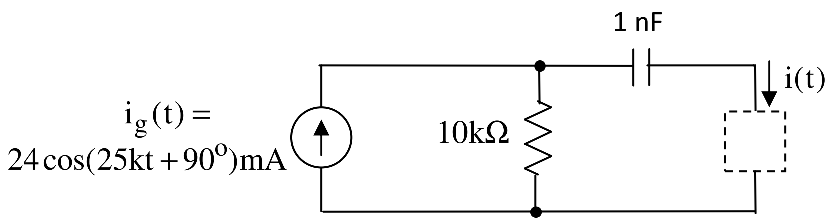
1.



Choose an R, an L, or a C to be placed in the dashed-line box to make

$$i(t) = I_o \cos(25kt + 135^o)$$

where I_o is a positive, (i.e., nonzero), real constant. State the value of the component you choose. Hint: Use a Thevenin equivalent.

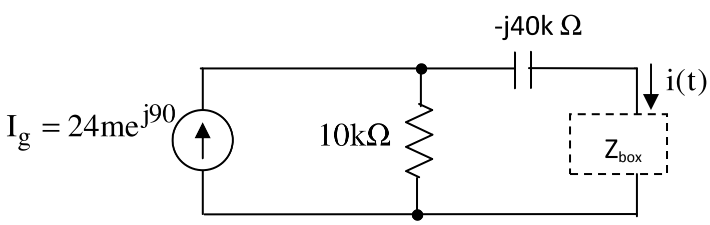
In the frequency domain, we represent the source with a phasor and use an impedance for the C.

$$\mathbf{I}_g = 24\,mA \angle 90^\circ, \qquad \mathbf{I} = I_o \angle 135^\circ$$

$$\mathbf{I}_g R = 24\,mA \angle 90^\circ \cdot 10\,k\Omega = 240 \angle 90^\circ\ V \equiv \mathbf{V}_g$$

$$Z_C = \frac{1}{j\omega C} = \frac{-j}{\omega C} = \frac{-j}{25k \cdot 1nF} = \frac{-j}{25\mu}$$

$$Z_C = -j40k\,\Omega$$



The resultant circuit is a current divider:

$$I = \frac{I_g \cdot 10k}{10k - j40k + Z_{box}} = \frac{24m \cdot 10k \cdot e^{j90^o}}{10k - j40k + Z_{box}}$$

The desired output is:

$$I = I_o e^{j135^o}$$

In order for the above two equations to match, their angles need to match:

$$I = \frac{\angle\left(24m \cdot 10k \cdot e^{j90^o}\right)}{\angle\left(10k - j40k + Z_{box}\right)} = \angle I_o e^{j135^o}$$

$\frac{\angle 90^o}{\angle(10k - j40k + Z_{box})} = \angle 135^o$ In order for this equation to be satisfied, the angle on the bottom has to equal $\frac{\angle 90^o}{\angle 135^o} = \angle\left(90^o - 135^o\right) = \angle -45^o$

To achieve -45 degrees, the bottom has to have the real = -imaginary so that tan-1(-1)=-45

If an R,

10k+R=40k so R=30k. This is a valid value.

If an L,

10k=(40k-25kL) => L=(40k-10k)/25k=1.2H which is a valid value but large.

Therefore, an **R=30k or L=1.2H** will work to achieve the desired value.

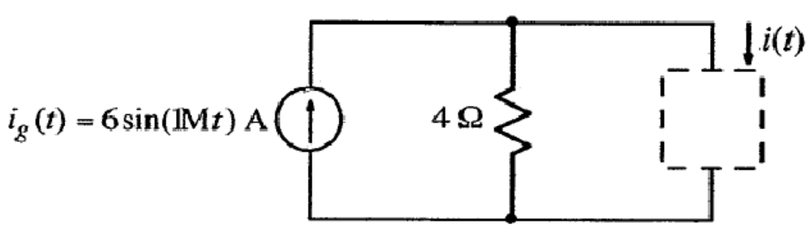
2. With your component from problem 1 in the circuit, calculate the resulting value of I_0.

