

GATE:2022 - BM 54

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I. QUESTION

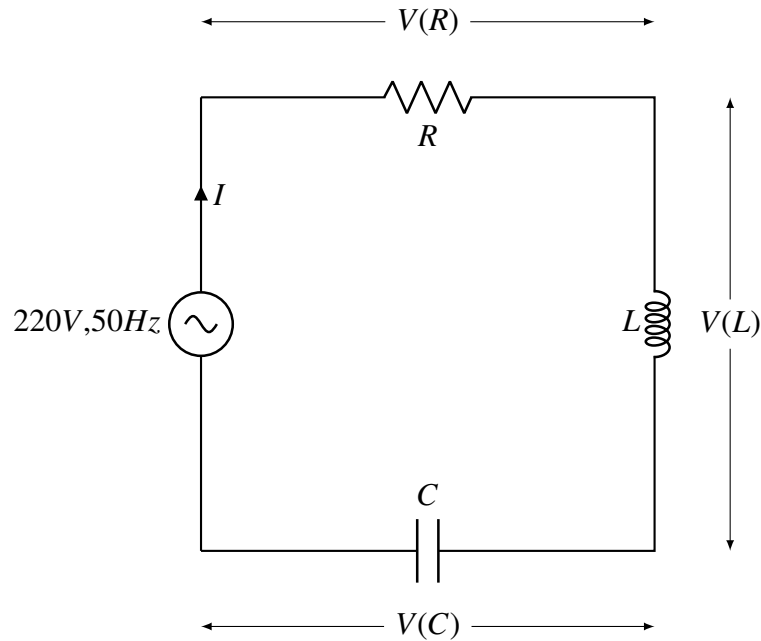
A series RLC circuit is connected to 220 V, 50 Hz supply. For a fixed a value of R and C, the inductor L is varied to deliver the maximum current. This value 0.4A and the corresponding potential drop across the capacitor is 330 V. The value of the inductor L is ? (Rounded off to two decimal places).

Solutions :

Symbols	Description
$X_1(s)$	Laplace transform of $x_1(t)$
$X_2(s)$	Laplace transform of $x_2(t)$
$u(t)$	Unit step function

TABLE I

PARAMETERS, DESCRIPTIONS



- 1) During maximum current $|Z_{net}|$ is minimum .

$$I = \frac{V}{Z_{net}} \quad (1)$$

$$= \frac{V}{R + \chi(L) + \chi(C)} \quad (2)$$

$$|I| = \left| \frac{V}{R + j\omega L + \frac{1}{j\omega C}} \right| \quad (3)$$

$$= \frac{|V|}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} \quad (4)$$

Varying L for maximum value of I :

$$\omega L = \frac{1}{\omega C} \quad (5)$$

Putting in (2):

$$I_{max} = \frac{V}{R} \quad (6)$$

I_{max} has same phase as V (Assume $\angle\phi$). For impedance across the capacitor :

$$V(C)|_{I=I_{max}} = I_{max}\chi(C) \quad (7)$$

$$-330\angle(90 + \phi) = 0.4\angle\phi\chi(C) \quad (8)$$

$$-330\angle 90 = 0.4\chi(C) \quad (9)$$

$$\Rightarrow \chi(C) = -825j\Omega \quad (10)$$

For value of inductor :

$$|j\omega L| = \left| \frac{1}{j\omega C} \right| \quad (11)$$

$$L = \frac{1}{\omega^2 C} \quad (12)$$

$$= \frac{-825}{100\pi} H \quad (13)$$

$$\approx 2.63H \quad (14)$$