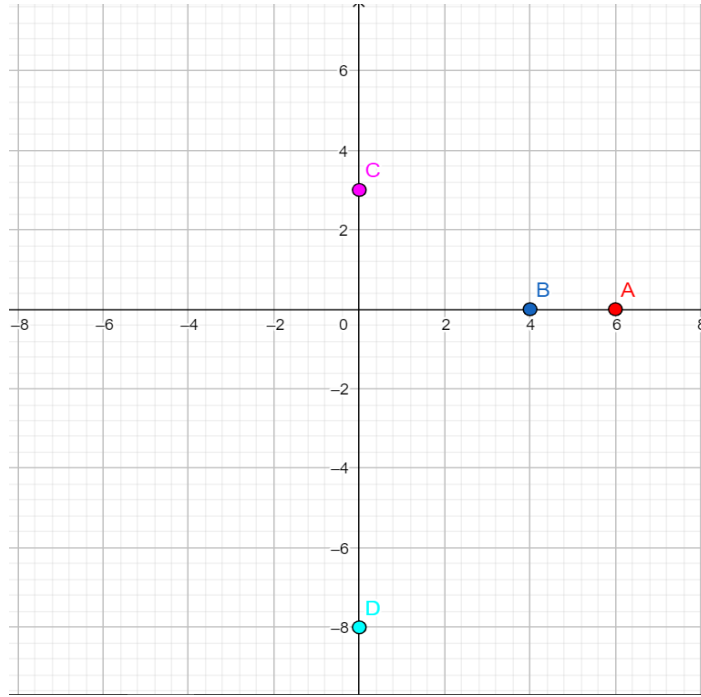


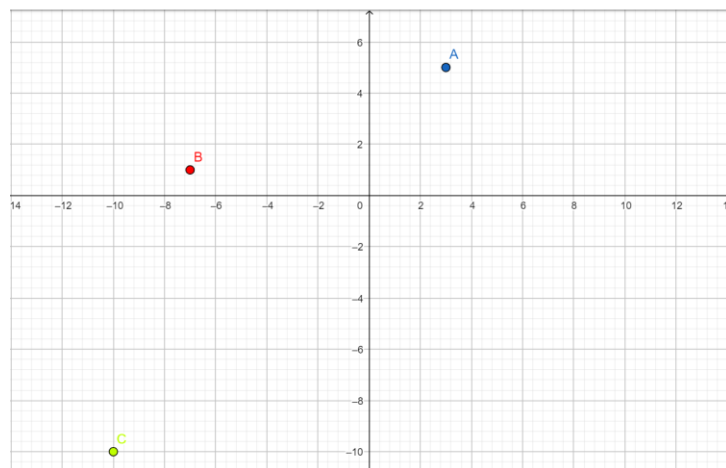
2. Localice los siguientes números complejo en el plano complejo

- a. $+6$ b. -2 c. $+j3$ d. $-j8$



4. Determine las coordenadas de cada punto que tenga igual magnitud, pero esté localizado a 180° de cada uno de los puntos del problema

- (a) $3, j5$ (b) $-7, j1$ (c) $-10, -10j$



Forma polar

- a. $3, j5 = 5,83 < 59,03^\circ$
- b. $-7, j1 = 7,07 < 171,86^\circ$
- c. $-10, -10j = 14,14 < -135^\circ$

Resolución (Aumentar 180° a los ángulos y luego pasar a forma rectangular)

- a. $5,83 < 239,03^\circ = -3 - 5j$
- b. $7,07 < 351,86^\circ = 7 - 1j$
- c. $14,14 < 45^\circ = 10 + 10j$

6. A continuación se describen puntos localizados en el plano complejo. Exprese cada punto como un número complejo en forma rectangular:

(a) 3 unidades a la derecha del origen sobre el eje real, y 5 unidades hacia arriba sobre el eje j.

- $3 + 5j$

(b) 2 unidades a la izquierda del origen sobre el eje real, y 1.5 unidades hacia arriba sobre el eje j.

- $-2 + 1,5j$

(c) 10 unidades a la izquierda del origen sobre el eje real, y 14 unidades hacia abajo sobre el eje -j.

- $-10 - 14j$

8. Convierta cada uno de los siguientes números rectangulares a forma polar:

- a. $40 - 40j = 56,56 < -45^\circ$
- b. $50 - 200j = 206,15 < -75,96^\circ$
- c. $35 - j20 = 40,31 < -29,74^\circ$
- d. $98 + j45 = 107,83 < 24,66^\circ$

10. Exprese cada uno de los siguientes números polares utilizando un ángulo negativo para reemplazar al positivo.

Solución: Restamos el ángulo con 360°

a. $10 < 120^\circ = 10 < -240^\circ$

b. $35 < 85^\circ = 35 < -275^\circ$

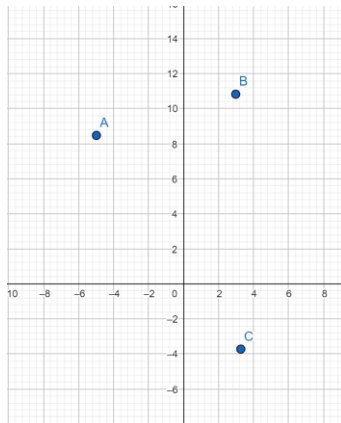
c. $5 < 310^\circ = 5 < -50^\circ$

12. Identifique el cuadrante en el cual se localiza cada uno de los puntos del problema 10.

a. $10 < 120^\circ = 10 < -240^\circ$ (2° Cuadrante)

b. $35 < 85^\circ = 35 < -275^\circ$ (1° Cuadrante)

c. $5 < 310^\circ = 5 < -50^\circ$ (4° Cuadrante)



14. Sume los siguientes conjuntos de números complejos:

a. $9 + j3$ y $5 - j8 = 14 + 11j$

b. $3,5 - j4$ y $2,2 + j6 = 5,7 + 10j$

c. $-18 + j23$ y $30 - j15 = 12 + 38j$

d. $12 \angle 45^\circ$ y $20 \angle 32^\circ = 25,44 + 19,08j$

e. $15 - j10$ y $-25 - j30 = -10 - 40j$

f. $0,8 + j0,5$ y $1,2 - j1,5 = 2 - j$

16. Multiplique los siguientes números

a. $4,5 \angle 48^\circ$ y $3,2 \angle 90^\circ = 14,4 \angle 138^\circ$

b. $120 \angle 220^\circ$ y $95 \angle 200^\circ = 11400 \angle 60^\circ$

c. $-3 \angle 150^\circ$ y $4 - j3 = -3 \angle 150^\circ$ y $5 \angle -36,86^\circ$

d. $67 + j84$ y $102 \angle 40^\circ = 8525,08 \angle 129,65^\circ$

e. $15 - j10$ y $-25 - j30 = 15 + 220j$

f. $0,8 + j0,5$ y $1,2 - j1,5 = 0,8 - 0,9j$

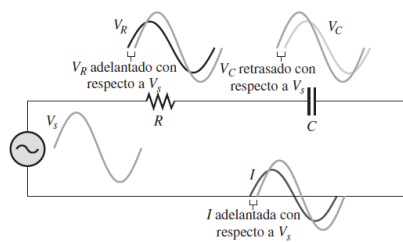
18. Realice las siguientes operaciones:

$$(a) \frac{2.5 \angle 65^\circ - 1.8 \angle -23^\circ}{1.2 \angle 37^\circ} = 2,524 \angle 64,431^\circ$$

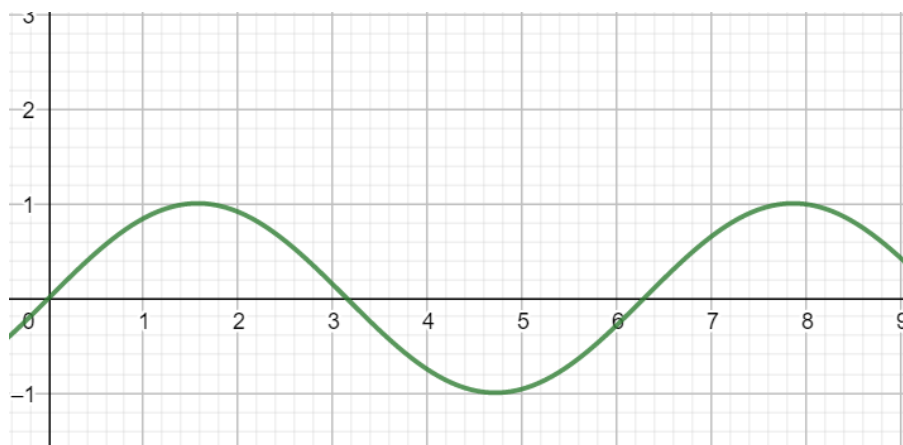
$$(b) \frac{(100 \angle 15^\circ)(85 - j150)}{25 + j45} = -94,598 - 321,28 j$$

$$(c) \frac{(250 \angle 90^\circ + 175 \angle 75^\circ)(50 - j100)}{(125 + j90)(35 \angle 50^\circ)} = 3,644 - 7,944 j$$

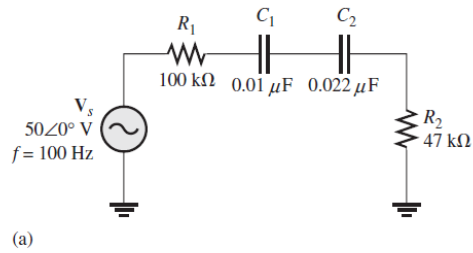
20. ¿Cuál es la forma de onda de la corriente en el circuito del problema 19?



