CHAPTER-5
POTENTIOMETERS & Instrument Transformer

10. Ans: (b)

Sol: Measurement of reactance of a coil by using

Polar type ac potentiometer

Given that $I = 12\angle 13.8^0$, $V = 27.8\angle 29.7^0$

$Z = \frac{V}{I}\angle\theta_C - \theta_S$

Reactance $X = Z\sin(\theta_C - \theta_S)$, Where $\theta_C = 29.7^0$, $\theta_S = 13.8^0$

$Z = \frac{27.8}{12}\angle 29.7 - 13.8$

$Z = 2.31\angle 15.9\Omega$

Reactance $X = 2.31\sin(29.7 - 13.8)$

$X = 0.632\Omega$

11. Ans: (b)

Sol: The voltage read by potentiometer is 1.2V

The voltmeter reads 0.6V with 20,000Ω/V on 5V range

Input resistance $R_V = S_{DC} \times$ voltage

$R_V = 20,000 \times 5$

$R_V = 1,00,000\Omega$

12. Ans: (a)

Sol: Given that

Working current $I_w = 10mA$

Dial resistor having 15 steps of 10Ω each

i.e. = 150Ω

slide wire resistance is = 10Ω

Total resistance = 150 + 10 = 160Ω

Range of voltage $= I_W \times R_{total}$

$= 10 \times 10^{-3} \times 160 = 1.6V$

Resolution: slide wire provide with 100 divisions and since the total resistance of slide wire (10Ω) corresponding to a voltage drop of (10mA × 10Ω = 0.1V), each division of slide wire corresponds to = $\frac{0.1}{100} = 0.001$

With certainly the reading upto $\frac{1}{5}$ of scale division

Then resolution is $\frac{1}{5}\times 0.001 = 0.2mV$

13. Ans: (a)

Sol: For the voltage division $\left(\frac{V_0}{V_{in}}\right)$ is independent of frequency, the impedance ratio should also be independent of frequency

$$\frac{Z_1}{Z_2} = \frac{R_1 \frac{1}{j\omega c_1}}{R_1 + \frac{1}{j\omega C_1}} \times \frac{R_2 + \frac{1}{j\omega c_2}}{R_2 \times \frac{1}{j\omega c_2}}$$

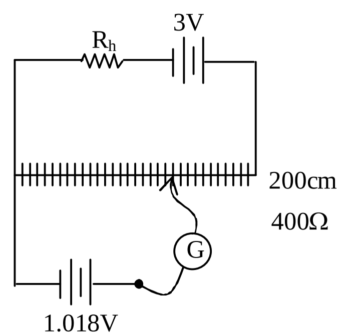
$$= \frac{R_1}{1+j\omega c_1 R_1} \times \frac{1+j\omega c_2 R_2}{R_2}$$

$$= \frac{R_1}{R_2} \cdot \frac{1+j\omega c_2 R_2}{1+j\omega c_1 R_1} \Rightarrow C_2R_2 = C_1R_1$$

$$C_1 = \frac{C_1 R_1}{R_2} = \frac{1\times10^{-6}\times10}{1\times10^{3}} = 10\mu F$$

15. Ans: (a)

Sol: Given that,



Working battery is 3V

Slide wire is 400Ω

Length L = 200 cm

Let 1cm = 2Ω

Standard cell voltage is 1.018V

Sliding contact at 101.8cm

Sliding contact resistance = 2 × 101.8 = 203.6Ω

Current through the slide wire is

$1.018V = I_W \times 203.6$

$I_W = 5\times10^{-3}$

$I_W = \frac{E}{R_h + 400} \Rightarrow R_h + 400 = \frac{3}{5\times10^{-3}} = 600$

$R_h = 600 - 400 = 200\Omega$

16. Ans: (a)

Sol: Resistance of unknown resistor $R = \frac{V_R}{V_S}.S = \frac{0.4221}{1.0235}\times0.1 = 0.041208\Omega$

Current through the resistor $= \frac{V_S}{S} = \frac{1.0235}{0.1} = 10.235A$

Power loss in unknown resistance $= I^2R = (10.235)^2 \times 0.041208 = 4.316W$

17. Ans: (b)

Sol: Voltage drop per unit length $= \frac{1.45}{50} = 0.029V/cm$

Voltage drop across 75 cm length = 0.029× 75 = 2.175V

Current through resistor $= \frac{2.175}{0.1} = 21.75A$

27. Ans: (a)

Sol: Given that

$f = 50Hz, \quad N_2 = 500$

$I_S = 5A, \quad R = 1\Omega$

Magnatizing turns = 200AT

Bar primary = 1turn

$I_0 = 200 \times 1$

$I_0 = 200A$

About α, δ nothing is mentioned neglect

Phase angle error $\theta = \dfrac{I_0 \cos(\alpha+\delta)}{nI_s}$ red

$$\theta = \frac{I_0}{nI_s} \times \frac{180}{\pi} \text{ degrees}$$

$$\theta = \frac{200 \times 180}{500 \times \pi \times 5} = 4.6 \text{ degrees}$$

28. Ans: b

Sol: The flux in the CT core is

$$\text{emf } E_2 = 4.44 \times f \times \phi_m \times N_2$$

$$\phi_m = \frac{E_2}{4.44 \times f \times N_2} = \frac{5 \times 1}{4.44 \times 50 \times 500} = 45\mu Wb$$

