CLASS TEST

Sl. 01 ECEE_ABCDEFGHIJK_300923

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ELECTRICAL & ELECTRONICS MEASUREMENTS

EC + EE

Date of Test : 30/09/2023

ANSWER KEY

1.	(a)	7.	(c)	13.	(c)	19.	(b)	25.	(d)
2.	(a)	8.	(d)	14.	(d)	20.	(c)	26.	(a)
3.	(b)	9.	(a)	15.	(b)	21.	(c)	27.	(b)
4.	(a)	10.	(b)	16.	(d)	22.	(a)	28.	(c)
5.	(a)	11.	(a)	17.	(b)	23.	(d)	29.	(d)
6.	(a)	12.	(d)	18.	(b)	24.	(c)	30.	(a)

DETAILED EXPLANATIONS

1. (a)

Unknown resistance, $$R_x = \frac{R_2 R_3}{R_1} = \frac{1000 \times 842}{100} = 8420\,\Omega$$

Relative limiting error of unknown resistance is

$$\frac{\delta R_x}{R_x} = \pm\left(\frac{\delta R_2}{R_2} + \frac{\delta R_3}{R_3} + \frac{\delta R_1}{R_1}\right) = \pm\,(0.5 + 0.5 + 0.5) = \pm\,1.5\%$$

$$\text{Limiting error in ohm} = 8420 \times \frac{1.5}{100} = \pm\,126.3\ \Omega$$

Guaranteed values of resistance are between

8420 – 126.3 to 8420 + 126.3

8293.7 Ω to 8546.3 Ω

2. (a)

$$\text{Amplitude of signal} = \frac{6 \times 5}{2} = 15\text{ v}$$

$$\therefore\quad \text{Rms value of voltage} = \frac{15}{\sqrt{2}} = 10.6\text{ v}$$

3. (b)

At steady state, $N = KVI\sin(\Delta - \phi)$

i.e., $N = KVI\cos\phi$ (for $\Delta = 90°$)

i.e. for $\Delta = 90°$, the speed of rotation is proportional to power. Hence the flux of pressure coil must be made to lag the supply voltage by exactly 90°. For this to occur, the pressure coil winding should be highly inductive by adjusting the position of shading band.

4. (a)

Redrawing the above circuit,

$$z_1 = \frac{1}{j\omega(2c_1)}\,\Omega$$

$$z_2 = 35\text{ k}\Omega$$

$$z_3 = \frac{10^6}{j0.1\omega}\,\Omega$$

$$z_4 = 105\text{ k}\Omega$$

At balance, current through galvanometer: $I_g = 0$

and $$|z_1||z_4| = |z_2||z_3|$$

$$\therefore\quad \frac{1}{w(2c_1)} \times (105k) = (35k)\left(\frac{10^6}{0.1w}\right)$$

$$c_1 = \frac{105 \times 0.1}{35 \times 2} = 0.15\ \mu\text{F}$$

5. (a)

Fixed coil is also called current coil which is fixed and is connected in series with load while moving coil or pressure coil is connected across the load and carries current proportional to voltage.

6. (a)

$$\text{Resolution, } R = \frac{1}{10^n} = \frac{1}{10^4} = 0.0001$$

$$\text{Resolution on 1V range} = 1 \times 0.0001$$

Therefore, on 1V range, any reading can be displayed to 4^{th} decimal place. Hence, 0.8245 will be displayed as 0.8245 on 1V range.

7. (c)

$$P = \frac{100}{\sqrt{2}} \times \frac{8}{\sqrt{2}} + \frac{50}{\sqrt{2}} \times \frac{6}{\sqrt{2}} \times \cos 75°$$

$$= 400 + 150 \times \cos 75°$$

$$= 438.89 \approx 439 \text{ W}$$

8. (d)

Given,

$$C_1 = 460 \text{ pF and } C_2 = 100 \text{ pF}$$

Self or distributed capacitance will be given by

$$C_d = \left(\frac{C_1 - 4C_2}{3}\right) = \frac{(460 - 4 \times 100)}{3} = 20\,\text{pF}$$

9. (a)

