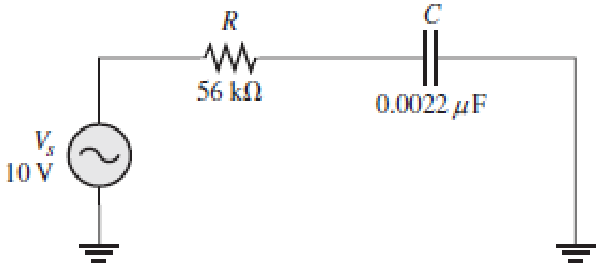
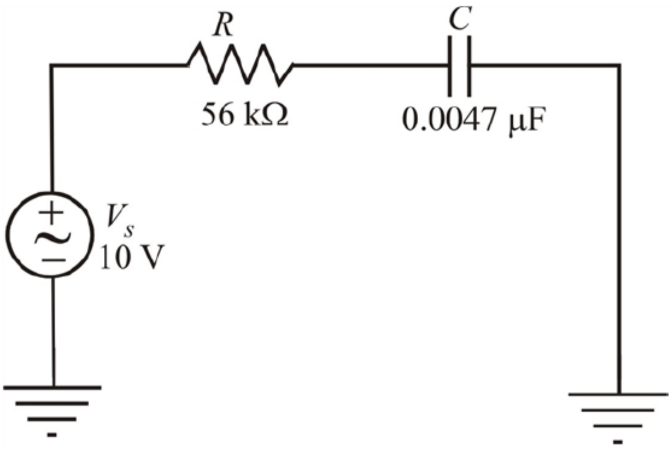
24. Repita el problema 23 con *C* = 0.0047 μF.

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

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2\pi(100)(0.0047x10^{-6})}$$

$$X_c = \frac{1}{2.95\ x10^{-6}}$$

$$X_c = 338.63\ k\Omega$$

$$Z = R - jX_c$$

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

B) 500 Hz

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2\pi(500)(0.0047x10^{-6})}$$

$$X_c = \frac{1}{1.477\ x10^{-5}}$$

$$X_c = 677.26\ k\Omega$$

$$Z = R - jX_c$$

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

C) 1 kHz

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

$$X_c = \frac{1}{2\pi(1000)(0.0047x10^{-6})}$$

$$X_c = \frac{1}{2.95\ x10^{-5}}$$

$$X_c = 338.62\ k\Omega$$

$$Z = R - jX_c$$

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

D) 2.5 kHz

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

$$X_c = \frac{1}{2\pi(2500)(0.0047x10^{-6})}$$

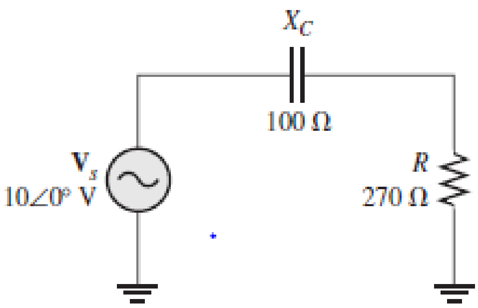
$$X_c = \frac{1}{7.38\ x10^{-5}}$$

$$X_c = 135.45\ k\Omega$$

$$Z = R - jX_c$$

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

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



(a)

$$Z = R - jX_c$$

$$Z = 270 - j100$$

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

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

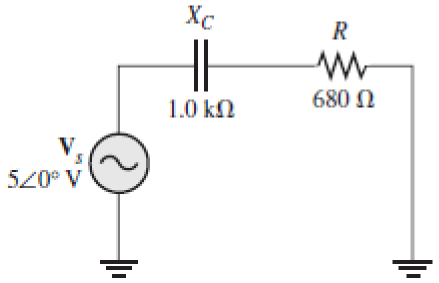
$$Z = \sqrt{82900} < -tan^{-1}(0.37)$$

$$Z = 287.9 < -20.32° \, \Omega$$

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

$$I = \frac{10 < 0°}{287.9 < -20.32°}$$

$$I = 0.035 < 20.32° \, A$$



(b)

$$Z = R - jX_c$$

$$Z = 680 - j1000$$

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

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

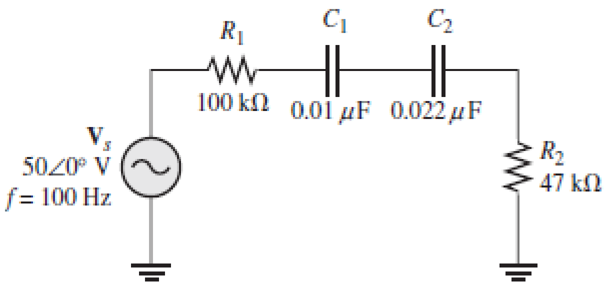
$$Z = 1.21 < -55.78° \, k\Omega$$

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

$$I = \frac{5 < 0° \, V}{1.21 < -55.78° \, k\Omega}$$

$$I = 4.13 < 55.78° \, mA$$

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



(a)