Función seno:



22. Determine la magnitud de la impedancia y el ángulo de fase en cada circuito de la figura 15-85.



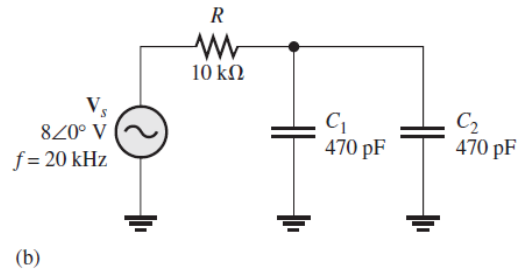
$$C_{eq} = \frac{0,01 \mu * 0,022\mu}{0,01\mu + 0,022\mu} = 6,87nF = X_c$$

$$R_{eq} = 100k + 47k = 147 k\Omega$$

$$Z_{eq} = Req - jX_c$$

$$\text{Magnitud : } \sqrt{Req^2 + X_c^2} = \sqrt{147k^2 + 6,87n^2} = 147000$$

$$\text{Angulo de fase : } \theta = -\tan\left(\frac{X_c}{Req}\right) = \tan\left(\frac{6,87n}{147 k}\right) = -90^\circ$$



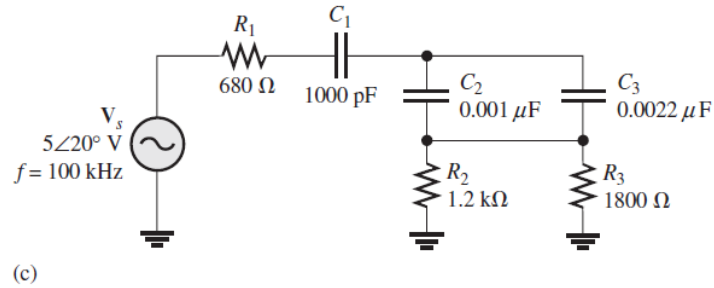
$$C_{eq} = 470 p + 470 p = 9,4x10^{-10} F$$

$$R_{eq} = 10k\Omega$$

$$Z_{eq} = Req - jX_c$$

$$\text{Magnitud : } \sqrt{Req^2 + X_c^2} = \sqrt{10k^2 + (9,4x10^{-10})^2} = 10000$$

Angulo de fase : $\theta = -\tan\left(\frac{X_c}{R_{eq}}\right) = -\tan\left(\frac{9,4 \times 10^{-10}}{10k}\right) = -5,385 \times 10^{-12}^\circ$



$$R_{eq1} = R2 || R3 = \frac{1,2k * 1800}{1,2k + 1800} = 720 \Omega$$

$$C_{eq1} = C2 || C3 = 0,001\mu + 0,0022\mu = 3,2 n F$$

$$C_{eq2} = C_{eq1} + C1 = \frac{1000 p * 3,2 n}{1000 p + 3,2 n} = 7,619 \times 10^{-10} F$$

$$R_{eq2} = R_{eq1} + R1 = 720 + 680 = 1400 \Omega$$

$$C_{eq2} = X_c$$

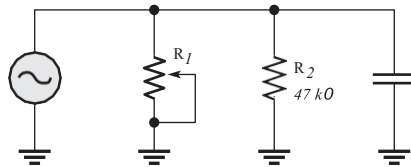
$$R_{eq2} = R_{eq}$$

Magnitud : $\sqrt{R_{eq}^2 + X_c^2} = \sqrt{1400^2 + (7,619 \times 10^{-10})^2} = 1400$

Angulo de fase : $\theta = -\tan\left(\frac{X_c}{R_{eq}}\right) = -\tan\left(\frac{7,619 \times 10^{-10}}{1400}\right) = -3,118 \times 10^{-11}^\circ$

***48. Determine el valor al cual R1 debe ser ajustado para obtener un ángulo de fase de 30° entre el voltaje**

de fuente y la corriente total en la figura 15-99.



$$X_{C1} = \frac{1}{2\pi(1000\text{Hz})(0.01) * 10^{-6}} = -j15.9154k\Omega$$

$$z1 = \frac{1}{\frac{1}{47} - \frac{1}{j15.9154k\Omega}} = 4.83495 - 14.278j$$

$$z2 = \frac{1}{\frac{1}{4.83495 - 14.278j} + \frac{1}{R1}} =$$

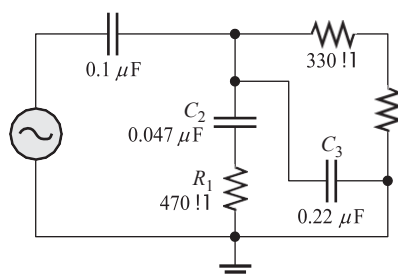
$$I_T = \frac{V_s}{Z_{eq}} = \frac{10 \angle 0}{\frac{1}{\frac{1}{4.83495 - 14.278j} + \frac{1}{R1}}} = 0.042815 \angle 75.1411(A)$$

PARTE 3: CIRCUITOS EN SERIE-PARALELO

SECCIÓN 15-7 Análisis de circuitos RC en serie-paralelo

50. ¿Es el circuito de la figura 15-100 predominantemente resistivo o predominantemente capacitivo?

► **FIGURA 15-100**



$$R1 = 330\Omega + 180\Omega = 510\Omega$$

$$X_{c1} = \frac{1}{2\pi(15000\text{Hz})(0.1) * 10^{-6}} = -j106.103\Omega$$

$$X_{c2} = \frac{1}{2\pi(15000\text{Hz})(0.047) * 10^{-6}} = -j225.751\Omega$$

$$X_{c3} = \frac{1}{2\pi(15000\text{Hz})(0.22) * 10^{-6}} = -j48.228\Omega$$

$$z1 = \frac{1}{\frac{1}{510} - \frac{1}{48.228j}} = 4.5202 - j47.80$$

$$z2 = 470 - j225.751$$

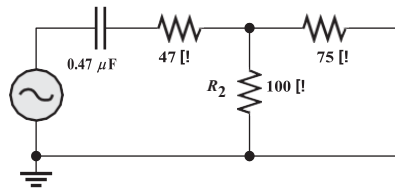
$$z3 = \frac{1}{\frac{1}{4.5202 - j47.80} + \frac{1}{470 - j225.751}} = 7.7078 - 45.051j$$

$$Z_{eq} = 7.7078 - 45.051j - 106.103j = 7.70 - 151.15j$$

Por lo tanto es un circuito RC.

52. Para el circuito de la figura 15-101, determine lo siguiente:

(a) (b) (c) (d) (e) (f)



$$R_a = \frac{1}{\frac{1}{75\Omega} + \frac{1}{100\Omega}} = 42.8471\Omega$$

$$X_{c1} = \frac{1}{2\pi(1000\text{Hz})(0.47) * 10^{-6}} = -j338.627\Omega$$

$$z1 = 47 - j338.627 = 341.8731 \angle -82.098^\circ$$

$$Z_{eq} = 42.841\Omega + 47 - j338.627 = 89.8471 - 338.27j = 350.3421 \angle -75.1411^\circ$$

$$I_T = \frac{V_s}{Z_{eq}} = \frac{15}{350.3421 \angle -75.1411^\circ} = 0.042815 \angle 75.1411^\circ (\text{A})$$

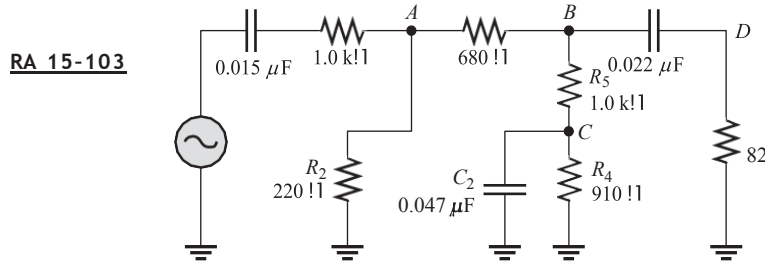
$$V_{z1} = I * Z2 = 0.042815 \angle 75.1411^\circ * 341.8731 \angle -82.098^\circ = 14.63 \angle -6.95^\circ (\text{V})$$

$$V_{ra} = I * R_a = 0.042815 \angle 75.1411^\circ * 42.8471\Omega = 1.8344 \angle 75.1411^\circ (\text{V})$$

$$V_{c1} = I * C1 = 0.042815 \angle 75.1411^\circ * 338.627 \angle -90^\circ = 14.498 \angle -14.85^\circ (\text{V})$$

$$V_{r1} = I * C1 = 0.042815 \angle 75.1411^\circ * 47 = 2.01 \angle 75.14^\circ (\text{V})$$

