1.SPECIFIC RESISTANCE OF THE MATERIAL OF THE COIL USING METRE BRIDGE

AIM To determine the specific resistance of the material of the given coil using metre bridge

APPARATUS REQUIRED Meter bridge, galvanometer, key, resistance box, connecting wires, Lechlanche cell, jockey and high resistance.

FORMULA

$$\boldsymbol{\rho} = \frac{X\pi r^2}{L}\Omega m$$

where, ρ → Specific resistance of the given coil (Ωm)

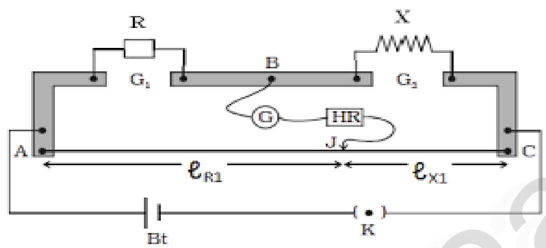
X → Resistance of the given coil (Ω)

R → Known resistance (Ω)

L → Length of the coil (m)

r → Radius of the wire (m)

CIRCUIT DIAGRAM



Procedure

- The arrangement of the apparatus should be as shown in the circuit diagram.
- All the other connections should be as shown in the circuit diagram.
- With a suitable resistance included in the resistance box, the circuit is switched on
- By moving the jockey over the wire, the point on the wire at which the galvanometer shows null deflection i.e., balancing point *J* is found.
- The balancing length *AJ*= *l* is noted.
- The unknown resistance X_1 is found using the formula $X_1 = \frac{R(100-l)}{l}$
- The experiment is repeated for different values of *R*.
- The same procedure is repeated after interchanging *R* and *X*.
- The unknown resistance $X_2$is found using the formula $X_2 = \frac{Rl}{(100-l)}$
- The experiment is repeated for same values of *R* as before.
- The resistance of the given coil is found from the mean value of *X*1 and *X*2.

- The radius of the wire *r* is found using screw gauge
- The length of the coil *L* is measured using meter scale.
- From the values of *X*, *r* and *L*, the specific resistance of the material of the wire is determined

OBSERVATION

length of the coil, L =100cm=1m

Table 1 To find the resistance of the given coil

S.NO	Resistance(R (Ω))	Before interchanging		After interchanging		Mean
		Balancing length l (cm)	$X_1=\frac{R(100-l)}{l}$ (Ω)	Balancing length l (cm	$X_2=\frac{Rl}{(100-l)}$ (Ω)	$X=\frac{X_1+X_2}{2}$(Ω)
1	2	25.9	5.772	74	5.692	5.732
2	3	34.1	5.798	65.8	5.772	5.785
3	4	40.9	5.780	59.1	5.779	5.736
					Mean resistance(X)	5.751

Table 2 To find the radius of the wire

Zero error = Nil

Zero correction = Nil

L.C=0.01mm

S.NO	PSR(mm)	HSC(div)	$Total\ reading = PSR + (HSC \times LC)mm$	Corrected reading= $TR \pm ZC$mm
1	0	58	0.58	0.58
2	0	58	0.58	0.58
3	0	59	0.59	0.59
4	0	58	0.58	0.58
5	0	59	0.59	0.59
Mean diameter (d)				0.584
Radius of the wire (r)=d/2				r =0.584/2=0.292mm

Radius of the wire $r = 0.292 \times 10^{-3} m$

CALCULATION

$X_1=\frac{R(100-l)}{l}$ $X_1=\frac{2(100-25.9)}{25.9}=\frac{2\times74.1}{25.9}=\frac{148.2}{25.9}$ $X_1=5.772$	$X_2=\frac{Rl}{(100-l)}$ $X_2=\frac{2\times74}{(100-74)}=\frac{148}{26}=5.692$ $X_2=5.692$
$X_1=\frac{R(100-l)}{l}$ $X_1=\frac{3(100-34.1)}{34.1}=\frac{3\times65.9}{34.1}=\frac{197.7}{34.1}$ $X_1=5.798$	$X_2=\frac{Rl}{(100-l)}$ $X_2=\frac{3\times65.8}{(100-65.8)}=\frac{197.4}{34.2}=5.772$ $X_2=5.772$
$X_1=\frac{R(100-l)}{l}$ $X_1=\frac{4(100-40.9)}{40.9}=\frac{4\times59.1}{40.9}=\frac{236.4}{40.9}$ $X_1=5.780$	$X_2=\frac{Rl}{(100-l)}$ $X_2=\frac{4\times59.1}{(100-59.1)}=\frac{236.4}{59.1}=5.692$ $X_2=5.692$
Mean $X=\frac{X_1+X_2}{2}=\frac{5.772+5.692}{2}=\frac{11.464}{2}=5.732$	$X=\frac{X_1+X_2}{2}=\frac{5.798+5.772}{2}=\frac{11.570}{2}=5.785$
$X=\frac{X_1+X_2}{2}=\frac{5.780+5.692}{2}=\frac{11.472}{2}=5.736$	Mean resistance(X) $X=\frac{5.732+5.785+5.736}{3}=\frac{17.253}{3}=5.751$

Specificresistance of the given wire $\rho=\frac{X\pi r^2}{L}$

Resistance of the wire(X) $= 5.751\Omega$
Radius of the wire(r) $= 0.292\times10^{-3}$m
Length of the wire(L) $= 1$m

Specificresistance of the given wire $\rho=\frac{5.751\times3.14\times0.292\times0.292\times10^{-6}}{1}$

$$\rho=\frac{5.751\times3.14\times0.292\times0.292\times10^{-6}}{1}$$

$$\rho=1.550\times10^{-6}\Omega m$$

RESULT: **The Specificresistance of the given wire $\rho=1.550\times10^{-6}\Omega m$**

2.HORIZONTAL COMPONENT OF EARTH'S MAGNETIC FIELD USING TANGENT GALVANOMETER

AIM : To determine the horizontal component of the Earth's magnetic field using tangent galvanometer

APPARATUS REQUIRED Tangent galvanometer (TG), commutator, battery, rheostat, ammeter, key and connecting wires.

FORMULA

$$B_H = \frac{\mu_0 nk}{2r} \ (Tesla)$$

$$k = \frac{I}{\tan\theta} (A)$$

where, B_H → Horizontal component of the Earth's magnetic field (T)

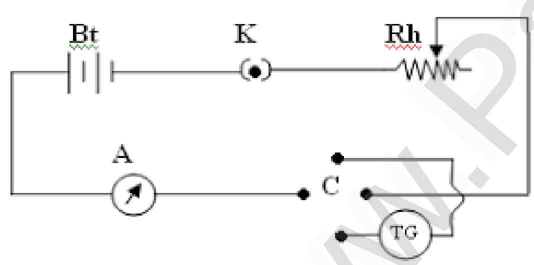
μ_0 → Permeability of free space ($4\pi \times 10^{-7}$ H m−1)

n → Number of turns of TG in the circuit (No unit)

k → Reduction factor of TG (A)

r → Radius of the coil (m)

CIRCUIT DIAGRAM



PROCEDURE

- The preliminary adjustments are made
- The connections are made as shown in circuit diagram
- The number of turns *n* is selected and the circuit is switched on.
- The range of current through TG is chosen in such a way that the deflection of the aluminium pointer lies between 30°-60°
- A suitable current is allowed to pass through the circuit, the deflections θ_1 and θ_2 are noted from two ends of the aluminium pointer.

- Now the direction of current is reversed using commutator C, the deflections θ_3 and θ_4 in the opposite directions are noted.
- The mean value θ of θ_1, θ_2, θ_3 and θ_4 is calculated and tabulated.
- The reduction factor k is calculated for each case and it is found that k is a constant.
- The experiment is repeated for various values of current and the readings are noted and tabulated.
- The radius of the circular coil is found by measuring the circumference of the coil using a thread around the coil.
- From the values of *r*, *n* and *k*, the horizontal component of Earth's magnetic field is determined

OBSERVATION

Number of turns of the coil n = 2

Circumference of the coil (2πr) =50cm $=50 \times 10^{-2}$

Radius of the coil $r = \frac{50\times10^{-2}}{2\pi} = 7.961 \times 10^{-2} m$

S.NO	Current(I) (A)	Deflection in TG (IN Degree)				Mean θ (in degree)	$k = \frac{I}{\tan\theta}(A)$
		θ_1	θ_2	θ_3	θ_4		
1	1.4	31°	31°	31°	31°	31°	2.329
2	1.6	36°	36°	36°	36°	36°	2.202
3	1.8	40°	40°	40°	40°	40°	2.145
4	2	44°	44°	44°	44°	44°	2.071
				Mean (k)			2.187

Calculation

i)1. $k = \frac{I}{\tan\theta}(A)$

1. $k = \frac{1.4}{\tan 31°} = \frac{1.4}{0.6009} = 2.329$

2. $k = \frac{1.6}{\tan 36°} = \frac{1.6}{0.7263} = 2.202$

3. $k = \frac{1.8}{\tan 40°} = \frac{1.8}{0.8391} = 2.145$

$4. k = \frac{2}{\tan 44°} = \frac{2}{0.9657} = 2.071$

$$Mean\ (k) = \frac{2.329 + 2.202 + 2.145 + 2.071}{4} = 2.187$$

ii)To find

$\mathbf{B_H}$ → Horizontal component of the Earth's magnetic field

$$B_H = \frac{\mu_0 n k}{2r}\ (Tesla)$$

Here

$\mu_0 = 4 \times \pi \times 10^{-7} \mathrm{H/m}$

n − number of turns of TG in the circuit = 2

k − reduction factor of TG = 2.187 A

r − radius of the coil = 7.961×10^{-2} m

$$B_H = \frac{4 \times 3.14 \times 10^{-7} \times 2 \times 2.187}{2 \times 7.961 \times 10^{-2}}$$

$$B_H = \frac{4 \times 3.14 \times 10^{-5} \times 2.187}{7.961}$$

$$B_H = \frac{27.468 \times 10^{-5}}{7.961}$$

$$B_H = 3.405 \times 10^{-5}\ \mathrm{Tesla}$$

RESULT

The horizontal component of Earth's magnetic field is found to be $B_H = 3.405 \times 10^{-5}\ Tesla$