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

$$X_{c1} = \frac{1}{2\pi(100)\,0.01\,x10^{-6}}$$

$$X_{c1} = \frac{1}{6.283\,x10^{-6}}$$

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

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

$$X_{c2} = \frac{1}{2\pi(100)\ 0.022\,x10^{-6}}$$

$$X_{c2} = \frac{1}{1.382\,x10^{-5}}$$

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

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

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

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

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

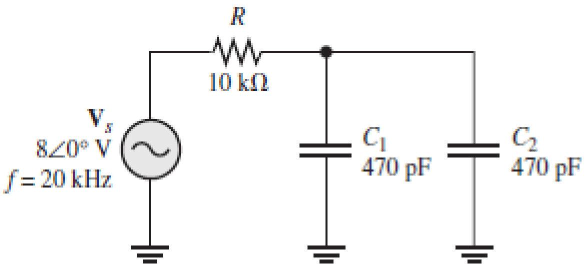
$$Z = \sqrt{(147k)^2 + (-231.54k)^2} < -tan^{-1}\left(\frac{-231.54}{147}\right)$$

$$Z = 274.26 < -57.59°\ k\Omega$$

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

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

$$I = 182 < 57.59°\ \mu A$$



(b)

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

$$X_{c1} = \frac{1}{2\pi(20x10^3)\ 470\,x10^{-12}}$$

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

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

$$X_{c2} = \frac{1}{2\pi(20x10^3)\ 470\,x10^{-12}}$$

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

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

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

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

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

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

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

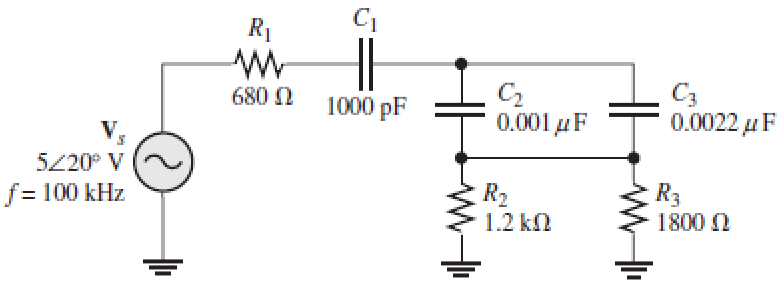
$$Z = \sqrt{(10k)^2 + (-8.47k)^2} < -tan^{-1}\left(\frac{-8.47}{10}\right)$$

$$Z = 13.1 < -40.26°\ k\Omega$$

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

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

$$I = 610.6 < 40.26°\ \mu A$$



(c)

