RPSC AEn-2024 Main Test Series

ELECTRICAL ENGINEERING | Test 5

Test Mode : • Offline • Online

Subjects : Electrical Measurement and Instrumentation

DETAILED EXPLANATIONS

PART-A

1. Solution:

CRO is a digital instrument, which works on the principle of thermionic emission i.e. emission of electron from a heated surface. It is a linear device. With the use of CRO, one can measure peak to peak, rms, peak or average value of voltage and current.

Calibration of CRO is done by applying a known quality of square signal having a frequency of 1 kHz and peak to peak magnitude of 1 mV.

2. Solution:

The sensitivity of a d.c. voltmeter is an important factor when selecting a meter for a certain voltage measurement. A low resistance voltmeter may cause loading of circuit if measuring voltage in high resistance circuit. This is called loading effect of an instrument and is caused principally by low sensitive instruments.

3. Solution:

It is an instrument which can be used to measure voltage, current and resistor is called multimeter. The instrument is provided with a selector switch which can be set for different modes of operation like measurement of voltage, current and resistance and also for various ranges of these quantities.

4. Solution:

- The LVDT have a high range for measurement of displacement.
- LVDT has less friction and high resolution.
- Low power consumption.
- Immunity from external effects.

5. Solution:

The concept of balancing in an AC bridges is used for measurement of capacitance, dissipation factor and relative permittivity. Bridges which we use are:

(i) De Sauty's Bridge

(ii) Schering Bridge

6. Solution:

A sensor or a detector is that part of transducer which responds to a physical phenomenon or change in a physical phenomenon in a specific manner.

7. Solution:

A voltmeter is a measuring instrument which measures voltage or potential difference between two points in a electrical or electronic circuit.

8. Solution:

Phase, frequency, entire time varying voltage and signal, analysis of waveforms.

9. Solution:

An ammeter is a measuring instrument used to measure the current in an arm of a circuit. Electric current has unit ampere (A) and hence the name of instrument derived as ammeter.

10. Solution:

For alternating electric current, RMS value is equal to that value of the direct current that would produce the same average power dissipation in a resistive load over the same time period.

PART-B

11. Solution:

1. **Accuracy:** It is the closeness with which an instrument reading approaches the true value of the quantity being measured.
2. **Precision:** It is a measure of the reproducibility of the measurements. It is a measure of degree of agreement within a group of measurements.

- Precision is not the guarantee of accuracy.
- An instrument with more significant figure has more precision.

3. **Sensitivity:** It is the ratio of the magnitude of output signal to the magnitude of input signal applied to the instrument.
   - An instrument requires high degree of sensitivity.
   - Sensitivity $\propto \dfrac{1}{\text{Deflection factor}}$
4. **Resolution:** The smallest change in input which can be detected with certainty by an instrument is its resolution.
5. **Linearity:** The output is linearly proportional to the input. For a linear instrument the sensitivity is constant for the entire range of instrument. Linearity is the most important parameter compared to all other parameters.

Note:

- Linearity is more important than the sensitivity.
- Accuracy is more important than resolution.

12. Solution:

Measurement of Medium Resistance

The different methods employed are:

(i) Ammeter-voltmeter method

(ii) Wheatstone bridge method

(iii) Ohmmeter method

(iv) Substitution method

Measurement of Low Resistance

The different methods employed are:

(i) Kelvin's double bridge method

(ii) Ammeter voltmeter method

(iii) Potentiometer method

Measurement of High Resistance

The different methods employed are:

(i) Loss of charge method

(ii) Meggar

(iii) Direct deflection method

(iv) Mega-ohm bridge method

13. Solution:

- When instruments are used in conjunction with instrument transformers, their readings do not depend upon their constants (R, L, C) as is the case with shunts and multipliers.
- Current transformers have been standardized at 5 A secondary winding current and voltage transformers at from 100 to 120 V secondary winding voltage.
- With the standardization of C.T. and P.T. secondary winding ratings, it is possible to standardize instruments around these ratings and therefore great reduction in cost of instruments.

14. Solution:

Current transformer secondary should never be left open circuited with primary winding energized because the primary mmf is left uncountered as there is no secondary mmf due to zero secondary current, hence inducing high voltage in secondary winding which can effect insulation and people nearby. Also eddy current and hysteresis losses would be very high, leading to increased errors overheating and complete damage sometimes.

