quanta. This means that the incidence of radiation on the particle which is in exited state stimulates the emission of a similar radiation by the particle which is in exited state, this emission is called stimulated emission.

The remarkable feature of the stimulated emission is that it is coherent with the stimulating incident radiation. It has the same frequency and phase as the incident radiation.



PROCEDURE:

1. Arrange the laser and grating on the optical bench in the same line.
2. Focus the laser beam on the grating and observe the diffraction pattern on the screen.
3. Measure the distance between the screen and grating (Y) cm.
4. Measure the distance between the corresponding maxima of the same order (2X) cm.
5. Repeat the experiment with different distances and find the mean (λ) A°.

$1A = 10^{-8}$ cm

TABLE:

S. No.	Order of the spectrum	Distance between corresponding orders (2X) Cm	X Cm	Distance between screen & grating (Y) Cm	$\tan\theta = \frac{x}{y}$	$\sin\theta$	$\lambda = \frac{\sin\theta}{Nn}$ A°
1	1	2.7	1.35	20	0.0675	0.067	6807.21
2	2	5.3	[illegible]	20	0.1325	[illegible]	[illegible]
3	3	8.3	4.15	20	0.2075	[illegible]	[illegible]
4	4	11	5.5	20	0.275	[illegible]	[illegible]
5	5	14.3	7.15	20	0.3575	[illegible]	[illegible]
1	1	3.4	1.7	25	0.068	0.062	6807.21
2	2	6.7	3.35	25	0.134	0.1328	6746.25
3	3	10.3	5.15	25	0.206	0.201	6807.21
4	4	13.9	6.95	25	0.278	0.267	6781.81
5	5	17.8	8.9	25	0.356	0.325	6807.21
1	1	4.2	2.1	30	0.0700	0.0698	7091.69
2	2	8.1	4.05	30	0.135	0.133	6756.49
3	3	12.4	6.2	30	0.2066	0.201	6807.21
4	4	14.5	7.25	30	0.2416	0.234	[illegible]3.61
5	5	21.2	10.6	30	0.3533	0.332	6746.25
						Mean	6748.2

N=984.25

RESULT:

The wavelength of the given semiconductor red laser is found to be 6748.2 A°.

FIBRE OPTICS

AIM:

To determine the numerical aperture (NA), power losses due to macro bending and adaptor of given optical fibre.

APPARATUS:

LED, NA Jig, D.M.M, scaled screen, adaptor, one and three meter length of optical fibre, mandrel

PRINCIPLE & FORMULA:

1. The Numerical Aperture (N.A) of an optical fibre (step index) is given by

$$N.A. = \left(N^2_{core} - N^2_{clad}\right)^{\frac{1}{2}} \quad \text{-----} \quad (1)$$

N.A

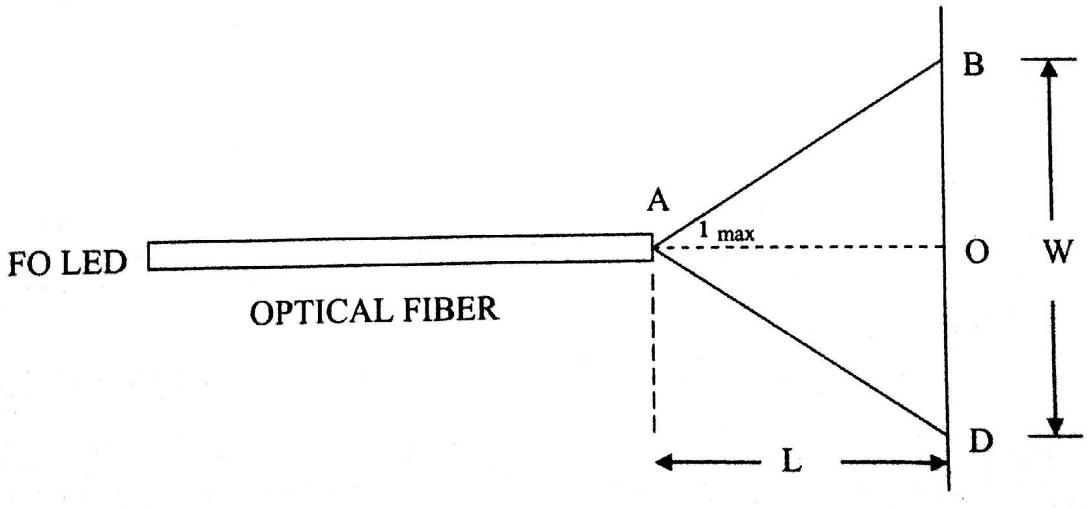
$$= \text{Sin } i_{max}$$

i.e., $$i_{max} = \text{Sin}^{-1} (N.A) \quad \text{-----} \quad (2)$$

n_{core} = refractive index of core, n_{clnd} = refractive index of clading

i_{max} = acceptance angle

As shown in the figre, light from the end of the optical fibre 'A' falls on the screen BD. Let the diameter of light falling on the screen BD=W, Let the distance between end of the fibre and the screen AO=L



$$N.A. = \frac{W}{\left(4L^2 + W^2\right)^{\frac{1}{2}}}$$

Knowing W and L, the N.A can be calculated and substituting this N.A value in Eq(2), the acceptance angle 'θ' can be calculated.

2. Losses of power in fibre optic cable is mainly due to absorption or scattering of light with Optical fibre, macro bending and joints between cable (adaptor). This loss of power 'P' from input (P_o) to output (P_L) at a distance 'L', can be written as $P_L = P_o e^{-\alpha L}$

Where 'α' is the attenuation coefficient in decibles (dB) per unit length. (generally dB/KM)

$$\alpha = \frac{10.\log_{10}\left(\frac{P_o}{P_L}\right)}{L}$$

$$P_L = P_O 10 e^{-\frac{\alpha L}{10}}$$

PROCEDURE:

1. Insert one end of either one or three meter length optical fibre cable the LED and NA jig.. Switch on LED, then red light will appear at the end of the fibre on the N.A Jig. Turn SET P0/IF knob the intensity will increase. Arrange the scaled screen at a distance L, then view the red spot on the screen. Measure the diameter of the spot (w). Note the measured values L and W in the table. Repeat the experiment with different distances and note the readings.