0 - 200 V voltmeter has sensitivity 2000 Ω/V

So, $R_{int} = 200 \times 2000 = 400 \text{ k}\Omega$

Now to be extended to 2000 V

So, $m = \dfrac{2000}{20} = 10$

$\therefore$ $R_{ext} = R_{int}(m - 1)$

$= 400k(10 - 1) = 3600 \text{ k}\Omega$

10. (b)

2 cm deflection for 220 volt

1 cm deflection for $\dfrac{220}{2}$ volt

So, 4 cm deflection for $\dfrac{220}{2} \times 4 = 440$ volt

11. (a)

At balanced condition,

$$\frac{1000}{R_x + jwl_x} = \frac{R_s}{(jwR_sc_s + 1) \times 1000}$$

or $10^6(jwR_sc_s + 1) = R_s(R_x + jwL_x)$

Equating real and imaginary terms,

$$10^6 = R_sR_x$$

$$R_x = \frac{10^6}{R_s} = 1000\ \Omega$$

and $$10^6\, c_s = L_x$$

$$L_x = 10^6 \times 0.5 \times 10^{-6} = 0.5\ \text{H}$$

12. (d)

$$\text{Resolution} = \frac{1}{10^4} = 0.0001$$

$$\text{On 10 V range, resolution} = 0.0001 \times 10 = 0.001$$

$$\therefore \quad \text{1 digit error} = \text{1 count error} = 0.001$$

$$\therefore \quad \text{Error} = \pm\left[\frac{0.5}{100}\times 1 + (2\times 0.001)\right] = \pm[0.005 + 0.002] = \pm 0.007$$

$$\therefore \quad \text{Maximum possible error} = 0.007\ \text{V}$$

13. (c)

The meter uses a full wave rectifier circuit and it indicates a value of 2.22 V. The form factor for full wave rectified sinusoidal waveform is 1.11.

$$\therefore \text{Average value of voltage } V_{av} = \frac{2.22}{1.11} = 2\ \text{V}$$

For a triangular wave shape, peak value of voltage

$$V_m = 2\, V_{av} = 4\text{V}$$

$$\text{rms value of voltage} = \frac{V_m}{\sqrt{3}} = \frac{4}{\sqrt{3}} = 2.31\ \text{V}$$

$$\therefore \quad \text{Error} = \frac{2.22 - 2.31}{2.31}\times 100 = -3.9\%$$

15. (b)

Given, $V_m = 1$ V and $V_{ref} = 5$ V.

$$T_1 = 25\times\frac{1}{50} = 0.5\ \text{sec}$$

$$t_{conv} = T_1 + T_2$$

and $$V_m = \frac{V_{ref}}{T_1}\times T_2$$

$$\therefore \quad t_{conv} = 0.5\ \text{sec} + \left[\frac{V_m}{V_{ref}}\times T_1\right] = 0.5\ \text{sec} + \left[\frac{1}{5}\times 0.5\ \text{sec}\right]$$

$$t_{conv} = 0.6\ \text{sec}$$

16. (d)

To get circular pattern, $|V_1|$ and $|V_2|$ should be equal and phase difference should be 90°

$$|V_1| = |V_2|$$

$$\frac{1}{\omega C} = R$$

$$\Rightarrow \quad R = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 1 \times 10^{-6}} = 3.18\ \text{k}\Omega$$

17. (b)

$$\text{Percentage error} = \frac{I^2 R_C}{VI\cos\phi} = \frac{(12)^2 \times 0.1}{250 \times 12 \times 1} \times 100 = \frac{14.4}{3000} \times 100 = 0.48\%$$

18. (b)

Given 10 divisions on horizontal scale

$V(t) = 5\sin(314t + 45°)$

Here, $f = 50$ Hz

$T = 20$ msec

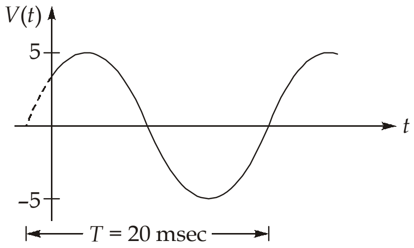
Now, Line base setting = 5 ms/div

Total divisions = 10

So, total time span = 5 msec/div × 10 div

= 50 msec

Hence, number of cycles $= \dfrac{50\,\text{m sec}}{20\,\text{m sec}} = 2.5$ cycles



19. (b)

For closed Lissajous pattern,

$$\frac{f_y}{f_x} = \frac{\text{Number of Tangencies in Horizontal plane}}{\text{Number of Tangencies in Vertical plane}}$$

$$\frac{f_y}{f_x} = \frac{3f_1}{f_1} = \frac{3}{1}$$

Hence, option (b) is correct.

