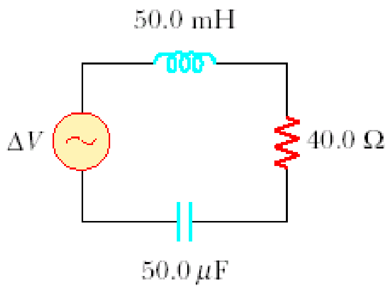
30. The voltage source in the Figure has an output of ΔV_{rms} = 100 V at ω = 1 000 rad/s. Determine (a) the current in the circuit and (b) the power supplied by the source. (c) Show that the power delivered to the resistor is equal to the power supplied by the source.



P33.30 $X_L = \omega L = [(1\,000/\text{s})(0.050\,0\text{ H})] = 50.0\ \Omega$

$$X_C = \frac{1}{\omega C} = \left[(1\,000/\text{s})(50.0\times10^{-6}\text{ F})\right]^{-1} = 20.0\ \Omega$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{(40.0)^2 + (50.0 - 20.0)^2} = 50.0\ \Omega$$

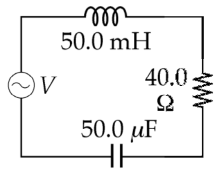


FIG. P33.30

(a)
$$I_{rms} = \frac{(\Delta V_{rms})}{Z} = \frac{100\text{ V}}{50.0\ \Omega}$$

$$I_{rms} = \boxed{2.00\text{ A}}$$

$$\phi = \arctan\left(\frac{X_L - X_C}{R}\right)$$

$$\phi = \arctan\frac{30.0\ \Omega}{40.0\ \Omega} = 36.9°$$

(b) $$P = (\Delta V_{rms}) I_{rms}\cos\phi = 100\text{ V}(2.00\text{ A})\cos 36.9° = \boxed{160\text{ W}}$$

(c) $$P_R = I_{rms}^2 R = (2.00\text{ A})^2\, 40.0\ \Omega = \boxed{160\text{ W}}$$

31. An AC voltage of the form $\Delta v = (100\text{ V})\sin(1\,000t)$ is applied to a series *RLC* circuit. Assume the resistance is 400 **Ω**, the capacitance is 5.00 μF, and the inductance is 0.500 H. Find the average power delivered to the circuit.

P33.31 $\omega = 1\,000\text{ rad/s}$, $R = 400\ \Omega$, $C = 5.00\times10^{-6}\text{ F}$, $L = 0.500\text{ H}$

$$\Delta V_{max} = 100\text{ V},\quad \omega L = 500\ \Omega,\quad \left(\frac{1}{\omega C}\right) = 200\ \Omega$$

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} = \sqrt{400^2 + 300^2} = 500\ \Omega$$

$$I_{max} = \frac{\Delta V_{max}}{Z} = \frac{100}{500} = 0.200\text{ A}$$

The average power dissipated in the circuit is $P = I_{rms}^2 R = \left(\frac{I_{max}^2}{2}\right) R$.

$$P = \frac{(0.200\text{ A})^2}{2}(400\ \Omega) = \boxed{8.00\text{ W}}$$

37. An *RLC* circuit is used in a radio to tune into an FM station broadcasting at 99.7 MHz. The resistance in the circuit is 12.0 **Ω**, and the inductance is 1.40 μH. What capacitance should be used?

P33.37 $\omega_0 = 2\pi\left(99.7\times10^6\right) = 6.26\times10^8 \text{ rad/s} = \frac{1}{\sqrt{LC}}$

$$C = \frac{1}{\omega_0^2 L} = \frac{1}{\left(6.26\times10^8\right)^2\left(1.40\times10^{-6}\right)} = \boxed{1.82 \text{ pF}}$$

40. A series *RLC* circuit has components with following values: $L = 20.0$ mH, $C = 100$ nF, $R = 20.0$ **Ω**, and $\Delta V_{max} = 100$ V, with $\Delta v = \Delta V_{max} \sin \omega t$. Find (a) the resonant frequency, (b) the amplitude of the current at the resonant frequency, (c) the Q of the circuit, and (d) the amplitude of the voltage across the inductor at resonance.

P33.40 $L = 20.0 \text{ mH}$, $C = 1.00\times10^{-7}$, $R = 20.0\ \Omega$, $\Delta V_{max} = 100 \text{ V}$

(a) The resonant frequency for a series –*RLC* circuit is

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} = \boxed{3.56 \text{ kHz}}.$$

(b) At resonance, $I_{max} = \frac{\Delta V_{max}}{R} = \boxed{5.00 \text{ A}}$.

(c) From Equation 33.38, $Q = \frac{\omega_0 L}{R} = \boxed{22.4}$.

(d) $\Delta V_{L,max} = X_L I_{max} = \omega_0 L I_{max} = \boxed{2.24 \text{ kV}}$