Ex:

\[ v_s(t) = 60\cos(200kt) \text{ V} \]

a) Draw a frequency-domain equivalent of the above circuit. Show a numerical phasor value for \( v_s(t) \), and show numerical impedance values for \( R \), \( L \), and \( C \). Label the dependent source appropriately.

b) Find the Thevenin equivalent (in the frequency domain) for the above circuit. Give the numerical phasor value for \( V_{\text{Th}} \) and the numerical impedance value of \( z_{\text{Th}} \).

**Sol'n:**

a) We calculate the impedances for the frequency-domain circuit:

\[ V_s = 60 \angle 0^\circ \text{ V} \]

\[ z_L = j\omega L = j200k \cdot 10 \mu \Omega = j2 \Omega \]

\[ z_C = \frac{1}{j\omega C} = \frac{1}{j200k \cdot 2.5 \mu} = -j2 \Omega \]

The frequency domain circuit:

\[ V_s = 60 \angle 0^\circ \text{ V} \]

\[ j2 \Omega \]

\[ jV_x \]

\[ 2 \Omega \]

\[ -j2 \Omega \]

\[ V_x \]
b) The Thevenin equivalent voltage is the voltage at a and b for the circuit with no load attached at a and b. We may perform a source transformation on the left side to obtain the following circuit:

\[
\begin{align*}
\mathbf{I}_s &= 30 \angle -90^\circ \, \text{A} \\
\mathbf{V}_x &= \frac{j \mathbf{V}_x}{2}
\end{align*}
\]

In the above circuit, the inductance and capacitance in parallel are equivalent to an open circuit. With the inductor and capacitor gone, we see that current from \( \mathbf{I}_s \) flows through the dependent current source. Thus, the dependent current source must have the same current as \( \mathbf{I}_s \):

\[
\frac{j \mathbf{V}_x}{2} = \mathbf{I}_s
\]

or

\[
\mathbf{V}_x = \frac{2 \mathbf{I}_s}{j} = \frac{2 \cdot 30 \angle -90^\circ}{1 \angle -90^\circ} = 60 \, \text{V}
\]

This voltage is the same as the Thevenin equivalent voltage:

\[
\mathbf{V}_{Th} = \mathbf{V}_x = 60 \, \text{V}
\]

To find the Thevenin impedance, we turn off the independent current (and remove the \( L \) and \( C \) that cancel out). Then we apply a voltage (1 V) to the a and b terminals:
We see that $V_x = 1 \, \text{V}$ and the dependent current source carries the current $i_a$:

$$i_a = \frac{jV_x}{2} = j\frac{1}{2} \, \text{A}$$

The Thevenin impedance is $1 \, \text{V}$ divided by the current, $i_a$:

$$z_{Th} = \frac{1 \, \text{V}}{i_a} = \frac{1 \, \text{V}}{j\frac{1}{2} \, \text{A}} = -j2 \, \Omega$$

Thus, we have the following Thevenin equivalent circuit:

$V_{Th} = 60 \, \text{V}$

$z_{Th} = -j2 \, \Omega$