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

$$X_{c1} = \frac{1}{2\pi(100x10^3)\ 1000\ x10^{-12}}$$

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

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

$$X_{c2} = \frac{1}{2\pi(100x10^3)\ 0.001\ x10^{-6}}$$

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

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

$$X_{c3} = \frac{1}{2\pi(100x10^3)\ 0.0022\ x10^{-6}}$$

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

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

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

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

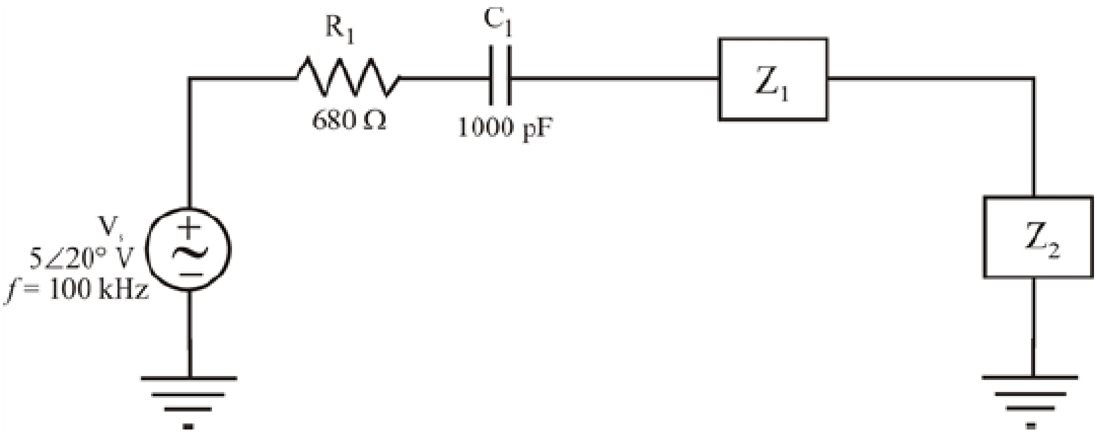
$$Z_1 = \frac{-1150.2k}{-j2313}$$

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

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

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

$$Z_2 = 720\ \Omega$$



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

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

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

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

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

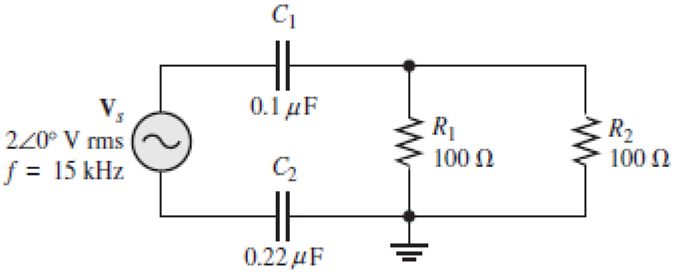
$$Z = 2.51 < -56.15°\ k\Omega$$

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

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

$$I = 1.99 < 76.15°\ mA$$

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

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

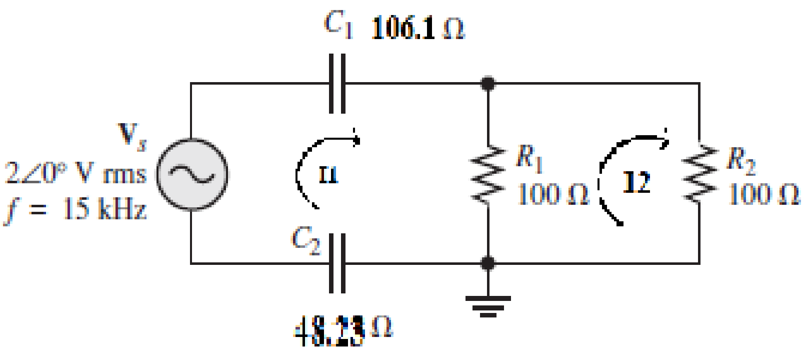
$$X_{c1} = \frac{1}{2\pi(15000)\ 0.1\ x10^{-6}}$$

$$X_{c1} = 106.1\ \Omega$$

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

$$X_{c2} = \frac{1}{2\pi(15000)\ 0.22\ x10^{-6}}$$

$$X_{c2} = 48.23\ \Omega$$



LVK:

