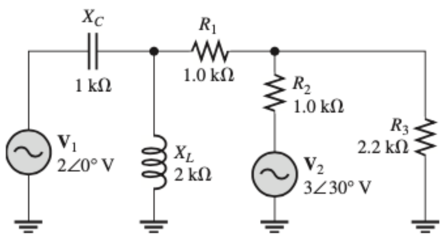
1. Con el método de superposición, calcule la corriente a través de R_3 en la figura 19-44.



- Circuitamos el voltaje V2 y calculamos la impedancia total

$$Z_T = (((R2||R3) + R1)||X_L) + Xc$$

$$Z_T = (1.6875||X_L) + Xc$$

$$Z_T = \left(\frac{1}{1.6875} + \frac{1}{j2}\right)^{-1} - j1$$

$$Z_T = 0.9857 - j0.168\ k\Omega//$$

$$I_T = \frac{V_{S1}}{Z_T} = \frac{2V}{0.9857 - j0.168\ k\Omega} = 2\angle 10.764° mA$$

- Calculamos el voltaje de la impedancia

$$V_{eq1} = I_T Z_{eq1} = (2\angle 10.764° mA)(1.29\angle 44.63° k\Omega) = 2.58\angle 55.393°\ V$$

$$I_{2,3} = \frac{V_{eq1}}{Z_{eq2}} = \frac{2.58\angle 55.393°\ V}{1.6875\ k\Omega} = 1.528\angle 55.393° mA$$

- Hallamos la corriente 3

$$V_3 = I_{2,3}R_{2,3} = (1.528\angle 55.393° mA)(0.6875 k\Omega) = 1.051\angle 55.393°\ V$$

$$I_3 = \frac{V_3}{R_3} = \frac{4.892\angle 55.393°\ V}{2.2\ k\Omega} = 0.477\angle 55.393° mA$$

- Circuitamos el voltaje V1 y calculamos la corriente R3, y la impedancia

$$Z_T = ((Z_{eq1} + R1)||R3) + R2$$

$$Z_T = \left(\left(\left(\frac{1}{-j1} + \frac{1}{2j}\right)^{-1} + 1\right)||R3\right) + R2 = \left(\frac{1}{1 - j2} + \frac{1}{2.2}\right)^{-1} + 1$$

$$Z_T = 2.112 - j0.68\ k\Omega$$

$$I_T = \frac{V_{S2}}{Z_T} = \frac{3\angle 30°\ V}{2.112 - j0.68\ k\Omega} = 1.352\angle 49.82° mA$$

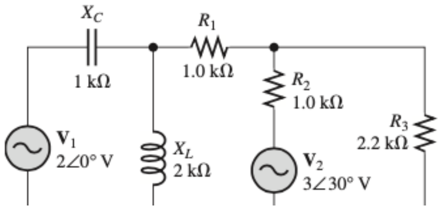
$$V_3 = I_T Z_{eq2} = (1.352\angle 49.82° mA)(1.112 - j0.68\ k\Omega) = 1.762\angle 14.898°\ V$$

$$I_3 = \frac{V_3}{R_3} = \frac{1.762\angle 14.898°\ V}{2.2\ k\Omega} = 0.801\angle 14.898° mA$$

$$I_{3T} = I_{3A} + I_{3B} = 0.477\angle 55.381° mA + 0.801\angle 14.898° mA$$

$$I3 = 1.218 < 29.854°\ mA$$

2. Use el teorema de superposición para determinar la corriente y el voltaje a través de la rama R_2 de la figura 19-44.



$$Zi = \frac{(1 < -90°)(2 < 90°)}{-j + j2} + 1 = -j2 + 1 = 2.24 < -63.44°$$

$$Zt = 1 + \frac{(2.24 < -63.44°)(2.2 < 0°)}{1 - j2 + 2.2} = 1 + 1.31 < -31.44° = 2.225 < -17.91°$$

$$It = \frac{3 < 30°}{2.225 < -17.91°} = 1.35 < 47.91°\ mA$$

$$Rt = 1 + \frac{1 * 2.2}{1 + 2.2} = 1.69$$

$$Zt = -j + \frac{(1.69 < 0°)(2 < 90°)}{1.69 + j2} = -j + 1.29 < 40.2° = 1 < -9.67°$$

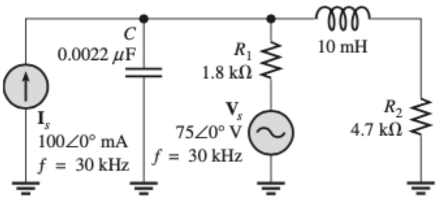
$$It = \frac{2 < 0°}{1 < -9.67°} = 2 < 9.67°\ mA$$