S. No	L (mm)	W (mm)	N.A	i_{max}
1	50	50	0·4472	26·56
2	40	44	0·4648	27·69
3	30	30	0·4472	26·56

2. Insert one end of the three meter length plastic optical fibre cable to the FOLED and connect another end to the power meter module. Connect D.M.M test leads to Pout, red lead to red socket and black lead to black socket respectively. Set D.M.M to 2000 mV range. Switch on LED, adjust the Set Po/IF knob to set output power of the FOLED to the value -22.0 dBm or minimum (milli decibles) and note this as Po, wind the fibre on the mandrel and note the reading as P_{OW_1}, similarly for two and three turns. Note the readings as P_{OW_2} and P_{OW_3} respectively.

O/P power (dBm)		Loss due to turns (dBm)
Po0	- −9·88	
P_{OW_1}	- −9·98	(P_O0 - P_{OW_1}) = −0·10
P_{OW_2}	- −10·04	(P_O0 - P_{OW_2}) = −0·16
P_{OW_3}	- −10·17	(P_O0 - P_{OW_3}) = −0·29

3. Connect one meter OF cable as given above and set D.M.M for a constant value (-120mV or minmum) and note the reading as P_1. Similarly take P_2 by replacing one meter cable with 3 meter

cable without disturbing SET Po/I_f knob. Now join the 1 and 3 m cables with the adopter as shown in the figure and note DMM reading as P_3.

OBSERVATIONS:

P_1 = -9.98 dBm

P_2 = -10.40 dBm

P_3 = -13.12 dBm

$X = \frac{P_2 - P_1}{2}$.

CALCULATIONS:

Take P_1, P_2 and P_3 as shown in Fig., without disturbing the SET Po / I_f knob.

Loss in one meter cable (X) = $\frac{P_2 - P_1}{2}$ = -0.15 dBm

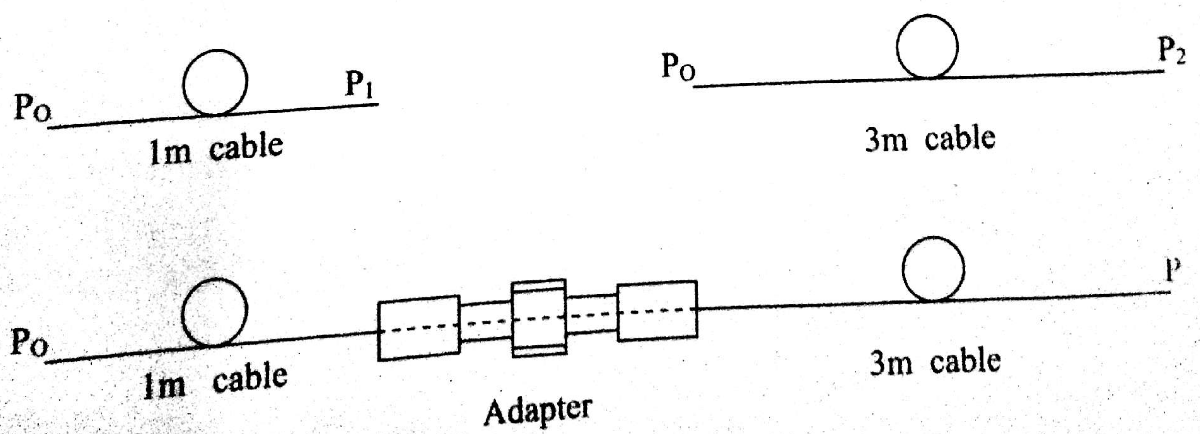
Loss due to adopter = $P_3 - P_1 - 3X$ = -1.22 dBm

RESULT:

1. N.A of given Optical fibre is 0.4530
2. Power loss due to one turn -0.10 dBm, two turns -0.16 dBm and three turns -0.2 dBm
3. Power loss due to one meter cable -0.15 dBm and due to adaptor -1.22 dBm

PRECAUTIONS :

1. Gently insert the optical fibre cable is to LED by turning clockwise direction of its clinch nut. (until you feel the fibre touches the micro lens)
2. Do not push applying over force which may damage micro lens
3. Gently tight the clinch nut that holds the inserted fibre firmly.
4. Before taking reading check out fibre is free of all twists and strains.
5. Two cables must meet at the center of the adopter while taking P_3 reading.



SOLAR CELL

Vijendar Reddy

AIM:

To draw the I-V characteristics of a solar cell and calculate the (a) Fill factor (FF), (b) Efficiency (η) and (c) Series resistance (R_s)

APPARATUS:

Solar cell, illuminator, voltmeter, ammeter and potentiometer etc.

PRINCIPLE & FORMULA:

Solar cell is a p-n junction diode. We know that a built- in- voltage exists across a p-n junction, but this voltage cannot deliver current in an external circuit. However, if light is illuminated on the junction, there flows current in the circuit. This effect is called the Photovoltaic effect.

To understand the principle underlying the Photovoltaic effect, let the junction be illuminated. Under this condition, many excess electron-hole pairs are generated in the regions on either side of the junction via absorption of photons. As the field within the junction is from n-side to p-side, the excess minority carriers thus generated diffuse to the junction where they are carried across and become majority charge carriers- the holes generated on n-side move to p-side and the electrons generated on p-side move towards n-side. If the junction is now open circuited, the majority carriers charge will build up on both sides of the junction (positive charge on p-side and negative charge on n-side) tending to lower the built-in-voltage. This change in built-in-voltage, (V_o) appears as a measurable P.D. across the junction, which there by behaves as a source of voltage V_o.

If the external circuit is closed, the current will therefore flow therein. This current will continue as long as there is diffusion of excess electrons from n-side and of excess holes from p-side. This means that the current will flow as long as the semiconductor junction regions are illuminated. This explains how the incident light sets up the current flow in the external circuit.

