CLASS TEST

Sl. 01 PT_A+B+C_290722

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ELECTRICAL & ELECTRONICS MEASUREMENTS

EC+EE

Date of Test : 06/08/2022

ANSWER KEY

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

1. (b)

Given, meter constant = 450 rev per kWhr

Load current = 12 A at 0.8 p.f. lag

Voltage rating = 230 V

Total power consumed by load,

$$230 \times 12 \times 0.8 = 2208 \text{ W or } 2.208 \text{ kW}$$

In one hour no. of revolution $= 2.208 \times 450 = 993.60$ rev per hour

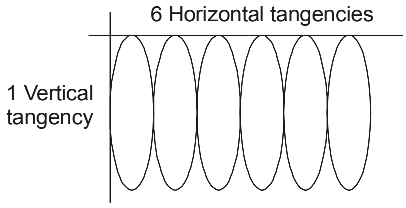
$$\text{No. of revolutions in a minute} = \frac{993.60}{60} = 16.56 \text{ rpm}$$

2. (d)

We know,

$$\frac{f_y}{f_x} = \frac{\text{No. of Horizontal tangencies}}{\text{No. of Vertical tangencies}}$$

$$\frac{4200}{700} = \frac{6}{1}$$



Hence option (d) is correct.

3. (a)

As the ammeters are connected in parallel, so voltage is same

$$R_A = \frac{V}{I_{fsd-A}} = \frac{V}{15 \text{ mA}}$$

$$R_B = \frac{V}{I_{fsd-B}} = \frac{V}{50 \text{ mA}}$$

$$\frac{R_A}{R_B} = \frac{50 \text{ mA}}{15 \text{ mA}} = \frac{10}{3} = 10:3$$

4. (b)

Value of resistor, $R_1 = 2 \times 10^4 \pm 7\%$

i.e. $R_1 = 20000 \pm \frac{7}{100} \times 20000$

$= (20000 \pm 1400)\ \Omega$

Value of resistor, $R_2 = 6 \times 10^3 \pm 4\%$

$= 6000 \pm \frac{6000 \times 4}{100} = (6000 \pm 240)\ \Omega$

Series network $= (26000 \pm 1640)\ \Omega$

$$\text{The tolerance limit} = \frac{1640}{26000} \times 100 = 6.307 \approx 6.31\%$$

5. (c)

Limiting error can be calculated using

$$P = I^2R$$

Taking log on both sides

$$ln\ P = 2\ ln\ I + ln\ R$$

$$\frac{\partial R}{R} = \frac{\partial P}{P} - \frac{2\partial I}{I}$$

So limiting error, $\frac{\partial R}{R} = \pm\left(\frac{\partial P}{P} + \frac{2\partial I}{I}\right)$

$$= \pm 0.02 \pm 2(0.03)$$

$$= \pm 0.02 \pm 0.06 = 0.08 \text{ or } 8\%$$

6. (b)

We know, $\theta = \frac{GI}{K} = \frac{NBAI}{K}$

For	K	B
1°C rise	0.05% decrease	0.03% decrease
10°C rise	0.5% decrease	0.3% decrease

So change in K. $K' = K - 0.5\%$ of K

$$= K - \frac{0.5}{100}K = K - \frac{5}{1000}K$$

$$K' = \frac{995\,k}{1000}$$

$$B' = B - 0.3\% \text{ of } B = \frac{997B}{1000}$$

$$\theta' = \frac{NB'A}{K'}I = \frac{(0.997)}{(0.995)}\frac{NBA}{K}.I$$

$$\theta' = 1.002\ \theta$$

∴ Change in reading $= \frac{\theta' - \theta}{\theta} \times 100$

$$= \frac{0.002\theta}{\theta} \times 100 = 0.2\ \%\ \text{increase}$$

7. (b)

The multiplication factor,

$$m = \frac{I}{I_m} = \frac{200\text{ mA}}{100\ \mu\text{A}} = 2000$$

∴ The shunt resistance required,

$$R_s = \frac{R_m}{m-1} = \frac{500}{2000-1} = \frac{500}{1999} = 0.250\ \Omega$$

8. (c)

