The intensity of a lightbulb with a resistance of 110 ohms is controlled by connecting it in series with an inductor whose inductance can be varied from L=0 to L =Lmax. This "light dimmer" circuit is connected to an ac generator with frequency of 60 Hz and an rms voltage of 120V. P=130 w The inductor is now adjusted to L=Lmax. The average power dissipated in the lightbulb is one-fourth of 130 W. What is the value of Lmax?

Solution:

The rms current flowing in the circuit:

$$I = \frac{V}{Z}$$

where, Z is impedance of the circuit.

$$Z = \sqrt{R^2 + \omega^2 L_{max}^2}$$

The average power dissipated of the circuit is

$$P_{av} = VI \cos\varphi$$

The power factor of the circuit

$$\cos\varphi = \frac{R}{Z}$$

$$P_{av} = \frac{V^2 R}{Z^2} = \frac{1}{4} \times 130 \ W$$

$$\frac{V^2 R}{R^2 + \omega^2 L_{max}^2} = 32.5 \ W$$

So,

$$L_{max} = \frac{1}{\omega^2}\left(\frac{V^2 R}{32.5} - R^2\right) = \frac{1}{4\pi^2 f^2}\left(\frac{V^2 R}{32.5} - R^2\right)$$

$$L_{max} = \frac{1}{4\pi^2(60)^2}\left(\frac{120^2 \times 110}{32.5} - 110^2\right) = 0.258 \ H$$

Answer: $0.258 \ H$

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