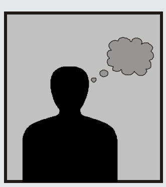
GATE

MADE EASY Workbook 2025



Detailed Explanations of Try Yourself *Questions*

Instrumentation Engineering

Measurements

MADE EASY PUBLICATIONS

1 Error Analysis

Detailed Explanation *of* Try Yourself Questions

T1. Sol.

Probable error, $$\delta I = \sqrt{\left(\frac{\partial I}{\partial I_1}\right)^2 \delta I_1^2 + \left(\frac{\partial I}{\partial I_2}\right)^2 \delta I_2^2}$$

Here, $$I = I_1 + I_2$$

So, $$\frac{\partial I}{\partial I_1} = \frac{\partial I}{\partial I_2} = 1$$

$$\delta I = \sqrt{(1)^2(1)^2 + (1)^2(2)^2} = 2.24 \text{ A}$$

therefore, $$I = 300 \pm 2.24 \text{ A}$$

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2 Indicating Meters

Detailed Explanation of Try Yourself Questions

T1. (d)

Average value of rectangular current wave = $\sqrt{\frac{1}{2T}\left[(12^2 \times T)+(5^2 \times T)\right]} \simeq 9.2$

Average volts = 9.2 × 10 = 92 V

The MI meter will read 92 V.

4 Instrument Transformers

Detailed Explanation *of* Try Yourself Questions

T1. (c)

$$\text{Phase angle error for CT is} = \frac{180}{\pi}\left(\frac{I_m \cos\delta - I_e \sin\delta}{K_t\, I_s}\right)\text{degree}$$

Here,
$$K_t = \frac{1000}{5} = 200,\ I_s = 5\text{ A}$$
$$I_m = 11\text{ A}$$
$$I_e = 6.5\text{ A}$$
$$\delta = 30°$$

$$\text{So, phase angle error} = \frac{180}{\pi}\left(\frac{11\cos 30° - 6.5\sin 30°}{200\times 5}\right) = 0.359°$$

T2. (b)

Secondary circuit phase angle, $\delta = \tan^{-1}\left(\frac{1}{1.5}\right) = 33.69°$

$\cos\delta = \cos 33.39° = 0.835$

or, $\sin\delta = \sin 33.69° = 0.555$

Turn ratio, $K_t = \frac{N_s}{N_p} = \frac{300}{1} = 300$

Magnetizing current, $I_m = \frac{\text{Magnetising mmf}}{N_p} = \frac{100}{1} = 90\text{ A}$

Secondary circuit burden impedance $= \sqrt{(1.5)^2 + (1.0)^2} = 1.8\ \Omega$

Secondary induced voltage, $E_s = 5\times 1.8 = 9\text{ V}$

Primary induced voltage, $E_p = \frac{E_s}{300} = \frac{9\text{ V}}{300}$

Loss component, $I_w = \frac{\text{iron loss}}{E_p} = \frac{1.2}{(9/300)} = 40\text{ A}$

Phase angle, $\theta = \frac{180}{\pi}\left(\frac{I_m \cos\delta - I_w \sin\delta}{K_t I_s}\right)$

$$= \frac{180}{\pi}\left(\frac{100 \times 0.835 - 40 \times 0.555}{300 \times 5}\right) = 2.34^\circ$$

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5 Measurement of R, L and C/Bridges

Detailed Explanation *of* Try Yourself Questions

T1. Sol.

$$R_3 = 5\ \Omega,$$
$$C = 1\ \text{mF},$$
$$R_1 = 160\ \Omega,$$
$$R_2 = 20\ \Omega$$

By using balance equation, $R = \dfrac{R_2 R_1}{R_3}$

$$L = R_2 R_1 C$$

and quality factor $= Q = \dfrac{\omega L}{R}$

So, $R = \dfrac{20 \times 160}{5} = 640\ \Omega$

$$L = 20 \times 160 \times 1 \times 10^{-3} = 3.2\ \text{H}$$

$$Q = \frac{2\pi \times 50 \times 3.2}{640} = 1.57$$

T2. (b)

At balance,

$$Z_1 Z_4 = Z_2 Z_3$$

$$\frac{10 \times 10^3 \times X_C}{10 \times 10^3 + X_C} \times Z = 500 \times 10^3$$

as, $X_C = \dfrac{1}{j\omega C} = \dfrac{1}{j \times 100\pi \times 100 \times 10^{-9}} = -j\dfrac{10^5}{\pi}$

$$\therefore \quad \frac{-j10^4 \times 10^5}{\pi\left(10^4 - \dfrac{j \times 10^5}{\pi}\right)} \times 2 = 5 \times 10^5$$

$$\Rightarrow \quad \frac{-j10^3}{1000\pi - j10^4}(R + jX) = 5$$

$$\Rightarrow \quad -jR + X = 5\pi - j5 \times 10$$

$$\Rightarrow \quad R = 50\ \Omega$$

and $$L = \frac{5}{2 \times 50} = 50 \text{ mH}$$

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6 CRO, Q-meter

Detailed Explanation of Try Yourself Questions

T1. Sol.

Using the equation,
$$V_{p-p} = \left(\frac{\text{volts}}{\text{div}}\right) \times \left(\frac{\text{no. of div}}{1}\right)$$
$$V_{p-p} = 0.5 \text{ V} \times 3 = 1.5 \text{ V}$$

T2. Sol.

The period of the signal is calculate using the equation
$$T = \left(\frac{\text{time}}{\text{div}}\right) \times \left(\frac{\text{no. of div}}{\text{cycle}}\right)$$
$$T = 2\ \mu\text{s} \times 4 = 8\ \mu\text{s}$$

Hence, frequency is
$$f = \frac{1}{T} = \frac{1}{8\ \mu\text{s}} = 125 \text{ kHz}$$

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