15. Solution:

$$\text{Range of } R_1 = 10 \pm 10 \times \frac{5}{100} = 9.5\ \Omega \text{ to } 10.5\ \Omega$$

$$\text{Range of } R_2 = 5 \pm 5 \times \frac{10}{100} = 4.5\ \Omega \text{ to } 5.5\ \Omega$$

$$\because \quad R_p = \frac{R_1 R_2}{R_1 + R_2}$$

$$\therefore \quad \text{Range of } R_p = \frac{9.5 \times 4.5}{9.5 + 4.5} \text{ to } \frac{10.5 \times 5.5}{10.5 + 5.5} = 3.05\ \Omega \text{ to } 3.61\ \Omega$$

16. Solution:

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

where, $I = 10$ A

and $T = 240\ \mu$N-m $= 240 \times 10^{-6}$ N-m

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

$$240 \times 10^{-6} = \frac{1}{2} \times 10^2 \times \frac{dL}{d\theta}$$

Rate of change of self-inductance $= \frac{dL}{d\theta} = 4.8 \times 10^{-6}$ H/radian

$$\Rightarrow \quad \frac{dL}{d\theta} = 4.8\ \mu\text{H/radian}$$

17. Solution:

$$C_p = 0.102\ \mu\text{F},\ R_p = 1.25\ \text{M}\Omega$$

$$\text{Power loss} = \frac{V^2}{R_p} = \frac{(5\times10^3)^2}{1.25\times10^6} = \frac{25}{1.25} = 20\ \text{W}$$

$$\tan\delta = R/X = \frac{1}{\omega C_p R_p}$$

$$= \frac{1}{2\times\pi\times50\times0.102\times10^{-6}\times1.25\times10^6} = 0.025$$

18. Solution:

$$\frac{f_y}{f_x} = \frac{\text{Horizontal Tangencies}}{\text{Vertical Tangencies}}$$

$$\Rightarrow \quad \frac{f_y}{3} = \frac{3}{2} \Rightarrow f_y = 4.5\ \text{kHz}$$

PART-C

19. Solution:

$$\text{Measured value} = VI\sin(\Delta - \phi)$$

Where,

$$\Delta = \text{Phase angle between voltage and flux}$$

$$\cos\phi = \text{Power factor}$$

$$\text{True value} = VI\cos\phi$$

$$\text{Error} = \text{Measured value} - \text{True value}$$

Case-I:

$$\Delta = 85°,\ \text{pf} = \cos\phi = 1,\ \phi = 0°$$

$$V = 220\ \text{V},\ I = 5\ \text{A}$$

$$\text{Error} = VI\sin(\Delta - \phi) - VI\cos\phi$$

$$= 220\times5\sin(85 - 0°) - 220\times5\times1 \approx -4.2\ \text{W}$$

Case-II:

$$\Delta = 85°,\ \text{pf} = \cos\phi = 0.5,\ \phi = 60°$$

$$V = 220\ \text{V},\ I = 5\ \text{A}$$

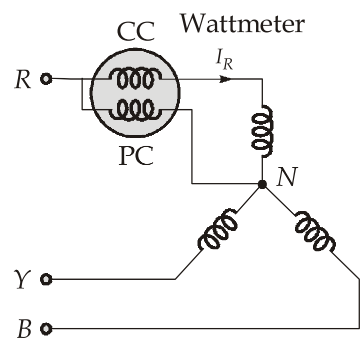
$$\text{Error} = VI\sin(\Delta - \phi) - VI\cos\phi$$

$$= 220\times5\times\sin(85 - 60°) - 220\times5\times0.5 = -85.1\ \text{W}$$

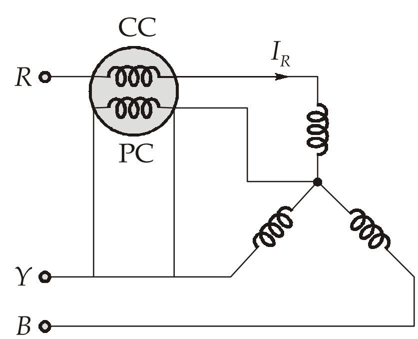
20. Solution:

Taking V_R as the reference and assuming phase to neutral voltage = V

$$V_R = V\angle 0°;\ V_Y = V\angle -120° \text{ and } V_B = V\angle -240°$$



$$V_R I_R \cos\phi = 400 \text{ W}$$
$$VI_R \times 0.8 = 400 \text{ W}$$
$$VI_R = \frac{400}{0.8} = 500 \quad \text{...(i)}$$
$$I_R = I_R\angle -36.87° \quad \text{[p.f. = 0.8 lag, inductive load]}$$



$$V_{YB} = V_Y - V_B = V\angle -120° - V\angle -240°$$
$$= \sqrt{3}\ \text{V}\angle -90° \text{ V}$$
$$I_R = I_R\angle -36.87° \text{ A}$$

Angle between V_{YB} and I_R

$$\theta = -90° - (-36.87°) = 53.13°$$

As pressure coil connected between Y and B phases.

$$\text{Reading of wattmeter} = V_{YB} I_R \cos\theta$$

From equation (i),

$$= \sqrt{3}\,\text{V} \times I_R \times \cos(-53.13)$$
$$= \sqrt{3} \times 500 \times 0.6 = 519.6 \text{ W}$$

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