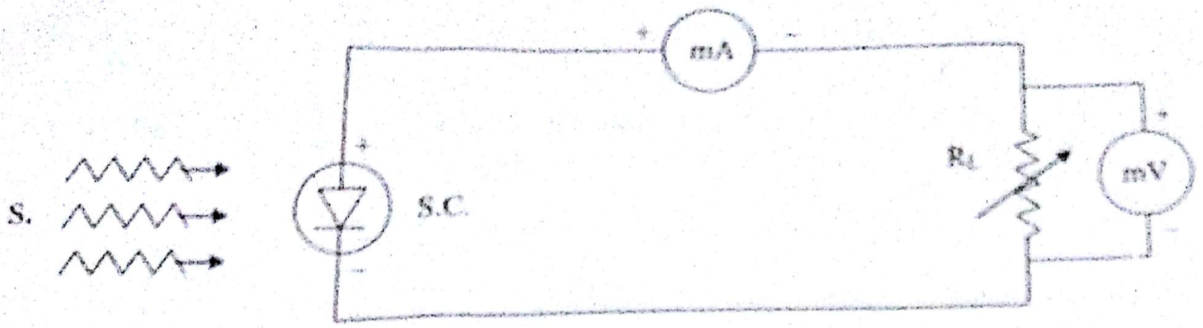
When the p-n junction is used in open circuit mode, the current flowing through the junction, I=0, the junction voltage, $V = V_{oc}$ (open circuit voltage).

When the output is short circuited, V=0 then $I = I_{sc}$ (Short circuit current).

V_m = maximum voltage, I_m = maximum current

Then ideal output power $P_I = V_{oc} I_{sc}$; Maximum useful power $P_m = V_m I_m$

Knowing the above, we can calculate the following parameters like Fill factor, Efficiency and Series Resistance



Circuit Diagram

PROCEDURE:

Complete the circuit connections as shown in the figure. Then place the light source 'S' at a distance of 15 cm from the solar cell (S.C.). Adjust the potentiometer R_L until you obtain the zero voltage in the voltmeter and maximum current in the ammeter. This maximum current is called the short circuit current I_{sc}. Then, with the help of potentiometer increase the voltage in steps of 0.2V and note down the corresponding current, till you get maximum voltage in the voltmeter. Now remove all the connections of the circuit and find out open circuit voltage (V_{oc}) [i.e. connecting +ve of the cell to the +ve of voltmeter and -ve of the cell to the -ve of voltmeter]. Repeat the experiment for another intensity by placing the light source at 25 cm. Note the P_{input} values corresponding to the distance between source and solar cell from the data sheet.

GRAPH:

Plot the graph between V and I. Select a point P on each curve and draw perpendicular lines from P onto both the axes such that the area (V_m, I_m) covered by the rectangle is maximum. Note the I_m and V_m from each curve and calculate fill factor and Efficiency. To find out the series resistance, find the differences between the consecutive V_m's (ΔV) and I_m's (ΔI) from the graph.

CALLCULATIONS:

0.324

(a) Fill factor = $\frac{P_m}{P_L}$, $\frac{P_{m_1}}{P_{L_1}} = 0.319$ $\frac{P_{m_2}}{P_{L_2}} = 0.330$

(b) Efficiency (η) = $\frac{P_{output}}{P_{input}}$, where P_{input} is constant for a particular distance $= 0.0684 \times 10^{6}$

18.73×10^{6}

$\frac{11707}{625 \times 10^{-6}} = \cancel{18731200}$

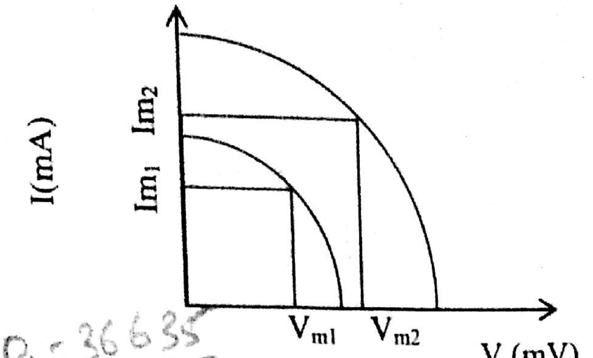
where $P_{output} = \frac{V_m I_m}{\text{Area of the cell (A)}}$, and where A = ---- m^2 and

$\eta_1 = 0.972 \times$

(c)Series resistance (R) = $\frac{\Delta V}{\Delta I}$, where ΔV, ΔI can be obtained from the I-V characteristic curve.

$\frac{6657}{625 \times 10^{-6}} = 10.65 \times 10^{6}$

$\eta_1 =$ 0.064



without other connections only volt, S.C

P_{l_1} = 36635 / 85

P_{l_2} = 20131.4

TABLE:

V_{oc} = 432 mV I_{sc} = 84.5 mA

1. P_{input} = W/m^2

P = VI

V_{oc} = 382 mV I_{sc} = 52.7 mA

2. P_{input} = W/m^2

S.No	Voltage (V) mV	Current (I) mA
842	0.10	84.2
2469	0.30	82.3
3930	0.50	78.6
5474	0.70	78.2
6849	0.90	76.1
8030	1.10	73.0
9113	1.30	70.1
9975	1.50	66.5
10778	1.70	63.4
11324	1.90	59.6
11592	2.10	55.2
Pm 11707	2.30	50.9
11375	2.50	45.5
10530	2.70	39
9309	2.90	32.1
7347	3.10	23.7
5247	3.30	15.9
2065	3.50	5.9
360	3.60	1.0
	3.90	
	4.10	
	4.30	

S.No	Voltage (V) mV	Current (I) mA
515	10	52.9
1518	30	50.6
2435	50	48.7
3346	70	47.8
4095	90	45.5
4708	110	42.8
5252	130	40.4
5865	150	39.1
6069	170	35.7
6308	190	33.2
Pm 6657	210	31.7
6302	230	27.4
5900	250	23.6
5132	270	19.1
4321	290	14.9
2914	310	9.4
1056	330	3.2

RESULT:

For a solar cell the values for various parameters found to be:

1. Fill factor = 0.324
2. Efficiency = 0.0684 × 10 6.8%
3. Series resistance = 0.99 Ω

24/01

PRECAUTIONS:

1. See that the light from the source falls normally on the solar cell.
2. Make sure that the connections are made properly and ensure good contact.

HALL EFFECT

AIM:

To determine the Hall coefficient (Hall Constant), carrier concentration and mobility of charge carriers of a semiconducting material.

APPARATUS:

Hall effect setup, hall probe, constant current source/voltmeter and a variable current source.