3.COMPARISON OF EMF OF TWO CELLS USING POTENTIOMETER

AIM To compare the emf of the given two cells using a potentiometer

APPARATUS REQUIRED Battery eliminator, key, rheostat, DPDT switch, Lechlanche and Daniel cells, galvanometer, high resistance box, pencil jockey and connecting wires

FORMULA

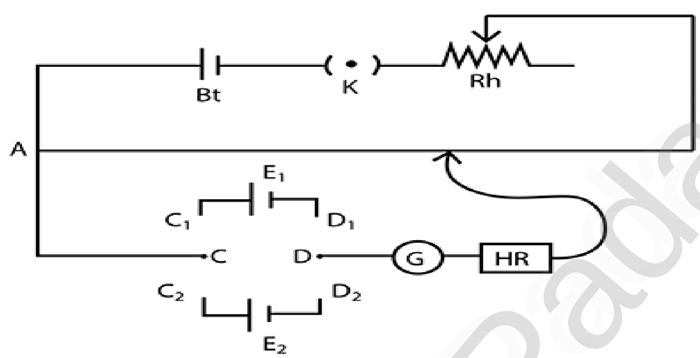
$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2} \ (no\ unit)$$

where,

ε_1 and ε_2 are the emf of Lechlanche and Daniel cells respectively (V)

l_1 and l_2 are the balancing lengths for Lechlanche and Daniel cells respectively (cm)

CIRCUIT DIAGRAM



PROCEDURE

- The apparatus is arranged as shown in the circuit diagram.
- The primary circuit consisting of battery, key and rheostat is connected to the potentiometer in series.
- The positive poles of the cells are connected to terminals C1 & C2 and the negative poles to terminals D1 & D2 of the DPDT switch. The potentiometer is connected to the common terminals C and D as shown in the circuit.
- Using the two-way key, Lechlanche cell is included in the circuit. By sliding the jockey on the potentiometer wire, the balancing point is found and the corresponding balancing length is measured.
- Similarly, the balancing length is found by including Daniel cell in the circuit.
- The experiment is repeated for different sets of balancing lengths by adjusting the rheostat.
- From different values of l_1 and l_2 , the ratio of emf of the two cells is calculated.

OBSERVATION

Table: To find the ratio of emf of two cells

S.NO	Balancing length for lechlanche cell l_1 cm	Balancing length for Daniel cell $l_2 cm$	$\frac{\varepsilon_1}{\varepsilon_2}=\frac{l_1}{l_2}$ $(no\ unit)$
1	598	446	1.341
2	686	497	1.380
3	725	526	1.378
4	762	553	1.378
5	789	572	1.379
		$Mean\left(\frac{\varepsilon_1}{\varepsilon_2}\right)$	1.371

CALCULATION

1. $\frac{\varepsilon_1}{\varepsilon_2}=\frac{l_1}{l_2}=\frac{598}{446}=1.341$

2. $\frac{\varepsilon_1}{\varepsilon_2}=\frac{l_1}{l_2}=\frac{686}{497}=1.380$

3. $\frac{\varepsilon_1}{\varepsilon_2}=\frac{l_1}{l_2}=\frac{725}{526}=1.378$

4. $\frac{\varepsilon_1}{\varepsilon_2}=\frac{l_1}{l_2}=\frac{762}{553}=1.378$

5. $\frac{\varepsilon_1}{\varepsilon_2}=\frac{l_1}{l_2}=\frac{789}{572}=1.379$

$$Mean\left(\frac{\varepsilon_1}{\varepsilon_2}\right)=\frac{1.341+1.380+1.378+1.378+1.379}{5}=1.371$$

RESULT

Ratio of emf of the given two cells $\left(\frac{\varepsilon_1}{\varepsilon_2}\right)=1.371(\ nounit)$

4. REFRACTIVE INDEX OF THE MATERIAL OF THE PRISM

AIM To determine the refractive index of the material of a prism using spectrometer

APPARATUS REQUIRED Spectrometer, prism, prism clamp, sodium vapour lamp, spirit level.

FORMULA

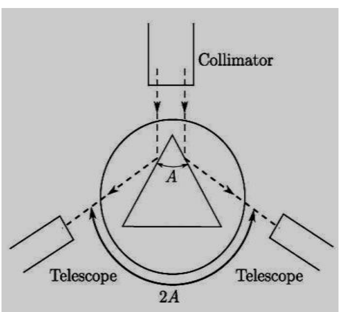
$$\mu = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)} \quad (no\ unit)$$

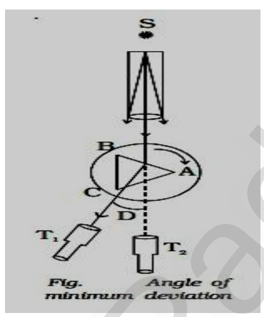
where,

μ → Refractive index of the material of the prism (No unit)

A → Angle of the prism (degree)

D → Angle of minimum deviation (degree)





PROCEDURE

Least count

1 MSD = 30′

Number of vernier scale divisions = 30

For spectrometer, 30 vernier scale divisions will cover 29 main scale divisions.

∴ 30 VSD = 29 MSD

Or 1 VSD = $\frac{29}{30} MSD$

Least count (LC) = 1 MSD – 1 VSD

$$LC = \frac{1}{30} MSD$$

$$LC = \frac{1}{30} \times 30' = 1'$$

The preliminary adjustments of the spectrometer is made, the slit is illuminated with sodium vapor lamp

i)Determination of angle of the prism (A)

- The prism is placed on the prism table with its refracting edge is facing the collimator.
- The light emerging from the collimator is incident on both reflecting faces of the prism and is reflected.
- The telescope is rotated towards left to obtain reflected image of the slit from face 1 of the prism vernier A and vernier B readings are noted
- The telescope is now rotated towards right to obtain the reflected image from face 2 of the prism. As before, the readings are taken.
- The difference between the two readings gives 2A from which the angle of the prism A is calculated.

Determination of angle of minimum deviation (D)

- The prism table is rotated such that the light emerging from the collimator is incident on one of the refracting faces of the prism, gets refracted and emerges out from the other refracting face.
- The telescope is turned to view the refracted image.
- Looking through the telescope, the prism table is rotated in such a direction that the image moves towards the direct ray.
- At one particular position, the refracted ray begins to retrace its path. The position where the refracted image returns is the position of minimum deviation.
- The telescope is fixed in this position and is adjusted until the vertical cross-wire coincides with the refracted image of the slit.
- The readings are taken from both vernier scales.
- The prism is now removed and the telescope is rotated to obtain the direct ray image and the readings are taken.
- The readings are tabulated and the difference between these two readings gives the angle of minimum deviation D.
- From the values of A and D, the refractive index of the material of the glass prism is determined.

OBSERVATION

Table 1 To find the angle of the prism (A)

Image	Vernier A			Vernier B		
	MSR	VC	TR	MSR	VC	TR
Reflected image from face 1	36°	12	36°12'	216°	16	216°16'
Reflected image from face 2	156°	16	156°16'	336°	20	336°20'
Difference 2A	156°16'-36°12'=120°4'			336°20'-216°16'=120°4'		
Mean 2A= $\frac{120°4'+120°4'}{2} = \frac{240°8'}{2} = 120°4'$						
Mean A = $\frac{120°4'}{2} = 60°2'$						

$\therefore$ The angle of the given prism $A = 60°2'$

Table 2 To find the angle of minimum deviation (D)

Image	Vernier A			Vernier B		
	MSR	VC	TR	MSR	VC	TR
Refracted image	39°	12	39°12'	219°	12	219°12'
Direct image	0°	0	0°0'	180°	0	180°0'
Difference D	39°12'-0°0'=39°12'			219°12'-180°0'=39°12'		

Mean D=39°12'

$\therefore$ The angle of minimum deviation $D = 39°12'$

CALCULATION

$$\mu = \frac{sin\left(\frac{A+D}{2}\right)}{sin\left(\frac{A}{2}\right)}$$

$$\mu = \frac{sin\left(\frac{60°2' + 39°12'}{2}\right)}{sin\left(\frac{60°2'}{2}\right)}$$

$$\mu = \frac{sin\left(\frac{99°14'}{2}\right)}{sin\left(\frac{60°2'}{2}\right)}$$

$$\mu = \frac{sin(49°37')}{sin(30°1')}$$

$sin(49°37') = 0.7617$, $sin(30°1') = 0.5015$

$\mu = \frac{0.7617}{0.5015}$ =1.518

RESULT:

Refractive index of the material of the prism=1.518 (No unit)

5.WAVELENGTH OF THE CONSTITUENT COLOURS OF A COMPOSITE LIGHT USING DIFFRACTION GRATING AND SPECTROMETER

AIM : To determine the wavelength of the constituent colours of a composite light using diffraction grating and spectrometer

APPARATUS REQUIRED Spectrometer, mercury vapour lamp, diffraction grating, grating table, and spirit level.

FORMULA

$$\lambda = \frac{\sin\theta}{nN} \text{A}^0$$

where, λ → Wavelength of the constituent colours of a composite light (A^0)

N → Number of lines per metre length of the given grating (No unit) (the value of N for the grating is given) **6000 lines per centimetre**

n → Order of the diffraction (No unit)

θ → Angle of diffraction (degree)

PROCEDURE

Least count

1 MSD = 30′

Number of vernier scale divisions = 30

For spectrometer, 30 vernier scale divisions will cover 29 main scale divisions.