We know

$$R_S = S_{dc} \times \text{Range}_{dc} - R_m$$

and $$S_{dc} = \frac{1}{I_{fs}} = \frac{1}{1\,\text{mA}} = \frac{1\,\text{k}\Omega}{\text{V}}$$

$$R_s = \frac{1\,\text{k}\Omega}{\text{V}} \times \frac{0.45\text{E}_{\text{rms}}}{1} - \text{R}_{\text{m}}$$

$$= \frac{1\text{k}\Omega}{\text{V}} \times \frac{0.45 \times 20\text{V}}{1} - 300$$

$$= 9000 - 300 = 8700\Omega = 8.7\text{ k}\Omega$$

9. (c)

We know

$$f \propto \frac{1}{\sqrt{C}}$$

So, $$\frac{f_1}{f_2} = \sqrt{\frac{C_2 + C_d}{C_1 + C_d}}$$

where C_d is self capacitance of the coil.

$$\frac{3}{1} = \frac{\sqrt{C_d + 360}}{\sqrt{C_d + 12}}$$

Squaring both sides, we get,

$$9 = \frac{C_d + 360}{C_d + 12}$$

$$108 + 9C_d = C_d + 360$$

$$8C_d = 252$$

$\Rightarrow$ $$C_d = \frac{252}{8} = 31.5\text{ pF}$$

10. (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,

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,

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

11. (c)

Given,

Secondary winding impedance,

$$= (0.583 + j\,0.25)\ \Omega$$
$$= 0.6343\angle 23.21°\ \Omega$$

Secondary load angle, $\delta = 23.21°$

Magnetizing current at primary,

$$I_\mu = 10.6\ \text{A}$$

Core loss component current,

$$I_c = 5.28\ \text{A}$$

$$\text{Turn ratio, } n = \frac{400}{4} = 100$$

$$\beta = \frac{180}{\pi} \times \frac{I_\mu \cos\delta - I_c \sin\delta}{n I_2}$$

$$= \frac{180}{\pi} \times \frac{(10.6\cos 23.21° - 5.28\sin 23.21°)}{100 \times 5} = 0.878° \approx 0.88°$$

12. (a)

At balance condition, $Z_1 Z_4 = Z_2 Z_3$

$$\left(\frac{R_1}{1 + j\omega C_1 R_1}\right) R_4 = \left(R_2 - \frac{j}{\omega C_2}\right) R_3$$

$$\frac{R_4}{R_3} = \frac{R_2}{R_1} + \frac{C_1}{C_2} + j\left(\omega C_1 R_2 - \frac{1}{\omega C_2 R_1}\right)$$

Equating the real and imaginary parts

$$\frac{R_4}{R_3} = \frac{R_2}{R_1} + \frac{C_1}{C_2}$$

and $$\omega C_1 R_2 - \frac{1}{\omega C_2 R_1} = 0$$

$$\omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$$

As given in question, $R_2 = R_1$

and $C_2 = C_1$

$$\omega = \frac{1}{RC}$$

and $$f = \frac{1}{2\pi RC}$$

Hence option (a) is correct.

13. (c)

Given, input signal $x(t) = 10\sin(20t)$

$$x_1(t) = \frac{d}{dt}x(t) = \frac{d}{dt}(10\sin 20t) = 200\cos 20t$$

$$x_2(t) = \frac{200\cos 20t}{20} = 10\cos 20t$$

$x_1(t)$ and $x_2(t)$ are same signal but 90° displaced in time domain.

$$x_2(t) = 10\sin(20t + 90°)$$

Hence, in XY mode CRO shows circle as output.

Hence option (c) is correct.

14. (b)

We know, Deflection, $D = \frac{L l_d E_d}{2 d E_a}$

Voltage required at deflecting plates,

$$E_d = \frac{2 d E_a D}{L l_d} = \frac{2 \times d \times E_a \times D}{L l_d}$$

$$= \frac{2 \times 5 \times 10^{-3} \times 4 \times 10^{-2} \times 1500}{50 \times 10^{-2} \times 1.5 \times 10^{-2}}$$

$$E_d = \frac{60000 \times 10^{-5}}{75 \times 10^{-4}} = 80 \text{ V}$$

Input voltage to amplifier = 2 V

We know input voltage required for a deflection of 4 cm

$$= \frac{E_d}{\text{Amplifier gain}}$$

So, amplifier gain $= \frac{E_d}{2} = \frac{80}{2} = 40$

15. (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

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

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

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

16. (b)