54. Determine el voltaje y su ángulo de fase en cada punto rotulado en la figura 15-103.



$$X_{c1} = \frac{1}{2\pi(2500\text{Hz})(0.015) * 10^{-6}} = -j4244.1318\Omega = -j4.244k\Omega$$

$$X_{c2} = \frac{1}{2\pi(2500\text{Hz})(0.047) * 10^{-6}} = -j1354.5101\Omega = -j1.3545k\Omega$$

$$X_{c3} = \frac{1}{2\pi(2500\text{Hz})(0.022) * 10^{-6}} = -j2893.7262\Omega = -j2.8937k\Omega$$

$$z_4 = 1.0 - 4.244j$$

$$z_2 = \frac{1}{\frac{1}{0.91} + \frac{1}{-j1.3545}} = 0.626 - 0.4212j$$

$$z_1 = 0.82 - 2.893j$$

$$z_3 = z_2 + 1.0k\Omega = 0.626 - 0.4212j + 1.0 = 1.626 - 0.4212j$$

$$z_5 = \frac{1}{\frac{1}{1.626 - 0.4212j} + \frac{1}{0.82 - 2.893j}} = 1.0028 - 0.7055j$$

$$z_6 = z_5 + 0.68k\Omega = 1.6828 - 0.7055j$$

$$z_7 = \frac{1}{\frac{1}{1.6828 - 0.7055j} + \frac{1}{0.22k\Omega}} = 0.1976 - 8.2911j * 10^{-3}$$

$$z_{eq} = z_7 + z_4 = 0.1976 - 8.2911j * 10^{-3} + 1.0 - 4.244j = 1.1976 - 4.2522j = 8.775 \angle -75.497$$

$$I_T = I_A = \frac{10 \angle 0}{8.775 \angle -75.497} = 1.1394 \angle 75.4978 \text{ (ma)}$$

$$V_{z7} = V_A = I_A * Z_7 = 1.1394 \angle 75.4978 * 0.1977 \angle -75.497 = 0.2253 \angle 73.095 \text{ (v)}$$

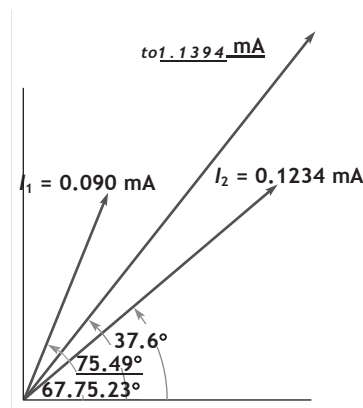
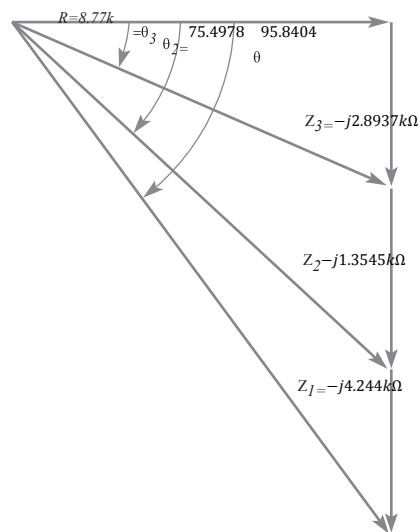
$$I_{z6} = \frac{v_{z7}}{z_6} = \frac{0.2253 \angle 73.095}{1.8247 \angle -22.745} = 0.1234 \angle 95.8404 \text{ (ma)}$$

$$V_{z5} = v_B = V_D = I_{z6} * Z_5 = 0.1234 \angle 95.8404 * 1.2261 \angle -35.127 = 0.1513 \angle 60.71 \text{ (v)}$$

$$I_{Z3} = \frac{V_{Z5}}{Z3} = \frac{0.1513 \angle 60.71}{1.6796 \angle -14.522} = 0.090 \angle 75.2327(\text{mA})$$

$$V_{Z2} = V_C = I_{Z3} * Z2 = 0.090 \angle 75.2327 * 0.7545 \angle -33.934 = 0.0679 \angle 41.2983 (v)$$

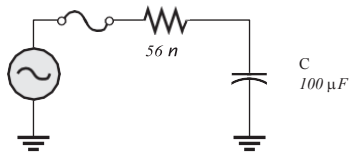
56. Trace el diagrama fasorial de voltaje y corriente para la figura 15-103.



SECCIÓN 15-8 Potencia en circuitos RC

58. En la figura 15-88, ¿cuáles son la potencia real y la potencia reactiva?

R



$$x_{c1} = \frac{-j}{2\pi(20\text{Hz})(100) * 10^{-6}} = -j79.577\Omega$$

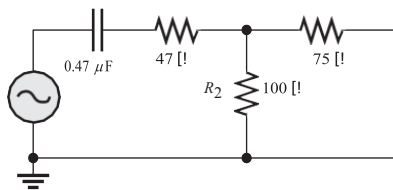
$$z_1 = 56 - 79.577j = 137.392 \angle -35.394$$

$$I_T = \frac{V}{Z_1} = \frac{10 \angle 0}{137.392 \angle -35.394} = 0.0727 \angle 35.394$$

$$P_{real} = I_T^2 * R = (0.0727 \angle 35.394)^2 * 56 = 0.2959 \angle 70.788 \text{ W}$$

$$Q_c = I_T^2 * x_c = (0.0727 \angle 35.394)^2 * 79.577 \angle -90 = 0.4205 \angle -19.212 \text{ w}$$

60. Determine P_{real} , P_r , P_a , y FP para el circuito de la figura 15-101. Trace el triángulo de potencia.



$$I_T = \frac{V_s}{Z_{eq}} = \frac{15}{350.3421 \angle -75.1411} = 0.042815 \angle 75.1411(A)$$

$$P_r = I_T^2 * R = (0.042815 \angle 75.1411)^2 * 89.8471 = 0.1647 \angle 150.28(W)$$

$$Q_c = I_T^2 * x_c = (0.042815 \angle 75.1411)^2 * (-338.27) = 0.620 \angle -29.7178(W)$$

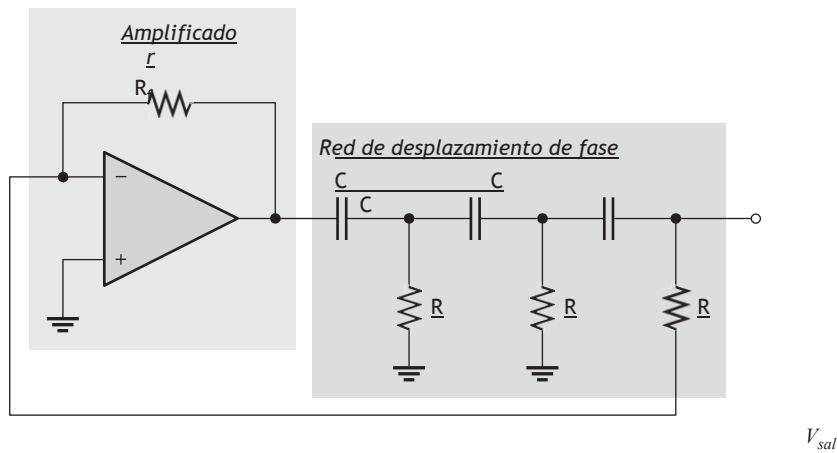
$$Q_c = I_T * V_t = (0.042815 \angle 75.1411) * 15v = 0.6422 \angle 75.1411$$

$$F_p = \cos(75.1411) = 0.2564$$

SECCIÓN 15-9 Aplicaciones básicas

62. Calcule la frecuencia de oscilación para el circuito de la figura 15-62 si todos los capacitores son de

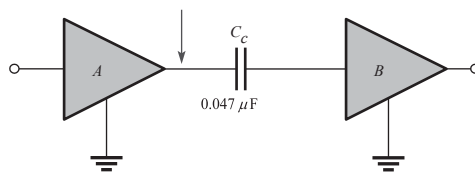
0.0022 mF y todos los resistores de 10 k Ω .



$$f_r = \frac{1}{2\pi\sqrt{16} * RC} = \frac{1}{2\pi\sqrt{16} * 10k\Omega * 0.0022\mu f} = 1.80kHz$$

64. El valor rms del voltaje de señal que sale del amplificador A en la figura 15-105 es de 50 mV. Si la resistencia

de entrada al amplificador B es de 10 k Ω , ¿qué tanto de la señal se pierde debido al capacitor de acoplamiento cuando la frecuencia es de 3 kHz?

