CHAPTER – 4
MEASUREMENT OF RESISTANCE

One Mark Questions

02. Ans: (d)

Sol: There are three meters

(i). Meter one having a sensitivity S = 1000Ω/v

Resistance offered R_v = sensitivity × voltage range

$R_v = 1000 \times 100 = 100k\Omega$

(ii). Meter two having a sensitivity S = 20,000Ω/v

$R_v = 20,000 \times 100 = 2M\Omega$

(iii) Meter three is an Electronic meter

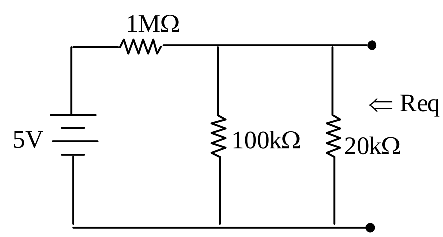
Meters two and three having high sensitivity less loading effect

Meter one has less sensitivity more loading effect

Two Marks Questions

30. Ans: (b)

Sol: The given circuit is



Sensitivity (S) = 20,000Ω/v

$R_v = S \times$ voltage range

$R_v = 20,000 \times 1$

$R_v = 20k\Omega$

From the circuit $R_{eq} = \dfrac{100\times10^3 \times 20\times10^3}{100\times10^3 + 20\times10^3} + 1 \times 10^6$

$R_{eq} = 1016.66\Omega$

From voltage division rule

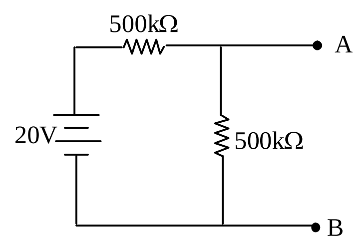
$$V_m = 5\times\frac{100}{100+1019.6} = 0.45V$$

31. Ans: (d)

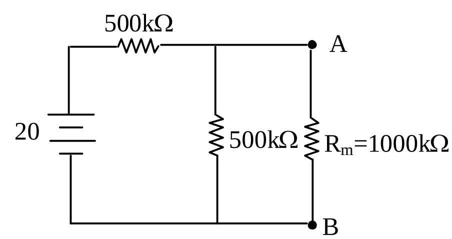
Sol: Voltage across the 500kΩ resistor is exactly 10V

Sensitivity of voltmeter 20kΩ/V

The readings indicated on its 50V and 5V range?



Voltage across V_{AB} by voltage division rule



$$V_{AB} = \frac{500}{500+500}\times 20$$

$V_{AB} = 10V$

Reading indicated on 50V range is

$R_v = S \times$ voltage range

$R_v = 20 \times 10^3 \times 50 = 1000\ k\Omega$

R_v connected across ‘AB’

$$R_{eq} = \frac{500 \times 1000}{500 + 1000} = 333.3\Omega$$

$$V = 20 \times \frac{333.3}{500 + 333.3} = 8V$$

Reading indicated on ‘5V’ range is

$R_v = S \times$ voltage range

$R_v = 20 \times 10^3 \times 5 = 100k\Omega$

$$R_{eq} = \frac{500 \times 100}{500 + 100} = 83.33\Omega$$

$$V = 20 \times \frac{83.33}{500 + 83.33} = 2.86\ V$$

32. Ans: (a)

Sol: Voltmeter reads 60V on 100V full scale

Ammeter reads 0.8A on 1 A full scale

Both meters are having guaranteed accuracy error 1% of full scale

$V_m = 60V$ $\quad I_m = 0.8A$

Voltmeter, G.A.E = 1% of full scale voltage

$$= \frac{1}{100} \times 100 = 1$$

$$\text{\% Limiting error} = \frac{G.A.E}{V_m} \times 100$$

$$= \frac{1}{60} \times 100 = 1.66\%$$

Ammeter, G.A.E = 1% of full scale current

$$= \frac{1}{100} \times 1 = 0.01$$

$$\text{\% limiting error} = \frac{G.A.E}{I_m} \times 100$$

$$= \frac{0.01}{0.8} \times 100 = 1.25\%$$

$$\text{Resistance } R = \frac{V_m(\pm L.E)}{I_m(\pm L.E)}$$

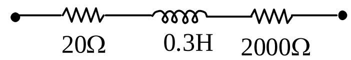
$$R = \frac{60(\pm 1.66\%)}{0.8(\pm 1.25\%)}$$

