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Measurement

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CLASS TEST 2019-2020

ELECTRICAL ENGINEERING

Date of Test : 01/07/2019

ANSWER KEY ➤ Measurements

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

Detailed Explanations

1. (d)

∵ Power dissipation across the resistor

$$P = VI$$

relative limiting error in measurement of power across the resistor is

$$\frac{\delta P}{P} = \pm\left[\frac{\delta V}{V} + \frac{\delta I}{I}\right]$$

$$\delta V = \pm\frac{2}{100}\times 100 = \pm 2\text{ V}$$

$$\frac{\delta V}{V}\% = \pm\frac{2}{80}\times 100 = \pm 2.5\%$$

$$\delta I = \pm\frac{2}{100}\times 150 = \pm 3\text{ mA}$$

$$\frac{\delta I}{I}\% = \pm\frac{3}{80}\times 100 = \pm 3.75\%$$

$$\frac{\delta P}{P}\% = \pm[2.5 + 3.75] = 6.25\%$$

2. (b)

In order to achieve converging balance, the elements which are not common in the equation of R_1 and L_1 are chosen as variables.

So, R_4 and C_4 should be chosen for achieving converging balance.

3. (a)

The frequency ratio of two signals is given by

$$\frac{f_y}{f_x} = \frac{\text{number of intersections of the horizontal line with the curve}}{\text{number of intersections of the vertical line with the curve}}$$

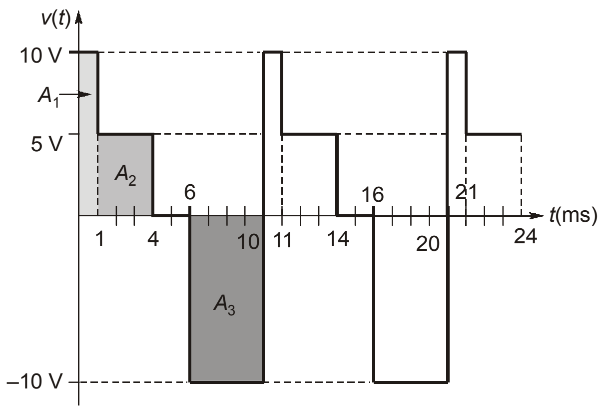
$$\frac{f_y}{f_x} = \frac{9}{7}$$

$$\Rightarrow \quad \frac{f_x}{f_y} = \frac{7}{9}$$

$$\Rightarrow \quad \frac{f_x}{f_y} = 0.77\text{ A}$$

5. (b)

As PMMC reads only DC value or average value and average value is equal to



$$V_{avg} = \frac{\text{Area under the curve}}{\text{Total time}}$$

$$V_{avg} = \frac{A_1 + A_2 - A_3}{10}$$

$$= \frac{[10 \times 1] + [5 \times 3] - [4 \times 10]}{10} = -1.5 \text{ V}$$

6. (a)

For the instrument to have uniform scale, the deflection (θ) should vary linearly with the quantity to be measured.

In Electrodynamo Wattmeter the deflection, $\theta \propto P_T$

and in permanent magnet moving coil, $\theta \propto I$

∴ Both of these instruments have uniform scale.

7. (a)

Torque produced

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

where

$$I = 5 \text{ A}$$

$$T = 180 \, \mu\text{N-m}$$

$$= 180 \times 10^{-6} \text{ N-m}$$

$$T = \frac{1}{2} \times 5^2 \times \frac{dL}{d\theta}$$

$$180 \times 10^{-6} = \frac{1}{2} \times 5^2 \times \frac{dL}{d\theta}$$

Date of change of self inductance

$$\frac{dL}{d\theta} = 14.4 \times 10^{-6} \text{ H/radian}$$

$$\frac{dL}{d\theta} = 14.4 \, \mu\text{H/radian}$$

8. (c)

- In self-generating (or active) transducers, the energy requirement of the transducer are met entirely from the input signal.
- In a photovoltaic cell, the incident light energy whose intensity being measured, supplies the entire energy for generating the proportional amount of output voltage, so it is self generating transducer.
- In Bourdon tube of a pressure gauge input pressure which is to be measured cause the deflection of pointer no other external energy is required for deflection.
- In thermocouple the heat energy whose temperature is to be measured generate emf.
- In LVDT some excitation energy is required for generating emf in secondary winding. So these are power operated or passive transducers.