∴ 30 VSD = 29 MSD

Or 1 VSD = $\frac{29}{30} MSD$

Least count (LC) = 1 MSD – 1 VSD

$$LC = \frac{1}{30} MSD$$

$$LC = \frac{1}{30} \times 30' = 1'$$

The preliminary adjustments of the spectrometer is made, the slit is illuminated with mercury vapor lamp

Adjustment of the grating for normal incidence

- The telescope is exactly opposite to the cross wires made coincide with the image of the slit
- The prism table is adjusted such that the two-venier readings are 0^0 and 180^0 .In this position the vernier table screw is fixed. This is the reading for the direct ray.
- Now the telescope is turned through 90^0
- The grating is placed on the prism table vertically the grating is adjusted, such that the reflected image of the slit is made to coincide with the vertical cross wires of the telescope
- Now the vernier disc is released. The vernier disc along with grating table is rotated through an angle of 45^0 in the appropriate direction such that the light from the collimator is incident normally on the grating

Determination of wave length of the constituent colours of the mercury spectrum

- The telescope is turned opposite to the collimator and focuses the telescope on to the left side first order spectrum.
- The vertical wire is made to coincide with the violet spectral line and note the readings of VA,VB
- Repeat the experiment for the other spectral lines and the readings are tabulated
- Now the telescope is focused on the right side of the spectral line, the experiment is repeated above from violet to red and the readings VA', VB' are noted in the tabular colum
- The difference between these two readings gives the value of 2θ for the particular spectral line.

DIAGRAMS

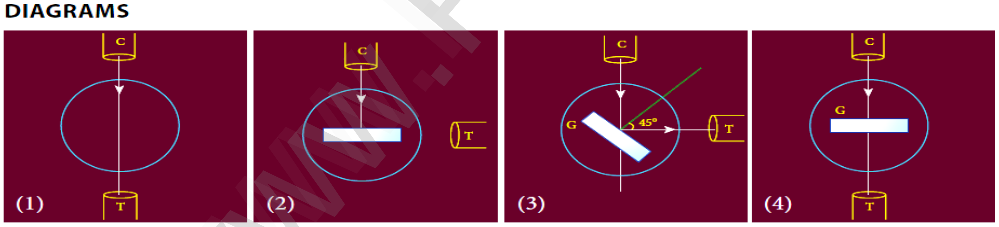


Figure (a) Normal incidence

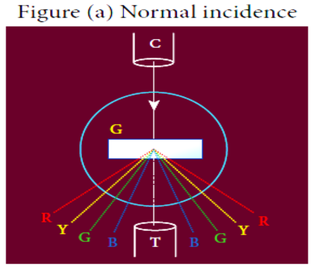


Figure (b) Angle of diffraction

OBSERVATION

Least count=1' Direct ray reading : 0° & 180°

Colour of the light	Diffracted ray reading(in Degree)												Difference (2θ) In degree			θ In degree
	LEFT						RIGHT									
	Vernier A			Vernier B			VernierA			Vernier B			VER A	VER B	MEAN	
	MSR	VC	TR	MSR	VC	TR	MSR	VC	TR	MSR	VC	TR				
Blue	209°	12	209°12'	29°	15	29°15'	239°	12	239°12'	59°	15	59°15'	30°	30°	30°	15°
Green	205°30'	22	205°52'	25°30'	22	25°52'	242°30'	12	242°42'	62°30'	12	62°42'	36°50'	36°50'	36°50'	18°25'
Yellow	204°30'	6	204°36'	24°30'	8	24°38'	243°30'	6	243°36'	63°30'	8	63°38'	39°	39°	39°	19°30'
Red	202°30'	20	202°50'	22°30'	12	22°42'	246°30'	20	246°50'	66°30'	12	66°42'	44°	44°	44°	22°

VERNIER CALCULATION

$$total\ reading = MSR + (VC \times LC)$$

$$total\ reading = 209° + (12 \times 1') = 209°12'$$

Calculation

To find the wave length of prominent colours of the mercury spectrum

i) For blue

$$for\ blue\ \lambda = \frac{\sin\theta}{nN}$$

$$Here\ \theta = 15°\ ,\quad n = 1\quad N = 6000 lines\ /cm = \ 6\times10^{5} lines/m$$

$$\therefore for\ blue\ \lambda = \frac{\sin 15°}{1\times6\times10^{5}}$$

$$\lambda = \frac{\sin 15°}{1\times6\times10^{5}}$$

$$\sin 15° = 0.2588$$

$$\lambda = \frac{0.2588}{1\times6\times10^{5}}$$

$$\lambda = 0.04313\times10^{-5}m$$

$$\lambda = 4313\times10^{-5}\times10^{-5}m$$

$$\boldsymbol{\lambda_b} = 4313A°$$

ii) For Green

$$for\ Green\ \lambda = \frac{\sin\theta}{nN}$$

$$Here\ \theta = 18°25'\ ,\quad n = 1\quad N = 6000 lines\ /cm = \ 6\times10^{5} lines/m$$

$$\therefore \lambda = \frac{\sin 18°25'}{1\times6\times10^{5}}$$

$$\sin 18°25' = 0.3159$$

$$\lambda = \frac{0.3159}{1\times6\times10^{5}}$$

$$\lambda = \frac{0.3159\times10^{-5}}{6}$$

$$\lambda = 0.05265\times10^{-5}m$$

$$\lambda = 5265\times10^{-5}\times10^{-5}m$$

$$\boldsymbol{\lambda_g} = 5265A°$$

iii) For Yellow

$$for\ Yellow\ \lambda = \frac{\sin\theta}{nN}$$

$$Here\ \theta = 19°30'\ ,\quad n = 1\quad N = 6000 lines\ /cm = \ 6\times10^{5} lines/m$$

$$\therefore \lambda = \frac{\sin 19°30'}{1\times6\times10^{5}}$$

$$\sin 19°30' = 0.3338\ \therefore$$

$$\lambda = \frac{0.3338}{1\times6\times10^{5}}$$

$$\lambda = \frac{0.3338\times10^{-5}}{6}$$

$$\lambda = 0.05563\times10^{-5}m$$

$\lambda = 5563 \times 10^{-5} \times 10^{-5} m$

$\boldsymbol{\lambda_y} = 5563 A°$

iv) For Red

$$for\ Red\ \lambda = \frac{\sin\theta}{nN}$$

$Here\ \theta = 22°$, $n = 1$ $N = 6000 lines/cm = 6 \times 10^5 lines/m$

$\therefore \lambda = \dfrac{\sin 22°}{1 \times 6 \times 10^5}$

$\sin 22° = 0.3746$

$\lambda = \dfrac{0.3746}{1 \times 6 \times 10^5}$

$\lambda = \dfrac{0.3746 \times 10^{-5}}{6}$

$\lambda = 0.06243 \times 10^{-5} m$

$\lambda = 6243 \times 10^{-5} \times 10^{-5} m$

$\boldsymbol{\lambda_r} = 6243 A°$

RESULT

1. The wavelength of blue line $\boldsymbol{\lambda_b = 4313 \times 10^{-10} m}$
2. The wavelength of green line $\boldsymbol{\lambda_g = 5265 \times 10^{-10} m}$
3. The wavelength of yellow line $\boldsymbol{\lambda_y = 5563 \times 10^{-10} m}$
4. The wavelength of red line $\boldsymbol{\lambda_r = 6243 \times 10^{-10} m}$

6. VOLTAGE-CURRENT CHARACTERISTICS OF A PN JUNCTION DIODE

AIM To draw the voltage-current (V- I) characteristics of the PN junction diode and to determine its knee voltage and forward resistance.

APPARATUS REQUIRED PN junction diode (IN4007), variable DC power supply, milli-ammeter, micro-ammeter, voltmeter, resistance and

FORMULA :

Forward resistance of the PN junction diode

$$R_f = \frac{\Delta V_f}{\Delta I_f}$$

Where,

ΔV_f → change in forward voltage (volt)

ΔI_f → change in forward current (volt)

CIRCUIT DIAGRAM

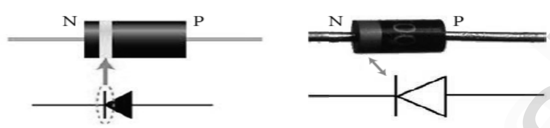


Figure (a) PN junction diode and its symbol (Silver ring denotes the negative terminal of the diode)

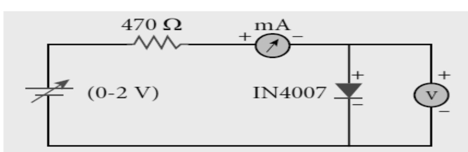


Figure (b) PN junction diode in forward bias

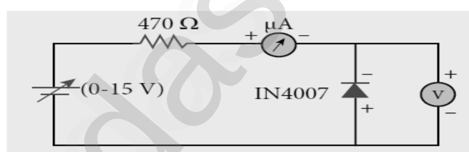


Figure (c) PN junction diode in reverse bias

PROCEDURE

i) Forward bias characteristics

- The connections are made as in the circuit..
- The voltage across the diode can be varied with the help of variable DC power supply..
- The forward voltage (VF) is increased from 0.1 V to 0.8 V in suitable equal steps.
- The corresponding current (IF) is noted from milli ammeter. VF and IF are positive..
- A graph is drawn by taking VF along X-axis and IF along Y-axis.
- From the forward characteristic curve, knee voltage is marked and noted. The reciprocal of the slope gives the forward resistance of the diode.

ii) Reverse bias characteristics

- The connections are made as in the circuit
- The voltage across the diode can be varied with the help of variable DC power supply
- The reverse voltage (VR) across the diode is increased from 1 V in steps of 1 V upto 5V

- The corresponding current IR is noted from the micro ammeter VR and IR are negative.

