Analysis: First, we convert the circuit to phasor form, as shown in Figure 4.52(b). Next, we compute the Thévenin equivalent impedance with the load removed:

$$Z_T = Z_S + Z_L||Z_C = R_S + \frac{j\omega L \times 1/j\omega C}{j\omega L + 1/j\omega C}$$
$$= R_S + \frac{j\omega L}{j\omega L \times j\omega C + 1} = R_S + j\frac{\omega L}{1-\omega^2 LC}$$

We observe that the Thévenin equivalent voltage is equal to the source voltage, since once the load impedance is removed, no current flows in the circuit and the voltage drop across the impedances is zero. Thus,

$$\mathbf{V}_T = \mathbf{V}_S$$

Next, we evaluate the Thévenin equivalent at each of the two frequencies.

a. Let $f = 10^3$ Hz. Then $\omega = 6.2832 \times 10^3$. At this frequency,

$$Z_T = R_S + j\frac{\omega L}{1-\omega^2 LC} = 50 + j65.414 = 82.33\angle 0.9182$$

b. Let $f = 10^6$ Hz. Then $\omega = 6.2832 \times 10^6$. At this frequency,

$$Z_T = R_S + j\frac{\omega L}{1-\omega^2 LC} = 50 + j1.5916 = 50\angle(-0.0318)$$

$50 + j1.5916$ should be changed to $50 - j1.5916$

Comments: Note that at the higher frequency the equivalent impedance is very close to that of the resistor R_S. This happens because at high frequency the capacitor behaves very much as a short circuit, and the inductor as an open circuit. Thus, the two elements in parallel behave very much as a short circuit.

CHECK YOUR UNDERSTANDING

Determine the value of the capacitor and inductor impedance at the two frequencies to confirm the statement made in the "Comments" above.

Answer: At $\omega = 2\pi \times 10^3$, $Z_L = j62.832\ \Omega$, $Z_C = -j1.5915 \times 10^3\ \Omega$. At $\omega = 2\pi \times 10^6$, $Z_L = j6.2832 \times 10^4\ \Omega$, $Z_C = -j1.5915\ \Omega$.

EXAMPLE 4.21 Solution of AC Circuit by Mesh Analysis

Problem

Determine the currents $i_1(t)$ and $i_2(t)$ in the circuit of Figure 4.53, using node analysis.

Solution

Known Quantities: The values of the circuit elements are $R_1 = 100\ \Omega$, $R_2 = 75\ \Omega$, $C = 1\ \mu$F, $L = 0.5$ H. The value of the current source is $v_S(t) = 15\cos(1,500t)$ V.

Analysis: We follow the steps of the Focus on Methodology box "AC Circuit Analysis."