56. The current in the circuit satisfies $i(t) = I\sin(\omega_d t - \phi)$, where

$$\begin{aligned} I &= \frac{\mathcal{E}_m}{Z} = \frac{\mathcal{E}_m}{\sqrt{R^2 + (\omega_d L - 1/\omega_d C)^2}} \\ &= \frac{45.0\,\mathrm{V}}{\sqrt{(16.0\,\Omega)^2 + \{(3000\,\mathrm{rad/s})(9.20\,\mathrm{mH}) - 1/[(3000\,\mathrm{rad/s})(31.2\,\mu\mathrm{F})]\}^2}} \\ &= 1.93\ \mathrm{A} \end{aligned}$$

and

$$\begin{aligned} \phi &= \tan^{-1}\left(\frac{X_L - X_C}{R}\right) = \tan^{-1}\left(\frac{\omega_d L - 1/\omega_d C}{R}\right) \\ &= \tan^{-1}\left[\frac{(3000\,\mathrm{rad/s})(9.20\,\mathrm{mH})}{16.0\,\Omega} - \frac{1}{(3000\,\mathrm{rad/s})(16.0\,\Omega)(31.2\,\mu\mathrm{F})}\right] \\ &= 46.5^\circ\ . \end{aligned}$$

(a) The power supplied by the generator is

$$\begin{aligned} P_g &= i(t)\mathcal{E}(t) = I\sin(\omega_d t - \phi)\mathcal{E}_m \sin\omega_d t \\ &= (1.93\,\mathrm{A})(45.0\,\mathrm{V})\sin[(3000\,\mathrm{rad/s})(0.442\,\mathrm{ms})]\sin[(3000\,\mathrm{rad/s})(0.442\,\mathrm{ms}) - 46.5^\circ] \\ &= 41.4\ \mathrm{W}\ . \end{aligned}$$

(b) The rate at which the energy in the capacitor changes is

$$\begin{aligned} P_c &= -\frac{d}{dt}\left(\frac{q^2}{2C}\right) = -i\frac{q}{C} = -iV_c \\ &= -I\sin(\omega_d t - \phi)\left(\frac{I}{\omega_d C}\right)\cos(\omega_d t - \phi) = -\frac{I^2}{2\omega_d C}\sin[2(\omega_d t - \phi)] \\ &= -\frac{(1.93\,\mathrm{A})^2}{2(3000\,\mathrm{rad/s})(31.2\times 10^{-6}\,\mathrm{F})}\sin[2(3000\,\mathrm{rad/s})(0.442\,\mathrm{ms}) - 2(46.5^\circ)] \\ &= -17.0\ \mathrm{W}\ . \end{aligned}$$

(c) The rate at which the energy in the inductor changes is

$$\begin{aligned} P_i &= \frac{d}{dt}\left(\frac{1}{2}Li^2\right) = Li\frac{di}{dt} = LI\sin(\omega_d t - \phi)\frac{d}{dt}[I\sin(\omega_d t - \phi)] \\ &= \frac{1}{2}\omega_d LI^2\sin[2(\omega_d t - \phi)] \\ &= \frac{1}{2}(3000\,\mathrm{rad/s})(1.93\,\mathrm{A})^2(9.20\,\mathrm{mH})\sin[2(3000\,\mathrm{rad/s})(0.442\,\mathrm{ms}) - 2(46.5^\circ)] \\ &= 44.1\ \mathrm{W}\ . \end{aligned}$$

(d) The rate at which energy is being dissipated by the resistor is

$$\begin{aligned} P_r &= i^2 R = I^2 R\sin^2(\omega_d t - \phi) \\ &= (1.93\,\mathrm{A})^2(16.0\,\Omega)\sin^2\left[(3000\,\mathrm{rad/s})(0.442\,\mathrm{ms}) - 46.5^\circ\right] \\ &= 14.4\,\mathrm{W}\ . \end{aligned}$$

(e) The negative result for P_i means that energy is being taken away from the inductor at this particular time.

(f) $P_i + P_r + P_c = 44.1\mathrm{W} - 17.0\,\mathrm{W} + 14.4\,\mathrm{W} = 41.5\,\mathrm{W} = P_g$.