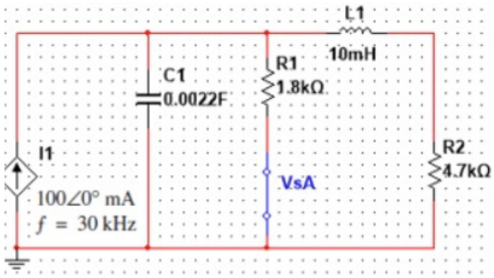
$$I1 = \frac{2 < 90°}{1.69 + j2} * 2 < 9.67° = 1.53 < 49.87°$$

$$I2 = \frac{2.2}{3.2} * 1.53 < 49.87° = 1.05 < 49.87°$$

$$\text{It} = 1.05 < 49.87° + 1.35 < 47.91° = 2.4 < 48.77° \text{mA}$$

3. Con el teorema de superposición, calcule la corriente a través de R_1 en la figura 19-45.





$$X_c = \frac{1}{2\pi f C}$$
$$X_c = \frac{1}{2\pi(30 * 10^3)(0{,}0022)}$$
$$X_c = 2.41k\Omega$$
$$X_l = 2\pi f l$$
$$X_c = 2\pi(30 * 10^3)$$
$$X_l = 1884\Omega$$

$$100 * 10^{-3} < 0° + \frac{V_1}{2411 < -90°} + \frac{V_1}{1{,}8k\Omega} + \frac{V_1}{1884 < 90°\Omega + 4{,}7k\Omega} = 0$$

$$V_1 = 122{,}86 < 155{,}2°V$$

$$I_1 = \frac{122{,}86 < 155{,}2°}{1800}$$

$$I_1 = 68{,}26 < 155{,}2°mA$$

$$\frac{V_1}{2{,}41 < -90°k\Omega} + \frac{V_2 - 75° < 0°}{1{,}8k\Omega} + \frac{V_2}{1884 < 90°\Omega + 4{,}7k\Omega} = 0$$

$$V_{2=}51{,}2 < -24{,}79°V$$

$$V_2 = I_2 R_1 + V_s$$

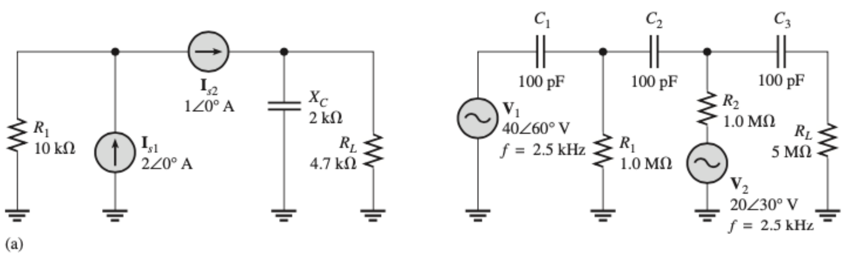
$$I_2 = \frac{V_2 - V_s}{R_1}$$

$$I_2 = 19{,}83 < -143°mA$$

$$I = I_1 + I_2$$

$$I = 80 < -12{,}07°mA$$

4. Con el teorema de superposición, determine la corriente a través de R_L en cada circuito de la figura 19-46.



$$I2 = \frac{2 < -90°}{4.7 - j2} * 1 < 0° = 0.39 < -67°\ A$$

$$Zd = \frac{(4.7 < 0°)(2 < -90°)}{4.7 - j2} = 1.84 < -67°$$
$$Id2 = \frac{10 < 0°}{10 + 0.719 - j1.695} * 2 < 0° = 1.84 < 8.98°$$
$$I2 = \frac{2 < -90°}{4.7 - j2} * 1.84 < 8.98° = 0.72 < -58.02°\ A$$

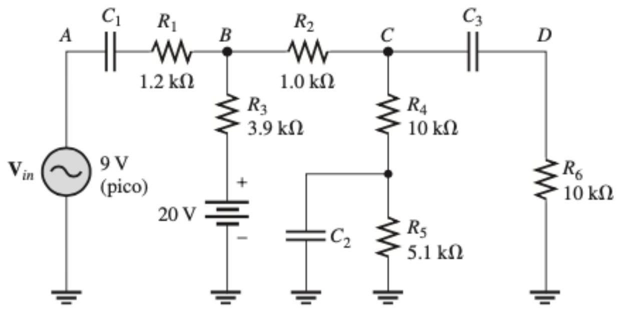
$$It = 0.39 < 67°\ A + 0.72 < -58.02°A = 1.11 < -61.17°A$$

$$Xc1 = Xc2 = Xc3 = \frac{1}{2 * \pi * 2500 * 100 * 10^{-12}} = 0.64M\Omega$$
$$RA = 5 - j0.64 = 5.041 < -7.3°$$
$$RB = \frac{(1 < 0°)(5.041 < -7.3°)}{1 + 5 - j0.64} = 0.84 < -1.2°$$
$$RC = -j0.64 + 0.84 < -1.2° = 1.067 < -38°$$

$$RD = \frac{(1 < 0°)(1.067 < -38°)}{1 + 0.84 - 0.658} = 0.55 < -18.3°$$
$$Rt = -j0.64 + 0.55 < -18.3° = 2.52 < -35.2°$$
$$Is1 = \frac{40 < 60°}{2.52 < -35.2°} = 15.87 < 24.8\ \mu A$$
$$IA = \frac{1 < 0°}{1 + 1.067 < -38°} * 15.87 < 24.8 = 7.05 < 60°\ \mu A$$
$$Il1 = \frac{(1 < 0°)(7.05 < 60°)}{1 + 5.041 < -7.3°} = 1.17 < 66.1°\ \mu A$$

$$RA = \frac{(0.64 < -90°)(1 < 0°)}{1 - j0.64} = 0.54 < -57.4°$$
$$RB = -j0.64 + 0.54 < -57.4° = 1.133 < -75.1°$$
$$RC = 5 - j0.64 = 5.041 < -7.3°$$
$$RD = \frac{(1.133 < -75.1°)(5.041 < -7.3°)}{1.133 < -75.1° + 5.041 < -7.3°} = 1.11 < -64.25°$$
$$Rt = 1.11 < -64.25° + 1 = 1.788 < -34°\ M\Omega$$
$$Is2 = \frac{20 < 30°}{1.788 < -34°} = 11.19 < 64°\ \mu A$$
$$ItL = \frac{1.133 < -75.1°}{1.133 < -75.1° + 5.041 < -7.3°} * 11.19 < 64° = 2.27 < 7.05°\ \mu A$$
$$Il = 2.24 < 7.05° + 1.17 < 66.1° = 3.041 < 26.31°\ \mu A$$

***5.** Determine el voltaje en cada punto (A, B, C, D) señalado en la figura 19-47. Suponga $X_C = 0$ para todos los capacitores. Trace las formas de onda de voltaje en cada punto.