$I_o = |I| = |V_g / Z_{tot}| = |V_g| / |Z_{tot}|$

For $R = 30k\Omega$, $I_o = 240V / |40k - j40k\Omega| = \frac{240A}{\sqrt{2}\cdot 40k} = 3\sqrt{2}$ mA.

For $L = 1.2H$, $I_o = 240V / |10k - j10k\Omega| = \frac{240A}{\sqrt{2}\cdot 10k} = 12\sqrt{2}$ mA.

3.



Choose an R, an L, or a C to be placed in the dashed-line box to make

$$i(t) = I_0 \cos(1Mt - 120^\circ)$$

where I_0 is a positive, (i.e., nonzero and non-negative), real constant. State the value of the component you choose.

The phase for the current source becomes: $I_g = 6e^{j-90^o}$ {Note the -90 because cos(xt-90)=sin(xt)}

And the desired phasor becomes: $I = I_o e^{j\left(-120^o\right)}$

An equation can be written for the desired phasor by observing that it is a current divider:

$$I = \frac{I_g \cdot 4}{4 + Z_{box}} = \frac{6 \cdot 4 \cdot e^{j-90^o}}{4 + Z_{box}}$$

In order for the above two equations to match, their angles need to match:

$$I=\frac{\angle\left(24e^{j-90^o}\right)}{\angle(4+Z_{box})}=\angle I_o e^{-j120^o} \qquad \frac{\angle-90^o}{\angle(4+Z_{box})}=\angle-120^o$$

In order for this equation to be satisfied, the angle on the bottom has to equal $\frac{\angle-90^o}{\angle-120^o}=\angle\left(-90^o+120^o\right)=\angle+30^o$

To get the bottom to equal +30 degrees the Zbox needs to be an inductor because a R will only result in an angle of 0; a capacitor will only result in angles (because of the -) between 0 and -90 (not a +angle):

$$\tan^{-1}\left(\frac{1x10^6 L}{4}\right)=30^o$$

$$\frac{1x10^6 L}{4}=\tan\left(30^o\right)$$

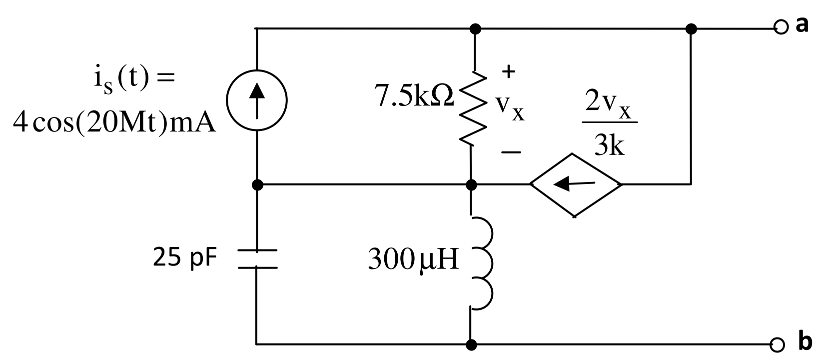
$$L=\frac{\tan\left(30^o\right)\cdot 4}{1x10^6}=2.3\mu H$$

4. With your component from problem 3 in the circuit, calculate the resulting value of I_o.

$$I=\frac{24\cdot e^{j-90^o}}{4+j(1x10^6)\cdot 2.3x10^{-6}}=\frac{24\cdot e^{j-90^o}}{4.6\cdot e^{j30^o}}=5.2\cdot e^{j-120^o}$$

So **Io=5.2A**

5.