PRINCIPLE & FORMULA:

If a magnetic field is applied perpendicularly to the current carrying conductor, then a voltage develops in a direction perpendicular to both the current and applied magnetic field directions. This voltage is called Hall voltage and the phenomenon is known as Hall effect.

Consider a rectangular specimen, carrying a current (I_x) along the lengthwise direction (i.e. X-axis) of a specimen. If an uniform magnetic field B_Z is applied along the Z-axis, then emf develop along the Y-axis as shown in fig.(1). This voltage is called Hall Voltage.

As constant current flows through the specimen along positive X-direction, conducting electrons move with velocity v_d in opposite direction. Now, if the magnetic field is applied in direction perpendicular to the current direction, then due to Lorentz force (F_L), the moving charges deflect downwards of the specimen as shown in fig. (1). As a result, positive charges accumulate on one surface and automatically opposite surface acquires negative charge. This results in setting an electric field along Y-axis of specimen called Hall Field. The force due to this electric field opposes the Lorentz force and at steady state these two forces become equal and opposite.

This res

i.e. $e(v \times B_z) = e E_H$ $J = -nev$

Therefore $E_H = (v \times B_z) = vB_Z$ ----- (1) $e(v \times B_z) = e E_H$

We know that current density J is given by

$J = -nev$ ----- (2)

Dividing equation (1) by (2), we get

$$\frac{E_H}{J} = \frac{-B_Z}{ne} \quad \text{or} \quad \frac{V_H d}{B_Z I_x} \qquad \text{----- (3)} \qquad \frac{V_H d}{B_z I_x}$$

$$\frac{-1}{ne} = \frac{E_H}{JB_Z}$$

Where R.H.S. in above equation is called Hall Constant (R_H)

i.e. $R_H = \frac{E_H}{JB_Z}$ or

$e(V \times B_Z) = eE_H$

$E_H = V B_Z$

$J = -neV$

$$\boxed{R_H = \frac{V_H d}{B_Z I_X}}$$

$\frac{-1}{ne} = \frac{E_H}{JB_Z} = \frac{V_H d}{B_Z I_X}$ ----- (4)

Hall voltage depends on applied magnetic field, and current flowing through the specimen. The graph between V_H and B_Z is linear and slope of this gives $\left[\frac{V_H}{B_Z}\right]$

Therefore $R_H = (\text{Slope})\frac{d}{I_X}$ ----- (5)

Where d is the thickness of the sample and I_x is the current passing through the specimen.

Therefore from equation (3) $\frac{-1}{ne} = R_H$ ----- (6)

Negative represents the type of current carriers or type of semi-conducting material. Here it is negative type (n-type).

Therefore $\frac{1}{n} = -R_H e$ or $\frac{1}{n} = -R_H e$.

$n = \frac{-1}{R_H e}$ $n = \frac{-1}{R_H e}$ ----- (7)

Equation (7) gives the carrier concentration where e in the charge of the electron we know that conductivity is given by

$\boxed{\sigma = ne\mu}$ or $\sigma = ne\mu$

$\mu = \frac{\sigma}{ne} = R_H \sigma$ $\mu = \frac{\sigma}{ne} = R_H \sigma$ 0.1 coulomb/volt sec cm ----- (8)

Where μ is the mobility which is the drift velocity of the charge carrier per unit electric field and σ is the conductivity (σ = 0.1 coulomb/volt sec. cm for Ge crystal).

PROCEDURE:

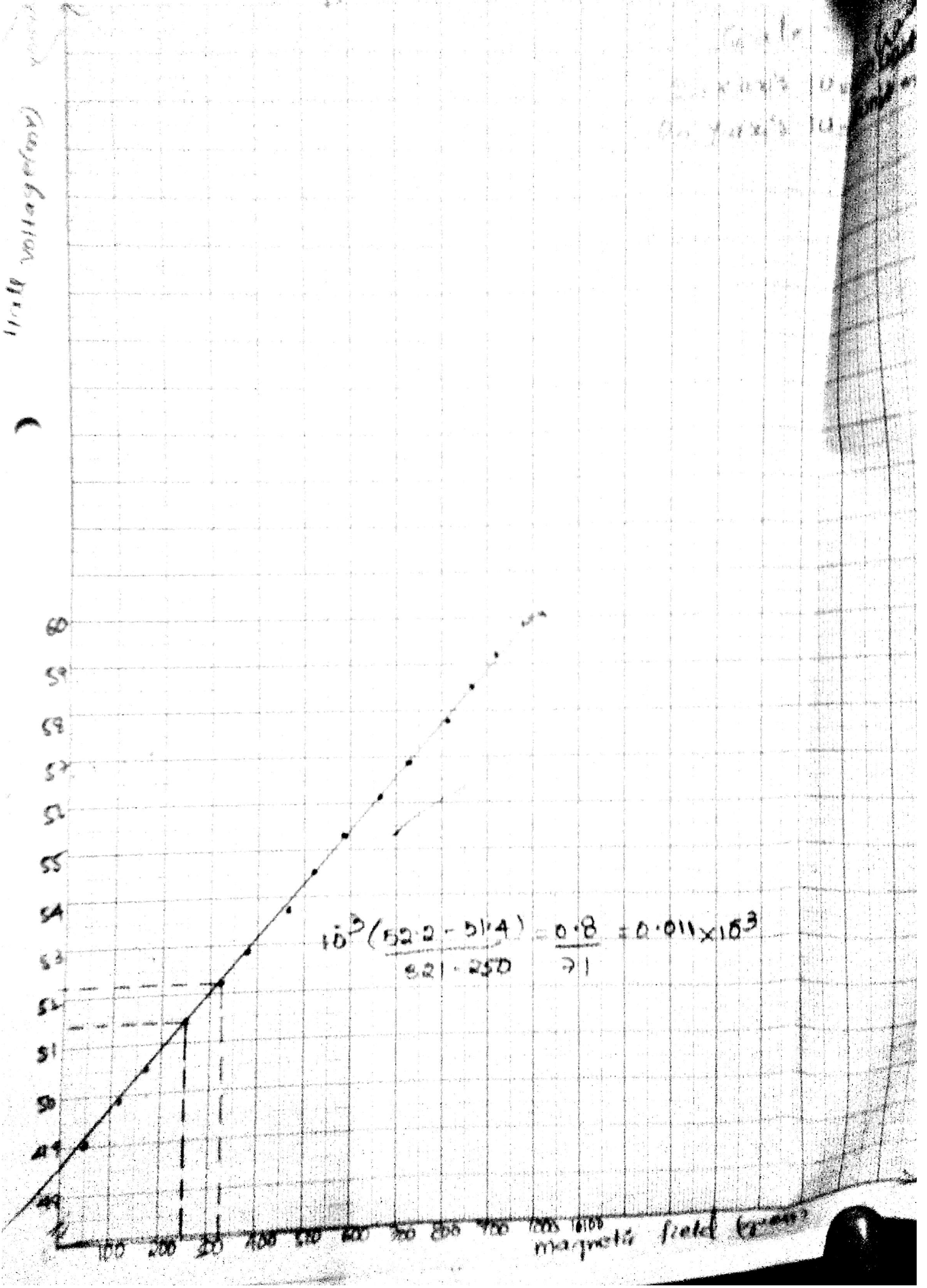
Connect the widthwise connections of the Hall probe to the terminals marked as 'voltage' and lengthwise connections to the terminals marked as 'current' and switch 'ON' the Hall effect setup. Turn the nob towards current side and slowly adjust the current to few mA say 2 or 3 mA (which is constant, flows through the sample). Then turn the nob towards the voltage side. This voltmeter measures the Hall voltage. Hall voltage (V_H) appears in the voltmeter only when magnetic field is applied. But sometimes voltmeter may show some value (V_o) even in the absence of applied and find out the slope.