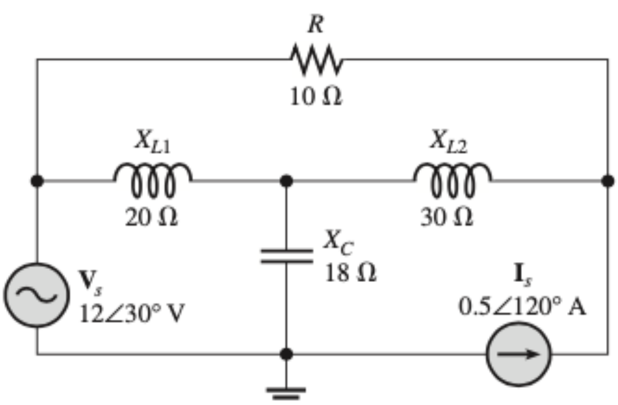
Voltaje en dc:

$$V_A = 0V$$
$$V_B = 16.1V$$
$$V_c = 15.1V$$
$$V_D = 0V$$

Voltaje en ac(pico):

$$V_A = 9V$$
$$V_B = 5.96V$$
$$V_c = V_D = 4.96V$$

***6.** Use el teorema de superposición para determinar la corriente en el capacitor de la figura 19-48.



$$Z1 = \frac{(30 < 90°)(18 < -90°)}{j30 - j18} = 45 < -90°$$

$$Z2 = j20 - j45 = 25 < -90°$$

$$Zt = \frac{(25 < -90°)(10 < 0°)}{10 - j25} = 9.28 < -21.8°$$

$$Is = \frac{12 < 30°}{9.28 < -21.8°} = 1.3 < 51.8° A$$

$$I1 = \frac{10 < 0°}{10 - j25} * 1.3 < 51.8° = 0.48 < 120° A$$

$$Ic = \frac{30 < 90°}{j30 - j18} * 0.48 < 120° = 1.2 < 120° A$$

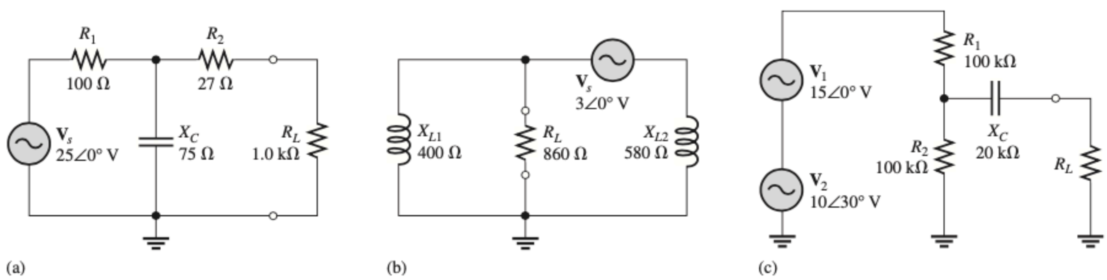
$$I1 = \frac{10 < 0°}{10 - j25} * 0.5 < 120° = 0.19 < 188.2° A$$

$$Ic = \frac{20 < 90°}{j20 - j18} * 0.19 < 188.2° = 1.9 < 188.2°$$

$$It = 1.9 < 188.2° + 1.2 < 120° = 2.597 < 162.82° A$$

Teorema de Thevenin

7. En cada circuito de la figura 19-49, determine el circuito equivalente de Thevenin para la parte vista por R_L.



- Hallamos la impedancia

$$Z = \frac{(-J75)(100)}{-J75 + 100} = 36 - J48$$

- Se obtiene la impedancia de Thevenin

$$\mathbf{Z = (27) + (36 - J48) = 63 - J48\ \Omega}$$

- Hallamos el Vth:

$$A: 100I1 - J75I1 = 25$$

$$I1(100 - J75) = 25$$

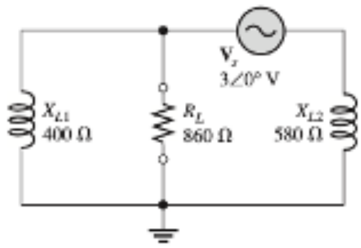
$$\mathbf{I1 = \frac{4}{25} + J\frac{3}{25}}$$

Aplicamos la ley de Ohm

V=IZ

$$V = (\frac{4}{25} + J\frac{3}{25})(-J75)$$

$$\mathbf{V = 9 - J12}$$



(b)