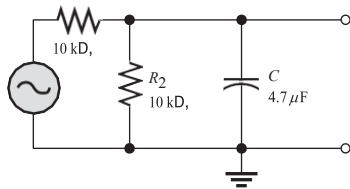


$$f_r = \frac{1}{2\pi\sqrt{16} * RC} = \frac{x}{2\pi\sqrt{16} * 10k\Omega * 0.0022\mu f} = 3kHz$$

SECCIÓN 15-10 Localización de fallas

*66. Los capacitores de la figura 15-107 han desarrollado un resistencia de fuga de 2 k Ω .
Determine los voltajes

de salida en esta condición para cada circuito.



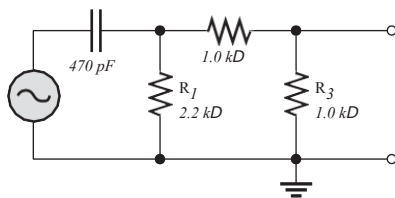
$$x_{c1} = \frac{-j}{2\pi(10\text{Hz})(4.7) \times 10^{-6}} = -j3.38627\text{k}\Omega$$

$$z_1 = \frac{1}{\frac{1}{-j3.38627\text{k}\Omega} + \frac{1}{10\text{k}\Omega}} = 1.0287 - 3.0379j = 3.20736 \angle -71.2925^\circ$$

$$Z_{eq} = z_1 + 10\text{k} = 3.20736 \angle -71.2925^\circ + 10 = 11.4394 \angle -15.400^\circ$$

$$I_T = \frac{V}{Z} = \frac{1 \angle 0^\circ}{11.4394 \angle -15.400^\circ} = 0.08741 \angle 15.400^\circ \text{ (mA)}$$

$$V_{sl} = I \times Z_1 = 0.08741 \angle 15.400^\circ \times 3.20736 \angle -71.2925^\circ = 0.2803 \angle -55.8925^\circ \text{ (V)}$$



$$x_{c1} = \frac{-j}{2\pi(100\text{Hz})(470) \times 10^{-10}} = -j33.8627\text{k}\Omega$$

$$R_a = 2.0\text{k}\Omega + 2.0\text{k}\Omega = 4.0\text{k}\Omega$$

$$R_b = \frac{1}{\frac{1}{4.0\text{k}\Omega} + \frac{1}{2\text{k}\Omega}} = 1.33\text{k}\Omega$$

$$z_1 = 1.33\text{k}\Omega - j33.8627\text{k}\Omega = 33.88 \angle -87.750^\circ$$

$$I_T = \frac{V}{Z_1} = \frac{5 \angle 0^\circ}{33.88 \angle -87.750^\circ} = 0.1475 \angle 87.75^\circ \text{ (mA)}$$

$$V_{rb} = I_t \times r_b = 0.1475 \angle 87.75^\circ \times 1.33\text{k}\Omega = 0.1962 \angle 87.750^\circ \text{ (V)}$$

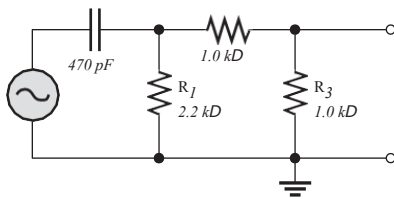
$$I_{ra} = \frac{V_{rb}}{r_a} = \frac{0.1962 < 87.750}{4} = 0.0490 < 87.750(ma)$$

$$V_{r1} = V_{sl} = I_{ra} * r_1 = 0.0490 < 87.750 * 2.0k\Omega = 0.098114 < 87.750(v)$$

68. Determine el voltaje de salida para el circuito de la figura 15-107(b) para cada uno de los siguientes

modos de falla, y compárelo con la salida correcta:

(a) C abierto (b) C en cortocircuito (c) abierto (d) abierto (e) abierto



A) Nos da ov en la salida ya que no se energiza la fase.

B)

$$R_a = 1 + 1 = 2k\Omega$$

$$R_b = R_{eq} = \frac{1}{\frac{1}{2} + \frac{1}{2.2}} = 1.0476k\Omega$$

$$I_t = \frac{V_t}{R_t} = \frac{5}{1.0476} = 4.7728(ma)$$

$$I = \frac{V}{R} = \frac{5}{2} = 2.5(ma)$$

$$V_{salida} = I * 1 = 2.5(v)$$

C)

$$x_{c1} = \frac{-j}{2\pi(100Hz)(470) * 10^{-10}} = -j33.8627k\Omega$$

$$Z_{eq} = 2 - 33.8627j$$

$$I_t = \frac{V_t}{R_t} = \frac{5 < 0}{33.9217 < -86.6199} = 0.1473 < 86.61(ma)$$

$$V_{salida} = I * 1 = 0.1473 < 86.61 * 1 = 0.1473(v)$$

D)

Nos da ov en la salida ya que no se energiza la fase.

E)

$$x_{c1} = \frac{-j}{2\pi(100\text{Hz})(470) * 10^{-10}} = -j33.8627k\Omega$$

$$Z_{eq} = 3.2 - 33.8627j$$

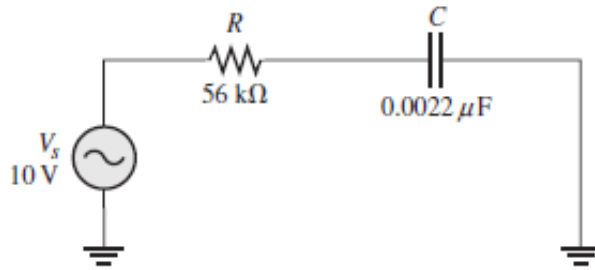
$$I_t = \frac{V_t}{Z_t} = \frac{5 \angle 0}{3.2 - 33.8627j} = 0.1470 \angle 84.601^\circ (ma)$$

$$V_{sl} = 5(v)$$

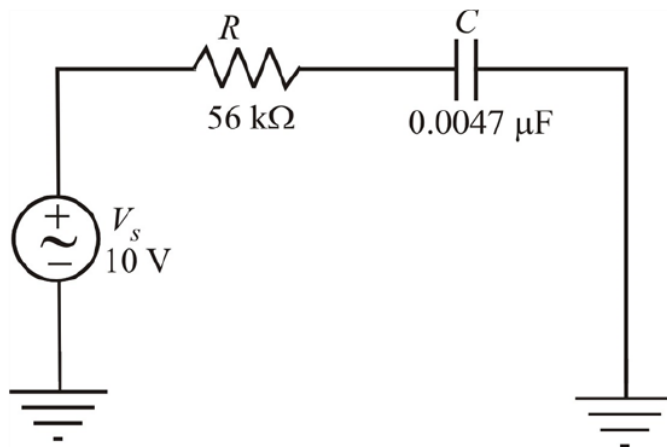
24. Repita el problema 23 con $C = 0.0047 \mu\text{F}$.

23 determine la impedancia expresada en forma rectangular para cada una de las siguientes frecuencias:

- A) 100 Hz B) 500 Hz C) 1kHz D) 2.5kHz



▲ FIGURA 15-86



- A) 100 Hz

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(100)(0.0047 \times 10^{-6})}$$

$$X_c = \frac{1}{2.95 \times 10^{-6}}$$

$$X_c = 338.63 \text{ k}\Omega$$

$$Z = R - jX_c$$

$$Z = (56 - j338.63) \text{ k}\Omega$$

- B) 500 Hz

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(500)(0.0047 \times 10^{-6})}$$

$$X_c = \frac{1}{1.477 \times 10^{-5}}$$

$$X_c = 677.26 \text{ k}\Omega$$

$$Z = R - jX_c$$

$$Z = (56 - j677.26) \text{ k}\Omega$$

C) 1 kHz

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(1000)(0.0047 \times 10^{-6})}$$

$$X_c = \frac{1}{2.95 \times 10^{-5}}$$

$$X_c = 338.62 \text{ k}\Omega$$

$$Z = R - jX_c$$

$$Z = (56 - j338.62) \text{ k}\Omega$$

D) 2.5 kHz

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(2500)(0.0047 \times 10^{-6})}$$