$R = 75(\pm 2.91\%)$

%L.E = 2.91%

33. Ans: (b)

Sol: From the given data



Total $R_{se} = 2020\ \Omega$

$L = 0.3H$

The meter read correctly at dc as well as at 50Hz ac

We have connect a capacitor of value

$$C = \frac{0.41 \times L_m}{(R_{se})^2}$$

$$C = \frac{0.41 \times 0.3}{(2020)^2} 40.$$

$$C = 0.0314\mu F$$

36. Ans: (b)

Sol: Ratio arms $\left(\frac{P}{Q}\right) = \frac{1000}{100} = 10\Omega$

Standard resistance arms $S_1 = 1000$, $S_2 = 100$, $S_3 = 10$, $S_4 = 1\Omega$

Bridge under balanced condition

$$\frac{R}{S} = \frac{P}{Q}$$

$$R = \left(\frac{P}{Q}\right) S_{var\ iable}$$

Unknown resistance $R_1 = 10 \times S_1$

$= 10 \times 1000 = 10000\Omega$

$R_2 = 10 \times 100 = 1000\ \Omega$

$R_3 = 10 \times 10 = 100\ \Omega$

$R_4 = 10 \times 1 = 10\ \Omega$

The minimum value of unknown resistance is $R_4 = 10\ \Omega$

The maximum value is obtained by adding '4' unknown values corresponding to each 'S'

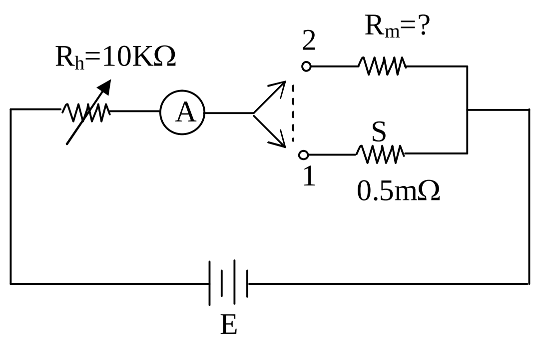
$R = 10000 + 1000 + 100 + 10$

$R = 11110\Omega$

40. Ans: (a)

Sol: $S = 0.5\ M\Omega$

$R_g = R_h = 10\ K\ \Omega$



(i) With standard resistor, 41 divisions

No.of divisions α current flowing through the meter

$$41 \;\alpha\; \frac{E}{0.5\times10^6+10\times10} \text{ ------- (i)} \qquad [\because \text{switch at positions}]$$

(ii) With unknown resistance, 51 divisions

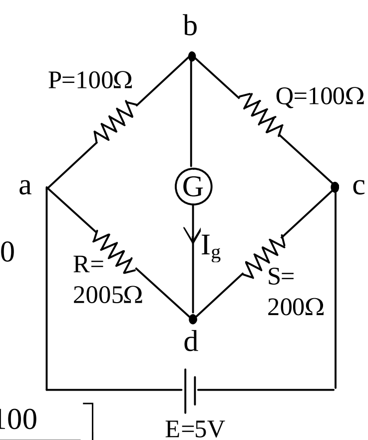
$$51 \;\alpha\; \frac{E}{R_m+10K\Omega} \text{ ----------- (ii)}$$

divide $\frac{(ii)}{(i)}$ them we get R_m

$$\frac{51}{41} = \frac{E}{R_m+10\times10^3} \times \frac{0.5\times10^6+10\times10^3}{E}$$

$R_m = 0.4\ M\Omega$

41. Ans: (a)



Sol: Resistance of unknown resistance required for balance is

$$R = (P/Q)S = \left(\frac{1000}{1000}\right)\times 200 = 2000\Omega$$

In the actual bridge R = 2005Ω

The deviation from balance condition is ΔR = 2005 – 2000

ΔR = 5Ω

Thevenine source generator emf $E_0 = E\left[\frac{R}{R+S} - \frac{P}{P+Q}\right]$

$$= 5\left[\frac{2005}{2005+200} - \frac{100}{1000+100}\right]$$

$= 1.0307 \times 10^{-3}$ V

Internal resistance of bridge looking into terminals b & d

$$R_0 = \frac{Rs}{R+S} + \frac{PQ}{P+Q}$$

$$R_0 = \frac{2005\times200}{2005+200} + \frac{1000\times100}{1000+100} = 272.8\Omega$$

