CLASS TEST

S.No.: 01SKEE_ABCDEFG_170924

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MEASUREMENTS

ELECTRICAL ENGINEERING

Date of Test : 17/09/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)

$$R_2 = \frac{0.9\text{ in}}{3.0\text{ in}} \times 5k = \frac{9}{30} \times 5k = 1500\ \Omega$$

$$\therefore \quad \frac{V_0}{V_t} = \frac{R_2}{R_1 + R_2};$$

$$V_0 = \left(\frac{R_2}{R_1 + R_2}\right) \times V_t = \frac{1500}{5k} \times 5V = \frac{1500}{1k} = 1.5\text{ V}$$

2. (b)

The movement induces emf and hence current in the aluminium frame of the coil. The torque developed due to this current is the damping torque.

3. (b)

Rate change of mutual inductance with deflection

$$\frac{dM}{d\theta} = \frac{d}{d\theta}[-6\cos(\theta + 30°)] = 6\sin(\theta + 30°)\text{mH}$$

$\frac{dM}{d\theta}$ at a deflection of 60° is

$$\left(\frac{dM}{d\theta}\right)_{\theta=60°} = 6\sin(60° + 30°)\text{ mH}$$

$$= 6 \times 10^{-3}\text{ H/degree}$$

$$\text{Deflecting torque, } T_d = I^2\frac{dM}{d\theta} = (50 \times 10^{-3})^2 \times 6 \times 10^{-3}$$

$$= 15 \times 10^{-6}\text{ Nm} = 15\ \mu\text{N-m}$$

4. (b)

$$\text{Current through the current coil} = \frac{24}{6} = 4\text{ A}$$

The pressure coil is energized by an ideal rectifier.

∴ The pressure coil carries current during one half cycle and in other half cycle there is no current in it. This means that there is a deflecting torque on the meter during on half-cycle.

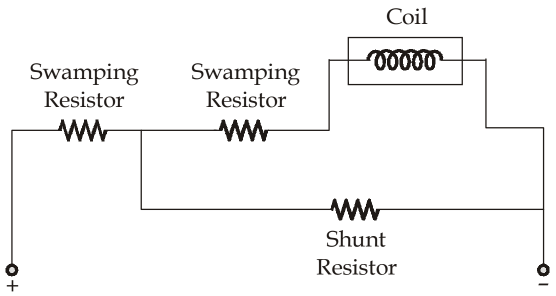
∴ Reading of wattmeter = average power over a cycle

$$= \frac{1}{2\pi}\left[\int_0^{2\pi} vi\,d\theta\right]$$

$$= \frac{1}{2\pi}\int_0^{\pi} \sqrt{2} \times 100\sin\theta \times 4\,d\theta = 180.06\text{ W}$$

5. **(a)**

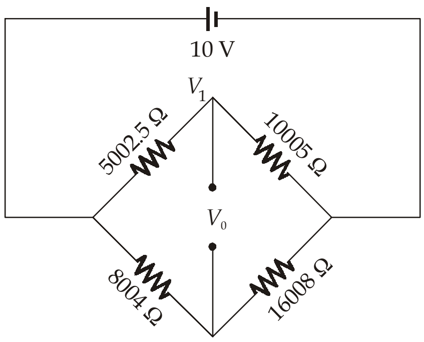
In the PMMC instruments, as temperature increases, the coil resistance increases with the moving coil to provide temperature compensation.



6. **(a)**

When signals to x and y Plates are in phase, the display is a straight line inclined at 45°.

7. **(b)**



$$V_0 = 10\left[\frac{5002.5}{5002.5+10005}\right] - 10\left[\frac{8004}{8004+16008}\right] = 0 \text{ mV}$$

8. **(c)**

Time base signal is not connected. The two waves are fed to x and y plates respectively.

9. **(c)**

An oscilloscope trigger function is important to achieve clear signal characterization, as it synchronizes the horizontal sweep of the oscilloscope to the proper point of the signal. The trigger control enables users to stabilize repetitive waveforms as well capture single–short waveforms.