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

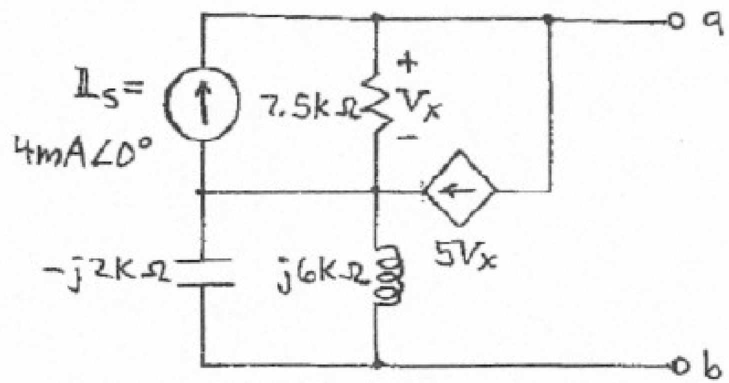
\

a) $\mathbb{I}_s = 4\,mA\angle 0^\circ$ $\qquad \omega = 20M\ r/s$ from $i_s(t)$

$$z_C = \frac{1}{j\omega C} = \frac{-j}{\omega C} = \frac{-j}{20M \cdot 25pF} = \frac{-j}{500\mu}\ \Omega$$

$$z_C = -j2k\Omega$$

$$z_L = j\omega L = j\,20M \cdot 300\mu H = j6k\Omega$$



6. Find the Thevenin equivalent (in the frequency domain) for the circuit from Problem 6. Give the numerical phasor value for $\mathbf{V}_{Th}$ and the numerical impedance value of z_{Th}.

We can replace the dependent source with an equivalent impedance since the voltage drop across the dependent source is V_x.

$$z_{eq} = \frac{V_x}{\frac{2V_x}{3k}} = \frac{3k\Omega}{2} = 1.5k\Omega$$

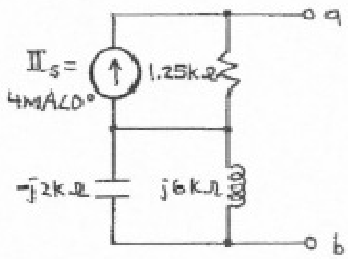
Note: We are using Ohms law: $z = \frac{V}{\mathbb{I}}$.

Note: This equivalent impedance is valid regardless of what is connected from a to b.

We may combine 7.5kΩ and $z_{eq} = 1.5k\Omega$ in parallel.

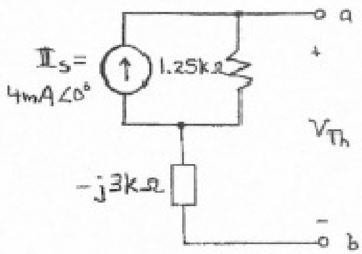
$$7.5k\Omega \| 1.5k\Omega = 1.5k\Omega \cdot 5\|1$$

$$= 1.5k\Omega \cdot \frac{5}{6} = 1.25k\Omega$$



Now we combine the Z_C and Z_L in parallel.

$$Z_C \| Z_L = j2k \cdot (-1 \| 3) = j2k\left(\frac{-3}{2}\right) = -j3k\Omega$$



$V_{Th} = V_{a,b}$ no Load

Since no current can flow thru the $-j3k\Omega$ owing to the lack of a complete circuit, I_s must flow thru the $1.25k\Omega$ and the voltage drop across the $-j3k\Omega$ must be zero.