20. (c)

For half wave rectifier type voltmeter,

$$V_{dc} = \frac{V_m}{\pi} = \frac{\sqrt{2}}{\pi} V_{rms} = 0.45\, V_{rms}$$

Series multiplier resistance,

$$R_s = \frac{0.45 \times V_{rms}}{I_{FSD}} - R_m = \frac{0.45 \times 10\ \text{V}}{1\ \text{mA}} - 200\ \Omega = (4.5 - 0.2)\ \text{k}\Omega$$

$$R_s = 4.3\ \text{k}\Omega$$

21. (c)

$$L = (10 + 5\theta - 2\theta^2)\ \mu\text{H}$$

$$\frac{dL}{d\theta} = (5 - 4\theta)\ \mu\text{H/radian}$$

and also, $$\frac{dL}{d\theta} = \frac{2k\theta}{I^2}$$

$$\therefore \quad (5 - 4\theta) \times 10^{-6} = \frac{2k\theta}{I^2} \quad \ldots(i)$$

Substituting, $\theta = \frac{\pi}{4}$ and $I = 5$ A in above expression, we get

$$\left[5 - 4\left(\frac{\pi}{4}\right)\right] \times 10^{-6} = \frac{2k \times \frac{\pi}{4}}{(5)^2}$$

$$[5 - \pi] \times 10^{-6} = \frac{\pi}{2 \times 25} k$$

$$\frac{50}{\pi}[5 - \pi] \times 10^{-6} = k$$

$$k = 2.95 \times 10^{-5} \text{ Nm/radian}$$

Substituting, $I = 10$ A and $k = 2.95 \times 10^{-5}$ in equation (i), we get

$$(5 - 4\theta) \times 10^{-6} = \frac{2 \times 2.95 \times 10^{-5} \times \theta}{10^2}$$

$$(5 - 4\theta) \times 10^{-6} = 5.9 \times 10^{-7}\,\theta$$

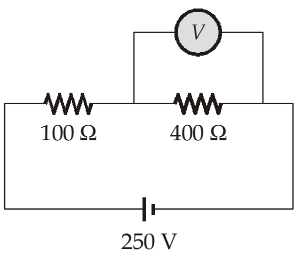
$$5 - 4\theta = 0.59\,\theta$$

$$5 = 4.59\,\theta$$

$$\theta = \frac{5}{4.59} = 1.089 \text{ radian (or) } 62.41°$$

22. (a)

$$\text{Percentage error} = \frac{\text{true value} - \text{measured value}}{\text{true value}} \times 100$$



True voltage across 400 Ω = 200 V

$$0.5 = \frac{200 - \text{measured value}}{200} \times 100$$

$$0.005 \times 200 = 200 - \text{measured value}$$

$$\text{measured value} = 199 \text{ volt}$$

$\therefore$ voltage across the combination of 400 Ω and voltmeter = 199 V

$$250 \times \frac{R_{eq}}{R_{eq} + 100} = 199 \text{ V}$$

$$250\,R_{eq} = 199\,R_{eq} + 19900$$

$$51\,R_{eq} = 19900$$

$$R_{eq} = 390.19$$

$$\therefore \quad \frac{400 \times R_V}{400 + R_V} = 390.19$$

$$400\, R_V = 390.19\, R_V + 156078.43$$

$$9.81\, R_V = 156078.43$$

$$R_V = 15.91 \text{ k}\Omega$$

23. (d)