Hence the current through the galvanometer $I_g = \frac{E_0}{R_0+G}$

$$I_g = \frac{1.0307\times10^{-3}}{272.8+100} = 2.77\mu A$$

Deflection of galvanometer $\theta = S_i \times I_g = 10\times 2.77 = 27.7$mm

Sensitivity of bridge $S_B = \frac{\theta}{\Delta R} = \frac{27.7}{5} = 5.54\text{mm}/\Omega$

42. Ans: (a)

Sol: Each arm having a guaranteed accuracy error of ±0.05%

Standard arm has a guaranteed accuracy of ±0.1%

Ratio arms of both are set at 1000Ω

Bridge is balanced with standard arm adjusted to determine the upper and lower limits of unknown resistance?

$$\text{Value of unknown resistance } R = \left(\frac{P}{Q}\right)\times S$$

$$= \frac{1000}{1000}\times 3154$$

$$= 3154\Omega$$

% error in determination of R

$$R = \frac{1000(\pm 0.05\%)}{1000(\pm 0.05\%)}\times 3154(\pm 0.1\%)$$

$$R = 3154\pm[0.05\%+0.05\%+0.1\%]$$

$$= 3154\pm 0.2\%$$

The upper and lower limits of unknown resistance is 3091 to 3217Ω

43. Ans: (a)

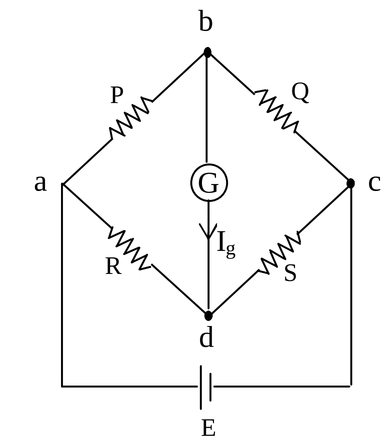
Sol: Given that

$P = 1k\Omega$, $R = 1k\Omega$

$S = 5k\Omega$ $G = 100\Omega$

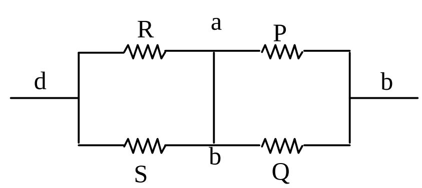
Thevenin's voltage $E_0 = 24mV$

$I_g = 13.6\mu A$



From circuit find thevenin equivalent circuit.