- The reverse voltage V_R and reverse current I_R are taken as negative
- A graph is drawn by taking VR along negative X-axis and IR along negative Y-axis.

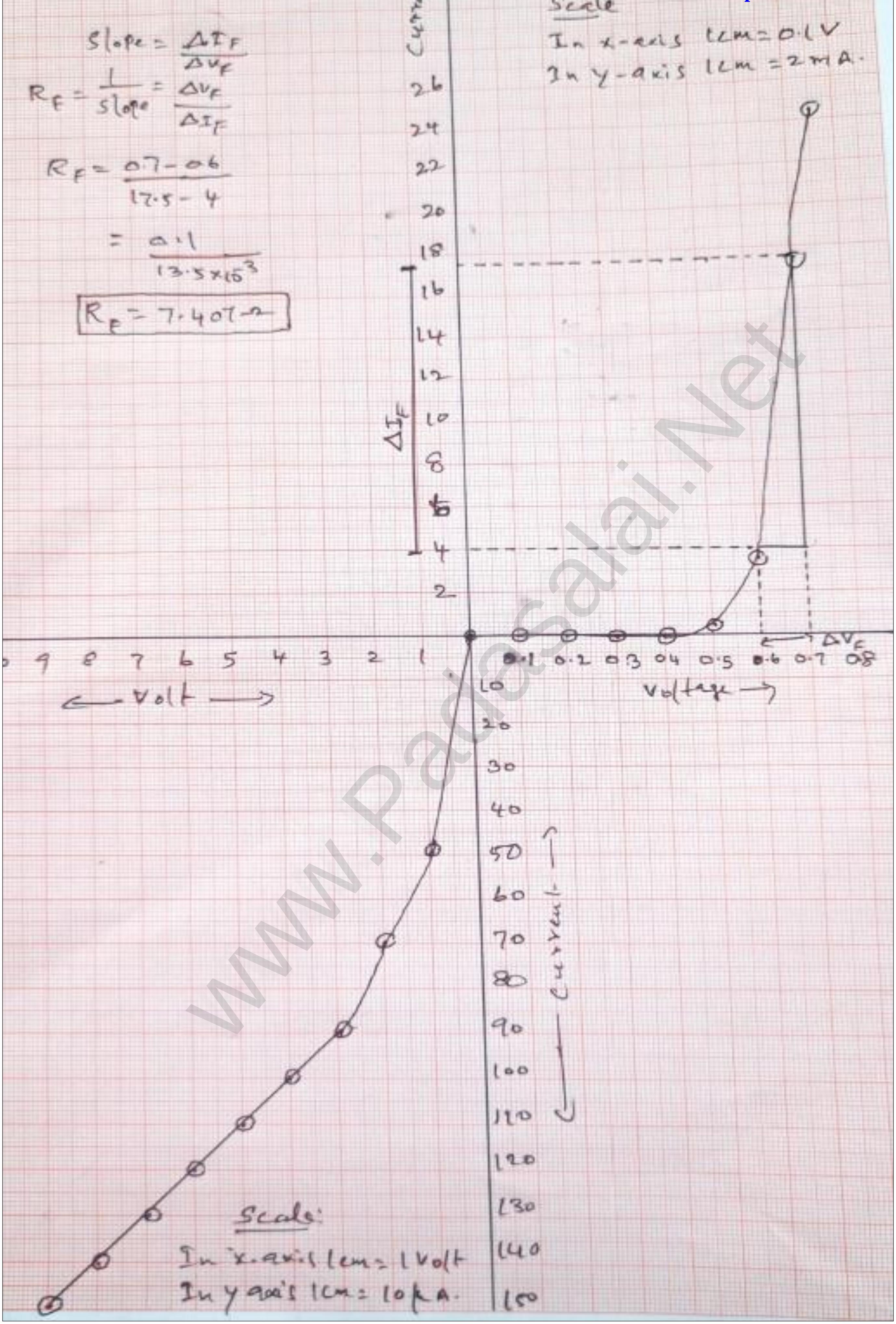
OBSERVATION

Table 1 Forward bias characteristic curve

S.NO	Forard bias voltageV_F (in volt)	Forwardbias current I_F (milli ampere)
1	0.1	0
2	0.2	0
3	0.3	0
4	0.4	0
5	0.5	0.5
6	0.6	3.5
7	0.7	17.5
8	0.8	24.5

Table 2 Reverse bias characteristic curve

S.NO	Reversebias voltageV_R (in volt)	Reversebias current I_R (microampere)
1	1	50
2	2	70
3	3	90
4	4	100
5	5	110
6	6	120
7	7	130
8	8	140
9	9	150
10	10	160


Slope = $\frac{\Delta I_F}{\Delta V_F}$
$R_F = \frac{1}{slope} = \frac{\Delta V_F}{\Delta I_F}$
$R_F = \frac{0.7 - 0.6}{17.5 - 4}$
$= \frac{0.1}{13.5 \times 10^{-3}}$
$R_F = 7.407 \Omega$
Scale
In x-axis 1cm = 0.1V
In y-axis 1cm = 2mA.
Current
ΔI_F
ΔV_F
Voltage →
← Volt →
Current
Scale:
In x-axis 1cm = 1Volt
In y axis 1cm = 10 µA.

CALCULATION :

- From the graph, the knee voltage is = 0.55 V
- Also from the graph,

$\Delta V_F = 0.1\ V$

$\Delta I_F = 13.5\ mA = 13.5 X\ 10^{-3}\ A$

$$slope = \frac{\Delta I_F}{\Delta V_F}$$

$$R_F = \frac{1}{SLOPE} = \frac{\Delta V_F}{\Delta I_F}$$

$$R_F = \frac{0.1}{13.5 \times 10^{-3}} = 7.407\Omega$$

RESULT

The V-I characteristics of the PN junction diode are studied.

(1) Knee voltage of the PN junction diode = $\mathbf{0.55\ V}$

(2) Forward resistance of the diode ; $\boldsymbol{R_F} = \mathbf{7}.407\ \mathbf{\Omega}$

7.VOLTAGE-CURRENT CHARACTERISTICS OF A ZENER DIODE

AIM :
To draw the voltage-current (V-I) characteristic curves of a Zener diode and to determine its knee voltage, forward resistance and reverse breakdown voltage.

APPARATUS REQUIRED :
Zener diode 1Z5.6V, variable dc power supply (0 – 15V), milli ammeter, volt meter, 470 Ω resistance, and connecting wires.

FORMULA :
Forward resistance of the PN junction diode

$$R_F = \frac{V_F}{I_F}\,\Omega$$

Where,
$\Delta \boldsymbol{Vf}$ → change in forward voltage (volt)

$\Delta \boldsymbol{If}$ → change in forward current (volt)

CIRCUIT DIAGRAM

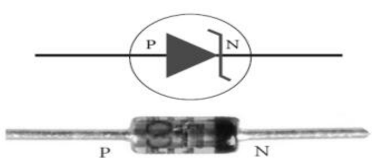


Figure (a) Zener diode and its symbol (The black colour ring denotes the negative terminal of the Zener diode)

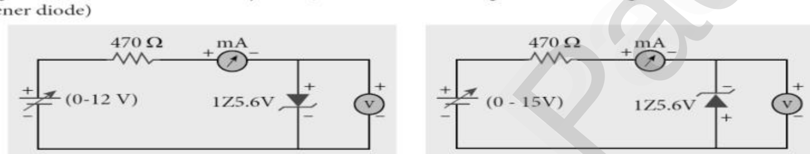


Figure (b) Zener diode in forward bias Figure (c) Zener diode in reverse bias

i)Forward bias characteristics

- In the forward bias, the P- region of the diode is connected to the positive terminal and N-region to the negative terminal of the DC power supply.
- The connections are given as per the circuit diagram.
- The voltage across the diode can be varied with the help of the variable DC power supply.
- The forward voltage (*V*F) across the diode is increased from 0.1V in steps of 0.1V up to 0.8V and the forward current (*I*F) through the diode is noted from the milli-ammeter. The readings are tabulated.

- The forward voltage and the forward current are taken as positive.
- A graph is drawn taking the forward voltage along the x-axis and the forward current along the y-axis.
- The voltage corresponding to the dotted line in the forward characteristics gives the knee voltage or threshold voltage or turn-on voltage of the diode.

- The slope in the linear portion of the forward characteristics is calculated. The reciprocal of the slope gives the forward resistance of the diode.