$$\therefore\ V_{Th} = I_s \cdot 1.25k\Omega$$

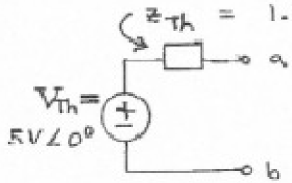
$$'' = 4mA\angle 0° \cdot 1.25k\Omega$$

$$V_{Th} = 5V\angle 0°$$

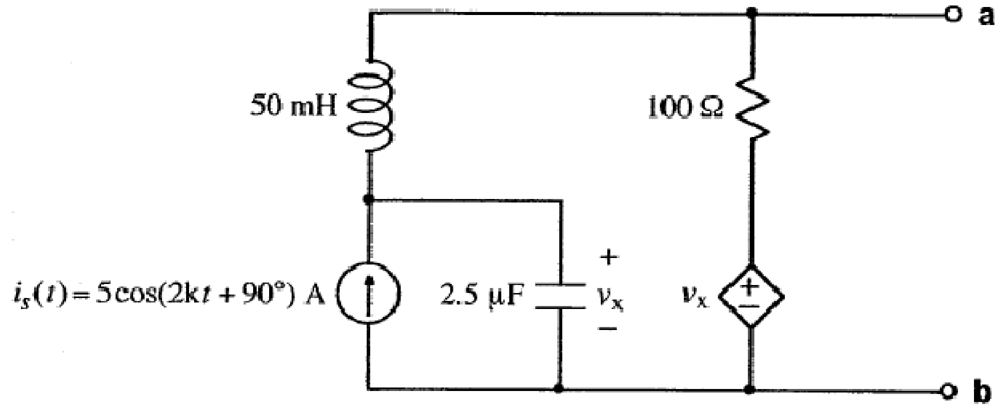
To find Z_{Th}, we turn off I_s, (which becomes an open circuit), and look into the circuit from the a, b terminals.

$$Z_{Th} = 1.25k\Omega + -j3k\Omega$$

$$Z_{Th} = 1.25k\Omega - j3k\Omega$$



7.

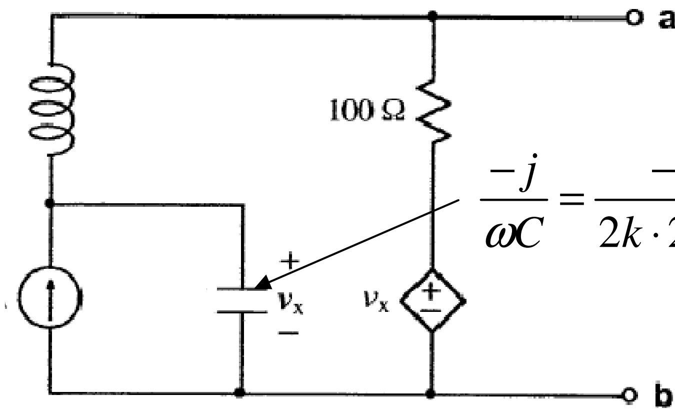


Draw a frequency-domain equivalent of the above circuit. Show a numerical phasor value for $i_S(t)$, and show numerical impedance values for R, L, and C. Label the dependent source appropriately.

$$j\omega L = j2k \cdot 50m = j100$$

$$\frac{-j}{\omega C} = \frac{-j}{2k \cdot 2.5\mu} = -j200$$

$$Is = 5e^{j90^o}$$



8. Find the Thevenin equivalent (in the frequency domain) for the circuit from Problem 8. Give the numerical phasor value for $\mathbf{V}_{Th}$ and the numerical impedance value of z_{Th}.

Using node-voltage with V_1 at the node above the current source. Vth is the open circuit voltage between a-b:

$$-5e^{j90^o} + \frac{V_1}{-j200} + \frac{V_1 - v_x}{j100 + 100} = 0$$

$$v_x = V_1$$

$$-5e^{j90^o} + \frac{V_1}{-j200} + 0 = 0$$

$$V_1 = -j200(5j) = 1kV$$

$$V_{Th} = V_1 = 1kV$$

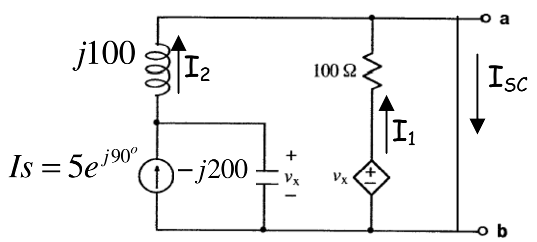
To find Z_{Th} short a-b and label it Isc. The new circuit becomes a current divider:

$$I_2 = \frac{5e^{j90^o}\cdot(-j200)}{-j200+j100} = \frac{-j200\cdot 5e^{j90^o}}{-j100} = 10e^{j90^o} = 10j$$