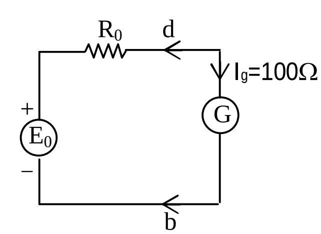
$$R_0 = \frac{RS}{R+S}+\frac{PQ}{P+Q}$$



$$I_0 = \frac{E_0}{R_0+G}$$

$$R_0 + G = \frac{24\times 10^{-3}}{13.6\times 10^{-6}} = 1764.70$$

$$R_0 = 1764.7 - 100 = 1665\Omega$$

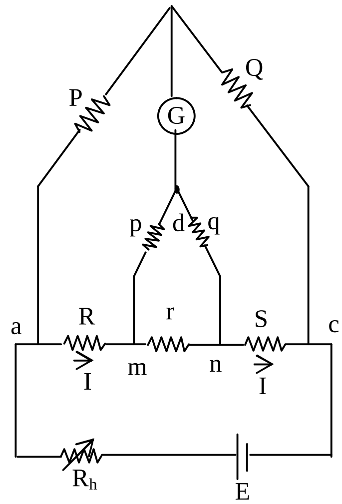


$$R_0 = \frac{1000\times 5000}{1000+5000}+\frac{1000\times Q}{1000+Q}$$

$$\frac{1000Q}{1000+Q} = 8317$$

$$Q = 4.95k\Omega$$

44. Ans: (a)



Sol: $S = 100.03 \times 10^{6}\Omega$

$p = 100.31\Omega \quad P = 100.24$

$q = 200\Omega \quad Q = 200\Omega$

$r = 100\times 10^{-6}\Omega$

$$R = \frac{P}{Q}.S + \frac{qr}{p+q+r}\left[\frac{P}{Q} - \frac{p}{q}\right]$$

$$R = \frac{100.24}{200}\times 100.03\times 10^{-6} + \frac{200\times 100\times 10^{-6}}{100.31+200+100\times 10^{-6}}\left[\frac{100.24}{200} - \frac{100.31}{200}\right]$$

$R = 49.97\times 10^{-6}\Omega$

45. Ans:

Sol: Given that

$C = 600\text{pF}$

$V = 250V \qquad \nu = 92V$

$$\text{Insulation resistance } R = \frac{0.43\times t}{C\log_{10}\left(\frac{V}{\nu}\right)}$$

$$R = \frac{0.434\times 60}{600\times 10^{-12}\times \log_{10}\left(\frac{250}{92}\right)}$$

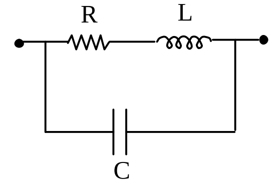
$R = 9.99\times 10^{10}$

$R = 100 \times 10^{9}\ \Omega$

PREVIOUS IES SOLUTIONS

01. Ans: (b)

Sol: The given circuit is



Equivalent impedance Z_{eq}

$Z_1 = R + j\omega L, \quad Z_2 = \frac{1}{j\omega c}$

$$Z_{eq} = \frac{Z_1Z_2}{Z_1Z_2} \Rightarrow \frac{\left(\frac{1}{j\omega c}\right)(R + j\omega L)}{\left(R + j\omega L + \frac{1}{j\omega c}\right)}$$

$$Z = \frac{R + j\omega\left(L - \omega^2L^2C - CR^2\right)}{1 + \omega^2C^2R^2 - 2\omega^2LC + \omega^4L^2C^2}$$

Effective reactance

$$X_{eff} = \frac{\omega\{L(1 - \omega^2LC) - CR^2\}}{1 + \omega^2C^2R^2 - 2\omega^2LC + \omega^4L^2C^2}$$

Since X_{eff} is small, we have; $\omega^2LC <<1$

So, ω^2LC can be neglected

$$\therefore\ X_{eff} = \frac{\omega(L - CR^2)}{1 + \omega^2C\left(CR^2 - 2L\right)}$$

If the resistance is non – inductive, then

$$L - CR^2 = 0 \Rightarrow R = \sqrt{L/C}$$

02. Ans: (b)

Sol:

$$V_A = 10\left[\frac{10}{20 + 10}\right]$$

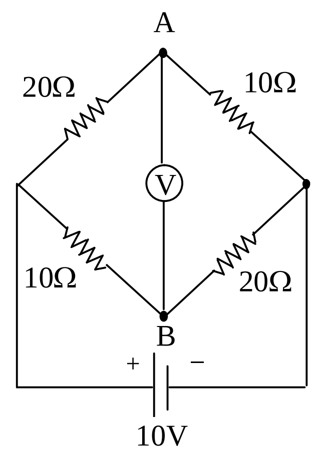
$V_A = 3.33V$

$$V_B = 10\left(\frac{20}{20 + 10}\right)$$

$V_B = 6.66V$

$V_B - V_A = 6.66 - 3.33 = 3.33V$

The reading of voltmeter is 3.33V



03. Ans: (a)

Sol: For accuracy = 99%, voltage across the meter should be 49.5V

$V_S = 50V$, $V_m = 49.5$ V

$$V_m = V_S \times \frac{R}{100k + R}$$

$$\frac{R}{100k + R} = \frac{49.5}{50}$$

$R = 0.99(100\times10^3 + R)$

$R = 99000 + 0.99R$

$0.01R = 9900$

$R = 9900000$

$R = 10M\Omega$

04. Ans: (b)

Sol: Total current $I = I_1 + I_2$

$I_1 = 150 \pm 1A$ $\quad I_2 = 250 \pm 2A$

Limits of error are given as standard

Deviations $d_1 = 1$ $\quad d_2 = 2$ $\quad n = 2$ $\quad \sigma = 2$

$$\sigma = \sqrt{\frac{d_1^2 + d_2^2}{n-1}}$$

$$\sigma = \sqrt{\frac{(1)^2 + (2)^2}{1}} = 2.236$$

$$\sigma = 2.24$$

$$I = 400 \pm 2.24$$

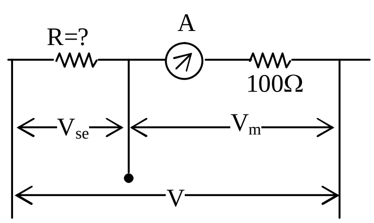
06. Ans: (a)

Sol: $V = 10.14V$, $\quad I = 5.07mA$

$$\text{Resistance } R = \frac{V}{I} = \frac{10.14}{5.07 \times 10^{-3}} = 2k\Omega$$

07. Ans: (c)

Sol: Given that $R_m = 100\Omega$ $\quad I_{FSD} = 1mA$



From the circuit

$V = V_{se} + V_m$ $\quad V = 10$

$V_{se} = V - V_m$

$1\times 10^{-3} R = 10 - 1\times 10^{-3} \times 100$

$R = 9900\Omega$

PREVIOUS GATE QUESTIONS

One Mark Questions:

2**. GATE-EE -2001**

Ans (a)

Sol: $R_1 = 10\Omega \pm 5\%$ $\quad R_2 = 5\Omega \pm 10\%$

R_1 Ranges $\rightarrow 10 \times \pm {}^{5}\!/_{100} \Rightarrow \pm 0.5 \quad \rightarrow R_1 (10.5 - 9.5)$

R_2 Ranges $\rightarrow 5 \times \pm {}^{10}\!/_{100} \Rightarrow \pm 0.5 \quad \rightarrow R_2 (5.5 - 4.5)$

For Parallel combination $\dfrac{10.5 \times 5.5}{10.5 + 5.5}$ and $\dfrac{9.5 \times 4.5}{9.5 + 4.5}$

$= 3.60\Omega$ and $3.05\ \Omega$

Two Marks Questions:

03. **GATE, IN – 1996**

Ans : (b)

Sol : From the circuit the bridge is under balanced condition when

$$\frac{X_C}{R} = 1 \Rightarrow X_c = R \text{ then}$$

Voltmeter reading is

$$V = V_S\left[\frac{R}{R+R}\right]$$

$$V = 10\left[\frac{R}{2R}\right] = 5V$$

04. **GATE – IN – 2003**

Ans : (a)

Sol : The output resistance obtained by using Thevenin's equivalent resistance by putting voltage source is zero

$$R_{12} = \frac{20\times10^3\times30\times10^3}{20\times10^3+30\times10^3} + \frac{25\times10^3\times25\times10^3}{25\times10^3+25\times10^3} = 24.5K\Omega$$

06. **GATE – IN – 2005**

Ans:(d)

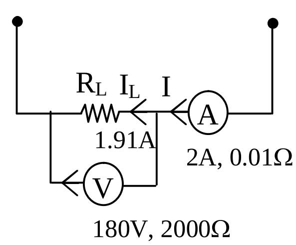
Sol: The ammeter resistance = 0.01Ω

Voltmeter resistance = 2000Ω

True value of resistance

$$(R_L)_t = \frac{\text{voltmeter reading}}{\text{ammeter reading}}$$

$$(R_L)_t = \frac{180}{2} = 90\Omega$$



$$I_L = I - \frac{V}{R_m}$$

$$= 2 - \frac{180}{2000}$$

$$= 1.91 \text{ Amp}$$

From the circuit measured value

$$(R_L)_m = \frac{180}{1.91} = 94.24\Omega$$

$$\%\text{error} = \frac{(R_L)_m - (R_L)t}{(R_L)_t}\times100$$

$$= \frac{94.24-90}{90}\times100 = 4.71\%$$