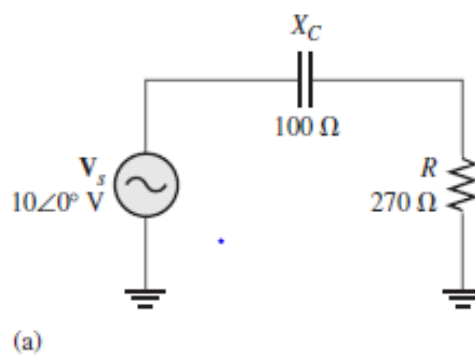
$$X_c = \frac{1}{7.38 \times 10^{-5}}$$

$$X_c = 135.45 \text{ k}\Omega$$

$$Z = R - jX_c$$

$$Z = (56 - j135.45) \text{ k}\Omega$$

26. Expreses la corriente en forma polar para cada circuito de la figura 15-84.



$$Z = R - jX_c$$

$$Z = 270 - j100$$

$$Z = \sqrt{R^2 + X_c^2} < -\tan^{-1}\left(\frac{X_c}{R}\right)$$

$$Z = \sqrt{270^2 + 100^2} < -\tan^{-1}\left(\frac{100}{270}\right)$$

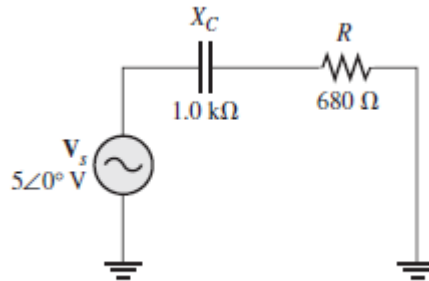
$$Z = \sqrt{82900} < -\tan^{-1}(0.37)$$

$$Z = 287.9 \angle -20.32^\circ \Omega$$

$$I = \frac{V_S}{Z}$$

$$I = \frac{10 \angle 0^\circ}{287.9 \angle -20.32^\circ}$$

$$I = 0.035 \angle 20.32^\circ \text{ A}$$



(b)

$$Z = R - jX_C$$

$$Z = 680 - j1000$$

$$Z = \sqrt{R^2 + X_C^2} \angle -\tan^{-1}\left(\frac{X_C}{R}\right)$$

$$Z = \sqrt{680^2 + 1000^2} \angle -\tan^{-1}\left(\frac{1000}{680}\right)$$

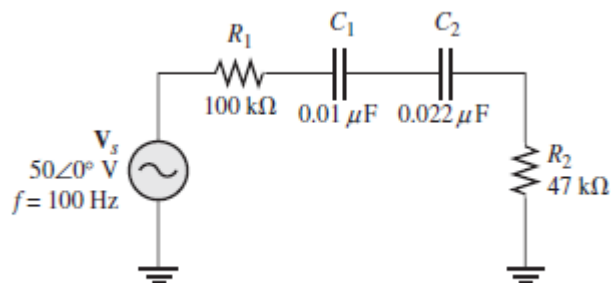
$$Z = 1.21 \angle -55.78^\circ \text{ k}\Omega$$

$$I = \frac{V_S}{Z}$$

$$I = \frac{5 \angle 0^\circ \text{ V}}{1.21 \angle -55.78^\circ \text{ k}\Omega}$$

$$I = 4.13 \angle 55.78^\circ \text{ mA}$$

28. Determine el ángulo de fase entre el voltaje aplicado y la corriente para cada circuito de la figura 15-85.



(a)

$$X_{C1} = \frac{1}{2\pi f C_1}$$

$$X_{C1} = \frac{1}{2\pi(100) 0.01 \times 10^{-6}}$$

$$X_{c1} = \frac{1}{6.283 \times 10^{-6}}$$

$$X_{c1} = 159.2 \text{ k}\Omega$$

$$X_{c2} = \frac{1}{2\pi f C_2}$$

$$X_{c2} = \frac{1}{2\pi(100) 0.022 \times 10^{-6}}$$

$$X_{c2} = \frac{1}{1.382 \times 10^{-5}}$$

$$X_{c2} = 72.34 \text{ k}\Omega$$

$$Z = R_1 + R_2 - jX_1 - jX_2$$

$$Z = 100 \text{ k} + 47 \text{ k} - j159.2 \text{ k} - j72.34 \text{ k}$$

$$Z = (147 - j231.54) \text{ k}\Omega$$

$$Z = \sqrt{A^2 + B^2} < -\tan^{-1}\left(\frac{B}{A}\right)$$

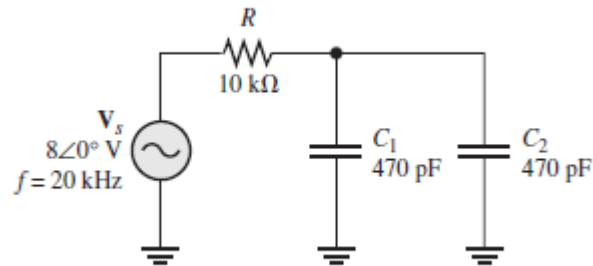
$$Z = \sqrt{(147 \text{ k})^2 + (-231.54 \text{ k})^2} < -\tan^{-1}\left(\frac{-231.54}{147}\right)$$

$$Z = 274.26 < -57.59^\circ \text{ k}\Omega$$

$$I = \frac{V_s}{Z}$$

$$I = \frac{50 < 0^\circ \text{ V}}{274.26 < -57.59^\circ \text{ k}\Omega}$$

$$I = 182 < 57.59^\circ \mu\text{A}$$



(b)

$$X_{c1} = \frac{1}{2\pi f C_1}$$

$$X_{c1} = \frac{1}{2\pi(20 \times 10^3) 470 \times 10^{-12}}$$

$$X_{c1} = 16.93 \text{ k}\Omega$$

$$X_{c2} = \frac{1}{2\pi f C_2}$$

$$X_{c2} = \frac{1}{2\pi(20 \times 10^3) 470 \times 10^{-12}}$$

$$X_{c2} = 16.93 \text{ k}\Omega$$

$$Z = R + (-jX_{c1} \parallel -jX_{c2})$$

$$Z = R + \frac{-jX_{C1}(-jX_{C2})}{-jX_{C1} - jX_{C2}}$$

$$Z = R + \frac{X_{C1}X_{C2}}{j(X_{C1} + X_{C2})}$$

$$Z = 10\text{ k} - j \frac{16.93\text{ k}(16.93\text{ k})}{16.93\text{ k} + 16.93\text{ k}}$$

$$Z = (10 - j8.47)\text{ k}\Omega$$

$$Z = \sqrt{A^2 + B^2} < -\tan^{-1}\left(\frac{B}{A}\right)$$

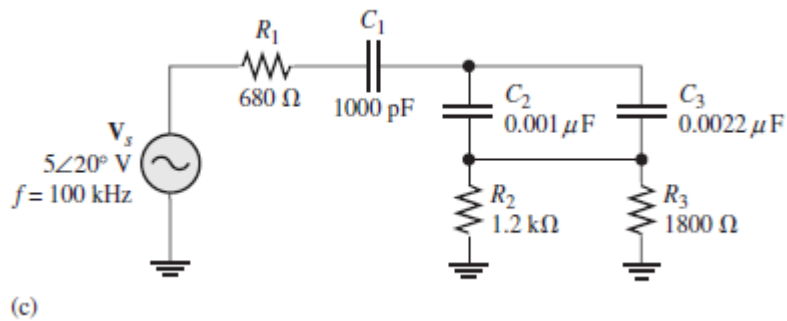
$$Z = \sqrt{(10\text{ k})^2 + (-8.47\text{ k})^2} < -\tan^{-1}\left(\frac{-8.47}{10}\right)$$

