In Problems 1 and 2, find the Thévenin and Norton equivalent circuits with respect to \( Z_{\text{load}} \) in the circuits below. Please write the values for the sources and equivalent impedances in phasor notation. Note that the values of the components in the circuits are impedances and are written in rectangular coordinates so you do not need a value for angular frequency.

1.

![Circuit Diagram](image1.png)

There is no solution. DC current source has no path to flow so that the capacitors never reach a finite voltage.

2.

![Circuit Diagram](image2.png)

\[
Z_{TH} = (5k + j5k)\| (1k - j3k)\| (-j6k) = 2.39 \, \text{k} \Omega \angle -61.4^\circ
\]

\[
V_{TH} = \frac{(1k - j3k)\| (-j6k)}{(5k + j5k) + (1k - j3k)\| (-j6k)} = 6.09 \, \text{V} \angle -146.4^\circ
\]

\[
I_N = \frac{18 \, \text{V} \angle -40^\circ}{5k + j5k} = 2.55 \, \text{mA} \angle -85^\circ
\]

3. Find the frequency, \( f \), and angular frequency, \( \omega \), such that the Thévenin equivalent impedance has only a real component.

![Circuit Diagram](image3.png)

\[
Z_{th} = R + \frac{1}{j\omega C} + j\omega L \rightarrow \text{imag}(Z_{th}) = 0 \rightarrow \omega^2 = \frac{1}{LC}
\]

So:

\[
\omega = \frac{1}{\sqrt{LC}} = 4.61 \, \text{krad/s}
\]

and \( f = 734 \, \text{Hz} \)
4. For the circuit below,

a. Calculate the voltage $v_R$ and the current $i_R$ and express in phasor notation when $Z_{match} = (0 + j0) \Omega$.

Since $Z_{match}$ is equal to 0 and the other component in the branch is a resistor, the current and voltage must be in phase (i.e., the phase angle of $v_R$ must equal $i_R$)

$$V_R = \frac{250 || j300 || 200}{250 || j300 || 200 - j500} 8 \angle -40^\circ = 1.76 V \angle 58.4^\circ$$

$$i_R = \frac{V_R}{250} = 7.04 mA \angle 58.4^\circ$$

$$v_R = 1.76 V \cos(\omega t + 58.4^\circ)$$

$$i_R = 7.04 mA \cos(\omega t + 58.4^\circ)$$

b. Find the impedance for $Z_{match}$ that will force the voltage $v_R$ to be 180° out of phase with the current $i_R$. In phase is a condition where the phase angle of the voltage is equal to the phase angle of the current. Note that this does not mean that the phase angle will be equal to 0°.

This will never occur because the current $i_R$ must have the same phase as $v_R$ because the current is flowing through a resistor.

c. Calculate the voltage $v_R$ and the current $i_R$ and express in phasor notation when $Z_{match}$ is $(250 - j400) \Omega$.

$$V_R = \frac{(500 - j400) || j300 || 200}{(500 - j400) || j300 || 200 - j500} 8 \angle -40^\circ = 1.00 V \angle 92.0^\circ$$

$$i_R = \frac{V_R}{250} = 40 mA \angle 92.0^\circ$$

$$v_R = 1 V \cos(\omega t + 92.0^\circ)$$

$$i_R = 40 mA \cos(\omega t + 92.0^\circ)$$

d. Is more power delivered to the 250 Ω resistor when $Z_{match}$ is equal to zero as compared to when $Z_{match}$ is equal to the value in part c?

$$P_R = V_R I_R$$

In part a, $P_R = 12.4 mW \angle 116.8^\circ$
In part c, $P_R = 40.0 mW \angle -176^\circ$