- Hallamos Zth:

$$Zth = J400 + J580 = J980\Omega$$

-Hallando Vth

Se retira la resistencia de carga y se mantiene la fuente de voltaje

Aplico el teorema de mallas

A: $J400I1 + J580I1 = 3$

$I1(J400 + J580) = 3$

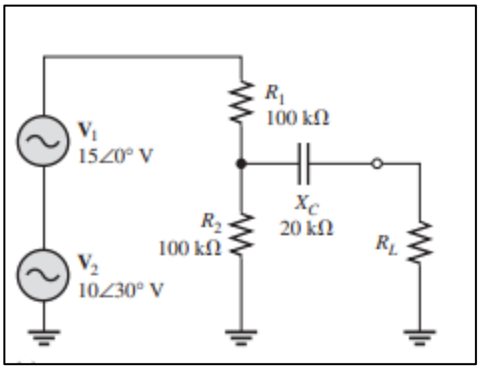
Determino la intensidad total

$$I1 = \frac{3}{J980}$$

Con la ley de ohm determino el voltaje

$$V = IZ = (\frac{3}{J980})(J980)$$

$$\mathbf{V\,th = 3V}$$



- Hallamos Zth:

-Se cortocircuita las fuentes de voltaje y retiramos la resistencia de carga

Determinamos la impedancia total

$$Z = \frac{(100)(100)}{100 + 100} - J20$$

La impedancia de Thevenin es:

$$Zth = 50 - J20\ \Omega$$

-Hallando Vth

Se retira la resistencia de carga y se mantiene la fuente de voltaje

Aplico el teorema de mallas y determino la corriente

$$A:\quad 100I1 + 100I1 = 23.66 + J5$$

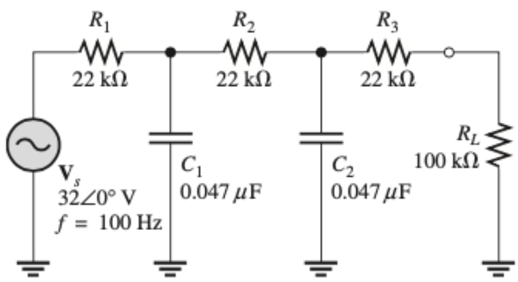
$$I1 = \frac{23.66 + J5}{200} = 0.1183 + J0.025\ mA$$

Observo que el voltaje de Thevenin

$$V = IZ = (0.1183 + J0.025)(100)$$

$$\mathbf{Vth = 11.83 + J2.5}$$

8. Aplique el teorema de Thevenin y determine la corriente a través de la carga R_L en la figura 19-50.



$$Xc1 = Xc2 = \frac{1}{2\pi * 100 * 0.047 * 10^{-6}} = 33.9k\Omega$$

$$RA = \frac{(33.9 < -90^\circ)(22 < 0^\circ)}{22 - j33.9} = 18.46 < -33^\circ$$

$$RB = 22 + 18.46 < -33^\circ = 38.82 < -15.02^\circ$$

$$RC = \frac{(33.9 < -90^\circ)(38.82 < -15.02^\circ)}{-j33.9 + 38.82 < -15.02^\circ} = 22.78 < -55.5^\circ$$

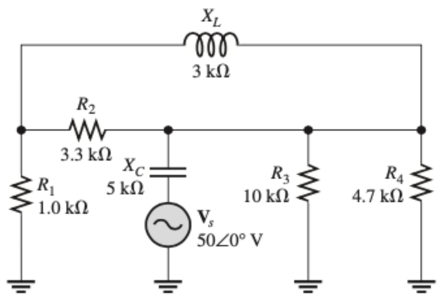
$$RTH = 22 + 22.78 < -55.5^\circ = 34.89 - j18.77\ k\Omega$$

$$It = \frac{32 < 0^\circ}{39.62 < -28.28^\circ} = 0.81 < 28.28^\circ\ mA$$

$$I1 = \frac{33.9 < -90^\circ}{-j33.9 + 38.82 < -15.02^\circ} * 0.81 < 28.28^\circ = 0.48 < -12.19^\circ$$

$$IR = \frac{33.9 < -90^\circ}{-j33.9 + 22} * 0.48 < -12.19^\circ = 0.4 < -45.19^\circ\ mA$$

***9.** Aplique el teorema de Thevenin y determine el voltaje en R_4 en la figura 19-51.



$$Z_{eq1} = (\frac{1}{3{,}3} + \frac{1}{J3})^{-1} = 1{,}493 + J1{,}642k\Omega$$

$$Z_{eq2} = Z_{eq1} + R_1 = 2{,}493 + J1{,}642k\Omega$$

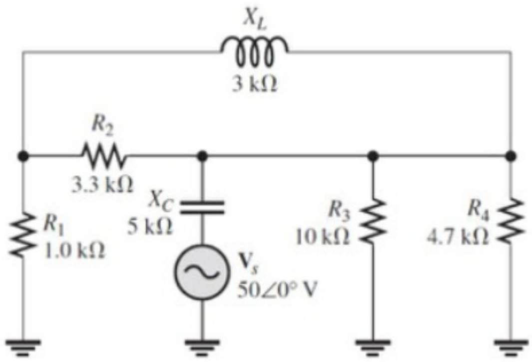
$$Z_{eq3} = (\frac{1}{Z_{eq3}} + \frac{1}{R_3})^{-1} = 2.131 + J1{,}0344$$

$$Z_r = Z_{eq3} + X_c = 2{,}1314 - J3{,}965k\Omega$$

$$I_r = \frac{V_s}{Z_r} = \frac{50V}{2{,}1314 - J3{,}965k\Omega} = 11{,}1 < 61{,}744^\circ mA$$

$$V_{th} = I_r * Z_{eq3} = (11{,}1 < 61{,}744^\circ mA)(2{,}131 + J1{,}0344k\Omega$$