ii) Reverse bias characteristics

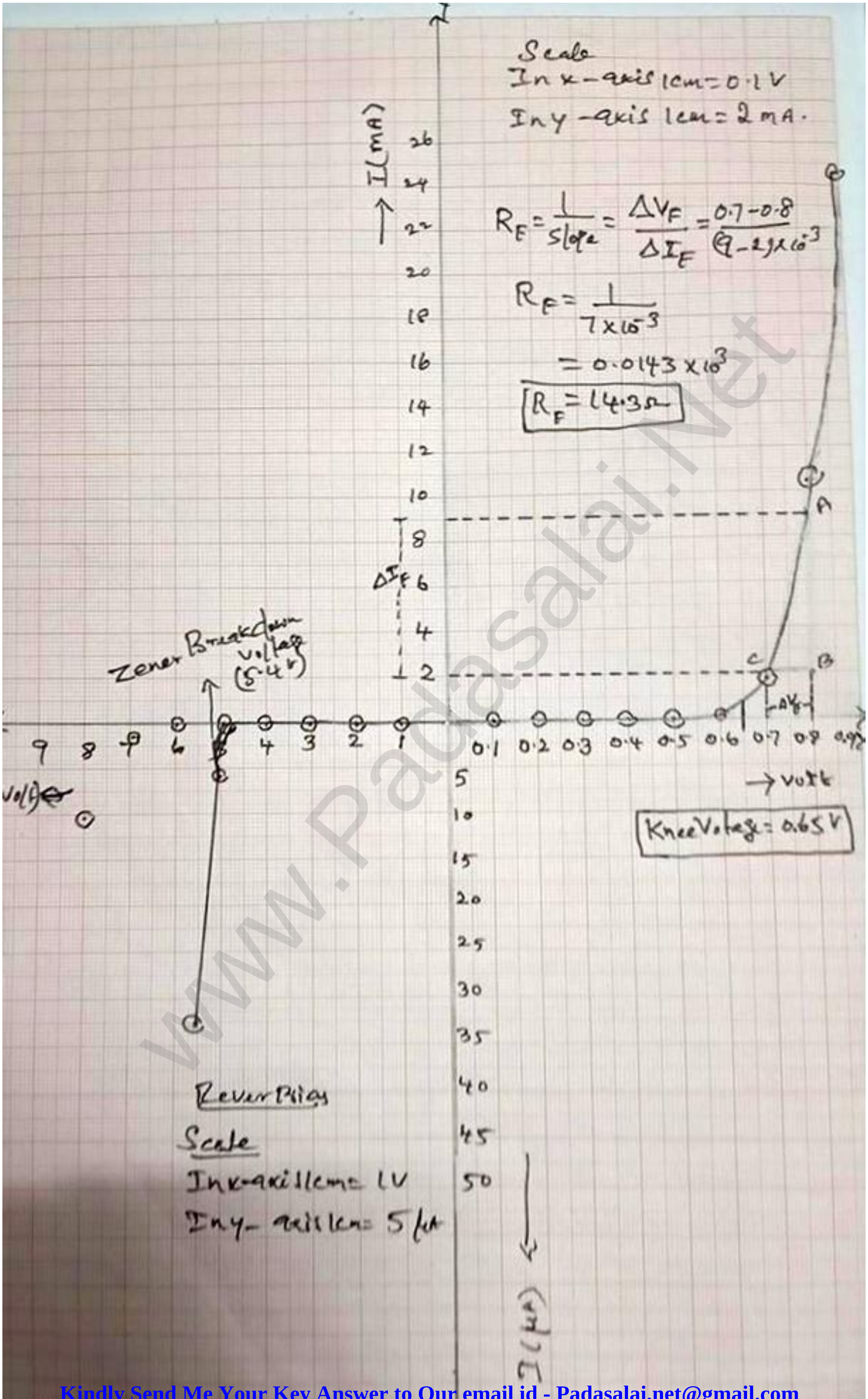
- In the reverse bias, the polarity of the DC power supply is reversed so that the P- region of the diode is connected to the negative terminal and N-region to the positive terminal of the DC power supply
- The connections are made as given in the circuit diagram.
- The voltage across the diode can be varied with the help of the variable DC power supply.
- The reverse voltage (*VR*) across the diode is increased from 0.5V in steps of 0.5V up to 6V and the reverse current (*IR*) through the diode is noted from the milli-ammeter. The readings are tabulated.
- Initially, the voltage is increased in steps of 0.5V. When the breakdown region is approximately reached, then the input voltage may be raised in steps of, say 0.1V to find the breakdown voltage.
- The reverse voltage and reverse current are taken as negative.
- A graph is drawn taking the reverse bias voltage along negative x-axis and the reverse bias current along negative y-axis.
- In the reverse bias, Zener breakdown occurs at a particular voltage called Zener voltage VZ (~5.6 to 5.8V) and a large amount of current flows through the diode which is the characteristics of a Zener diode.
- The breakdown voltage of the Zener diode is determined from the graph as shown.

OBSERVATION Table 1 Forward bias characteristic curve

S.NO	Forward bias voltage V_F (volt)	Forward bias current I_F (mA)
1	0.1	0
2	0.2	0
3	0.3	0
4	0.4	0
5	0.5	0
6	0.6	0.1
7	0.7	1.7
8	0.8	10.4
9	0.9	24.5

Table 2 Reverse bias characteristic curve

S.NO	Reverse bias voltage V_R (volt)	Reverse bias current I_R (mA)
1	1	0
2	2	0
3	3	0
4	4	0
5	5	6
6	5.45	34.8


Scale
In x-axis 1cm = 0.1 V
In y-axis 1cm = 2 mA.
$R_F = \frac{1}{slope} = \frac{\Delta V_F}{\Delta I_F} = \frac{0.7-0.8}{(9-2)\times10^{-3}}$
$R_F = \frac{1}{7\times10^{3}}$
$= 0.0143\times10^{3}$
$R_F = 14.3\Omega$
I (mA)
A
B
C
ΔI_F
ΔV_F
Zener Breakdown voltage (5.4V)
→ volt
Knee Voltage = 0.65 V
Reverse Bias
Scale
In x-axis 1cm = 1V
In y-axis 1cm = 5 μA
I (μA)

CALCULATION

From the graph

The knee voltage is= 0.65V

$\Delta V_F = 0.1V$

$\Delta I_F = 7 \times 10^{-3} A$

$$SLOPE = \frac{\Delta I_F}{\Delta V_F}$$

$$Forward\ resistance\ R_F = \frac{1}{Slope} = \frac{\Delta V_F}{\Delta I_F}$$

$$Forward\ resistance\ R_F = \frac{0.1}{7 \times 10^{-3}} = 0.0143 \times 10^3$$

$$Forward\ resistance\ R_F = 14.3\Omega$$

RESULT :

The V-I characteristics of the Zener diode are studied.

(1) Forward resistance of the diode : $\boldsymbol{R_F}$ **= 14.3 Ω**

(2) Knee voltage **= $\mathbf{0.65}\ \boldsymbol{V}$**

(3) The breakdown voltage of the Zener diode : $\boldsymbol{V_Z}$ **= 5. 4 V**

8. CHARACTERISTICS OF A NPN-JUNCTION TRANSISTOR IN COMMON EMITTER CONFIGURATION

AIM To study the characteristics and to determine the current gain of a NPN junction transistor in common emitter configuration.

APPARATUS REQUIRED Transistor - BC 548/BC107, bread board, micro ammeter, milli ammeter, voltmeters, variable DC power supply and connecting wires.

FORMULA

$$i) r_i = (\frac{\Delta V_{BE}}{\Delta I_B})_{V_{CE}} \quad \Omega \qquad ii)\ r_O = (\frac{\Delta V_{CE}}{\Delta I_C})_{I_B} \quad \Omega$$

$$iii)\ \beta = (\frac{\Delta I_C}{\Delta I_B})_{V_{CE}} \text{ no unit}$$

Where, r_i → Input impedance (Ω)
ΔV_{BE} → The change in base-emitter voltage (volt)
ΔI_B → The change in base current (μA)
r_o → Output impedance (Ω)
ΔV_{CE} → The change in collector-emitter voltage (volt)
ΔI_C → The change in collector current (mA)
β → Current gain of the transistor (No

CIRCUIT DIAGRAM

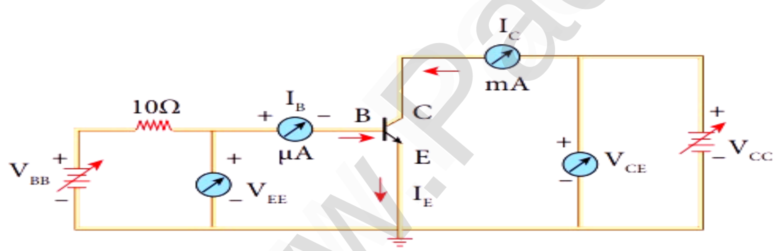


Figure (b) NPN junction transistor in CE configuration

PROCEDURE

- The connections are given as shown in the diagram.
- The current and voltage at the input and output regions can be varied by adjusting the DC power supply.

(i) Input characteristic curve: V_{BE} vs I_B (V_{CE} constant)

- The collector-emitter voltage V_{CE} is kept constant.
- The base-emitter voltage *VBE* is varied in steps of 0.1V and the corresponding base current (I_B) is noted. The readings are taken till V_{CE} reaches a constant value.

- The same procedure is repeated for different values of V_{CE}. The readings are tabulated.
- A graph is plotted by taking V_{BE} along x-axis and I_B along y-axis for both the values of V_{CE}.
- The curves thus obtained are called the input characteristics of a transistor.
- The reciprocal of the slope of these curves gives the input impedance of the transistor

S.NO	$V_{CE} = 1V$		$V_{CE} = 2V$	
	V_{BE} (volt)	I_B (μA)	V_{BE} (volt)	I_B (μA
1	0.1	0	0.1	0
2	0.2	0	0.2	0
3	0.3	0	0.3	0
4	0.4	0	0.4	0
5	0.5	2	0.5	2
6	0.6	6	0.6	6
7	0.7	30	0.7	34
8	0.8	70	0.8	80

(ii) Output characteristic curve: *VCE* vs *IC* (*IB* constant)

- The base current I_B is kept constant.
- V_{CE} is varied in steps of 1V and the corresponding collector current *IC* is noted. The readings are taken till the collector current becomes almost constant.
- Initially I_B is kept at 0 mA and the corresponding collector current is noted. This current is the reverse saturation current I_{CEO}.
- The experiment is repeated for various values of *IB*. The readings are tabulated.
- A graph is drawn by taking V_{CE} along *x*-axis and *IC* along *y*-axis for various values of I_B.
- The set of curves thus obtained is called the output characteristics of a transistor.
- The reciprocal of the slope of the curve gives output impedance of the transistor.