OBSERVATIONS:

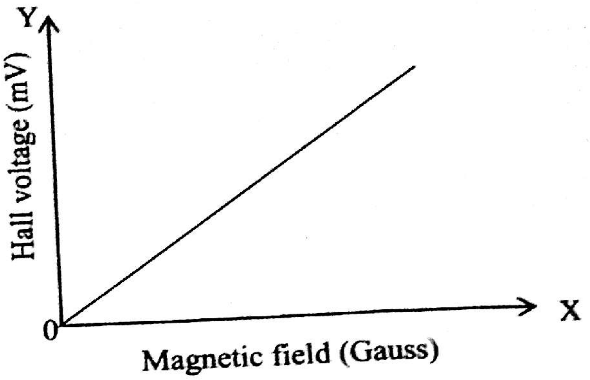
Thickness of the sample (d) = 0.05 cm

Current passing through the specimen I_X = 10.00 mA

S.No.	Current passed through electromagnet (Amp)	Corresponding magnetic field Gauss	Hall Voltage (V_H) mV
	0.1	6. (Bz)	48.2
	0.3	50	49.
	0.6	117	49.5
	0.9	171	50.5
	1.2	250	51.4
	1.5	321	52.2
	1.8	381	52.9
	2.1	459	53.7
	2.4	521	54.5
	2.7	592	55.3
	3.0	663	56.1
	3.3	725	56.9
	3.6	802	57.7
	3.9	868	58.5
	4.2	927	59.2
	4.5	984	59.8
	4.6	1003	60


60
59
58
57
56
55
54
53
52
51
50
49
48
100
200
300
400
500
600
700
800
900
1000
magnetic field
$10^{-3}\frac{(52.2-51.4)}{321-250} = \frac{0.8}{71} = 0.011\times10^{-3}$

GRAPH :



CALCULATIONS:

1. $R_H = (\text{Slope})\frac{d}{I_X} = \frac{(0.011)(0.05)\times 10^{-3}}{10\times 10^{-3}}$ cm^3/colomb $= 0.055\times 10^{-2} = 5.5\times 10^{-5}$

2. Carrier concentration $n = \frac{1}{R_H e} =$ cm^{-3} $\frac{1}{5.5\times 10^{-5}\times 1.6\times 10^{-19}} = 0.1136\times 10^{22}$

3. Mobility $(\mu) = \sigma R_H =$ cm^2.V^{-1}.sec^{-1}. $(0.1)(5.5\times 10^{-5})$ $= 5.5\times 10^{-3}\times 10^{-3} = 5.5\times 10^{-6}$

RESULT: The Hall coefficient, Carrier concentration and mobility of a given semiconductor are $0.055\times 10^{-3} = 5.5\times 10^{-5}$, $0.1136\times 10^{22} = 1.136\times 10^{23}$ & 5.5×10^{-6}

31/01

PRECAUTIONS:

1. Keep the sample perpendicular to the magnetic field
2. Before switching on the Hall effect set up, see that all knobs are set to read zero
3. Hall probe must be handled carefully
4. Do not send the high currents through the electromagnetic for longer times

PLANCK'S CONSTANT

AIM:

(i) To draw I-V Charecteristics of a given photo cell and (ii) to determine the Planck's constant (h).

APPARATUS:

Power supply, ammeter, lamp house and photocell etc.

PRINCIPLE & FORMULA:

The Planck's constant is given by

maximum energy of any of the electrons is equal to: $E=h\nu=hc/\lambda=eVs$

i.e., $$\frac{hc}{\lambda 1}=eV_1$$

$$\frac{hc}{\lambda 2}=eV_2$$

$$e(V_1-V_2) = hc\left(\frac{1}{\lambda 1}-\frac{1}{\lambda 2}\right)$$

$$e(V_1-V_2) = hc\left(\frac{\lambda 2-\lambda 1}{\lambda 1\,\lambda 2}\right)$$

$\boxed{E=\frac{hc}{\lambda}}$

$h=\frac{e(V_2-V_1)\lambda_1\lambda_2}{c(\lambda_1-\lambda_2)}$

N.A

or

$$h=\frac{e(V_2-V_1)\lambda_1\times\lambda_2}{C(\lambda_1-\lambda_2)} \quad \text{Joule - sec}$$

where e = charge of electron

V_2 = stopping potential, corresponding to wavelength 2

V_1 = stopping potential, corresponding to wavelength 1

C = velocity of light

λ_1 λ_2 are wavelengths of the incident light on the photocell

Normal ; 50V

sensitive ; 1V

PROCEDURE:

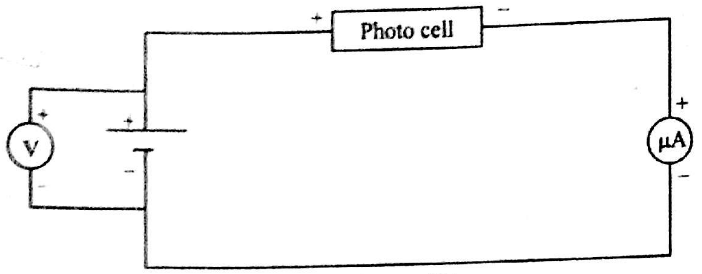
1. Set the zero adjustment of the instrument.