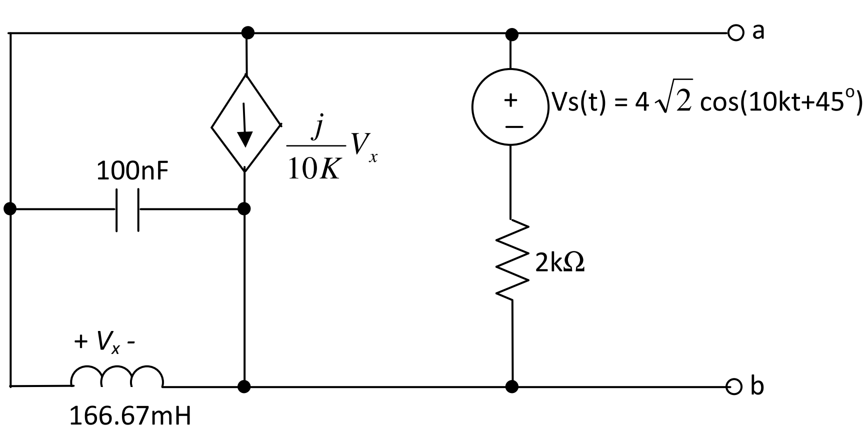
$$I_1 = \frac{v_x}{100} = \frac{10j\cdot j100}{100} = -10$$

$$I_{SC} = I_1 + I_2 = -10 + j10 = 10\cdot\sqrt{2}e^{j135^o}$$

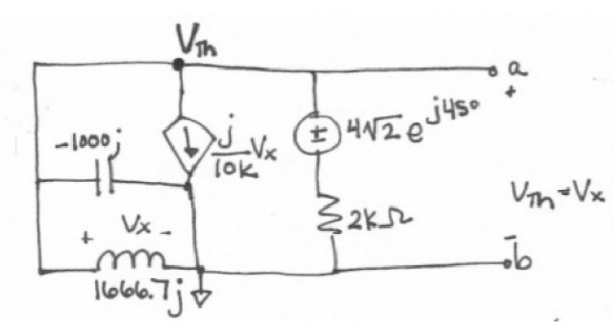
$$Z_{Th} = \frac{V_{Th}}{I_{SC}} = \frac{1k}{10\cdot\sqrt{2}e^{j45^o}} = 70e^{-j135^o}$$



9.



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.



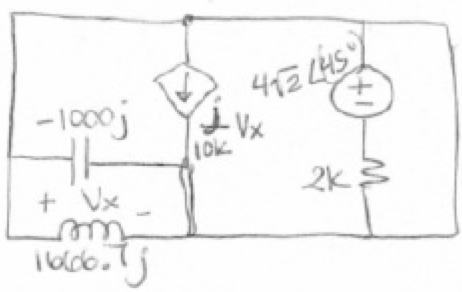
b) Find the Thevenin equivalent (in the frequency domain) for the above circuit. Give the numerical phasor value for V_{Th} and the numerical impedance value of z_{Th}.

b. Using node-V: $\frac{V_{Th}}{-1000j} + \frac{j}{10K}V_{Th} + \frac{V_{Th}}{1666.7j} + \frac{(V_{Th} - 4\sqrt{2}e^{j45°})}{2K} = 0$

$$V_{Th}\left(\frac{j}{1000} + \frac{j}{10K} + \frac{-j}{1666.7} + \frac{1}{2K}\right) = \frac{4\sqrt{2}e^{j45°}}{2K}$$

$$V_{Th}\left((1m + 0.1m - .6m)j + 0.5m\right) = 4\sqrt{2}e^{j45°}/2K$$

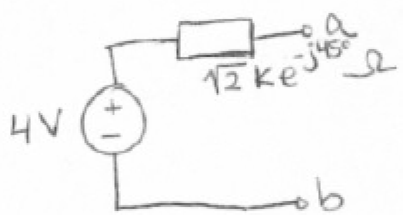
$$V_{Th}\left(0.5m(j+1)\right) = \frac{4\sqrt{2}e^{j45°}}{2K(0.5m\sqrt{2})e^{j45°}} = \boxed{4\,V}$$