$$Z = 13.1 < -40.26^\circ \text{ k}\Omega$$

$$I = \frac{V_s}{Z}$$

$$I = \frac{8 < 0^\circ \text{ V}}{13.1 < -40.26^\circ \text{ k}\Omega}$$

$$I = 610.6 < 40.26^\circ \mu\text{A}$$



$$X_{c1} = \frac{1}{2\pi f C_1}$$

$$X_{c1} = \frac{1}{2\pi(100 \times 10^3) 1000 \times 10^{-12}}$$

$$X_{c1} = 1.59\text{ k}\Omega$$

$$X_{c2} = \frac{1}{2\pi f C_2}$$

$$X_{c2} = \frac{1}{2\pi(100 \times 10^3) 0.001 \times 10^{-6}}$$

$$X_{c2} = 1.59\text{ k}\Omega$$

$$X_{c3} = \frac{1}{2\pi f C_3}$$

$$X_{c3} = \frac{1}{2\pi(100 \times 10^3) 0.0022 \times 10^{-6}}$$

$$X_{c3} = 723.4\ \Omega$$

$$Z_1 = (-jX_{C2} || -jX_{C3})$$

$$Z_1 = \frac{-jX_{C2} (-jX_{C3})}{-jX_{C2} - jX_{C3}}$$

$$Z_1 = \frac{X_{C2}X_{C3}}{j(X_{C2} + X_{C3})}$$

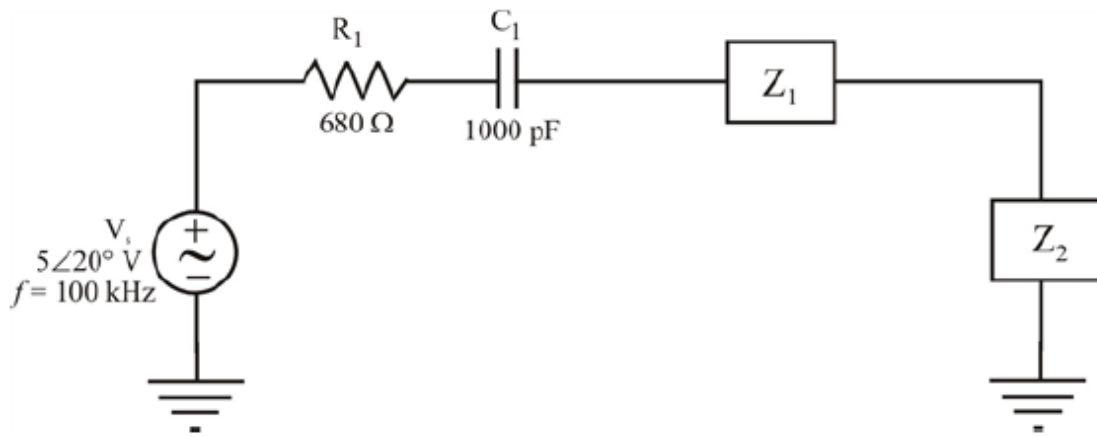
$$Z_1 = \frac{-1150.2k}{-j2313}$$

$$Z_1 = -j497.3 \Omega$$

$$Z_2 = (R_2 || R_3)$$

$$Z_2 = \frac{1200(1800)}{1200 + 1800}$$

$$Z_2 = 720 \Omega$$



$$Z_T = R_1 + (-jX_{C1}) + Z_1 + Z_2$$

$$Z_T = 680 - j1.59k - j497.3 + 720$$

$$Z_T = (1.4 - j2.087)k\Omega$$

$$Z = \sqrt{A^2 + B^2} < -\tan^{-1}\left(\frac{B}{A}\right)$$

$$Z = \sqrt{(1.4k)^2 + (-2.087k)^2} < -\tan^{-1}\left(\frac{-2.087}{1.4}\right)$$

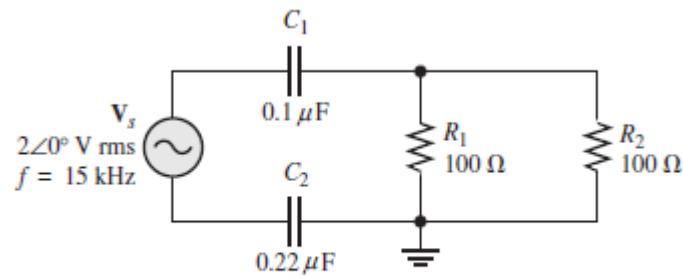
$$Z = 2.51 < -56.15^\circ k\Omega$$

$$I = \frac{V_s}{Z}$$

$$I = \frac{5 < 20^\circ \text{ V}}{2.51 < -56.15^\circ k\Omega}$$

$$I = 1.99 < 76.15^\circ \text{ mA}$$

30. Para el circuito de la figura 15-87, trace el diagrama fasorial que muestre todos los voltajes y la corriente total. Indique los ángulos de fase.



▲ FIGURA 15-87

$$X_{C1} = \frac{1}{2\pi f C_1}$$

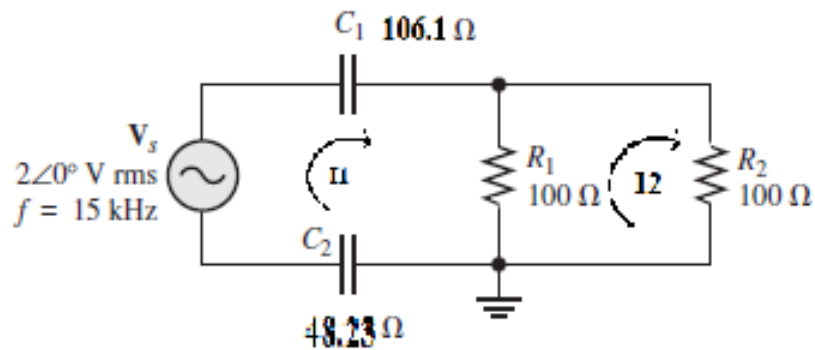
$$X_{C1} = \frac{1}{2\pi(15000) 0.1 \times 10^{-6}}$$

$$X_{C1} = 106.1 \Omega$$

$$X_{C2} = \frac{1}{2\pi f C_2}$$

$$X_{C2} = \frac{1}{2\pi(15000) 0.22 \times 10^{-6}}$$

$$X_{C2} = 48.23 \Omega$$



LVK:

$$(100 - j154.33)I_1 - 100(I_2) = 2 \angle 0^\circ$$

$$I_2 = 0.5I_1$$

$$I_1 = \frac{2 \angle 0^\circ}{50 - j154.33}$$

$$I_1 = 12.33 \angle 72.05^\circ \text{ mA}$$

$$I_2 = 6.17 \angle 72.05^\circ \text{ mA}$$

$$V_{C1} = (-jX_{C1})I_1$$

$$V_{C1} = (-j106.1)12.33 \times 10^{-3} \angle 72.05^\circ$$

$$V_{C1} = 1.308 \angle -17.95^\circ \text{ V}$$

$$V_{C2} = (-jX_{C2})I_1$$

$$V_{C2} = (-j48.23)12.33 \times 10^{-3} < 72.05^\circ$$

$$V_{C2} = 0.6 < -17.95^\circ V$$

$$V_{R1} = R_1(I_1 - I_2)$$

$$V_{R1} = 100(12.33m < 72.05^\circ - 6.17 < 72.05^\circ)$$

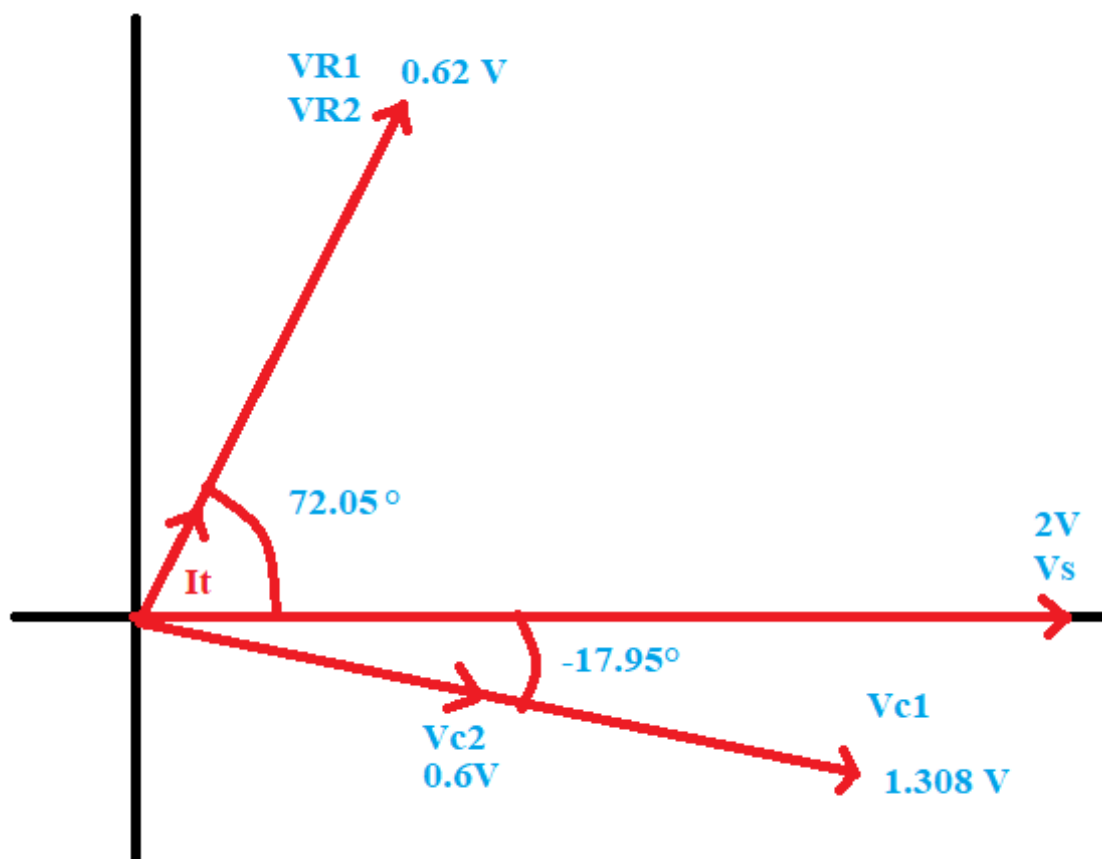
$$V_{R1} = 100(6.16m < 72.05^\circ)$$

$$V_{R1} = 0.62 < 72.05^\circ V$$

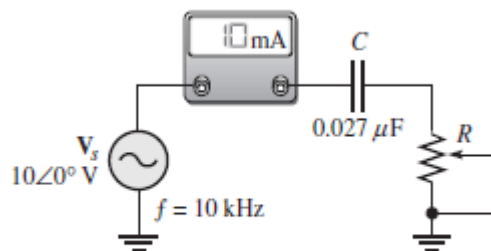
$$V_{R2} = I_2 R_2$$

$$V_{R2} = 100((6.16m < 72.05^\circ)$$

$$V_{R2} = 0.62 < 72.05^\circ V$$



32. ¿A qué valor se debe ajustar el reóstato de la figura 15-89 para hacer que la corriente total sea de 10 mA?
¿Cuál es el ángulo resultante?