S.NO	$I_B = 20\mu A$		$I_B = 40\mu A$	
	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA))
1	0.1	0	0.1	0
2	0.2	3.5	0.2	9.5
3	0.3	4	0.3	10.5
4	0.4	4	0.4	11
5	0.5	4	0.5	11
6	0.6	4	0.6	11
7	0.7	4	0.7	11
8	0.8	4	0.8	11
9	0.9	4	1.9	11
10	1	4	1	11

(iii) Transfer characteristic curve: I_B vs I_C (V_{CE} constant)

- The collector-emitter voltage V_{CE} is kept constant.
- The base current *I*B is varied in steps of 10 μA and the corresponding collector current *I*C is noted.
- This is repeated by changing the value of V_{CE}. The readings are tabulated.
- The transfer characteristics is a plot between the input current IB along *x*-axis and the output current I_C along *y*-axis keeping V_{CE} constant.
- The slope of the transfer characteristics plot gives the current gain β can be calculated.

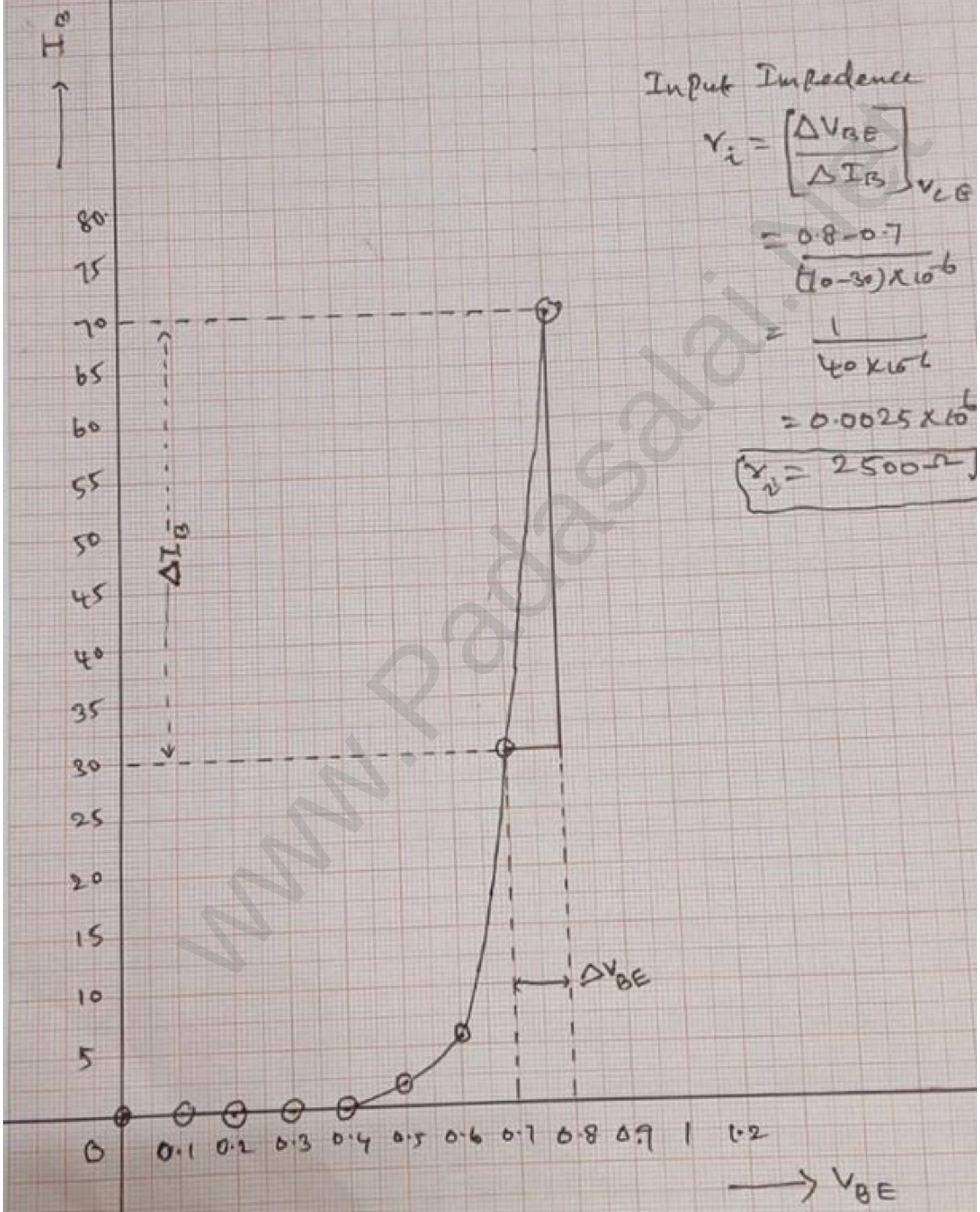
S.NO	$V_{CE} = 1V$		$V_{CE} = 2V$	
	I_B (μA	I_C (mA)	I_B (μA	I_C (mA)
1	0	0	0	0
2	20	5	20	6
3	40	10	40	11
4	60	16	60	17
5	80	22	80	23
6	100	27	100	29

Input characteristics

Scale:

In x axis 1cm = 0.1V

In y axis 1cm = 5 μA.



Input Impedance

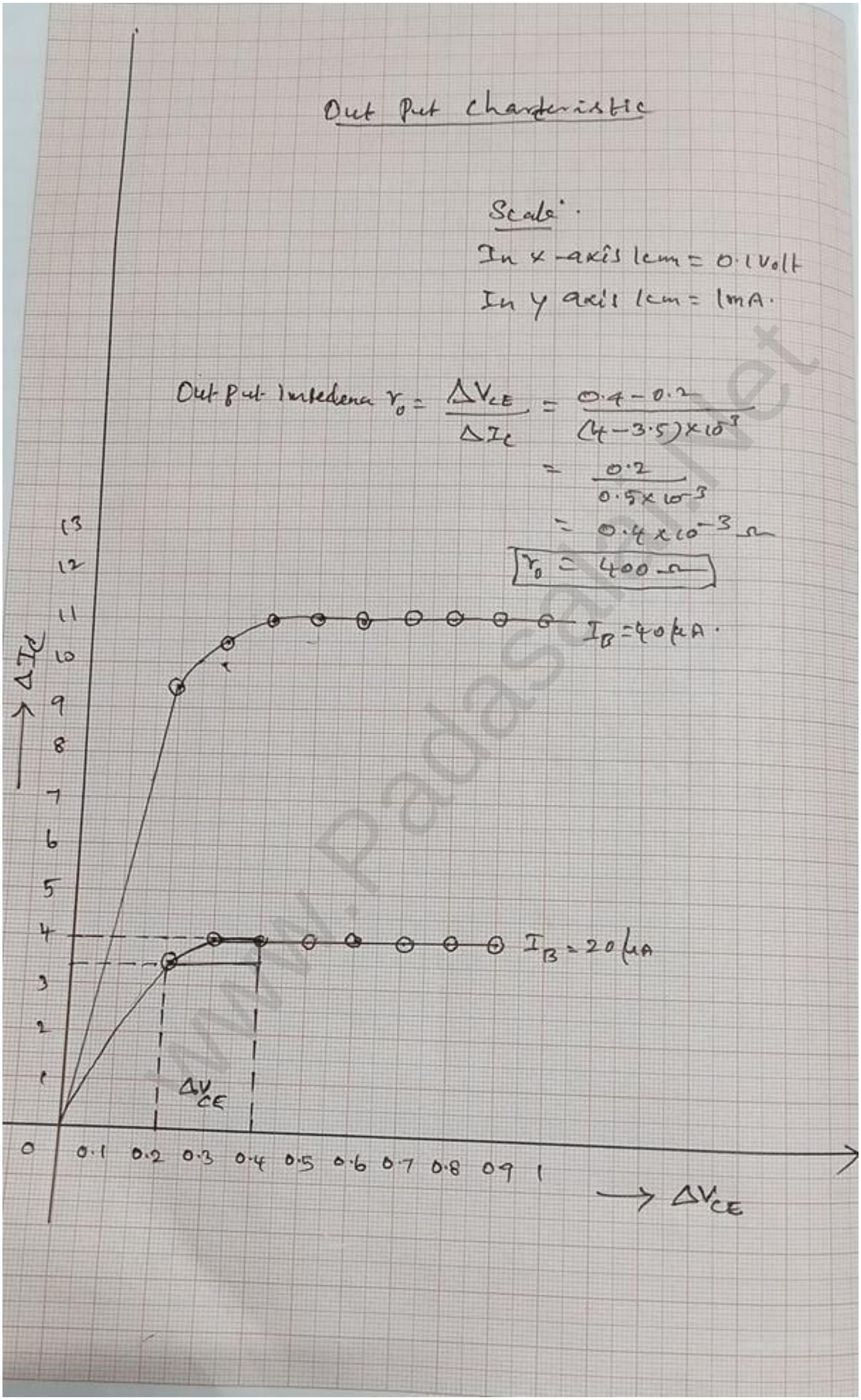
$$r_i = \left[\frac{\Delta V_{BE}}{\Delta I_B}\right]_{V_{CE}}$$