To measure saturation current:

2. The lamp house arrangement is adjusted to get a well focused spot. The photocell is placed 10 to 15 cm away from the lamp house. Make the connections and set the knobs to high voltage and normal mode (Forward potential)
3. Vary the input voltages and note the corresponding current readings till saturation is observed.
4. Repeat the same for two distances between photocell and the lamp house.

To measure the stopping potential:

1. Interchange the connections across the photo cell
2. Set the switches to low voltage and sensitivity mode to get the stopping potential.
3. Note the corresponding voltage (stopping potential) where current reduces to zero by placing a filter in front of photocell .
4. This is repeated using filters of different colours i.e. different wavelengths and also with white light source.



Forward bias

30

TABLE-I

d1= **cm** **d2=** **cm**

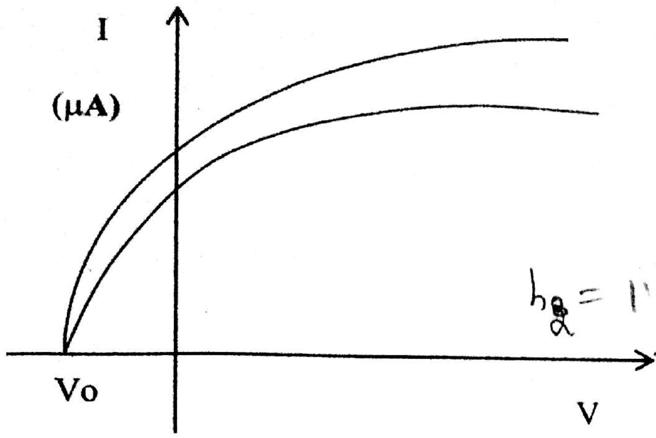
S. No.	Voltage (V)	Current (μA)
1	0	5
2	1	46
3	2	65
4	3	68
5	4	70
6	5	71
7	6	72
8	7	72
9	8	72
10	9	72

S. No.	Voltage (V)	Current (μA)
11	10	72
12	11	
13	12	
14	13	
15	14	
16	15	
17	16	
18	17	
19	18	
20	19	

Stopping potential using white light source: = 0.66

GRAPH:

Plot the graphs by taking potential on X-axis and current on Y-axis for white light with different intensities.



$$h_1 = \frac{1.6\times10^{-19}(0.32-0.6)\,4725\times5290\times10^{-20}}{3\times10^{8}(4725-5290)\times10^{-10}} = 6.6\times10^{-34}$$

$$h_2 = \frac{1.6\times10^{-19}(0.12-0.32)\,6150\times5290\times10^{-20}}{3\times10^{8}(5290-6150)\times10^{-10}}$$

4.1031×10^{-34}

$$h_3 = \frac{1.6\times10^{-19}(0.6-0.12)\times6150\times4725\times10^{-20}}{3\times10^{8}(6150-4725)\times10^{-10}}$$

5.22×10^{-34}

TABLE-II (Stopping potential)

S.No.	Colour	Wavelength (λ)	Stopping potential (V)
1	Blue	4725	0.6
2	Green	5290	0.32
3	Orange	6150	0.12

CALCULATIONS:

$$h = \frac{e(V_2 - V_1)\lambda_1 \times \lambda_2 \times 10^{-20}}{C(\lambda_1 - \lambda_2)\times 10^{-10}} \text{ Joule} - \text{sec}$$

$h = 6.6\times10^{-34}$

RESULT:

1. The planck's constant is found to be: 5.28×10^{-34} J-Sec
2. Write inference from the graph:

PRECAUTIONS:

1. Do not place the light source very close to the photocell.
2. Handle the photocell carefully
3. Stopping potential should be read carefully.
4. Zero adjustment should be done carefully.

P–N JUNCTION DIODE

AIM:

To study the I-V characteristics of P–N Junction diode and to calculate resistance of a diode in forward and reverse bias.

APPARATUS:

Power supply, Voltmeter, Ammeter, Diode and connecting wires

PRINCIPLE:

When a P–type material joined with N–type a P–N Junction is formed. The plane dividing the two zones is known as a junction. Due to diffusion some of the electrons from N–region cross over to P–region where they combine with holes and holes from P–region cross over to N–region where they combine with electrons and become neutral. Thus a layer is formed which is known as depletion layer or charge free region or space charge region because there is no charge available for conduction. The diffusion of the electrons and holes across the junction continues till a potential barrier is developed in depletion layer or space charge regions which prevents further diffusion or neutralization. The potential barrier can be increased or decreased by applying an external voltage.

Forward Bias:

When the junction is forward biased i.e., when the +ve terminal of the battery is connected to the P-type and –ve terminal is connected to the N–type material, the holes from P–type semi conductor are repelled by positive of the battery towards the junction and simultaneously the electrons in N–type semi conductor are repelled by negative terminal of the battery towards the junction. Here battery voltage should be high to impart, sufficient energy to these carriers to overcome the potential barrier at the junction and enable them to cross through it. Hence large current flows so long as the battery voltage is applied.

Reverse Bias:

The effect of reverse bias is to increase the potential barrier thus allowing a very little current to flow. When the junction is reverse biased i.e., when the +ve terminal of the battery connected to the N–type and –ve terminal is connected to the P-type material, the electrons in N–type semi conductors and holes in P–type semi conductors are attracted away from the junction under the action of applied voltage. Since there is no recombination of electron-hole pairs, the current is negligibly small.