10. **(b)**

11. **(a)**

$$R_x = \frac{C_1}{C_3}R_2 = \frac{0.5\mu\text{F}}{0.5\mu\text{F}} \times 2k = 2 \text{ k}\Omega$$

$$C_x = \frac{R_1}{R_2} \times C_3 = \frac{1k}{2k} \times 0.5\mu\text{F} = 0.25 \ \mu\text{F}$$

The dissipation factor is given by,

$$D = \omega R_x C_x$$
$$= 2 \times 3.142 \times 1000 \times 2 \times 1000 \times 0.25 \times 10^{-6}$$
$$= 3.142$$

12. (a)

$$\text{Turns ratio } n = K_n = 200$$

$$\text{Primary winding turns, } N_p = 1$$

$$\therefore \text{ Secondary winding turns, } N_s = nN_p = 200$$

$$\text{Primary induced voltage, } E_p = \frac{E_s}{n} = \frac{8}{200}\text{ V}$$

Loss component of exciting current,

$$I_e = \frac{\text{Iron loss}}{E_p} = \frac{1.5}{8/200} = 37.5\text{ A}$$

The magnetizing component,

$$I_m = \frac{\text{Magnetizing mmf}}{N_P} = 100\text{ A}$$

As the burden is purely resistive and therefore the secondary load angle is zero or $\delta = 0$.

$$\text{Actual ratio, } R = n + \frac{I_m \sin\delta + I_e \cos\delta}{I_s}$$

$$= 200 + \frac{37.5}{5} = 207.5$$

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

$$= \frac{200 - 207.5}{207.5} \times 100 = -3.61\%$$

13. (a)

Wagner's earth device is used for eliminating the effect of earth capacitance.

14. (a)

At 50 Hz supply, impedance of the instrument circuits,

$$Z = \frac{V_{ac}}{I_{ac}} = \frac{500}{0.1} = 5000\ \Omega$$

$$R = \sqrt{Z^2 - X_L^2} = \sqrt{(5000)^2 - (2\pi \times 50 \times 0.8)^2} = 4993.7\ \Omega$$

When connected to 300 V dc,

$$\text{Instrument current, } I_{dc} = \frac{V_{dc}}{R} = \frac{300}{4993.7} = 0.06008\text{ A}$$

Reading of instrument when connected to 300 V dc,

$$= \frac{V_{dc}}{I_{ac}} \times I_{dc} = \frac{500}{0.1} \times 0.06008 = 300.4\text{ V}$$

15. (c)

Meter-1:

$$V_{fsd} = 100\text{ V}$$

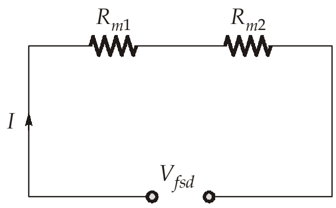
$$\text{Sensitivity} = 2\text{ k}\Omega/\text{V}$$

$$R_{m1} = 200\text{ k}\Omega$$

$$I_{\text{fsd 1}} = \frac{100}{200 \times 10^3} = 0.5\text{ mA}$$

Meter-2:

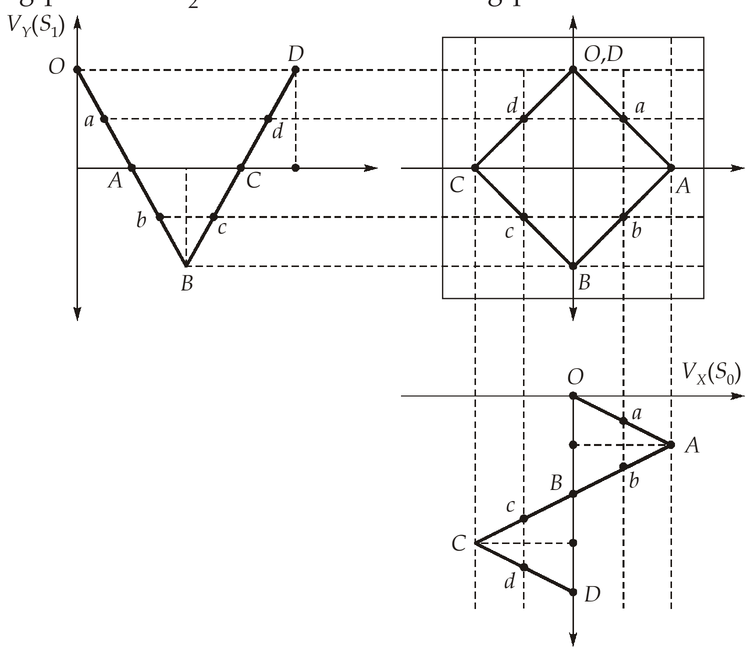
$$V_{fsd} = 100 \text{ V}$$
$$\text{Sensitivity} = 4 \text{ k}\Omega/\text{V}$$
$$R_{m1} = 400 \text{ k}\Omega$$
$$I_{\text{fsd 1}} = \frac{100}{400 \times 10^3} = 0.25 \text{ mA}$$