$$(100 - j154.33)I_1 - 100(I_2) = 2 < 0°$$

$$I_2 = 0.5I_1$$

$$I_1 = \frac{2 < 0°}{50 - j154.33}$$

$$I_1 = 12.33 < 72.05°\ mA$$

$$I_2 = 6.17 < 72.05°\ mA$$

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

$$V_{C1} = (-j106.1)12.33x10^{-3} < 72.05°$$

$$V_{C1} = 1.308 < -17.95°\ V$$

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

$$V_{C2} = (-j48.23)12.33x10^{-3} < 72.05°$$

$$V_{C2} = 0.6 < -17.95°\,V$$

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

$$V_{R1} = 100(12.33m < 72.05° - 6.17 < 72.05°)$$

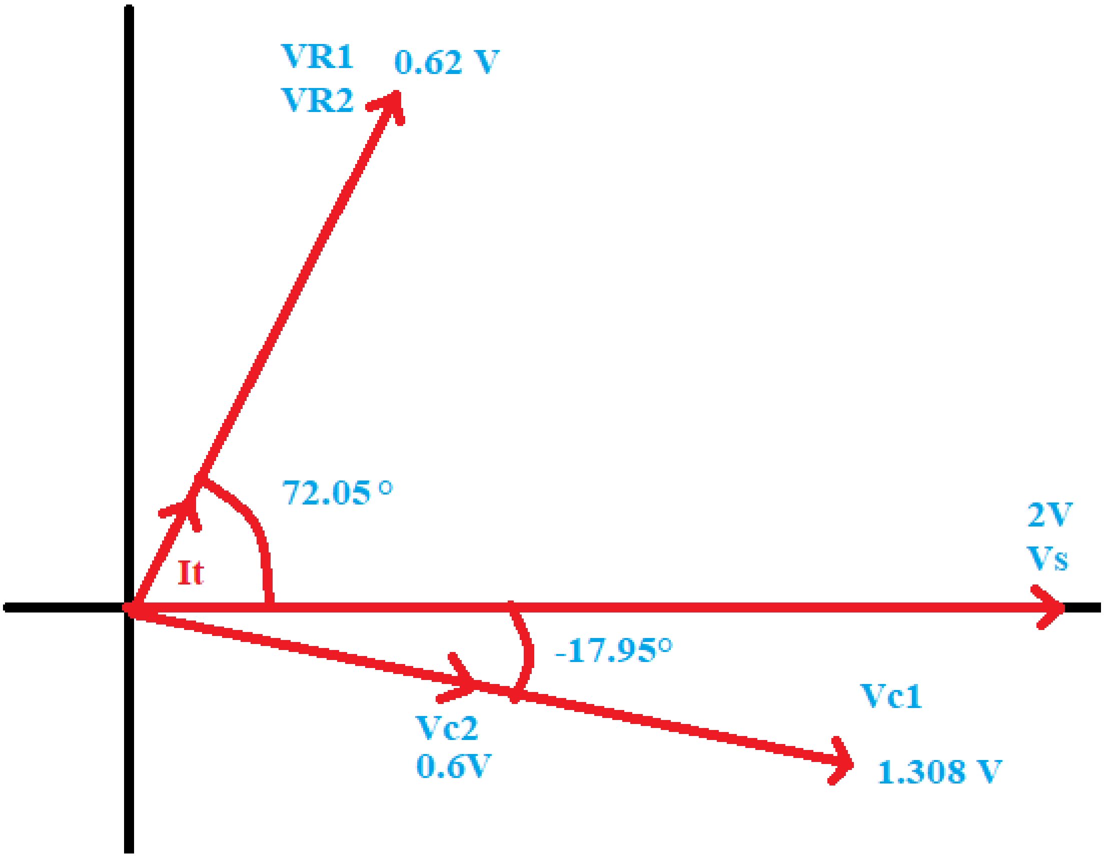
$$V_{R1} = 100(6.16m < 72.05°)$$

$$V_{R1} = 0.62 < 72.05°\,V$$

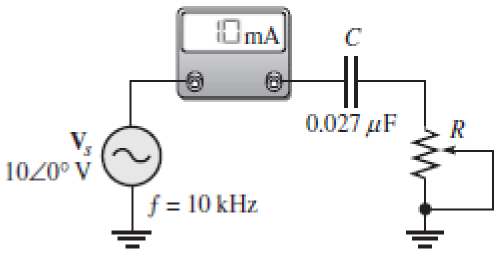
$$V_{R2} = I_2R_2$$

$$V_{R2} = 100((6.16m < 72.05°)$$

$$V_{R2} = 0.62 < 72.05°\,V$$



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

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2\pi(10000)\ 0.0.27\ x10^{-6}}$$

$$X_c = 589.5\ \Omega$$

$$Z = R - jX_c$$

$$Z = R - j589.5$$

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

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

$$10x10^{-3} = \frac{10}{\sqrt{R^2 + 589.5^2}}$$

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

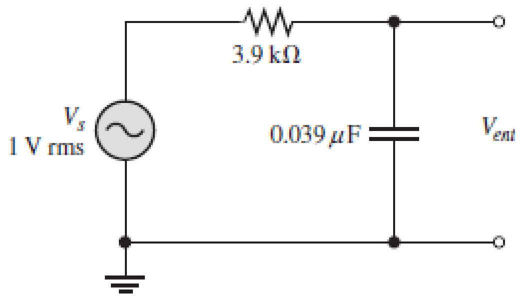
$$R = 807.77\ \Omega$$

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

$$\Theta = 36.12°$$

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)