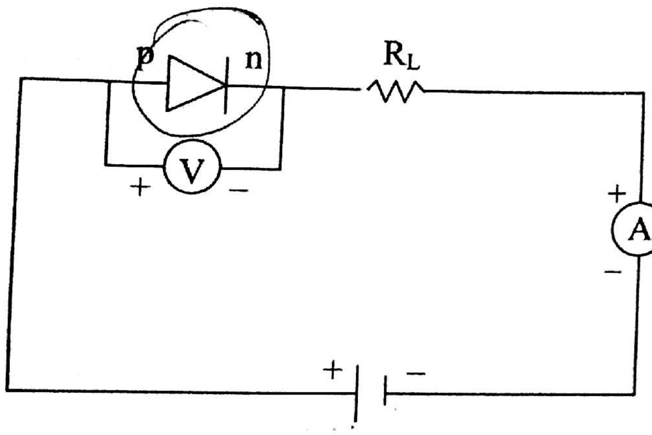
PROCEDURE:

a) Forward bias:

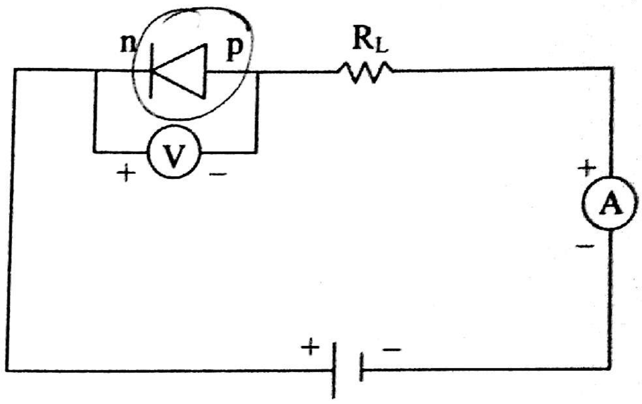
1. Connect the circuit as shown in the fig. (1)
2. Vary the potential difference and note the corresponding current value.
3. Draw the graph by taking potential or voltage (V) on X-axis and current (I) on Y-axis.

b) Reverse bias:

1. Make the connections as shown in fig (2).
2. Vary the potential difference and note the corresponding current value.
3. Draw the graph by taking potential or voltage (V) on X-axis and current (I) on Y-axis.

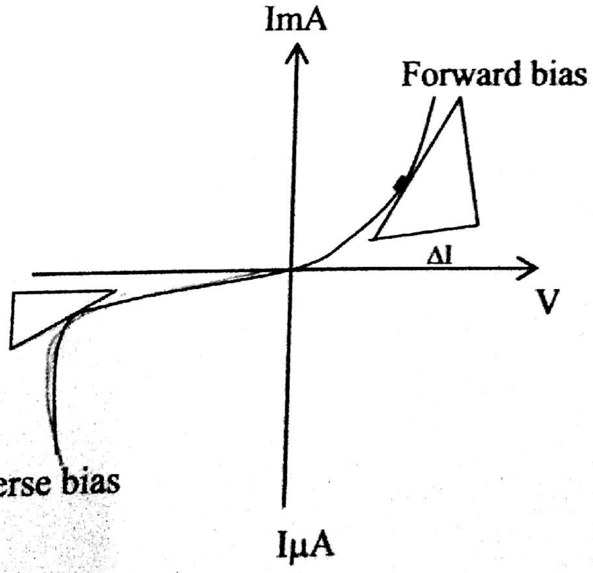


Forward bias



Reverse bias

Hyndavi Reddy



CALCULATIONS: From the graph, determine the slope, reciprocal of this slope gives the resistance

$$R_{F.B} = \frac{\Delta V}{\Delta I}, \quad R_{R.B} = \frac{\Delta V}{\Delta I}$$

RESULT: The characteristics of P-N junction diode have been studied and the resistance is found to be ....200.... Ω in forward bias and ....2K105.... Ω in reverse bias.

200KΩ

1 0 R

2/1

PRECAUTIONS:

1. See that the connections are made properly
2. Identify proper biasing.
3. Do not apply voltage beyond certain values in either bias.

TABLE:

Forward bias				Reverse bias		
S.No.	V (volts)	I (mA)		S.No.	V (volts)	I (μA)
1	0	0			0	0
	50	0			0.5	13.4
	100	0			1	15.6
	150	0			1.5	17.6
	200	0.2			2	19.6
	250	0.3			2.5	21.8
	300	0.5			3	24.2
	350	0.7			3.5	26.4
	400	1.0			4	28.7
	450	1.3			4.5	31.3
	500	1.5			5	33.8
	550	1.8			5.5	36.1
	600	2.1			6	38.7
	650	2.5			6.5	41.4
	700	2.8			7	44
	750	3.1			7.5	46.6
	800	3.5			8	49.4
	850	3.9			8.5	52.1
	900	4.3			9	55.4

A.7

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CHARACTERISTICS OF THERMISTOR

AIM:

To study the temperature characteristics of a thermistor and to evaluate the temperature co-efficient of resistance of a thermistor.

APPARATUS:

temp p-ch
temp-coeff.

ETB panel which consists of a thermistor, potentiometer of DC voltage 0-10 volts, micro and milliammeter of ranges 2.5mA and 0-250μA, oven to heat the thermistor.

PRINCIPLE & FORMULA:

Thermistors are semiconductor devices. The conductivity of semiconductors is due to the electrons and holes present. When the temperature is increased, then due to thermal energy, new hole-eectron pairs are generated by breaking the covalent bonds. This increment of charge carrier icreases the conductivity and decreases the resistivity of the semiconductor devices.

Thermistors have large negative temperature coefficient of resistance. This property enables them to be used as 'Thermometers' over restricted ranges and makes them valuable as resistance control devices in the condition of changing temperature.