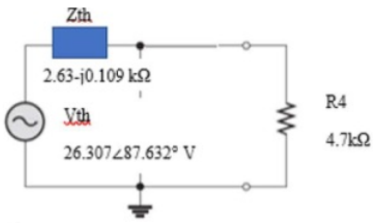
$$V_{th} = 26{,}307 < 87{,}632^\circ V$$



$$Z_{eq1} = (\frac{1}{3,3} + \frac{1}{J3})^{-1} = 1,493 + J1,642k\Omega$$

$$Z_{eq2=}Z_{eq1} + R_1 = 2,493 + J1,642k\Omega$$

$$Z_{th} = (\frac{1}{Z_{eq2}} + \frac{1}{X_c} + \frac{1}{R_3})^{-1} = 2,63 - J0,109k\Omega$$

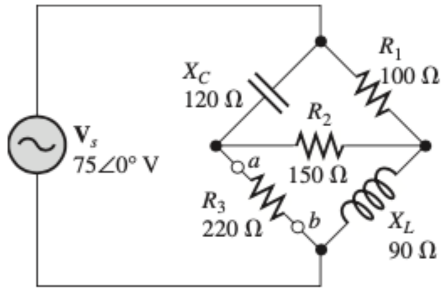


$$I_t = \frac{V_{th}}{Z_{th} + R_4} = \frac{26,307 < 87,632°V}{7,329 + J0,109k\Omega} = 3,589 < 88,484°mA$$

$$V_4 = I_t * R_4 = (3,589 < 88,484°mA)(4,7k\Omega)$$

$$V_4 = 16.868 < 88,484°V$$

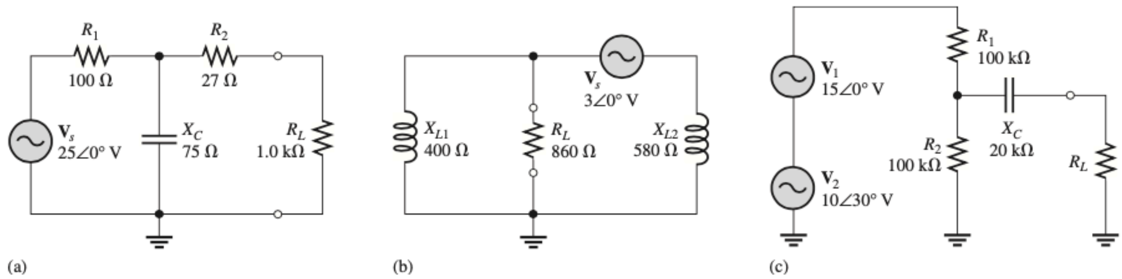
* **10.** Simplifique el circuito externo a R_3 mostrado en la figura 19-52 a su equivalente de Thevenin.



$$Xc = \frac{1}{2\pi fC}$$
$$Xc = \frac{1}{2\pi(3kHz)(0.047\mu F)} = -j1.128k\Omega$$
$$Zeq = Xc + R = 6.8 - j1.128k\Omega$$
$$ZL = 6.8 + j1.128k\Omega$$
$$Zeq = Xc + R = 8.2 - j5\ k\Omega$$
$$Zl = 8.2 + j5\ k\Omega$$
$$Xc = \frac{1}{2\pi fC}$$
$$Xc = \frac{1}{2\pi(0.12kHz)(22\mu F)} = -j60.286\Omega$$
$$Xl = 2\pi fL = 2\pi(0.12kHz)(0.1\mu H) = j75.398\Omega$$
$$Zth = \left(\frac{1}{XL} + \frac{1}{Xc}\right)^{-1} + R = 50 - j300.78\Omega$$
$$ZL = 50 + j300.78\Omega$$

Teorema de Norton

11. Para cada circuito de la figura 19-49, determine el equivalente de Norton visto por R_L.



(a) Fuente de corriente equivalente:

$$Z = R_1 + \frac{X_c\, R_2}{X_c + R_2} = 100\angle 0°\Omega + \frac{(75\angle -90°\Omega)(27\angle 0°\Omega)}{27\Omega - j75\Omega}$$

$$Z = 100\angle 0° + 25.4\angle -19.8°$$

$$Z = 100\ \Omega + 23.9\ \Omega - j8.6\ \Omega$$

$$Z = 123.9\ \Omega - j8.6\ \Omega$$

$$\boldsymbol{Z} = 124.22\angle -3.97°$$

$$I_s = \frac{V_s}{Z} = \frac{25\angle 0°}{124.22\angle -3.97°} = 201.25\angle 3.97°\ mA$$

$$I_n = \left(\frac{X_c}{R_2 + X_c}\right) I_s = \left(\frac{75\angle -90°}{27\Omega - j75\Omega}\right) 201.25\angle 3.97°\ mA = 189.175\angle -15.83°\ mA$$

$$I_n = 189.175 < -15.83° \, mA$$

Impedancia equivalente:

$$Z_n = R_2 + \frac{X_c \, R_1}{X_c + R_1} = 27 \angle 0°\Omega + \frac{(75 \angle -90°\Omega)(100 \angle 0°\Omega)}{100\Omega - j75\Omega}$$