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2\pi(1)\ 0.039\ x10^{-6}}$$

$$X_c = 4.08\ M\Omega$$

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

$$V_{out} = \frac{4.08\ M}{\sqrt{(3.9x10^3)^2 + (4.08x10^6)^2}} V_S$$

$$V_{out} = 1Vrms$$

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

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

$$\Theta = -0.055°$$

(b)

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

$$X_c = \frac{1}{2\pi(100)\ 0.039\ x10^{-6}}$$

$$X_c = 40.8\ k\Omega$$

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

$$V_{out} = \frac{40.8\ k}{\sqrt{(3.9x10^3)^2 + (40.8x10^3)^2}}\ V_S$$

$$V_{out} = 0.996\ Vrms$$

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

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

$$\Theta = -5.46°$$

(c)

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

$$X_c = \frac{1}{2\pi(1000)\ 0.039\ x10^{-6}}$$

$$X_c = 4.08\ k\Omega$$

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

$$V_{out} = \frac{4.08\ k}{\sqrt{(3.9x10^3)^2 + (4.08x10^3)^2}}\ V_S$$

$$V_{out} = 0.72\ Vrms$$

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

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

$$\Theta = -43.7°$$

(d)

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

$$X_c = \frac{1}{2\pi(10000)\ 0.039\ x10^{-6}}$$

$$X_c = 408.2\ \Omega$$

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

$$V_{out} = \frac{408.2}{\sqrt{(3.9x10^3)^2 + (408.2)^2}} V_S$$

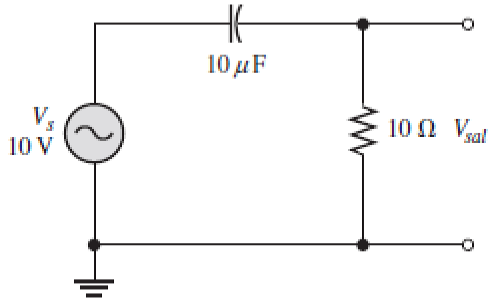
$$V_{out} = 0.12\ Vrms$$

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

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

$$\Theta = -84.02°$$

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



(a)

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

$$X_c = \frac{1}{2\pi(1)\ 10\ x10^{-6}}$$

$$X_c = 15.92\ k\Omega$$

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

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

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

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

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

$$\Theta = 89.96°$$

(b)

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

$$X_c = \frac{1}{2\pi(100)\ 10\ x10^{-6}}$$

$$X_c = 159.2\ \Omega$$

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

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

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

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

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

$$\Theta = 86.4°$$

(c)

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2\pi(1000)\ 10\, x10^{-6}}$$

$$X_c = 15.92\ \Omega$$

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

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

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

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

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

$$\Theta = 57.87°$$

(d)

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2\pi(10000)\ 10\, x10^{-6}}$$

$$X_c = 1.59\ \Omega$$

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

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

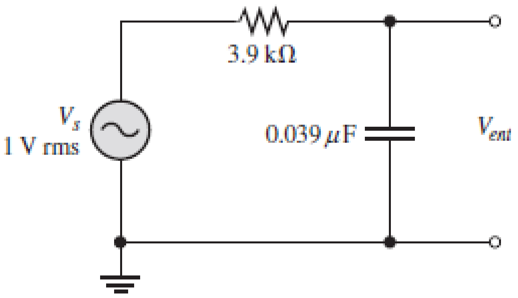
$$V_{out} = 9.87\, Vrms$$

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

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

$$\Theta = 9.034°$$

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.



$$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2\pi(5000)\ 0.039\ x10^{-6}}$$