29. Ans: (a)

Sol: Under balanced condition

$$I_W = \frac{E}{R_h + R_{slide}}$$

$$= \frac{3.2}{200 + 200 + 2800} = 1 \times 10^{-3} A$$

Then,

$$E_x = I_\omega \times 200 = 2 \times 10^{-3} \times 200 = 200mV$$

30. Ans:(c)

Sol: Before reversing of V_x

$$I = 0.2 \times 10^{-3} A$$

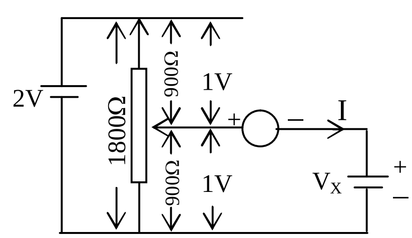
$$-V_x - IR_m - 1v = 0$$

$$V_x = -(0.2 \times 10^{-3} \times R - 1) \text{------------(1)}$$

After reversing of V_x

$$I = 3.8 \times 10^{-3} A$$

$$V_x = 3.8 \times 10^{-3} \times R - 1 \text{-------------- (2)}$$



Equating (1) & (2)

$$-[0.2 \times 10^{-3} R - 1] = [3.8 \times 10^{-3} \times R - 1]$$

$$R = \frac{2}{4\times10^{-3}} = 500\Omega$$

From (2) $V_x = 3.8\times10^{-3}\times500-1$

$V_x = 0.9V$

31.Ans:(a)

Sol: from the circuit

$$V = -\frac{R_f}{R}\times V_i = -\frac{15\times10^3}{10\times10^3}\times 1V = -1.5V$$

32. Ans(a)

Sol: E_x balances at 10 m 18cm

i.e 10.18m = 10.18Ω

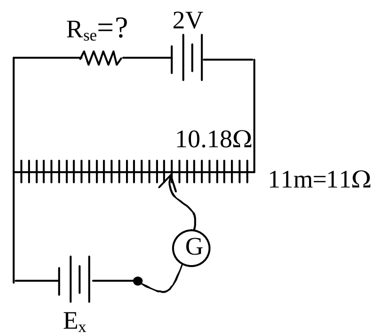
$E_x = I_w \times$ resistance of slid wire at balance

$$I_w = \frac{1.018}{10.18} = 0.1A$$

$$I_W = \frac{E}{R_{SC}+11}$$

$$R_{se}+11 = \frac{2}{0.1}$$

$$R_{se} = 20-11 = 9\Omega$$



33. Ans(d)

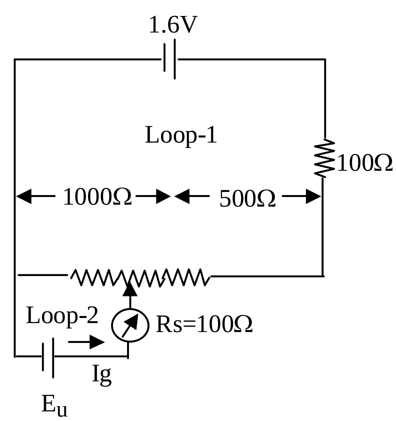
$I_g = 10\mu A$, Eu = ?

Write KVL for loop 1

$-1.6 + (100 + 500) I_w + 1000(I_w + I_g) = 0$

$1600I_w + 1000I_g = 1.6$

$$I_w = \frac{1.6-10\times10^{-3}}{1600} = 9.9375\times10^{-4}A.$$



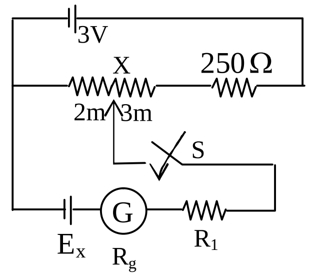
Write KVL for loop 2

$-Eu + 100\times10\times10^{-6} + 1000(10\times10^{-6} + 9.9375\times10^{-4}) = 0$

Eu = 1.00475

34. Ans: (b)

Sol: Given data $I_w = 10mA$, $R_g + R_1 = 100\Omega$



The unknown resistance 'X' can be obtained as

$$I_w = \frac{3}{X + 250}$$

$$X = \frac{3}{10 \times 10^{-3}} - 250 = 50\Omega$$

The sliding contact differentiates the unknown resistance into 20Ω and 30Ω.

Now find out true E_x value

$$E_x = \text{drop across } 20\Omega \text{ resistor} = 20 \times 10 \times 10^{-3} = 0.2 \text{ V}$$

But the galvanometer can only detect current greater than 10μA.

Now the error is nothing but voltage drop across $R_g + R_1$.

$$I_g(R_g + R_1) = 10 \times 10^{-6}(100) = 1mV$$

$$\text{percentage error} = \frac{1 \times 10^{-3}}{0.2} \times 100 = 0.5$$

37. Ans: (a)

Sol :

Sol: Nominal ratio $K_n = \frac{200}{1} = 200$

Since no turns compensation nominal ratio = turns ratio (n)

Actual ratio $R = \frac{I_p}{I_s} = \frac{100}{0.495} = 202.02$

Ratio error = $\frac{K_n - R}{R} \times 100$

$= \frac{200 - 202.02}{202.02} \times 100$

= -0.99%

$\simeq -1.0\%$