$$Z_n = 27 \angle 0°\Omega + 60 \angle -53.13$$

$$Z_n = 27 + 36 - \text{j}48$$

$$\boldsymbol{Z_n = 63 \, \Omega - j48 \, \Omega}$$

(b) Fuente de corriente equivalente:

$$Z = X_{L2} + X_{L1} = 580 \angle 90°\Omega + 400 \angle 90°\Omega$$

$$Z = j580 + j400$$

$$Z = j980$$

$$\boldsymbol{Z} = 980 \angle 90°$$

$$I_s = \frac{V_s}{Z} = \frac{3\angle 0°}{980 \angle 90°} = 3.06\angle -90° \, mA$$

$$I_n = \left(\frac{X_{L1} + X_{L2}}{X_{L2}}\right) I_s = \left(\frac{980 \angle 90°\Omega}{580 \angle 90°\Omega}\right) 3.06\angle -90° \, mA = 5.14 \angle -90° \, mA$$

$$\boldsymbol{I_n = 5.14 \angle -90° \, mA}$$

Impedancia equivalente:

$$Z_n = \frac{X_{L1} \, X_{L2}}{X_{L1} + X_{L2}} = \frac{(400 \angle 90°\Omega)(580 \angle 90°\Omega)}{j980\Omega}$$

$$Z_n = \frac{232000 \angle 180°\Omega}{980 \angle 90°}$$

$$Z_n = 236.75 \angle 90°$$

$$\boldsymbol{Z_n = j236.75 \, \Omega}$$

(c) Fuente de corriente equivalente:

$$Z = R_1 + \frac{X_c\, R_2}{X_c + R_2} = 100 \angle 0°k\Omega + \frac{(20 \angle -90°k\Omega)(100 \angle 0°k\Omega)}{100k\Omega - j20k\Omega}$$

$$Z = 100 \angle 0° + 19.60 \angle -78.7°$$

$$Z = 100\ k\Omega + 3.85k\Omega - j19.22k\ \Omega$$

$$Z = 103.85\ k\Omega - j19.22\ k\Omega$$

$$\boldsymbol{Z} = 105.6 \angle -10.48°\ k\Omega$$

$$I_s = \frac{V_s}{Z} = \frac{24.18 \angle 11.93°}{105.6 * 10^3 \angle -10.48°} = 228.9\angle 22.4°\ \mu A$$

$$I_n = \left(\frac{R_2}{R_2 + X_c}\right) I_s = \left(\frac{100 \angle 0°}{100\Omega - j20\Omega}\right) 227\angle 22.43°\ \mu A = 224.4 \angle 33.7°\ \mu A$$

$$\boldsymbol{I_n = 224.4 \angle 33.7°\ \mu A}$$

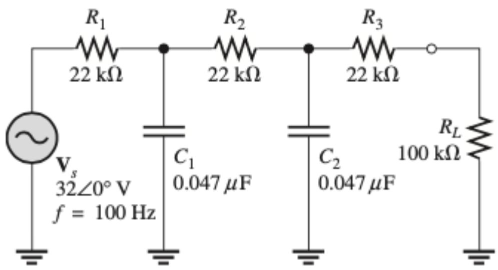
Impedancia equivalente:

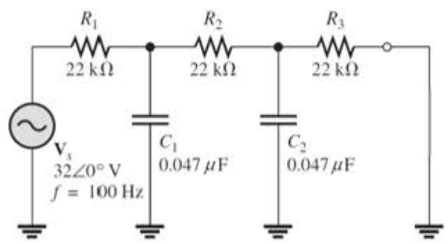
$$Z_n = X_c + \frac{R_2\, R_1}{R_2 + R_1} = -j20 + \frac{(100 \angle 0°\Omega)(100 \angle 0°\Omega)}{200\Omega}$$

$$Z_n = -j20 + 50\angle 0°\Omega$$

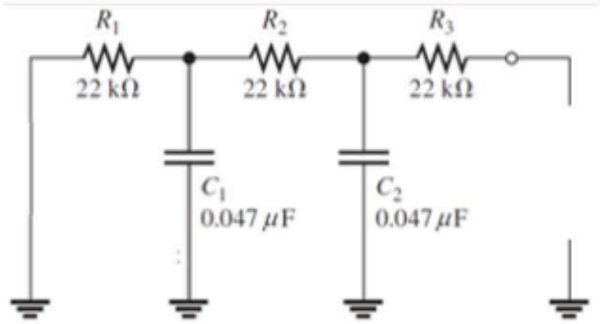
$$\boldsymbol{Z_n = 50\ k\Omega - j20\ k\Omega}$$

12. Aplique el teorema de Norton y determine la corriente a través del resistor de carga R_L en la figura 19-50.





Ahora para calcular la impedancia de Norton, se pone en cortocircuito a la fuente y se obtiene la impedancia a partir de la abertura de RL:



$$Z_{eq1} = \left(\frac{1}{Xc1} + \frac{1}{R1}\right)^{-1} = 15.469 - j10.051\ k\Omega//$$

$$Z_{eq2} = Z_{eq1} + R2 = 37.469 - j10.051\ k\Omega$$

$$Z_{eq3} = \left(\frac{1}{Z_{eq2}} + \frac{1}{Xc2}\right)^{-1} = 12.892 - j18.751\ k\Omega$$

$$Z_n = Z_{eq3} + R3 = 34.892 - j18.751\ k\Omega//$$

Con dicho voltaje se calcula la corriente que pasa por Zeq1, y con ella, se calcula su voltaje el cual será igual al voltaje de R3, con lo cual se hallaría la corriente de Norton In:

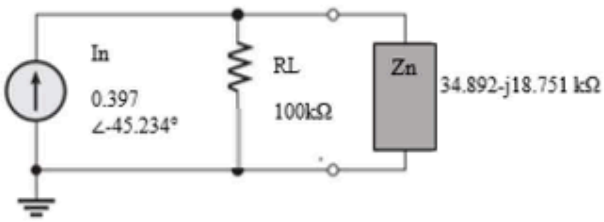
$$I_{eq1} = I_{eq2} = \frac{V_{eq2}}{Z_{eq2}} = \frac{18.382\angle -27.236°\ V}{37.469 - j10.051\ k\Omega} = 0.474\angle -12.22°\ mA//$$

$$V_3 = V_{eq1} = I_{eq1}Z_{eq1} = (0.474\angle -12.22°\ mA)(15.469 - j10.051\ k\Omega)$$

$$V_3 = 8.741\angle -45.234°\ V//$$

$$I_n = I_3 = \frac{V_3}{R3} = \frac{8.741\angle -45.234°\ V}{22\ k\Omega} = 0.397\angle -45.234°\ mA//$$

Con los valores de In y Zn, se arma el circuito equivalente de Norton:



La impedancia total del circuito será igual a:

$$Z_T = \left(\frac{1}{Z_n} + \frac{1}{RL}\right)^{-1} = 27.272 - j10.11\ k\Omega$$

Aplicando ley de Ohm para hallar el voltaje de RL y con ello su corriente:

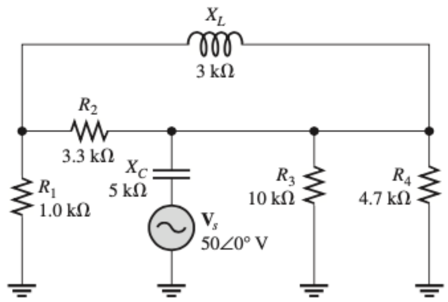
$$V_T = I_n * Z_T = (0.397\angle -45.234°\ mA)(27.272 - j10.11\ k\Omega)$$

$$V_T = 11.547\angle -65.574°\ V//$$

$$I_L = \frac{V_T}{R_L} = \frac{11.547\angle -65.574°\ V}{100\ k\Omega}$$

$$I_L = 0.115 < -65.574°\ mA$$

* **13.** Aplique el teorema de Norton para determinar el voltaje en R_4 en la figura 19-51.



$$ZC = \frac{(10 < 0°)(5 < -90°)}{10 - j5} = 4.47 < -63.43°$$

$$ZL = \frac{(3 < 90°)(3.3 < 0°)}{3.3 + j3} = 2.22 < 47.73°$$

$$ZN = 1 + 2.22 < 47.73° + 4.47 < -63.43° = 5 < -27.65°\ k\Omega$$

$$ZR = \frac{1}{\frac{1}{10} + \frac{1}{4.7}} = 3.2$$

$$ZL = \frac{(3 < 90°)(3.3 < 0°)}{3.3 + j3} = 2.22 < 47.73°$$

$$ZR1 = 1 + 2.22 < 47.73° = 2.99 < 33.4°$$

$$ZA = \frac{(2.99 < 33.4°)(3.2 < 0°)}{2.99 < 33.4° + 3.2} = 1.61 < 17.3°$$

$$ZT = -j5 + 1.61 < 17.3° = 4.776 < -71.22°\ k\Omega$$

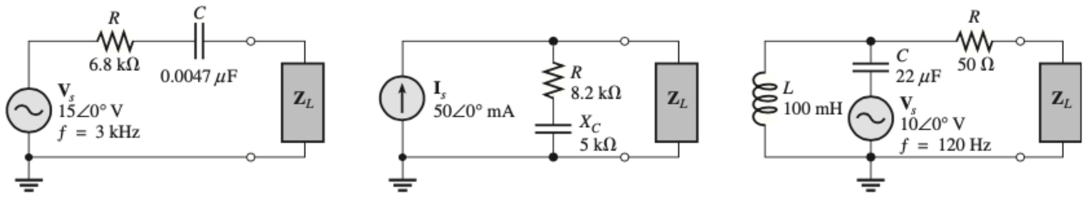
$$IT = \frac{50 < 0°}{4.776 < -71.22°} = 10.5 < 71.22°\ mA$$

$$IR = \frac{(2.99 < 33.4°)}{2.99 < 33.4° + 3.2} * 10.5 < 71.22°\ mA = 5.3 < 88.52°\ mA$$

$$IR4 = \frac{10}{14.7} * 5.3 < 88.52° = 3.61 < 88.52°\ mA$$

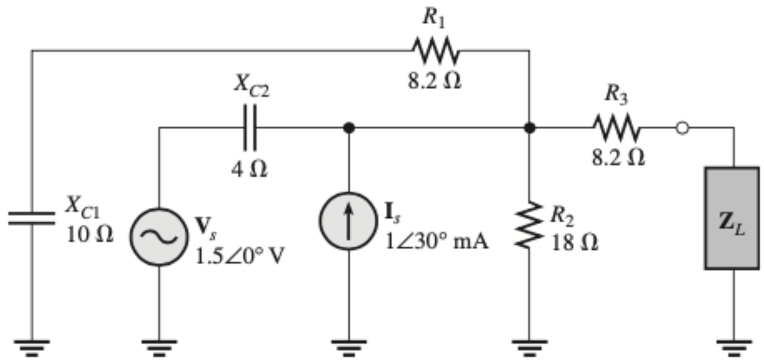
$$VR4 = 3.61 < 88.52°\ mA * 4.7 < 0° k\Omega = 16.97 < 88.52°\ V$$

14. En cada circuito de la figura 19-53, se tiene que transferir potencia máxima a la carga R_L. Determine el valor apropiado para la impedancia de carga en todos los casos.



