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 $\omega = 2\pi \times 50$rad/s. The input current drawn by the rectifier is given by

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

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	$100\pi rad/s$	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

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

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

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

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

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

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

$$P_{avg} = \sum_0^n (v_{rms})\,(I_{(n)rms})\cos\varphi \tag{5}$$

$$\text{Power Factor} = \frac{\sum_0^n I_{(n)rms}\cos\varphi}{I_{rms}} \tag{6}$$

$$I_{rms} = \sqrt{\left(\frac{10}{\sqrt{2}}\right)^2 + \left(\frac{4}{\sqrt{2}}^2\right) + \left(\frac{3}{\sqrt{2}}\right)^2} = 7.905A \tag{7}$$

The rms value of fundamental value of current

$$(I_{(1)rms}) = \sqrt{\left(\frac{10}{\sqrt{2}}\right)^2} \tag{8}$$

$$\varphi = 30^\circ \tag{9}$$

$$\text{Power Factor} = \frac{\frac{10}{\sqrt{2}}\cos 30}{7.905} \tag{10}$$

$$\implies 0.4473 \tag{11}$$