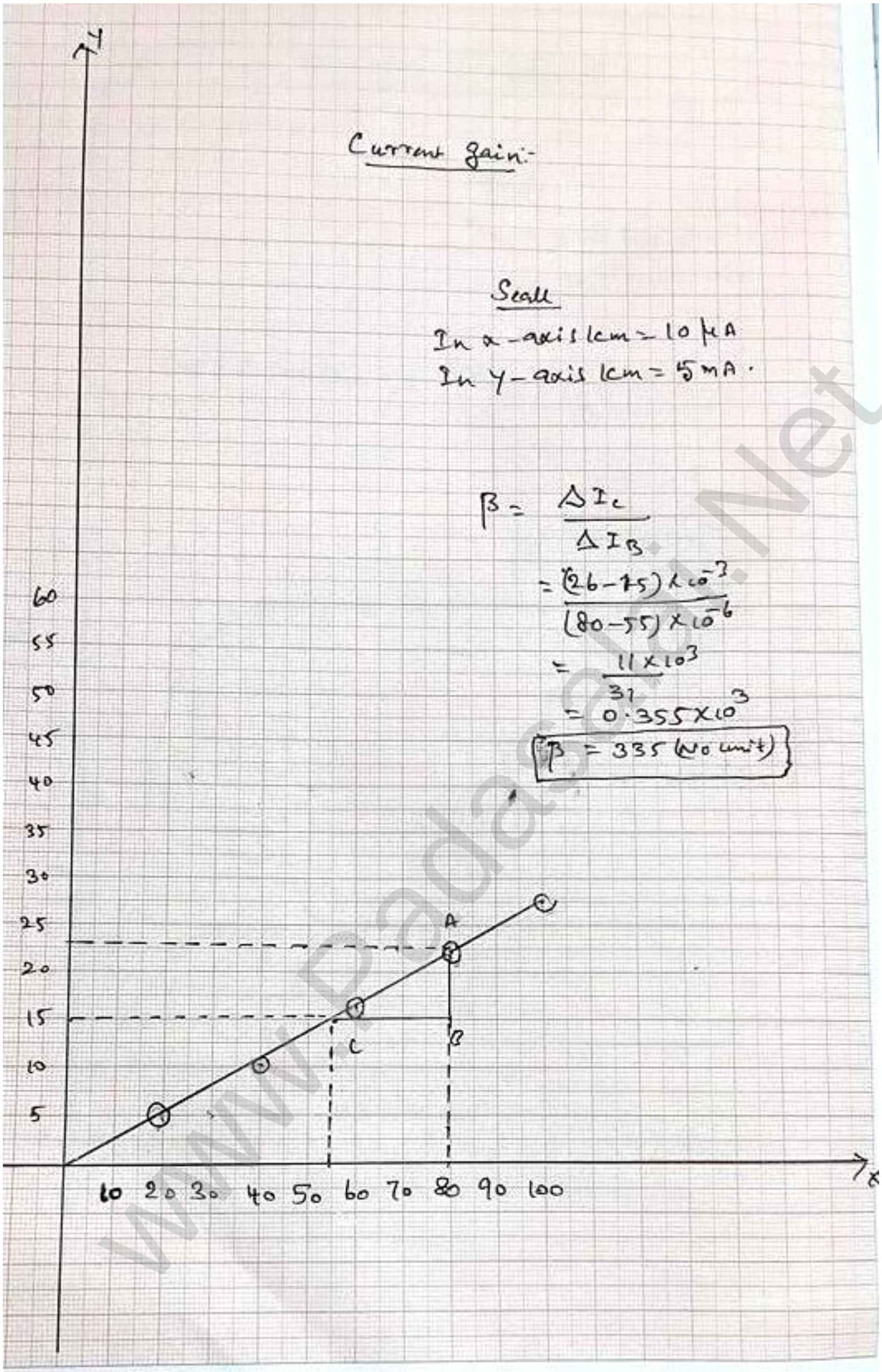
$$= \frac{0.8-0.7}{(70-30)\times 10^{-6}}$$

$$= \frac{1}{40\times 10^{-6}}$$

$$= 0.0025\times 10^{6}$$

$$\boxed{r_i = 2500\,\Omega}$$


Out put charateristic
Scale:
In x-axis 1cm = 0.1 volt
In y axis 1cm = 1mA.
Out put Impedance r0 = ΔVCE / ΔIc = (0.4 − 0.2) / ((4 − 3.5) × 10^-3)
= 0.2 / (0.5 × 10^-3)
= 0.4 × 10^-3 Ω
r0 = 400 Ω
IB = 40 μA
IB = 20 μA
ΔVCE
ΔIc
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
1 2 3 4 5 6 7 8 9 10 11 12 13



Current gain:-

Scale

In x-axis 1cm = 10 μA

In y-axis 1cm = 5 mA.

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

$$= \frac{(26-15)\times 10^{-3}}{(80-55)\times 10^{-6}}$$

$$= \frac{11\times 10^{3}}{31}$$

$$= 0.355\times 10^{3}$$

β = 335 (No unit)

CALCULATION

1)*Input impedance*

$$\text{Input impedance } r_i = \frac{\Delta V_{BE}}{\Delta I_B}$$

$$\text{FROM Graph slope} = \frac{\Delta I_B}{\Delta V_{BE}}$$

$$\text{Input impedance } r_i = \frac{1}{\text{SLOPE}} = \frac{\Delta V_{BE}}{\Delta I_B}$$

$$\text{Input impedance } r_i = \frac{0.1}{40 \times 10^{-6}}$$

$$\text{Input impedance } r_i = 0.0025 \times 10^{-6}$$

$$\text{Input impedance } r_i = 2500\Omega$$

2)**Output impedance**

$$\text{Output impedance } r_o = \frac{\Delta V_{CE}}{\Delta I_C}$$

$$\text{FROM Graph slope} = \frac{\Delta I_C}{\Delta V_{CE}}$$

$$\text{Input impedance } r_i = \frac{1}{\text{SLOPE}} = \frac{\Delta V_{CE}}{\Delta I_C}$$

$$\text{Input impedance } r_i = \frac{0.2}{0.5 \times 10^{-3}}$$

$$\text{Input impedance } r_i = 0.4 \times 10^{-3}$$

$$\text{Input impedance } r_i = 400\Omega$$

3)**Current gain**

$$\text{Current gain } \beta = \frac{\Delta I_C}{\Delta I_B}$$

$$\text{FROM Graph slope} = \frac{\Delta I_C}{\Delta I_B}$$

$$\text{Current gain } \beta = \text{Slope} = \frac{\Delta I_C}{\Delta I_B}$$

$$\text{Current gain } \beta = \frac{11 \times 10^{-3}}{31 \times 10^{-6}}$$

$$\text{Current gain } \beta = 0.355 \times 10^{3}$$

$$\text{Current gain } \beta = 355(\text{no unit})$$

RESULT

i) The input, output and transfer characteristics of the NPN junction in common emitter mode are drawn.

ii) (a) Input impedance = 2500Ω

(b) Output impedance = 400Ω

(c) Current gain β = 355(no unit)

9.VERIFICATION OF TRUTH TABLES OF LOGIC GATES USING INTEGRATED CIRCUITS

AIM To verify the truth tables of AND, OR, NOT, EX-OR, NAND and NOR gates using integrated circuits

COMPONENTS REQUIRED AND gate (IC 7408), NOT gate (IC 7404), OR gate (IC 7432), NAND gate (IC 7400), NOR gate (IC 7402), X-OR gate (IC 7486), Power supply, Digital IC trainer kit, connecting wires.

BOOLEAN EXPRESSIONS

1)AND gate $Y = A \cdot B$

2) OR gate $Y = A + B$

3) NOT gate $Y = \overline{A}$

4 EX-OR gate $Y = \overline{A}B + A\overline{B}$

5) NAND gate $Y = \overline{AB}$

6) NOR gate $Y = \overline{A + B}$

PROCEDURE

• To verify the truth table of a logic gate, the suitable IC is taken and the connections are given using the circuit diagram.

• For all the ICs, 5V is applied to the pin 14 while the pin 7 is connected to the ground.

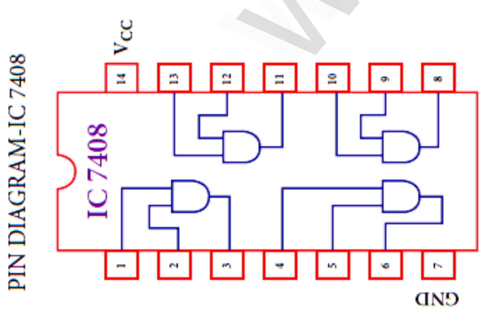
• The logical inputs of the truth table are applied and the corresponding output is noted.

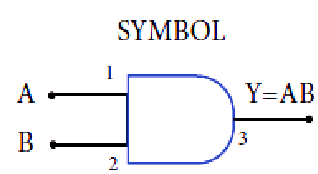
• Similarly the output is noted for all other combinations of inputs.

• In this way, the truth table of a logic gate is verified.

1)AND gate $Y = A \cdot B$

PINDIAGRAM , SYMBOL, TRUTH TABLE ,VERFICATION TABLE





TRUTH TABLE

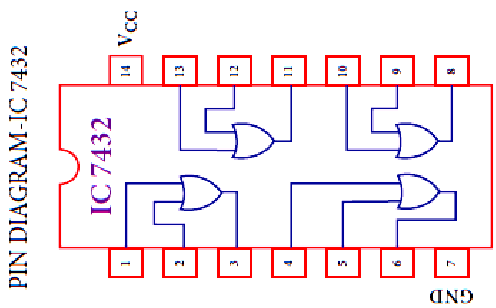
A	B	$Y = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1

VERIFICATION TABLE

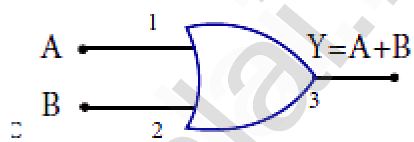
A	B	$Y = A \cdot B$
0	0	0V
0	1	0V
1	0	0V
1	1	5V

2) OR gate $Y = A + B$

PINDIAGRAM , SYMBOL, TRUTH TABLE ,VERFICATION TABLE



SYMBOL



TRUTH TABLE

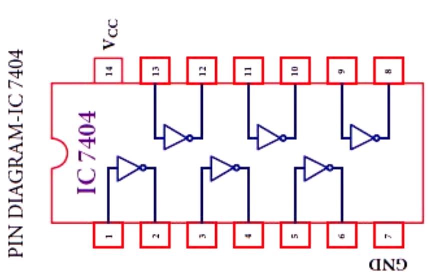
A	B	$Y = A + B$
0	0	0
0	1	1
1	0	1
1	1	1

VERIFICATION TABLE

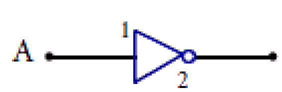
A	B	$Y = A \cdot B$
0	0	0V
0	1	5V
1	0	5V
1	1	5V