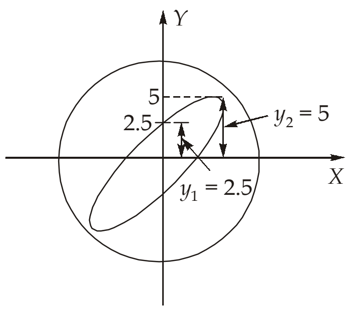
$$I = \min [I_{\text{fsd 1}}, I_{\text{fsd 2}}]$$
$$= 0.25 \text{ mA}$$
$$V = I \times 600 \times 10^3$$
$$= 0.25 \times 600 \times 10^{-3} \times 10^3 = 150 \text{ V}$$

16. (b)

The waveform pattern appearing on the screen of CRO is shown below. Here S_1 is applied to vertical deflecting plate and S_2 to horizontal deflecting plate.



17. (a)



As spot generating the pattern moves in clockwise direction

So, $\sin\phi = \dfrac{y_1}{y_2}$ (Where ϕ = phase differentiate)

$$\sin\phi = \frac{2.5}{5} = 0.5$$

$$\phi = 30°$$

18. (a)

Total power in the load circuit,

$$P = W_1 + W_2$$
$$= 6000 - 1000 = 5000 \text{ W}$$

$$\phi = \tan^{-1}\left[\frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}\right]$$
$$= \tan^{-1}\left[\frac{\sqrt{3}[(6000-(-1000)]}{6000-1000}\right]$$
$$= \tan^{-1}\left[\frac{\sqrt{3}(7000)}{5000}\right] = 67.58°$$

$$\cos\phi = 0.381$$

Load current per phase,

$$I_P = \frac{5000}{\sqrt{3}\times 440\times 0.381}$$
$$I_P = 17.22 \text{ A}$$

Load impedance per phase,

$$Z_P = \frac{V_P}{I_P} = \frac{440}{\left(\frac{17.22}{\sqrt{3}}\right)} = 44.25\ \Omega$$

Load resistance per phase,

$$R_p = Z_p \cos\phi = 44.25 \cos(67.58)$$
$$= 44.25 \times 0.381$$
$$R_p = 16.87\ \Omega$$

Load reactance per phase,

$$X_p = Z_p \sin\phi = 44.25 \sin(67.58)$$
$$X_p = 40.9\ \Omega$$

Reading of wattmeter B will be zero when power factor,

$$\cos\phi' = 0.5$$
$$\phi' = 60°$$

Since there is no change in resistance, reactance in circuit per phase,

$$X_p' = R_p \tan\phi'$$
$$X_p' = 16.87 \times \tan 60° = 29.22\ \Omega$$

Values of capacitive reactance introduced in each phase,

$$X_C = X_p - X_p'$$
$$= 40.9 - 29.22 = 11.68\ \Omega$$

$$\therefore \quad C = \frac{1}{2\pi f X_C} = \frac{1}{2\pi \times 50 \times 11.68}$$

$$C = 272.52\ \mu F$$

19. (c)

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

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

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

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

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

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

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

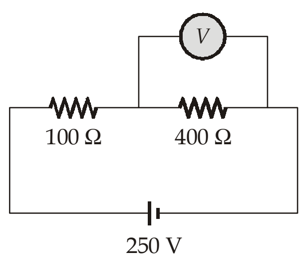
$$5 - 4\theta = 0.59\ \theta$$

$$5 = 4.59\ \theta$$

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

20. (a)

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



True voltage across 400 Ω = 200 V

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

$$0.005 \times 200 = 200 - \text{measured value}$$
$$\text{measured value} = 199 \text{ volt}$$