9. (a)

$$\because \quad \phi = \tan^{-1}\left[\sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)\right] = \tan^{-1}\left[\sqrt{3}\left(\frac{4-2}{4+2}\right)\right] = 30°$$

$$\text{Power factor} = \cos\phi = \cos 30° = 0.866$$

10. (c)

$\because$ The function of controlling mechanism are

- To produce a force equal and opposite to the deflecting force at the final steady position of pointer in order to make the deflection of the pointer definite for a particular magnitude of current.
- In the absence of a controlling mechanism, the pointer will shoot (swing) beyond the final steady position for any magnitude of current and thus the deflection will be indefinite and the pointer will continuously rotate.

11. (b)

D.C sensitivity is $S_{dc} = \frac{1}{I_{FSD}} = \frac{1}{100\ \mu A} = 10\ k\Omega/V$

For a full wave rectifier circuit AC sensitivity

$$S_{ac} = 0.9\ S_{dc} = 9\ k\Omega/V$$

Resistance of multiplier $R_s = S_{ac}\ V_{rms} - R_m - 2R_d$

Since diodes are ideal, $R_d = 0$

Then, $R_s = 9000 \times 10 - 1000$

$= 89000\ \Omega$

$= 89\ k\Omega$

12. (a)

$$\text{Energy} = VI\cos\phi \times t$$

$$= 200 \times 50 \times 0.5 \times 1\text{ h} = 5\text{ kWh}$$

Meter makes 200 revolution for 1 unit of energy i.e. 1 kWh

So, for 5 kWh $= 200 \times 5 = 1000$ revolution

$$\%\text{ error} = \frac{1200 - 1000}{1000} \times 100 = 20\%\text{ fast}$$

13. (a)

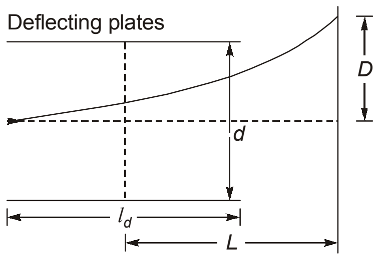
Deflection sensitivity, $S = \frac{L l_d}{2dV_a}$

Given, $L = 60$ cm,

$l_d = 30$ mm,

$d = 5$ mm.

$V_a = 3000$ V



$$= \frac{(0.60)\ (0.03)}{2 \times 0.005 \times 3000}\ \text{m/V}$$

$$= \frac{(0.60)\ (0.03)}{2 \times 0.005 \times 3}\ \text{mm/V}$$

$$= 0.6\ \text{mm/V}$$

14. (c)

$$V_0/V_1 = \frac{\frac{R_2}{1 + j\omega C_2 R_2}}{\frac{R_2}{1 + j\omega C_2 R_2} + \frac{R_1}{1 + j\omega C_1 R_1}}$$

$$= \frac{R_2(1+j\omega C_1R_1)}{R_2(1+j\omega C_1R_1)+R_1(1+j\omega C_2R_2)}$$

$$V_0/V_1 = \frac{(R_2 + j\omega C_1R_1R_2)}{(R_1+R_2)+j\omega R_1R_2(C_1+C_2)}$$

For V_0/V_1 to be independent of frequency, the imaginary part should be 0.

Which gives us,

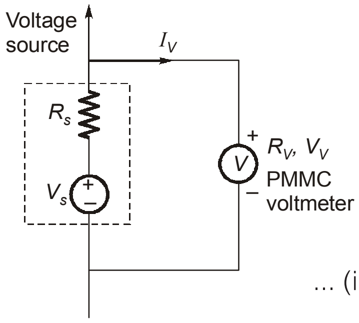
$$R_1C_1 = R_2C_2$$

$$\Rightarrow \quad 2000 \times 10 = 500 \times C_2$$

$$\Rightarrow \quad C_2 = 40\,\mu\text{F}$$

15. (d)

Reading of PMMC voltmeter (V_v) is given by



$$V_v = \frac{R_v}{R_s+R_v} \times V_s$$

For 10 V scale, $R_v = S_vV$

$$R_v = 10 \times 10 = 100\text{ k}\Omega$$

Using above formula, $$4 = V_s \times \frac{100}{R_s+100} \quad \text{... (i)}$$

For 20 V scale, $R_v = 10 \times 20 = 200\text{ k}\Omega$

Using same formula, $$6 = \frac{V_s \times 200}{R_s+200} \quad \text{... (ii)}$$

On solving equation (i) and (ii)

We get, $R_s = 200\text{ k}\Omega$

$$V_s = 12\text{ V}$$

16. (c)

$$\text{Error} = \pm(0.5\% \text{ of reading} + 5 \text{ counts})$$

Number of counts form 0 to 19999 are 20000

$$\therefore \quad \text{Error} = \pm\left[\left(25 \times \frac{0.5}{100}\right) + 5 \times \frac{100}{20000}\right]\ \Omega$$

$$= \pm 0.15\ \Omega$$

17. (d)