Bridge is at balance at frequency 2500 Hz

$$(R_1 + j\omega L_1)\left(\frac{R_4}{j\omega C_4 R_4 + 1}\right) = R_2 R_3$$

$$R_1 R_4 + j\omega R_4 L_1 = R_2 R_3 + j\omega R_4 C_4 R_2 R_3$$

Separating the real and imaginary terms

$$\therefore \quad R_1 R_4 = R_2 R_3$$

$$\therefore \quad R_1 = \frac{R_2 R_3}{R_4}$$

and $\quad L_1 = C_4 R_2 R_3$

$$\therefore \quad R_1 = \frac{480 \times 720}{1040} = 332.31\ \Omega$$

$$L_1 = 480 \times 720 \times 0.4 \times 10^{-6} = 0.138 \text{ H}$$

Q factor of the coil-1

$$= \frac{\omega L_1}{R_1} = \frac{2\pi \times 2500 \times 0.138}{332.31 \Omega}$$

$$= 6.52$$

24. (c)

$$\text{Output of EVM} = (\text{F.F. of calibrated signal}) \times V_{avg.} \text{ of applied signal}$$

$$V_{\text{rms (indicated)}} = \text{F.F. of sinusoidal waveform } 1.11 \times \frac{1}{2} \times \frac{100 \times 3.6}{3.6} = 55.50 \text{ volts}$$

25. (d)

$$C_x = \frac{R_4}{R_3} C_2 = \frac{318}{130} \times 106 \times 10^{-12} = 259.29 \text{ pF}$$

$$R_x = R_3 \times \frac{C_4}{C_2}$$

$$= 130 \times \frac{0.35 \times 10^{-6}}{106 \times 10^{-12}} = 429.25 \text{ k}\Omega$$

26. (a)

$$\text{Voltage sensitivity} = \frac{\text{Charge sensitivity}}{\text{Total capacitance in the measuring circuit}}$$

$$= \frac{4 \times 10^{-6}}{[1 + 0.2 + 0.4] \times 10^{-9}} = \frac{4 \times 10^{-6}}{1.6 \times 10^{-9}} = 2500 \text{ V/cm}$$

27. (b)

$$\text{Measured power} = \text{True power (load power)} + \text{losses in current coil}$$

$$P_m = P_t + I_L^2 r_C$$

$$= 200 \times 10 + 100 \times 0.02$$

$$P_m = (2000 + 2) \text{ watts}$$

$$\text{error} = \frac{P_m - P_t}{P_t} \times 100\% = \frac{2}{2000} \times 100\% = 0.10\% \text{ more}$$

28. (a)

$$\tan\theta = \sqrt{3}\left(\frac{\omega_1 - \omega_2}{\omega_1 + \omega_2}\right) = \frac{1}{\sqrt{3}}$$

$$\tan\theta = \left[\sqrt{3}\left(\frac{200-100}{200+100}\right)\right] = \frac{1}{\sqrt{3}}$$

$\therefore$

$$P = \omega_1 + \omega_2 = 200 + 100 = 300 \text{ W}$$

$$Q = P\tan\theta = 300 \times \frac{1}{\sqrt{3}} = \frac{300}{\sqrt{3}} \text{VAR}$$

29. (d)

Given,

$N = 200$; length of coil = 10 mm, depth of coil = 40 mm

$$B = 40 \times 10^{-3} \text{ T}$$

$$I = 50 \times 10^{-3} \text{ A}$$

$$\text{Area of the coil} = 400 \text{ m}^2 = 400 \times 10^{-6} \text{ m}^2$$

$$T_d = GI = \text{NBA I}$$

$$= 200 \times 40 \times 10^{-3} \times 400 \times 10^{-6} \times 50 \times 10^{-3}$$

$$= 160 \times 10^6 \times 10^{-12} = 160 \ \mu \text{ N-m}$$

30. (a)

Deflection in MI instruments,

$$\theta = \frac{1}{2}\frac{I^2}{K} \cdot \frac{dL}{d\theta}$$

$$\frac{dL}{d\theta} = (2 - 1.8\,\theta) \times 10^{-6} \text{ H/rad}$$

$\therefore$

$$\theta = \frac{1}{2} \times \frac{10^2}{5 \times 10^{-6}}(2 - 1.8\theta) \times 10^{-6}$$

$$\theta = 10(2 - 1.8\,\theta)$$

$$\theta = 20 - 18\,\theta$$

$$\theta = \frac{20}{19} = 1.052 \text{ rad (or) } 60.31°$$

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