∴ voltage across the combination of 400 Ω and voltmeter = 199 V

$$250 \times \frac{R_{eq}}{R_{eq} + 100} = 199 \text{ V}$$
$$250\, R_{eq} = 199\, R_{eq} + 19900$$
$$51\, R_{eq} = 19900$$
$$R_{eq} = 390.19$$
$$\therefore \quad \frac{400 \times R_V}{400 + R_V} = 390.19$$
$$400\, R_V = 390.19\, R_V + 156078.43$$
$$9.81\, R_V = 156078.43$$
$$R_V = 15.91 \text{ k}\Omega$$

21. (d)

$$C_x = \frac{R_4}{R_3} C_2$$
$$= \frac{318}{130} \times 106 \times 10^{-12} = 259.29 \text{ pF}$$
$$R_x = R_3 \times \frac{C_4}{C_2}$$
$$= 130 \times \frac{0.35 \times 10^{-6}}{106 \times 10^{-12}} = 429.25 \text{ k}\Omega$$

22. (c)

$$\frac{f_y}{f_x} = \frac{2\frac{1}{2}}{1}$$
$$f_y = 2.5 \times f_x$$

∴ frequency of vertical voltage signal

$$= 2.5 \times 3$$
$$= 7.5 \text{ kHz}$$

23. (b)

$$R_1 = R_2(k - 1)$$
$$= 1 \text{ M}\Omega\ (10 - 1)$$
$$= 9 \text{ M}\Omega$$
$$C_1 = \frac{C_2}{k - 1} = \frac{30 \text{ pF}}{10 - 1} = 3.33 \text{ pF}$$

24. (a)

Resistance of meter, A = 1 kΩ/V × 10 V

= 10 kΩ

The parallel combination of R_B and meter A is

$$R_{e1} = \frac{5\times 10}{5+10} = 3.33 \text{ k}\Omega$$

$$\therefore \quad V_{RB} = 30\times\frac{3.33}{3.33+25} = 3.53 \text{ V}$$

Resistance of meter B,

$$= 20 \text{ k}\Omega/\text{V} \times 10$$

$$= 200 \text{ k}\Omega$$

The parallel combination of R_B and meter B is

$$= \frac{5\times 200}{5+200} = 4.88 \text{ k}\Omega$$

$$\therefore \quad V_{RB} = 30\times\frac{4.88}{4.88+25} = 4.9 \text{ V}$$

25. (a)

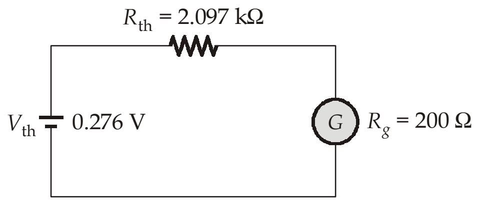
$$V_{\text{th}} = E\left[\frac{R_3}{R_3+R_1} - \frac{R_4}{R_4+R_2}\right]$$

$$= 6\left[\frac{3.5}{3.5+1} - \frac{7.5}{7.5+1.6}\right] = 6[0.778 - 0.824]$$

$$V_{\text{th}} = -0.276 \text{ Volt}$$

$$R_{\text{th}} = \frac{R_1R_3}{R_1+R_3} + \frac{R_2R_4}{R_2+R_4}$$

$$= \frac{1\times 3.5}{1+3.5} + \frac{1.6\times 7.5}{1.6+7.5} = 2.097 \text{ k}\Omega$$



$$I_g = \frac{V_{th}}{R_{th}+R_g} = \frac{0.276}{2.097 \text{ k}\Omega + 200\,\Omega} = 120 \text{ }\mu\text{A}$$

$$I_g \approx 120 \text{ }\mu\text{A}$$

26. (b)