We know for triangular wave form

$$\text{Average value} = \frac{V_m}{2}$$

$$\text{RMS value} = \frac{V_m}{\sqrt{3}}$$

$$\text{Comparing rms value } \frac{V_m}{\sqrt{3}} = \frac{40}{\sqrt{3}}$$

$$V_m = 40 \text{ V}$$

$$\text{Average value of triangular input} = \frac{40}{2} = 20 \text{ V}$$

17. (b)

For the meter,

Full scale deflection current = 2 mA

Internal resistance = 500 Ω

The voltage drop across voltmeter at full scale current

$$= 2 \text{ mA} \times 500 = 1 \text{ V}$$

The full scale deflection on required voltmeter

$$= 200 \text{ V}$$

Maximum possible voltage around meter

$$= 1 \text{ V}$$

Extra potential drop = 200 – 1 V = 199 V

Comparing voltage drop and resistances

$$\frac{199}{1} = \frac{x}{500}$$

$$x = 500 \times 199 = 99.5 \text{ k}\Omega$$

Alternatively:

$$V_m = 2 \times 10^{-3} \times 500 = 1 \text{ V}$$

$$m = \frac{V}{V_m} = \frac{200}{1} = 200$$

$$R_{se} = (m - 1) R_m$$

$$= (200 - 1) \times 500 = 99500 = 99.5 \text{ k}\Omega$$

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,

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

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

$$C = 272.52\ \mu\text{F}$$

19. (c)

We know, figure of merit = sensitivity

$$\text{Sensitivity} = \frac{1}{I_{fsd}}$$

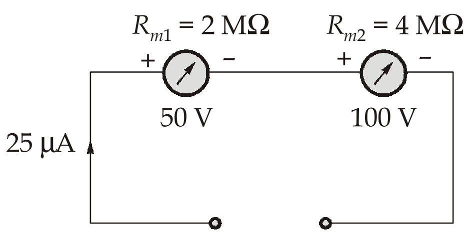
Full scale deflection current for meter 1

$$= \frac{1}{20\ \text{k}\Omega}\frac{V}{} = 0.05\ \text{mA} = 50\ \mu\text{A}$$

Full scale deflection current for meter 2

$$= \frac{1}{40\ \text{k}\Omega}\frac{V}{} = 0.025\ \text{mA} = 25\ \mu\text{A}$$

For series combination



Maximum allowable current = 25 μA

So maximum voltage measured from series combination

$$= 50 + 100 = 150\ \text{V}$$

20. (b)

We know ,
$$\omega = 2\pi f = 2\pi \times 1000 \text{ Hz} = 6283.19 \text{ Hz}$$
$$X_{L2} = \omega L_2 = 6283.19 \times 15.92 \times 10^{-3} = 100\ \Omega$$
$$X_{C3} = \frac{1}{\omega C_3} = \frac{1}{6283.19 \times 0.4 \times 10^{-6}} = 400\Omega$$

The impedance of the bridge arm
$$Z_1 = R_1 = 400\angle 0°\ \Omega$$
$$Z_2 = R_2 + jX_{L2} = 200 + j100$$
$$= 223.6\angle 26.6°\ \Omega$$
$$Z_3 = R_3 - jX_{C3}$$
$$= 300 - j400 = 500\angle -53.13°\ \Omega$$

$\therefore$
$$Z_x = \frac{Z_2 Z_3}{Z_1} = \frac{(223.6\angle 26.6°)(500\angle -53.13°)}{400\angle 0°}$$
$$= 279.5\angle -26.53°$$
$$= (250.07 - j124.84)\ \Omega$$

$$\text{we know } C = \frac{1}{\omega X_C} = \frac{1}{6283.19 \times 124.84} \approx 1.28\ \mu\text{F}$$

$\therefore$ Z impedance is series combination of 250.35 Ω resistance and 1.28 μF capacitance.

21. (b)

Let the reading of first wattmeter be P_1 and second wattmeter be P_2
$$P_1 = 3P_2$$

Using expression,
$$\tan\phi = \frac{\sqrt{3}(P_1 - P_2)}{P_1 + P_2}$$
$$\tan\phi = \frac{\sqrt{3}(3P_2 - P_2)}{3P_2 + P_2}$$
$$\tan\phi = \sqrt{3}\frac{2P_2}{4P_2} = \frac{\sqrt{3}}{2}$$
$$\phi = \tan^{-1}\frac{\sqrt{3}}{2} = 40.893°$$

As $180° - \pi$ radians

So, $40.893° - \dfrac{\pi}{180°} \times 40.893°$

So load impedance angle = 0.227 π

22. (b)