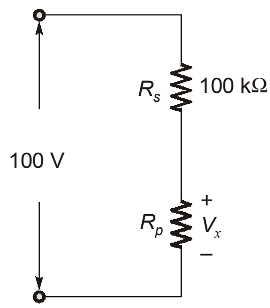
The equivalent resistance of the voltmeter on its 50 V scale is

$$R_V = 100\ \Omega/\text{V} \times 50\text{ V} = 5\text{ k}\Omega$$

Let R_p be the equivalent resistance of R_x and R_v

$$R_p = \frac{R_x \times R_v}{R_x+R_v} = \frac{5R_x}{5+R_x}$$

The equivalent circuit is



$$V_x = \frac{100 \times R_p}{R_p+R_s} = 4.65\text{ V}$$

$$\Rightarrow \quad = \frac{100 \times R_p}{R_p+100} = 4.65\text{ V}$$

$$R_p = \frac{4.65}{95.35} \times 100 = 4.878 \text{ k}\Omega$$

Then
$$R_x = \frac{R_p \times 5}{5 - R_p} = \frac{4.878 \times 5}{5 - 4.878} \approx 200 \text{ k}\Omega$$

18. (b)

To make a voltmeter of range (0-60 V) with maximum current limited to 50 μA, the value of multiplier resistor, R_{se}, will be given by,

$$I_{max} = \frac{V}{R_m + R_{se}}$$

$$50 \times 10^{-6} = \frac{60}{1000 + R_{se}}$$

$$R_{se} = \frac{60}{50 \times 10^{-6}} - 1000 = \frac{60 \times 10^6}{50} - 1000 = \left(\frac{60 \times 1000}{50} - 1\right) \text{k}\Omega = 1199 \text{ k}\Omega$$

19. (b)

Under balanced condition,

$$Z_1 Z_4 = Z_2 Z_3$$

$$\left(r_1 + \frac{1}{j\omega C_1}\right)\left(\frac{R_4}{1 + j\omega C_4 R_4}\right) = \frac{R_3}{j\omega C_2}$$

$$\left(r_1 + \frac{1}{j\omega C_1}\right) R_4 = \frac{R_3}{j\omega C_2}(1 + j\omega C_4 R_4)$$

$$r_1 R_4 + \frac{R_4}{j\omega C_1} = \frac{R_3}{j\omega C_2} + \frac{R_3 C_4 R_4}{C_2}$$

Separating real and imaginary parts we have

$$r_1 = \frac{R_3 C_4}{C_2} = \frac{1000 \times 0.5}{1} = 500 \text{ ohm}$$

$$C_1 = \frac{C_2 R_4}{R_3} = \frac{1 \times 500}{1000} = 0.5 \,\mu\text{F}$$

Dissipation factor,
$$D_1 = \tan\delta = \omega C_1 r_1$$
$$= 2 \times \pi \times 100 \times 0.5 \times 10^{-6} \times 500 \quad \text{(as frequency = 100 Hz)}$$
$$= 0.157$$

20. (d)

FOM of M_1 (S_{V1}) = 5 kΩ/V

FOM of M_2 (S_{V2}) = 10 kΩ/V

Full scale current through the meters are

$$I_{f1} = \frac{1}{S_{V1}} = \frac{1}{5} = 0.2 \text{ mA}$$

$$I_{f2} = \frac{1}{S_{V2}} = \frac{1}{10} = 0.1 \text{ mA}$$

In series combination, maximum current that can pass through when both the meters are connected in series will be 0.1 mA.

Resistance of M_1 = 5 kΩ/V × 200 = 1 MΩ

Resistance of M_2 = 10 kΩ/V × 200 = 2 MΩ

Hence, maximum voltage rating

= 0.1 mA (1 MΩ + 2 MΩ) = 300 V

21. (b)

$$V_1 = 100 \pm 1.5 \text{ V}$$
$$V_2 = 150 \pm 2 \text{ V}$$
$$V_3 = V_1 + V_2$$

Standard deviation in V_3 will be

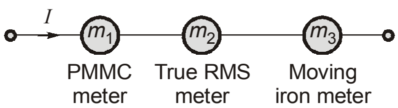
$$\sigma_{V_3} = \sqrt{\left(\frac{\partial V_3}{\partial V_1}\right)^2 \sigma_{V_1}^2 + \left(\frac{\partial V_3}{\partial V_2}\right)^2 \sigma_{V_2}^2}$$

$$\frac{\partial V_3}{\partial V_1} = \frac{\partial}{\partial V_1}(V_1 + V_2) = 1$$

$$\frac{\partial V_3}{\partial V_2} = \frac{\partial}{\partial V_2}(V_1 + V_2) = 1$$

