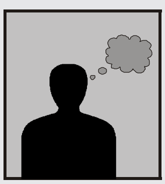
2017

MADE EASY WORKBOOK



Detailed Explanations of Try Yourself *Questions*

Electronics Engineering

Electronic Measurements & Instrumentation

MADE EASY Publications

1 Static and Dynamic Characteristics, Standards and Error Analysis

T1. (a)

Magnitude of limiting error of instrument is

$$= \frac{1}{100} \times 200 = 2\text{ V}$$

$\therefore$ relative limiting error $= \frac{2}{50} \times 100 = 4\%$

T2. (c)

Relative error =

$$\frac{\text{Measured value} - \text{True value}}{\text{True value}} \times 100$$

$$= \frac{205.5 - 202.4}{202.4} \times 100 = 1.53\%$$

Hence, option (c) is correct.

T3. (a)

Average current

$$= \frac{117.02 + 117.08 + 117.11 + 117.03}{4}$$

$= 117.06$ mA

as $I_{max} = 117.11$ mA and $I_{min} = 117.02$ mA

$\therefore$ Range of error

$$= \pm \frac{(I_{max} - I_{av}) + (I_{av} - I_{min})}{2}$$

$$= \pm \frac{0.05 + 0.04}{2} = \pm 0.045\text{ mA}$$

Alternate solution:

$$\text{Range of error} = \frac{\text{Max. value} - \text{Min. value}}{2}$$

$$= \pm \frac{117.11 - 117.02}{2}$$

$= \pm 0.045$

T4. (c)

The average value of measurement

$$= \frac{110.02 + 110.11 + 110.08 + 110.03}{4}$$

$= 110.06$

The average range of error is

$$= \frac{(\text{Maximum measured value} - \text{average value}) + (\text{Average value} - \text{Minimum measured value})}{2}$$

$= \pm 0.045$ V

■■■■

2 Measurement Instruments for Different Applications

Part-I: Current & Voltage Measurements

T1. (a)

Total voltage across PMMC

$= V_T = V_1 + V_2$

$= 2 + 3\sin(4t)$ V

PMMC reads average value

Average value of V_1 = 2 V

Average value of V_2 = 0

Average value of V_T = 2 V

So PMMC reads = 2 V

T2. (a)

$$V = 50 \text{ V}$$
$$S_V = 5 \text{ k}\Omega/\text{V}$$
$$I_{FS} = 200\ \mu\text{A}$$
$$R_m = 100\ \Omega$$
$$V_m = I_{FS} \times R_m = 20 \text{ mV}$$
$$m = \frac{V}{V_m} = 2500$$
$$R_s = R_m(m-1) = 249.9 \text{ k}\Omega$$

T3. (b)

T4. (c)

Full scale voltage = 10 V

Resistance of meter = $S_v \times 10$

= 2 × 10 = 20 kΩ

Reading of meter at its 10V scale

$$= \frac{\text{Resistance of meter} \times 8}{\text{Resistance of meter + output resistance}}$$

$$= \frac{20}{20+1} \times 8 = 7.62\text{V}$$

Part-II: Power & Energy Measurements

T1. (d)

Many wattmeters have errors caused by inductance of pressure coil.

T2. (c)

T3. (c)

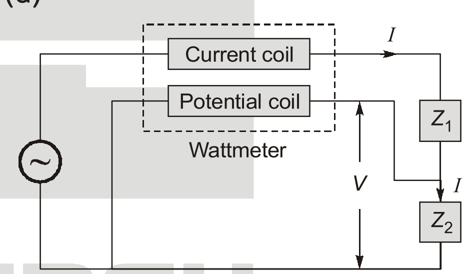
For type-1 error = $I^2 R_C$

For type-2 error = $\dfrac{V^2}{R_P}$

So, $$I^2 R_C = \frac{V^2}{R_P} = \frac{(200)^2}{10{,}000}$$

$$\Rightarrow \quad R_C = \frac{(200)^2}{10{,}000 \times (20)^2} = 0.01\,\Omega$$

T4. (d)



Potential coil draws negligible current, so current through z_1 and z_2 is same.

current through current coil = $I_{cc} = I$

Voltage across potential coil = V_{pc}

Voltage across $z_2 = V_{pc}$ = V

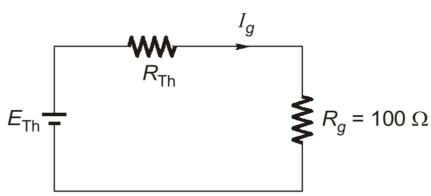
Wattmeter reads power consumed by z_2, as voltage across potential coil = Voltage across z_2

Current through current coil = current through z_2

Part-III: AC and DC Bridges

T1. (a)

Thevenin equivalent circuit across the Galvanometer resistance is



where, $$R_{Th} = \frac{5\times 2}{5+2} + \frac{Q+2}{Q+2}$$

$$= \frac{10}{7} + \frac{2Q}{Q+2} \quad \text{...(i)}$$

$$E_{Th} = 24\text{ mV} \quad \text{(given)}$$

$$\because \quad I_g = \frac{E_{Th}}{R_{Th}+100}$$

$$R_{Th} = 1.664\text{ k}\Omega$$

$$\frac{10}{7} + \frac{2Q}{Q+2} = 1.664\text{ k}\Omega$$

$$Q = 0.26\text{ k}\Omega$$

T2. (c)

T3. (a)

(i) Kelvin's double bridge mehtod is used for measurement of low resistance.