Given, $P_1 = 3650$ W,

$P_0 = 3385$ W

Uncertainties, $W_{\text{pi}} = \pm 10$ W

$W_{\text{po}} = \pm 10$ W

Losses in transformer,

$$P_L = P_i - P_0 = 3650 - 3385 = 265 \text{ W}$$

$$\therefore \quad \frac{\partial P_L}{\partial P_i} = 1, \quad \frac{\partial P_L}{\partial P_0} = -1$$

$$\therefore \quad \text{uncertainty in losses} = \pm\sqrt{\left(\frac{\partial P_L}{\partial P_i}\right)^2 W_{pi}^2 + \left(\frac{\partial P_L}{\partial P_0}\right) W_{po}^2}$$

$$= \pm\sqrt{(1)^2(10)^2 + (-1)^2(10)^2} = \pm 10\sqrt{2}$$

$$\therefore \quad \% \text{ uncertainty in loss} = \frac{\pm 10\sqrt{2}}{265} \times 100 = \pm 5.34\%$$

27. **(c)**

For the given setup,

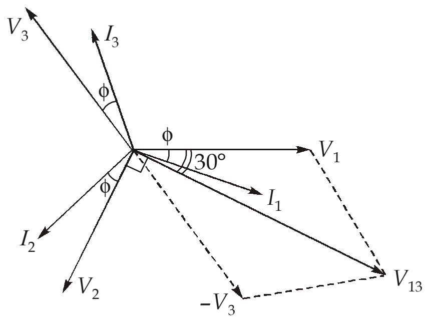
Taking voltage of phase 1 with respect to neutral V_1 as reference.

The phase current I_1 lags V_1 by a small angle ϕ.

The line voltages are given by

$$\bar{V}_{13} = \bar{V}_1 - \bar{V}_3$$

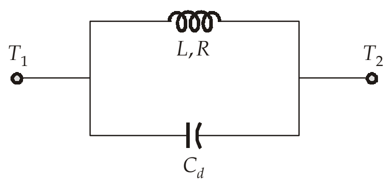
It is fairly observable from phasor diagram below that phase angle between line voltage V_{13} and current I_2 is



As angle between phase voltage V_1 and line voltage V_{13} is 30° and angle between two consecutive phases is 120° and hence angle between V_{13} and V_2 is 90° and total angle between V_{13} and $I_2 = 90° + \phi$.

28. **(a)**

For measuring self/distributed capacitance



For first resonance, $\quad f_1 = \dfrac{1}{2\pi\sqrt{L(C_1 + C_d)}}$

For second resonance, $\quad f_2 = \dfrac{1}{2\pi\sqrt{L(C_2 + C_d)}}$

and $\quad f_2 = nf_1$

Equating we get,

Self/distributed capacitance,

$$C_d = \frac{C_1 - n^2 C_2}{n^2 - 1} = \frac{1000 - 9(100)}{9 - 1} \qquad (\text{as } n = 3)$$

$$= \frac{1000 - 900}{8} = \frac{100}{8} = 12.5 \text{ pF}$$

29. **(a)**

Given,

Output of SAR type ADC = 01110110

Decimal equivalent of output $= 2^6 \times 1 + 2^5 \times 1 + 2^4 \times 1 + 2^2 \times 1 + 2^1 \times 1$

$= 64 + 32 + 16 + 4 + 2$

$= 118$

Input to ADC is analog voltage with amplitude, $A = 3.24$ V

$$\text{The resolution can be} = \frac{\text{Amplitude of analog signal}}{\text{Number of divisions}}$$

$$= \frac{3.24}{118} = 0.02745$$

$$= 27.458 \text{ mV} \approx 27.46 \text{ mV}$$

30. **(b)**

Distance of mass from spindle,

$d = 25.4$ mm

Weight of control mass, $m = 12$ gm

Deflecting torque, $T_d = 2.64 \times 10^{-3}$ N-m

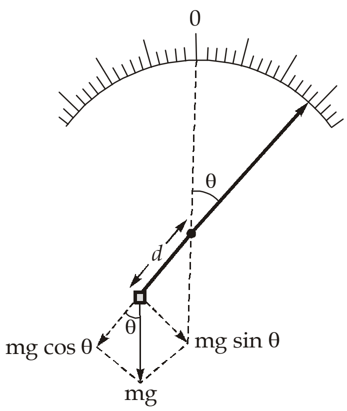
For equilibrium, $T_d = T_c$

Control torque, $T_c = mg \times d \sin\theta$

$2.64 \times 10^{-3} = 12 \times 10^{-3} \times 9.8 \times 25.4 \times 10^{-3} \sin\theta$

$\sin\theta = 0.8838$

$\theta = 62.106° \approx 62.11°$



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