Consider an alternating current RLC circuit containing, in series, a generator (RMS voltage 10 V and frequency 3.183 Hz), a resistor (resistance 4.0 Ω), an inductor (inductance 0.20 H), and a capacitor (capacitance 0.05 F).

Consider dialing up or down only one of these quantities while leaving all the others fixed.

1. Find the RMS current.

\[
V_{\text{RMS}} = 10 \text{V} \quad f = 3.183 \text{Hz} \quad R = 4.0 \Omega \quad L = 0.20 \text{H} \quad C = 0.05 \text{F}
\]

\[
\omega = 2\pi f = 20.0 \text{s}^{-1} \quad X_L = \omega L = 4.00 \Omega \quad X_C = \frac{1}{\omega C} = 1.00 \Omega
\]

\[
Z = \sqrt{R^2 + (X_L - X_C)^2} = 5.00 \Omega \quad I_{\text{RMS}} = \frac{V_{\text{RMS}}}{Z} = \frac{10 \text{V}}{5.00 \Omega} = 2.0 \text{A}
\]

2. What happens to the RMS current if you dial only the resistance very large?

\[
R \to \infty \implies Z \to \infty \implies I_{\text{RMS}} \to 0
\]

3. What happens to the RMS current if you dial only the inductance very large?

\[
L \to \infty \implies X_L \to \infty \implies Z \to \infty \implies I_{\text{RMS}} \to 0
\]

4. What happens to the RMS current if you dial only the capacitance very large?

\[
C \to \infty \implies X_C \to 0 \implies Z = \sqrt{R^2 + X_L^2} = 5.66 \Omega \implies I_{\text{RMS}} = \frac{10 \text{V}}{5.66 \Omega} = 1.8 \text{A}
\]

5. What happens to the RMS current if you dial only the capacitance very small?

\[
C \to 0 \implies X_C \to \infty \implies Z \to \infty \implies I_{\text{RMS}} \to 0
\]

6. What should you dial the frequency to in order to get the largest possible RMS current (i.e., deliver the largest power to the circuit)?

Max power when the circuit is driven at the resonant angular frequency \( \omega_0 = \frac{1}{\sqrt{LC}} = 10 \text{s}^{-1} \)

This is exactly half of the original angular frequency 20 s\(^{-1}\), so we want to dial the frequency to

\[
\frac{1}{2} (3.183 \text{Hz}) = 1.6 \text{Hz}
\]

7. (extra-credit) What is the RMS current at that frequency?

\[
X_L - X_C = 0 \text{ at the resonant angular frequency } \omega_0. \text{ To see this,}
\]

\[
X_L - X_C = \omega_0 L - \frac{1}{\omega_0 C} = \frac{L}{\omega_0} \left( \omega_0^2 - \frac{1}{LC} \right) = 0
\]

so, when the frequency is dialed to the resonant frequency,

\[
Z = \sqrt{R^2} = R = 4.0 \Omega \quad I_{\text{RMS}} = \frac{10 \text{V}}{4.0 \Omega} = 2.5 \text{A}
\]