(a) (b) (c)

* **15.** Determine $\mathbf{Z}_L$ para transferir potencia máxima en la figura 19-54.



$$Z1 = 8.2 - j10$$

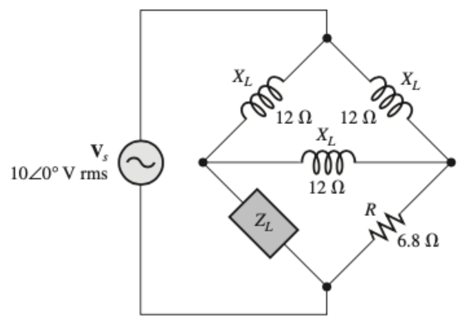
$$Z_2 = \frac{(4 < -90°)\ (18 < 0°)}{18 - j4} = 3.9 < -77.47°$$

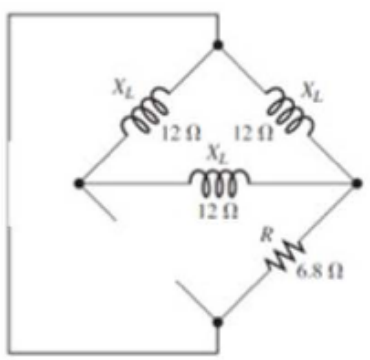
$$Z_2 = \frac{(12.93\ < 50.65°)(3.9 < -77.47°)}{8.2 - j10 + j3.806} = 3.05 < 71.34°$$

$$Z_{th} = 8.2 + 0.976 - j2.888 = 9.176\text{-}j2.888$$

$$Z_{th} = 9.176 + j2.888$$

***16.** Determine la impedancia de carga requerida para transferir potencia máxima a Z_L en la figura 19-55. Determine la potencia real máxima.





$$Z_{eq1} = XL1 + XL2 = j24\ \Omega$$

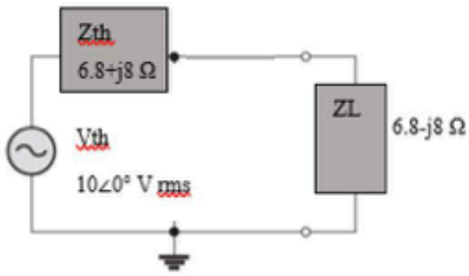
$$Z_{eq2} = \left(\frac{1}{Z_{eq1}} + \frac{1}{XL3}\right)^{-1} = j8\ \Omega$$

$$Z_{th} = Z_{eq2} + R = 6.8 + j8\,\Omega$$

$$Z_L = 6.8 - j8 Ohm$$

Para calcular el voltaje de Thévenin, se debe calcular el voltaje presente en las aberturas de ZL, el cual será igual al voltaje de la impedancia total del circuito pero sin ZL, por lo cual el voltaje seguirá siendo el mismo al de la fuente:

$$V_{th} = 10\angle 0°\ V\ \text{rms}//$$



Calculando la impedancia total del circuito para con ella obtener la corriente, y posteriormente la potencia real:

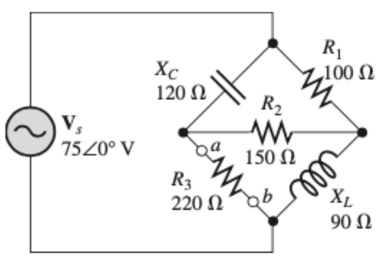
$$Z_T = Z_{th} + Z_L = 13.6\,\Omega//$$

$$I_T = \frac{V_{th}}{Z_T} = \frac{10\ V\ rms}{13.6\,\Omega} = 0.735\ A//$$

$$P_{L(real)} = {I_{R(T)}}^2 R_L = (0.735\ A)^2(6.8\Omega)$$

$$P_{L(real)} = 3.676\ \text{W}//$$

***17.** Se tiene que conectar una carga en el lugar de R_2 en la figura 19-52 para lograr transferencia de potencia máxima. Determine el tipo de carga y exprésela en forma rectangular.



$$\boldsymbol{Z_{Th}} = \frac{X_c R_3}{X_c + R_3} + \frac{X_L R_1}{X_{L+} R_1}$$

$$\boldsymbol{Z_{Th}} = \frac{(120\angle -90°)(220\angle 0°)}{220 - j120} + \frac{(100\angle 0°)(90\angle 90°)}{100 + j90}$$

$$\boldsymbol{Z_{Th}} = \frac{(26400\angle -90°)}{250.6\angle -28.61°} + \frac{(9000\angle 90°)}{134.53\angle -41.98°}$$

$$\boldsymbol{Z_{Th}} = 95.19\ \Omega - j42.75\Omega$$

Por lo tanto, la carga Rl a conectar en forma rectangular es:

$$\boldsymbol{R_L} = 95.19\ \Omega + j42.75\Omega$$