

Assignment

GATE-EC-39

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I. QUESTION

The voltage at the input of an AC-DC rectifier is given by $v(t) = 230\sqrt{2}\sin\omega t$, where $\omega = 2\pi \times 50\text{rad/s}$. The input current drawn by the rectifier is given by

$$i(t) = 10\sin\left(\omega t - \frac{\pi}{3}\right) + 4\sin\left(3\omega t - \frac{\pi}{6}\right) + 3\sin\left(5\omega t - \frac{\pi}{3}\right) \quad (1)$$

The power input, (rounded off to two decimal places), is _____ lag.

Solution:

Symbol	Value	Description
$v(t)$	$230\sqrt{2}\sin\omega t$	input voltage
ω	$100\pi\text{rad/s}$	Angular velocity
Power Factor	$\frac{P_{avg}}{V_{rms}I_{rms}}$	—
$\cos\varphi$	$\frac{1}{2}$	Fundamental displacement factor
φ	$\frac{\pi}{3}$	angle between $v(t)$ and I_n
I_n	$10\sin\left(\omega t - \frac{\pi}{3}\right)$	fundamental component of current

TABLE 0
VARIABLE DESCRIPTION

For current sources of the form $I(t) = I_0 + I_1(t) + \dots + I_n(t)$

$$P_{avg} = \frac{1}{T} \sum_1^n \int_0^T V(t) I_n(t) dt \quad (2)$$

$$P_{avg} = \frac{1}{T} \sum_1^n \int_0^T V_{pk} \sin(\omega t) I_{pk(n)} \sin(\omega t + \varphi) dt \quad (3)$$

$$P_{avg} = \sum_0^n \frac{V_{pk} I_{(n)pk}}{2} \cos\varphi \quad (4)$$

For a sine wave signal $V_{pk} = V_{rms} \sqrt{2}$

$$P_{avg} = \sum_0^n (V_{rms}) (I_{(n)rms}) \cos\varphi \quad (5)$$

$$\text{Power Factor} = \frac{P_{avg}}{V_{rms} I_{rms}} \quad (6)$$

$$\text{Power Factor} = \frac{\sum_0^n I_{(n)rms} \cos\varphi}{I_{rms}} \quad (7)$$

$$I_{rms} = \sqrt{\left(\frac{10}{\sqrt{2}}\right)^2 + \left(\frac{4}{\sqrt{2}}\right)^2 + \left(\frac{3}{\sqrt{2}}\right)^2} = 7.905A \quad (8)$$

The rms value of fundamental value of current

$$(I_{(1)rms}) = \sqrt{\left(\frac{10}{\sqrt{2}}\right)^2} \quad (9)$$

$$\varphi = 30^\circ \quad (10)$$

$$\text{Power Factor} = \frac{\frac{10}{\sqrt{2}} \cos 30}{7.905} \quad (11)$$

$$\Rightarrow 0.4473 \quad (12)$$

$$P_{avg} = \frac{1}{T} \int_0^T V(t) I(t) dt \quad (1)$$