(ii) Wien's bridge is primarily known as a frequency determining bridge.

T4. (c)

T5. (c)

The bridge is Maxwell bridge.

Element is an inductor

inductance = L_x effective resistance of the inductor = R_x

$$Q = \frac{\omega L_x}{R_x} = \omega C_1 R_1 \quad \text{...(i)}$$

The bridge is limited to measurement of low Q inductor (1 < Q < 10).

It is clear from eq. (i) that the measurement of high Q coils demands a large value of resistance R_1, perhaps 10^5 or 10^6 Ω. The resistance boxes of such high values are very expensive. Thus for values of Q > 10, the bridge is unsuitable. The bridge is also unsuited for coils with a very low values of Q (i.e. Q < 1)

T6. (a)

At balance condition

$$\left[\frac{R_1 \times \frac{1}{C_1 s}}{R_1 + \frac{1}{C_1 s}}\right]\left[R_x + \frac{1}{C_x s}\right] = R_2 \times \frac{1}{C_3 s}$$

$$\frac{R_1}{1+R_1 C_1 s}\left[R_x + \frac{1}{C_x s}\right] = \frac{R_2}{C_3 s}$$

$$R_1\left[R_x + \frac{1}{C_x s}\right] = \frac{R_2}{C_3 s}[1+R_1 C_1 s]$$

On comparing real and imaginary part

$$R_x = \frac{R_2 C_1}{C_3}, \quad C_x = \frac{R_1 C_3}{R_2}$$

$$\because \quad Q = \omega C_x R_x$$

$$= \omega C_1 R_1$$

■■■■

3 Digital Systems for Measurements and Digital Instruments

Part-I: Q-Meter & Digital Voltmeter

T1. (d)

Self-capacitance, $C_d = \frac{C_1 - 4C_2}{3}$

T2. (a)

A three digit display on a digital voltmeter for (0-1) V range will be able to indicate values from zero to 999 mV, with smallest increment or resolution of 1 mV. In practice a fourth digit usually capable of indicating either 0 or 1 only is placed to the left of active digits. This permits going above 999 to 1999 to give overlap between ranges for convenience. This is called over ranging. This type of display is known as a $3\frac{1}{2}$ digit display.

T3. (a)

$$\text{No. of pulses} = 400 \times 10^3 \times 20 \times 10^{-3} = 8000$$

T4. (d)

$$\begin{aligned}\text{Sensitivity} &= \text{Resolution} \times (\text{minimum full scale value})\\ &= \text{Resolution} \times \text{Range}\\ &= 0.0001 \times 100 \times 10^{-3}\ \text{V}\\ &= 0.01\ \text{mV}\end{aligned}$$

Part-III: Cathode Ray Oscilloscopes

T1. (c)

Time period of sine wave $= \frac{1}{200} = 5$ ms

$V_{pp} = (300\sqrt{2}) \times 2 > 800$ mV

T2. (b)

Vertical sensitivity of CRO

$$= \frac{1}{30}\ \text{cm/V}$$

$\because$ CRO read magnitude of ac voltage

$$\therefore \quad V_m = \sqrt{2} \times V_{rms} = \sqrt{2} \times 30$$

Movement of the spot

$$= \sqrt{2} \times 30\left(\frac{1}{30}\right) \approx 1.5\ \text{cm}$$

T3. (c)

■■■■

4 Transducers and Measurement of Non Electrical Quantities

T1. **(d)**

Active transducer or self-generating transducers are devices that do not require any power supply for their operation.

eg.: Photovoltaic cell, thermocouple and thermopile, piezoelectric crystals.

T2. **(b)**

$$\text{Gauge factor} = \frac{\frac{\Delta R}{R}}{\frac{\Delta l}{l}}$$

$$3 = \frac{\frac{1.5}{500}}{\frac{\Delta l}{l}}$$

$$\therefore \quad \boxed{\frac{\Delta l}{l} = 0.001}$$

T3. **(b)**

■■■■

5 Basics of Telemetry and Data Aquisition Systems

T1. (b)

The bit rate of digitally recorded signal is given as

$$R_b = n \cdot f_s \text{ where}$$
$$n = \text{number of bits}$$
$$f_s = \text{the frequency at which signal is sampled}$$

Now bandwidth of the signal is given as

$$BW = \frac{R_b}{2} = \frac{nf_s}{2} \text{ Hz}$$