▲ FIGURA 15-89

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(10000) 0.027 \times 10^{-6}}$$

$$X_c = 589.5 \, \Omega$$

$$Z = R - jX_c$$

$$Z = R - j589.5$$

$$Z = \sqrt{R^2 + 589.5^2} < \tan^{-1} \left(\frac{589.5}{R} \right)$$

$$I = \frac{V}{Z}$$

$$10 \times 10^{-3} = \frac{10}{\sqrt{R^2 + 589.5^2}}$$

$$R^2 + 589.5^2 = 10^6$$

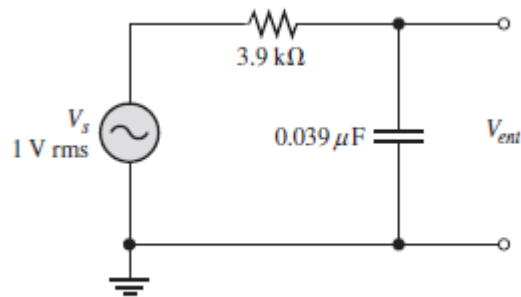
$$R = 807.77 \, \Omega$$

$$\theta = \tan^{-1} \left(\frac{589.5}{807.77} \right)$$

$$\theta = 36.12^\circ$$

34. Para el circuito de retraso de la figura 15-91, determine el desplazamiento de fase entre el voltaje de entrada y el voltaje de salida para cada una de las siguientes frecuencias:

(a) 1 Hz (b) 100 Hz (c) 1 kHz (d) 10 kHz



(a)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(1) 0.039 \times 10^{-6}}$$

$$X_c = 4.08 \, M\Omega$$

$$V_{out} = \frac{X_c}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_{out} = \frac{4.08 \, M}{\sqrt{(3.9 \times 10^3)^2 + (4.08 \times 10^6)^2}} V_s$$

$$V_{out} = 1 V_{rms}$$

$$\theta = -\tan^{-1} \left(\frac{R}{X_c} \right)$$

$$\theta = -\tan^{-1} \left(\frac{3.9k}{4.08M} \right)$$

$$\theta = -0.055^\circ$$

(b)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(100) 0.039 \times 10^{-6}}$$

$$X_c = 40.8 \text{ k}\Omega$$

$$V_{out} = \frac{X_c}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_{out} = \frac{40.8 \text{ k}}{\sqrt{(3.9 \times 10^3)^2 + (40.8 \times 10^3)^2}} V_s$$

$$V_{out} = 0.996 \text{ V}_{rms}$$

$$\theta = -\tan^{-1}\left(\frac{R}{X_c}\right)$$

$$\theta = -\tan^{-1}\left(\frac{3.9 \text{ k}}{40.8 \text{ k}}\right)$$

$$\theta = -5.46^\circ$$

(c)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(1000) 0.039 \times 10^{-6}}$$

$$X_c = 4.08 \text{ k}\Omega$$

$$V_{out} = \frac{X_c}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_{out} = \frac{4.08 \text{ k}}{\sqrt{(3.9 \times 10^3)^2 + (4.08 \times 10^3)^2}} V_s$$

$$V_{out} = 0.72 \text{ V}_{rms}$$

$$\theta = -\tan^{-1}\left(\frac{R}{X_c}\right)$$

$$\theta = -\tan^{-1}\left(\frac{3.9 \text{ k}}{4.08 \text{ k}}\right)$$

$$\theta = -43.7^\circ$$

(d)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(10000) 0.039 \times 10^{-6}}$$

$$X_c = 408.2 \text{ }\Omega$$

$$V_{out} = \frac{X_c}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_{out} = \frac{408.2}{\sqrt{(3.9 \times 10^3)^2 + (408.2)^2}} V_s$$

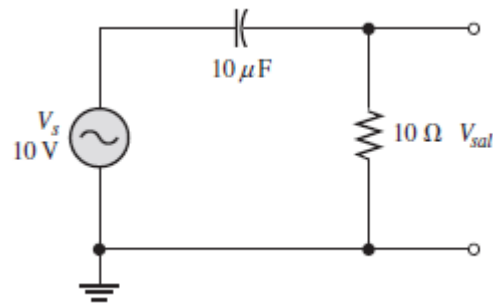
$$V_{out} = 0.12 \text{ Vrms}$$

$$\theta = -\tan^{-1}\left(\frac{R}{X_c}\right)$$

$$\theta = -\tan^{-1}\left(\frac{3.9k}{408.2k}\right)$$

$$\theta = -84.02^\circ$$

36. Repita el problema 34 para el circuito de adelanto de la figura 15-92.



(a)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(1) 10 \times 10^{-6}}$$

$$X_c = 15.92 \text{ k}\Omega$$

$$V_{out} = \frac{R}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_{out} = \frac{10}{\sqrt{(10)^2 + (15.92k)^2}} 10$$

$$V_{out} = 6.28 \text{ mVrms}$$

$$\theta = -\tan^{-1}\left(\frac{X_c}{R}\right)$$

$$\theta = -\tan^{-1}\left(\frac{15.92k}{10}\right)$$

$$\theta = 89.96^\circ$$

(b)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(100) 10 \times 10^{-6}}$$

$$X_c = 159.2 \Omega$$

$$V_{out} = \frac{R}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_{out} = \frac{10}{\sqrt{(10)^2 + (159.2)^2}} 10$$

$$V_{out} = 0.627 \text{ Vrms}$$

$$\theta = -\tan^{-1}\left(\frac{X_c}{R}\right)$$

$$\theta = -\tan^{-1}\left(\frac{159.2}{10}\right)$$

$$\theta = 86.4^\circ$$

(c)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(1000) 10 \times 10^{-6}}$$

$$X_c = 15.92 \Omega$$

$$V_{out} = \frac{R}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_{out} = \frac{10}{\sqrt{(10)^2 + (15.92)^2}} V_s$$

$$V_{out} = 5.32 \text{ Vrms}$$

$$\theta = -\tan^{-1}\left(\frac{X_c}{R}\right)$$

$$\theta = -\tan^{-1}\left(\frac{15.92}{10}\right)$$

$$\theta = 57.87^\circ$$

(d)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(10000) 10 \times 10^{-6}}$$

$$X_c = 1.59 \Omega$$

$$V_{out} = \frac{R}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_{out} = \frac{10}{\sqrt{(10)^2 + (1.59)^2}} V_s$$

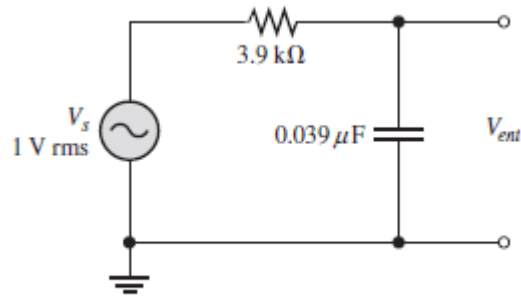
$$V_{out} = 9.87 \text{ Vrms}$$

$$\theta = -\tan^{-1}\left(\frac{X_c}{R}\right)$$

$$\theta = -\tan^{-1}\left(\frac{1.59}{10}\right)$$

$$\theta = 9.034^\circ$$

38. Trace el diagrama fasorial de voltaje para el circuito de la figura 15-91 para una frecuencia de 5 kHz con $V_s = V$ rms.