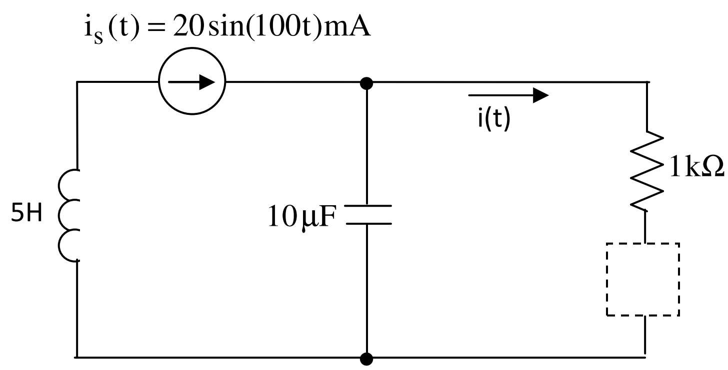
$\downarrow I_{sc} = \frac{4\sqrt{2}\angle 45°}{2K}$

$V_x = 0$

$$R_{Th} = \frac{V_{Th}}{I_{sc}} = \frac{4(2K)}{4\sqrt{2}e^{j45°}} = \frac{2K}{\sqrt{2}}e^{-j45°} = \sqrt{2}\,Ke^{-j45°}$$



10.



a. Choose an R, an L, or a C to be placed in the dashed-line box to make

$$i(t) = I_o\cos(100t - 240^o)$$

where I_o is a positive real constant (with units of Amps). State the value of the component you choose.

b. Calculate the resulting value of I_o.

$i_s(t) = 20\sin(100t)$ mA

$= 20\cos(100t - 90^\circ)$ mA

$P(i_s(t)) = 20\angle -90^\circ$ mA

$P(i(t)) = I_o \angle -240$

using current divider

$$\mathbb{I} = \mathbb{I}_s \frac{Z_C}{Z_C + 1k\Omega + Z}$$

$$Z_C = \frac{-j}{wC} = \frac{-j}{100 \times 10\mu} = -1kj$$

To find out if it is R, L, or C we need to find the phase first

$$\angle -240^\circ = \frac{\angle -90^\circ \times \angle -90^\circ}{\angle(-1kj + 1k\Omega + Z)}$$

$$\angle(Z + 1k(1-j)) = (-90^\circ) + (-90^\circ) + 240^\circ = 60^\circ$$

since the final phase is positive the component in the box must contain L, we can chose it to be L

Need to get a phase of 60°
from the following quantity ⇒

$$(1{,}000 - 1{,}000j + Z)$$

If $Z = R$ then [This is just Imaginary / Real]

$$\tan^{-1}\left(\frac{-1{,}000}{1{,}000+R}\right) = 60°$$

$$\frac{-1{,}000}{1{,}000+R} = \tan 60°$$

$$R = \frac{-1{,}000}{\tan(60°)} - 1{,}000 = -1577$$

∴ No! R can not be negative! (NOT AN R)

If $Z = C$ then

$$\tan^{-1}\left(\frac{-1{,}000 - \frac{1}{100 \cdot C}}{1{,}000}\right) = 60°$$

$$-\frac{1}{100 \cdot C} = \tan(60°) * 1{,}000 + 1{,}000$$

$$\therefore \quad C = -\frac{1}{100(2732)} = -3.66\,\mu F$$

No! C can not be a negative value! (NOT A C)

If $\boxed{Z = L}$ then $\tan^{-1}\left(\frac{-1{,}000 + 100(L)}{1{,}000}\right) = 60°$

$$L = \frac{(\tan 60°)(1{,}000) + 1{,}000}{100} = \boxed{27.32\text{ H}}$$

B) $I_o = I_s \dfrac{Z_C}{Z_C + Z_L + R}$

using magnitude only

$$I_o = 20\,mA \frac{1K}{2K} = 10\ mA$$