∴ $$\sigma_{V_3} = \sqrt{1^2 \times (1.5)^2 + 1^2 \times (2)^2} = \sqrt{6.25} = 2.5 \text{ V}$$

22. (c)



$$I = -5 + 8\sqrt{2}\sin(\omega t + 60°) + 6\sqrt{2}\sin(\omega t + 30°)$$
$$I_1 = -5 \text{ A}$$
$$I_2 = 8\sqrt{2}\sin(\omega t + 60°)$$
$$I_3 = 6\sqrt{2}\sin(\omega t + 30°)$$

Averave value of I_1 = –5 A

Averave value of I_2 = 0 A

Averave value of I_3 = 0 A

So, average value of I = –5 A

PMMC reads only average value of current, therefore PMMC reads = –5 A (since it is centre zero)

RMS meter and moving iron instrument both measures rms value

$$\text{RMS value of } I = \sqrt{(-5)^2 + \left(\frac{8\sqrt{2}}{\sqrt{2}}\right)^2 + \left(\frac{6\sqrt{2}}{\sqrt{2}}\right)^2} = 11.18 \text{ A}$$

23. (d)

The wattmeter measures the load power plus the loss in current coil as current coil is connected to load side.

So, Loss in current coil $= I^2 r = 10 \times 10 \times 0.02 = 2$ watt

Load power $= VI\cos\phi = 200 \times 10 \times 1 = 2000$ watt

So, $$\text{Error} = \frac{2}{2000} \times 100 = 0.1\%$$

i.e. wattmeter reads 0.1% more than load power

24. (b)

$C_1 = 110$ pF, $C_2 = 20$ pF

$$n = \frac{f_2}{f_1} = \frac{2f}{f} = 2$$

$$C_d = \frac{C_1 - n^2 C_2}{n^2 - 1} = \frac{110 - 4 \times 20}{3} = 10 \text{ pF}$$

25. (a)

$$\text{Number of pulses per second} = \frac{\text{Reading of digital meter}}{\text{Gating period}} = \frac{0048}{10^4 \times 10^{-6}} = 4800$$

$$\therefore \quad \text{Speed} = \frac{\text{No. of pulses per second}}{\text{No. of teeth}} = \frac{4800}{120} = 40 \text{ r.p.s.}$$

27. (b)

For the d.c. potentiometer, we have:

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

or, emf of the test cell, $$E_2 = E_1 \cdot \frac{l_2}{l_1} = (1.18) \times \frac{680}{600} \approx 1.34 \text{ V}$$

28. (b)

$$\text{Sensitivity of LVDT} = \frac{\text{Output Voltage}}{\text{Displacement}} = \frac{5 \times 10^{-3}}{2} = 2.5 \text{ mV/mm}$$

Sensitivity of instrument = Amplification factor × Sensitivity of LVDT

$= 200 \times 2.5$ mV/mm $= 500$ mV/mm

$$\text{Minimum voltage that can be read on the voltmeter} = \left(\frac{10}{100}\right) \times \frac{1}{5} = 0.02 \text{ V} = 20 \text{ mV}$$

Resolution: Minimum cange in input displacement that can read by instrument.

$\because$ Sensitivity, $$S = \frac{\Delta \text{ o/p}}{\Delta \text{ i/p}}$$

$$\therefore \quad \Delta(\text{i/p})_{min} = \frac{\Delta (\text{o/p})_{min}}{S} = \frac{20 \text{ mV}}{500 \text{ mV/mm}} = 40 \ \mu\text{m}$$

29. (c)

To by pass the additional current we have to connect a shunt resistance across the DC ammeter.

$\because$ $$I_{fsd} = 1 \text{ mA}$$
$$R_m = 100\ \Omega$$
$$R_{sh} = \frac{R_m}{m-1}$$

Where, multiplying factor, $$m = \frac{I}{I_{fsd}} = \frac{1}{1\times 10^{-3}} = 1000$$

$$R_{sh} = \frac{100}{1000-1} = 0.1001\ \Omega$$

30. (b)

$$V_0 = \left[g \times t \times \frac{F}{A}\right] \times \text{Gain}$$

$$F = \frac{V_0 \times A}{g \times t \times \text{gain}} = \frac{50 \times 5 \times 5 \times 10^{-6}}{0.025 \times 2 \times 10^{-3} \times 250} = 0.1 \text{ N}$$

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