$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(5000) 0.039 \times 10^{-6}}$$

$$X_c = 816.17 \Omega$$

$$V_{out} = \frac{X_c}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_{out} = \frac{816.17}{\sqrt{(3.9 \times 10^3)^2 + (816.17)^2}}$$

$$V_{out} = 0.205 V_{rms}$$

$$\theta = -\tan^{-1}\left(\frac{R}{X_c}\right)$$

$$\theta = -\tan^{-1}\left(\frac{3.9 \times 10^3}{816.17}\right)$$

$$\theta = -78.18^\circ$$

$$V_{out} < \theta = 0.205 < -78.18^\circ V$$

$$V_R = \frac{R}{\sqrt{(R)^2 + (X_c)^2}} V_s$$

$$V_R = \frac{3.9 \times 10^3}{\sqrt{(3.9 \times 10^3)^2 + (816.17)^2}}$$

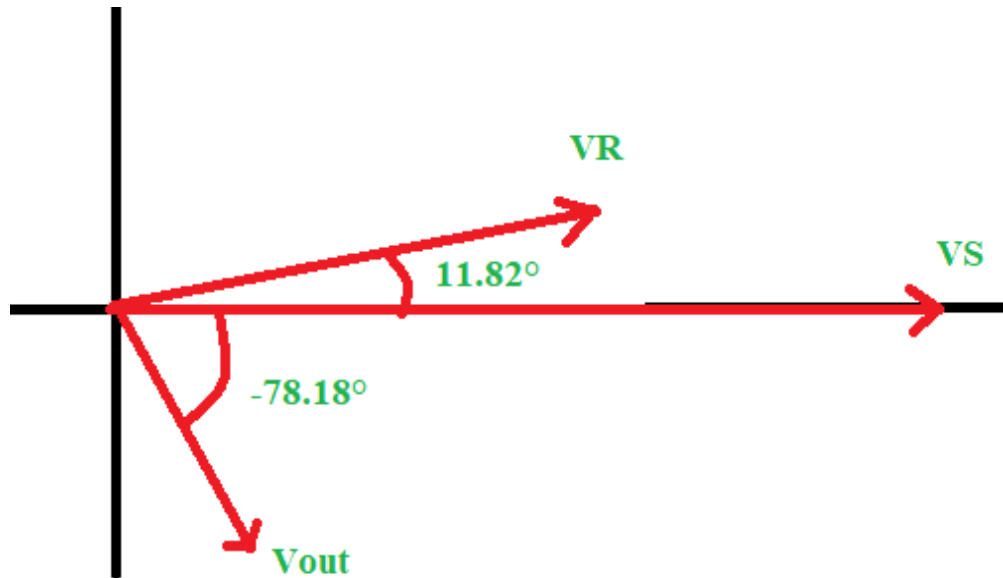
$$V_R = 0.98 V_{rms}$$

$$\theta = \tan^{-1}\left(\frac{X_c}{R}\right)$$

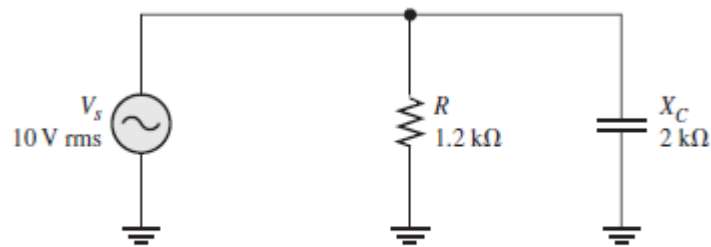
$$\theta = -\tan^{-1}\left(\frac{816.17}{3.9k}\right)$$

$$\theta = 11.82^\circ$$

$$V_R < \theta = 0.98 < 11.82^\circ V$$



40. Determine la impedancia y exprésela en forma polar para el circuito de la figura 15-93.



▲ FIGURA 15-93

$$Z = \frac{(R < 0^\circ)(X_c < -90^\circ)}{R < 0^\circ + (X_c < -90^\circ)}$$

$$Z = \frac{(RX_c)(< -90^\circ)}{\sqrt{(R)^2 + (X_c)^2} < -\tan^{-1}\left(\frac{X_c}{R}\right)}$$

$$Z = \frac{(RX_c)}{\sqrt{(R)^2 + (X_c)^2}} < (-90^\circ + \tan^{-1}\left(\frac{X_c}{R}\right))$$

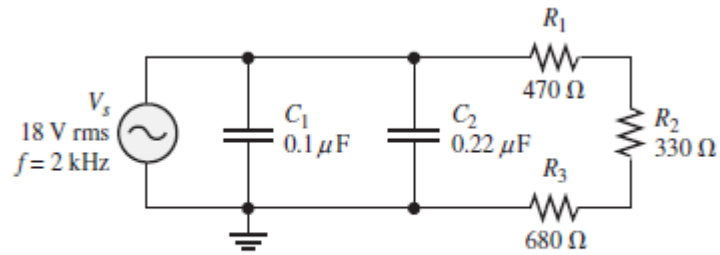
$$Z = \frac{2.4 \times 10^6}{\sqrt{5.44 \times 10^6}} < (-90^\circ + \tan^{-1}\left(\frac{2}{1.2}\right))$$

$$Z = 1.03 < -30.96^\circ\text{ k}\Omega$$

42. Repita el problema 41 para las siguientes frecuencias:

(a) 1.5 kHz (b) 3 kHz (c) 5 kHz (d) 10 kHz

41. Determine la magnitud de la impedancia y el ángulo de fase en la figura 15-94.



▲ FIGURA 15-94

(a)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2\pi(1.5k) 0.22 \times 10^{-3}}$$

$$X_c = 482.28 \, \Omega$$

$$Z = \frac{R X_c}{\sqrt{(R)^2 + (X_c)^2}}$$

$$Z = \frac{750 (482.28)}{\sqrt{(750)^2 + (482.28)^2}}$$

$$Z = 405.64 \, \Omega$$

$$\theta = \tan^{-1}\left(\frac{R}{X_c}\right)$$

$$\theta = \tan^{-1}\left(\frac{750}{482.28}\right)$$

$$\theta = 57.25^\circ$$

(b)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = 241.14 \, \Omega$$

$$Z = \frac{R X_c}{\sqrt{(R)^2 + (X_c)^2}}$$

$$Z = 230 \, \Omega$$

$$\theta = \tan^{-1}\left(\frac{R}{X_c}\right)$$

$$\theta = 72.17^\circ$$

(c)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = 144.68 \, \Omega$$

$$Z = \frac{R X_c}{\sqrt{(R)^2 + (X_c)^2}}$$

$$Z = 142 \, \Omega$$

$$\theta = \tan^{-1}\left(\frac{R}{X_c}\right)$$

$$\theta = 79.08^\circ$$

(d)

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = 72.34 \, \Omega$$

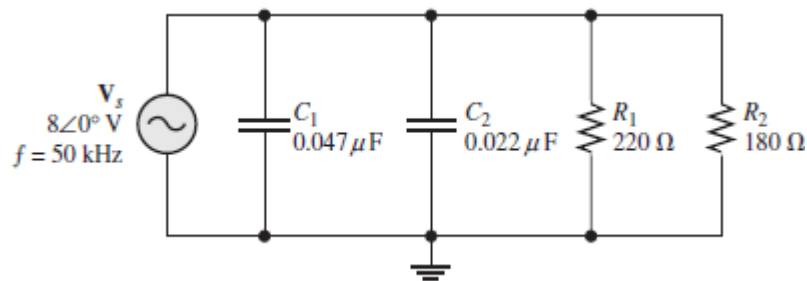
$$Z = \frac{R X_c}{\sqrt{(R)^2 + (X_c)^2}}$$

$$Z = 72 \, \Omega$$

$$\theta = \tan^{-1}\left(\frac{R}{X_c}\right)$$

$$\theta = 84.49^\circ$$

44. Para el circuito en paralelo de la figura 15-96, encuentre la magnitud de cada corriente de rama y la corriente total. ¿Cuál es el ángulo de fase entre el voltaje aplicado y la corriente total?



$$X_{c1} = \frac{1}{2\pi fC_1}$$

$$X_c = 67.73 \, \Omega$$

$$X_{c2} = \frac{1}{2\pi fC_2}$$

$$X_c = 144.68 \, \Omega$$

$$I_{c1} = \frac{V_s}{-jX_{c1}}$$

$$I_{c1} = 118 \angle 90^\circ \text{ mA}$$

$$I_{c2} = \frac{V_s}{-jX_{c2}}$$

$$I_{c1} = 55 \angle 90^\circ \text{ mA}$$

$$I_{R1} = \frac{V_s}{R_1}$$

$$I_{R1} = 36.4 \angle 90^\circ \text{ mA}$$

$$I_{R2} = \frac{V_S}{R_2}$$

$$I_{R1} = 44.4 < 90^\circ \text{ mA}$$

$$I_T = (I_{R1} + I_{R2}) + j(I_{C1} + I_{C2})$$

$$I_T = 190.9 < 64.96^\circ \text{ mA}$$

$$\theta = \theta_v - \theta_i$$

$$\theta = 0^\circ - 64.96^\circ$$

$$\theta = -64.96^\circ$$