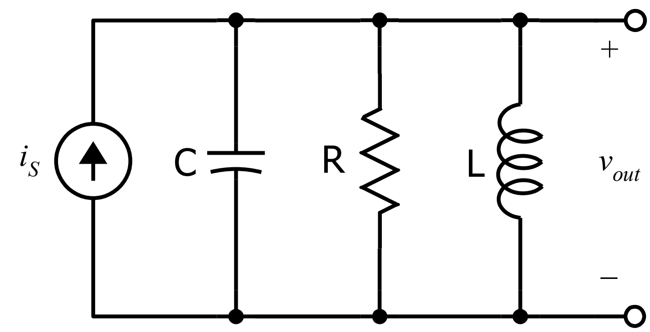
EE3 Fall 2021
Practice Problems 6



1. Find the impedance Z_{tot} presented by the RLC network to the current source. This is a symbolic exercise (no numbers).

   a. What is Z_{tot} when $\omega=0$?

   b. What is Z_{tot} when $\omega \rightarrow \infty$?

   c. What is Z_{tot} when $\omega = \frac{1}{\sqrt{(LC)}}$?

   d. What does the answer to (c.) tell you about the parallel combination of L&C when $\omega = \frac{1}{\sqrt{(LC)}}$?

$$
\begin{aligned}
Z_{tot} &= \frac{1}{j\omega C + \frac{1}{R} + \frac{1}{j\omega L}} \\
&= \frac{1}{j\omega C + \frac{R + j\omega L}{j\omega RL}} \\
&= \frac{j\omega RL}{\left(R - \omega^2 RLC\right) + j\omega L} \\
&= \frac{j\omega RL}{R\left(1 - \omega^2 LC\right) + j\omega L}
\end{aligned}
$$

a. $Z_{tot}\big|_{\omega = 0} = \frac{0}{R} = 0$

b. $Z_{tot}\big|_{\omega \rightarrow \infty} = \left.\frac{jRL}{-2\omega LC + \omega L}\right|_{\omega \rightarrow \infty} = 0$

c. $Z_{tot}\big|_{\omega = \frac{1}{\sqrt{(LC)}}} = \frac{j\omega RL}{R(0) + j\omega L} = R$

d. $L \| C$ at resonance has infinite impedance.
$L \| C$ at resonance is called a *tank circuit*.

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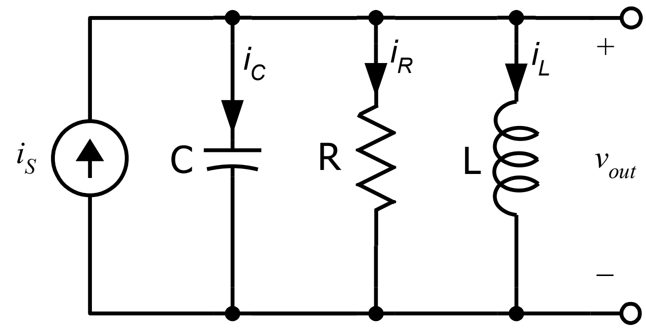

2. Consider this circuit to be a filter, with an input and an output. To answer the following questions use the two-question intuitive approach described in lecture.
   a. If the input is i_S, and the output is i_C, what kind of filter is this?
   b. If the input is i_S, and the output is i_R, what kind of filter is this?
   c. If the input is i_S, and the output is i_L, what kind of filter is this?
   d. If the input is i_S, and the output is v_{out}, what kind of filter is this?

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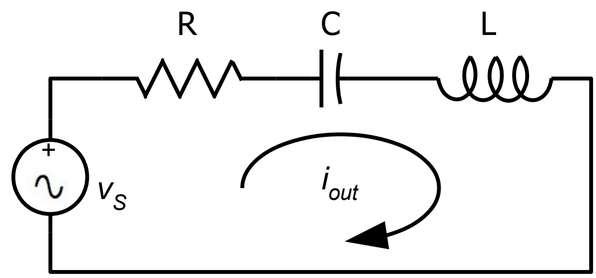

3. Consider this circuit to be a filter, with an input and an output. To answer the following questions use the two-question intuitive approach described in lecture.
   a. If the input is v_S, and the output is v_C, what kind of filter is this?
   b. If the input is v_S, and the output is v_R, what kind of filter is this?
   c. If the input is v_S, and the output is v_L, what kind of filter is this?
   d. If the input is v_S, and the output is i_{out}, what kind of filter is this?

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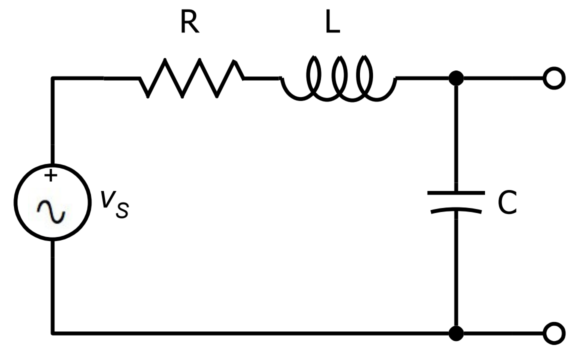

4. Find the impedance Z_{tot} presented by the RLC network to the current source. This is a symbolic exercise (no numbers).

a. What is Z_{tot} when $\omega = 0$?

b. What is Z_{tot} when $\omega \rightarrow \infty$?

c. What is Z_{tot} when $\omega = \frac{1}{\sqrt{(LC)}}$?

d. What does the answer to (c.) tell you about the series combination of L&C when $\omega = \frac{1}{\sqrt{(LC)}}$?

$$Z_{tot} = R + Z_L + Z_C = R + j\omega L - j\left(\frac{1}{\omega C}\right) = R + j\left(\omega L - \frac{1}{j\omega C}\right)$$

a. $Z_{tot}\Big|_{\omega=0} = R + j\{\rightarrow\infty\} \rightarrow \infty$

b. $Z_{tot}\Big|_{\omega\rightarrow\infty} = R + j\{\rightarrow\infty\} \rightarrow \infty$

c. $Z_{tot}\Big|_{\omega=\frac{1}{\sqrt{(LC)}}} = R + j0 = R$

d. L in series with C at resonance has zero impedance.
Do you see the logical dual?