3) NOT gate $Y = \overline{A}$

PINDIAGRAM , SYMBOL, TRUTH TABLE ,VERFICATION TABLE



SYMBOL



TRUTH TABLE

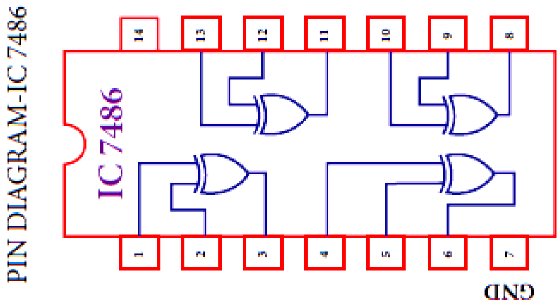
A	$Y = \bar{A}$
0	1
1	0

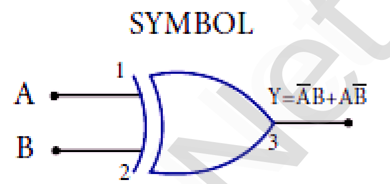
VERIFICATION TABLE

A	$Y = \bar{A}$
0	5V
1	0V

4 EX-OR gate $Y = \bar{A}B + A\bar{B}$

PINDIAGRAM , SYMBOL, TRUTH TABLE ,VERFICATION TABLE





TRUTH TABLE

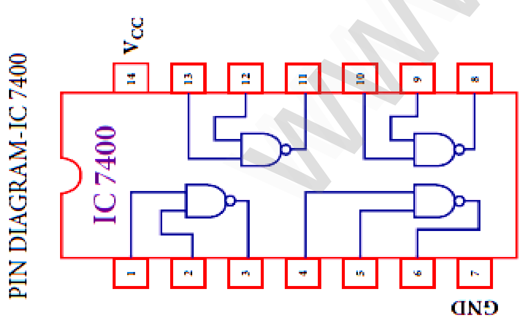
A	B	$Y = \bar{A}B + A\bar{B}$
0	0	0
0	1	1
1	0	1
1	1	0

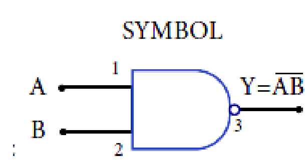
VERIFICATION TABLE

A	B	$Y = \bar{A}B + A\bar{B}$
0	0	0V
0	1	5V
1	0	5V
1	1	0V

5) NAND gate $Y = \overline{AB}$

PINDIAGRAM , SYMBOL, TRUTH TABLE ,VERFICATION TABLE





TRUTH TABLE

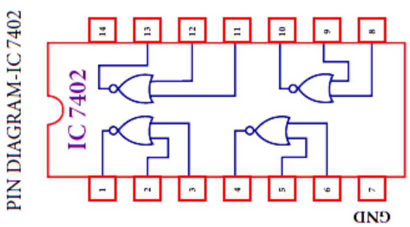
A	B	$Y = \overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

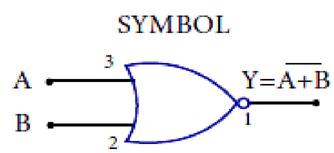
VERIFICATION TABLE

A	B	$Y = \overline{AB}$
0	0	5V
0	1	5V
1	0	5V
1	1	0V

6) NOR gate $Y = \overline{A+B}$

PINDIAGRAM , SYMBOL, TRUTH TABLE ,VERFICATION TABLE





TRUTH TABLE

A	B	$Y = \overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

VERIFICATION TABLE

A	B	$Y = \overline{A+B}$
0	0	5V
0	1	0V
1	0	0V
1	1	0V

CALCULATION

1)AND gate $Y = A \cdot B$

$Y = 0 \cdot 0 = 0$

$Y = 1 \cdot 0 = 0$

$Y = 0 \cdot 1 = 0$

$Y = 1 \cdot 1 = 1$

2) OR gate $Y = A + B$

$Y = 0 + 0 = 0$

$Y = 1 + 0 = 1$

$Y = 0 + 1 = 1$

$Y = 1 + 1 = 1$

3) NOT gate $Y = \overline{A}$

$Y = \overline{0} = 1$

$Y = \overline{1} = 0$

4 EX-OR gate $Y = \bar{A}B + A\bar{B}$

$Y = \bar{0}0 + 0\bar{0} = 0$

$Y = \bar{1}0 + 1\bar{0} = 1$

$Y = \bar{0}1 + 0\bar{1} = 1$

$Y = \bar{1}1 + 1\bar{1} = 0$

5) NAND gate $Y = \overline{AB}$

$Y = \overline{00}$ =1

$Y = \overline{10} = 1$

$Y = \overline{01} = 1$

$Y = \overline{11}$ =0

6) NOR gate $Y = \overline{A + B}$

$Y = \overline{0 + 0} = 1$

$Y = \overline{1 + 0} = 1$

$Y = \overline{0 + 1} = 1$

$Y = \overline{1 + 1} = 0$

RESULT

The truth table of logic gates AND, OR, NOT, Ex-OR, NAND and NOR using integrated circuits is verified

10.VERIFICATION OF DE MORGAN'S THEOREMS

AIM: To verify De Morgan's first and second theorems.

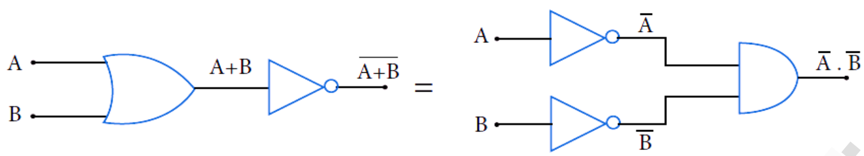
COMPONENTS REQUIRED: Power Supply (0 – 5V), IC 7400, 7408, 7432, 7404, and 7402, Digital IC trainer kit, connecting wires.

FORMULA De Morgan's first theorem $\overline{A+B} = \bar{A}.\bar{B}$.

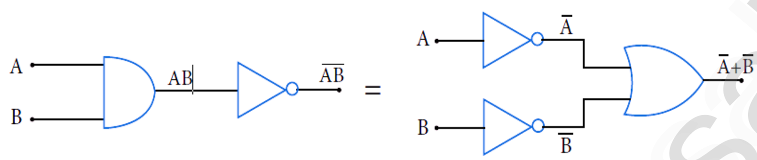
De Morgan's second theorem $\overline{A.B} = \bar{A} + \bar{B}$

CIRCUIT DIAGRAM:

De Morgan's first theorem



De Morgan's second theorem



PROCEDURE:

i) Verification of De Morgan's first theorem

• The connections are made for LHS $[\overline{A+B}]$ of the theorem as shown in the circuit diagram using appropriate ICs.

• The output is noted and tabulated for all combinations of logical inputs of the truth table.

• The same procedure is repeated for RHS $[\bar{A}.\bar{B}]$of the theorem.

• From the truth table, it can be shown that $\overline{A+B} = \bar{A}.\bar{B}$

ii) Verification of De Morgan's second theorem

• The connections are made for LHS$[\overline{A.B}]$ of the theorem as shown in the circuit diagram using appropriate ICs.

• The output is noted and tabulated for all combinations of logical inputs of the truth table.

• The same procedure is repeated for RHS$[\bar{A} + \bar{B}]$of the theorem.

• From the truth table, it can be shown that $\overline{A.B} = \bar{A} + \bar{B}$

OBSERVATION
De-Morgan's first theorem

A	B	$\overline{A+B}$	$\bar{A}.\bar{B}$
0	0	1	1
0	1	0	0
1	0	0	0
1	1	0	0

De-Morgan's second theorem

A	B	$\overline{A.B}$	$\bar{A}+\bar{B}$
0	0	1	1
0	1	1	1
1	0	1	1
1	1	0	0

CALCULATION

De-Morgan's first theorem

$\overline{A+B} = \bar{A}.\bar{B}$

LHS RHS

$A = 0\ , B = 0\ , \overline{A+B} = \overline{0+0} = \bar{0} = 1$ $\bar{A}.\bar{B} = \bar{0}.\bar{0} = 1.1 = 1$

$A = 0\ , B = 1\ , \overline{A+B} = \overline{0+1} = \bar{1} = 0$ $\bar{A}.\bar{B} = \bar{0}.\bar{1} = 1.0 = 0$

$A = 1\ , B = 0\ , \overline{A+B} = \overline{1+0} = \bar{1} = 0$ $\bar{A}.\bar{B} = \bar{1}.\bar{0} = 0.1 = 0$

$A = 1\ , B = 1\ , \overline{A+B} = \overline{1+1} = \bar{1} = 0$ $\bar{A}.\bar{B} = \bar{1}.\bar{1} = 0.0 = 0$

De-Morgan's second theorem

$\overline{A.B} = \bar{A} + \bar{B}$

LHS RHS

$A = 0\ , B = 0\ , \overline{A.B} = \overline{0.0} = \bar{0} = 1$ $\bar{A}+\bar{B} = \bar{0}+\bar{0} = 1+1 = 1$

$A = 0\ , B = 1\ , \overline{A.B} = \overline{0.1} = \bar{0} = 1$ $\bar{A}+\bar{B} = \bar{0}+\bar{1} = 1+0 = 1$

$A = 1, B = 0\ , \overline{A.B} = \overline{1.0} = \bar{0} = 1$ $\bar{A}+\bar{B} = \bar{1}+\bar{0} = 0+1 = 1$

$A = 1, B = 1\ , \overline{A.B} = \overline{1.1} = \bar{1} = 0$ $\bar{A}+\bar{B} = \bar{1}+\bar{1} = 0+0 = 0$

RESULT
De Morgan's first and second theorems are verified.

PREPARED BY

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