The equation governing the variation of resistance R of a thermistor with temperature T may be written as:

$$R = Ae^{\left(\frac{B}{T}\right)} \qquad ----- \qquad (1)$$

Where A and B are constants depending upon size and mode mounting and material of Thermistor respectively. By the definition the temperature coefficient of resistance α is given as

$$\alpha = \frac{1}{R}\left(\frac{dR}{dT}\right) \qquad ----- \qquad (2)$$

$\alpha = \frac{1}{R}\left(\frac{dR}{dT}\right)$

Since $R = Ae^{x}$ where $x = BT^{-1}$

$$\frac{dR}{dX} = Ae^{x} \text{ and } \frac{dx}{dT} = -\frac{B}{T^2}$$

$R = Ae^{x}$

$x = BT^{-1}$

Therefore

$$\frac{dR}{dT} = \left(\frac{dR}{dx}\right)\cdot\left(\frac{dx}{dT}\right) = Ae^{x}\left(-\frac{B}{T^2}\right) = -\left(\frac{AB}{T^2}\right)e^{\left(\frac{B}{T}\right)}$$

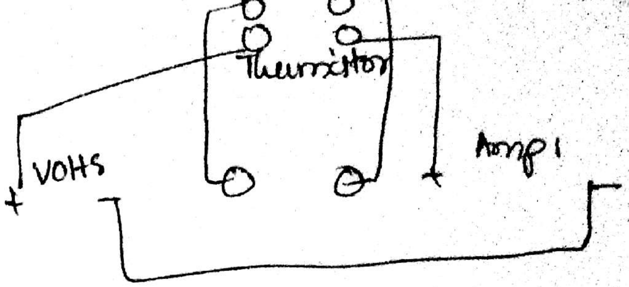
$\frac{dR}{dx} = Ae^{x}$ $\frac{dx}{dt} = \frac{-B}{T^2}$

Therefore

$$\alpha = \left\{\frac{1}{Ae^{\left(\frac{B}{T}\right)}}\right\} - \left(\frac{AB}{T^2}\right)e^{\left(\frac{B}{T}\right)}$$

$\frac{dR}{dt} = \frac{-AB}{T^2} e^{B/t}$

$$\alpha = -\frac{B}{T^2} \qquad ----- \qquad (3)$$



take natural log on both sides of equation (1), we have

$$\log_e R = \log_e A + \frac{B}{T}$$

Hence a graph of $\log_e R$ against $\frac{1}{T}$ gives a straight line whose slope yields the value of constant B and whose intercept on the Y-axis enables 'A' to be found. Hence the temperature coefficient of resistance α is given by equation (3).

PROCEDURE:

First let oven supply be off and fix the thermistor in the respective place and connect the thermistor lead to the point. Indicate 'Thermistor' input and put on the D.C power supply and set constant DC voltage by adjusting the nob and take down the reading of D.C. milliammeter on the appropriate scale (i.e. either on 250μA or 0-25mA which ever is suitable). This observation will give thermistor resistance at room temperature. Note down the current readings in regular intervals say for every 5°C while increasing and decreasing the temperature.

TABLE-I: $(2.9-3.3)\times10^{-3}$ R ⟶ –

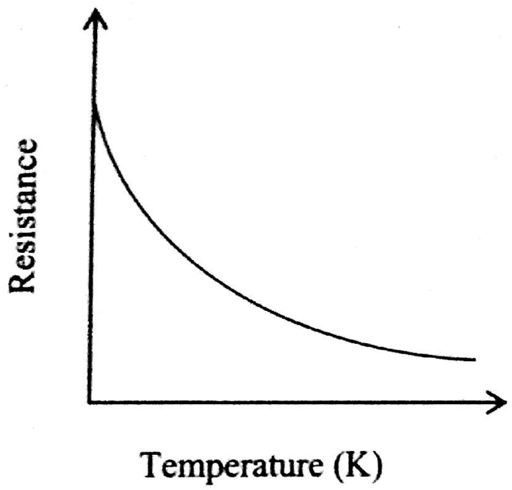
Voltage = 2.49 V initial+33°c

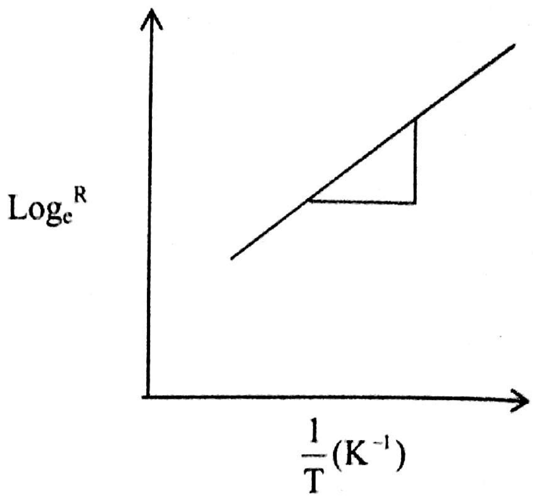
S.No.	Temperature		$\frac{1}{T}K^{-1}$	Current (I) μA			Resistance $\frac{V}{I}$ Ohms	$\log_e R$
	t°C	T°K +273		While increasing temperature	While decreasing temperature	Mean		
1	27	300	3.33×10^{-3}	27	27			
2	30	303	3.30×10^{-3}	85	30			
3	33	306	3.26×10^{-3}	99	$3\cancel{8}4$			
4	36	309	3.236×10^{-3}	138	37			
5	39	312	3.205×10^{-3}	149	41			
6	42	315	3.174×10^{-3}	196	45			
7	45	318	3.144×10^{-3}	236	50			
8	48	321	3.115×10^{-3}	293	55			
9	51	324	3.086×10^{-3}	295	60			
10	54	327	3.058×10^{-3}	326	67			
11	57	330	3.03×10^{-3}	368	76			9.325
12	60	333	3.003×10^{-3}	389	88			9.253

GRAPH:

1. Plot a graph by taking temperature (T) on X-axis and resistance (R) on Y-axis.
2. Plot a graph by taking $\frac{1}{T}$ on the X-axis and $\log_e R$ on the Y-axis.

The graph so obtained is a straight line not passing though the origin. The slope of the straight line is constant 'B' and the intercept on the y-axis is constant $\log_e{}^{A}$.





CALCULATIONS:

Constant A obtained from the graph =

Constant B obtained from the graph = Ohms °C

Temperature (T) = K

$$\alpha = \frac{1}{R}\frac{dR}{dT} = -\frac{B}{T^2} = K^{-1}$$

A, B, α.

RESULT:

The characteristic values A, B and negative temperature coefficient of resistance of a thermistor is found to be ______________, ________________ and ________________.

PRECAUTIONS:

1. Take the current readings when the temperature is constant
2. Also take the current readings along with increased and decreased temperatures.
3. Temperature must not be raised beyond 75°C.

Record

Record

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