PMMC always reads average value,
$$V_0 = \frac{1}{T}\int_0^T v\,dt$$

$$= \frac{1}{25}\left[(10\times5)+(-5\times5)+\left(\frac{1}{2}\times10\times10\right)\right]$$

$$= \frac{1}{25}[50-25+50] = 3\text{ V}$$

23. **(d)**

Given, temperature range (50° – (–20°) = 70°C

Resolution = 0.2°C

$$\text{Resolution relative to range} = \frac{0.2}{70} = 0.00286$$

For N bit ADC

$$\text{Resolution} = \frac{1}{2^N-1} = 0.00286$$

$$2^N = 350$$

$$N \simeq 9$$

24. **(d)**

For limiting error in V_0

Let
$$x = \frac{C_2}{C_1}$$

$$\Rightarrow \quad x = \frac{9}{1} = 9$$

$$\ln x = \ln C_2 - \ln C_1$$

$$\frac{dx}{x} = \frac{dC_2}{C_2} - \frac{dC_1}{C_1}$$

Limiting error in x

$$\frac{\Delta x}{x} = \pm\left(\frac{\Delta C_2}{C_2}+\frac{\Delta C_1}{C_1}\right)$$

$$= \pm\, 0.05 \pm 0.05 = \pm\, 0.1 = \pm\, 10\%$$

So, $x = 9 \pm 10\%$

$$\Delta x = \pm 10\% \text{ of } x = 10\% \text{ of } 9 = \pm 0.9$$

$$V_0 = \frac{V_i}{1+x}$$

$$\frac{dV_0}{dx} = \frac{-V_i}{(1+x)^2}$$

$$dV_0 = -V_i\frac{dx}{(1+x)^2}$$

Limiting error in V_0

$$\Delta V_0 = -V_i\frac{\Delta x}{(1+x)^2} = \frac{-200\times(0.9)}{(1+9)^2}$$

$$= \pm 1.8 = \pm 1.8 \text{ kV}$$

Nominal value, $$V_0 = \frac{V_i}{1+x} = \frac{200}{1+9} = 20 \text{ kV}$$

So, $$V_0 = 20 \text{ kV} \pm 1.8 \text{ kV}$$

$\therefore$ $$V_{0\,max} = 21.8 \text{ kV}$$

25. **(d)**

At balance condition for schering bridge

$$R_x = \frac{R_3 C_4}{C_2} = \frac{(100\times10^3)(0.01\times10^{-6})}{(0.1\times10^{-6})} = 10\text{ k}\Omega$$

$$C_x = \frac{C_2 R_4}{R_3} = \frac{(0.1\times10^{-6})(470\times10^3)}{100\times10^3}$$

$$= 0.47 \times 10^{-6} \text{ F} = 0.47\ \mu\text{F}$$

26. **(b)**

$$\text{Percentage error} = \frac{I^2 R_C}{VI\cos\phi}$$

$$= \frac{(12)^2 \times 0.1}{250\times12\times1}\times100$$

$$= \frac{14.4}{3000}\times100 = 0.48\%$$

27. **(c)**

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

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

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

$\therefore$ $$(5 - 4\theta)\times10^{-6} = \frac{2k\theta}{I^2} \quad \text{...(i)}$$

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

$$\left[5 - 4\left(\frac{\pi}{4}\right)\right]\times10^{-6} = \frac{2k\times\frac{\pi}{4}}{(5)^2}$$

$$[5 - \pi]\times10^{-6} = \frac{\pi}{2\times25}k$$

$$\frac{50}{\pi}[5-\pi]\times10^{-6} = k$$

$$k = 2.95\times10^{-5} \text{ Nm/radian}$$

Substituting, $I = 10$ A and $k = 2.95\times10^{-5}$ in equation (i), we get

$$(5 - 4\theta)\times10^{-6} = \frac{2\times2.95\times10^{-5}\times\theta}{10^2}$$

$$(5 - 4\theta) \times 10^{-6} = 5.9 \times 10^{-7}\,\theta$$
$$5 - 4\theta = 0.59\,\theta$$
$$5 = 4.59\,\theta$$
$$\theta = \frac{5}{4.59} = 1.089 \text{ radian (or) } 62.41°$$

28. (d)

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

29. (c)

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

$\therefore$ frequency of vertical voltage signal

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

30. (b)

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

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