$$X_c = 816.17\ \Omega$$

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

$$V_{out} = \frac{816.17}{\sqrt{(3.9x10^3)^2 + (816.17)^2}}$$

$$V_{out} = 0.205\ Vrms$$

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

$$\Theta = -tan^{-1}\left(\frac{3.9x10^3}{816.17}\right)$$

$$\Theta = -78.18°$$

$$V_{out} < \Theta = 0.205 < -78.18°\ V$$

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

$$V_R = \frac{3.9x10^3}{\sqrt{(3.9x10^3)^2 + (816.17)^2}}$$

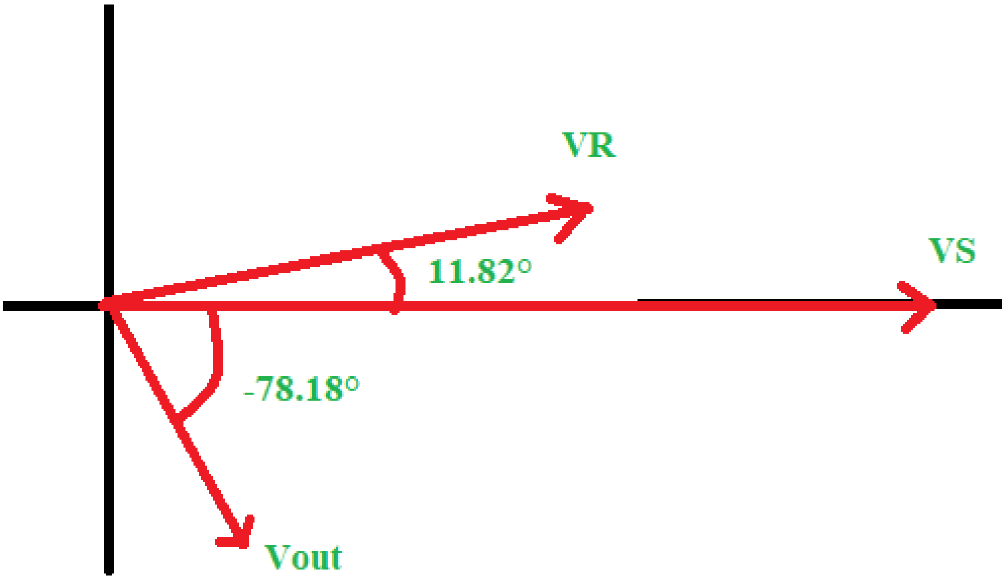
$$V_R = 0.98\ Vrms$$

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

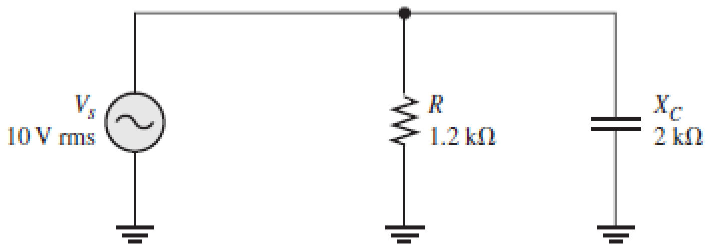
$$\Theta = -tan^{-1}\left(\frac{816.17}{3.9k}\right)$$

$$\Theta = 11.82°$$

$$V_R < \Theta = 0.98 < 11.82°\ V$$



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



▲ FIGURA 15–93

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

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

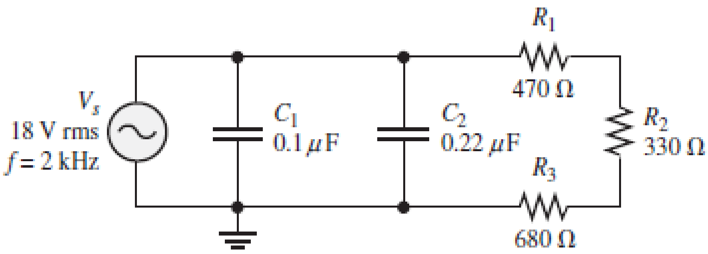
$$Z = \frac{(RX_c)}{\sqrt{(R)^2 + (X_c)^2}} < (-90°+tan^{-1}\left(\frac{X_c}{R}\right)\ )$$

$$Z = \frac{2.4x10^6}{\sqrt{5.44x10^6}} < (-90°+tan^{-1}\left(\frac{2}{1.2}\right)$$

$$Z = 1.03 < -30.96°\ k\Omega$$

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)

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = \frac{1}{2\pi(1.5k)\,0.22\,x10^{-3}}$$

$$X_c = 482.28\ \Omega$$

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

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

$$Z = 405.64\ \Omega$$

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

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

$$\Theta = 57.25°$$

(b)

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = 241.14\ \Omega$$

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

$$Z = 230\ \Omega$$

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

$$\Theta = 72.17°$$

(c)

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = 144.68\ \Omega$$

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

$$Z = 142\ \Omega$$

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

$$\Theta = 79.08°$$

(d)

$$X_c = \frac{1}{2\pi f C}$$

$$X_c = 72.34\ \Omega$$

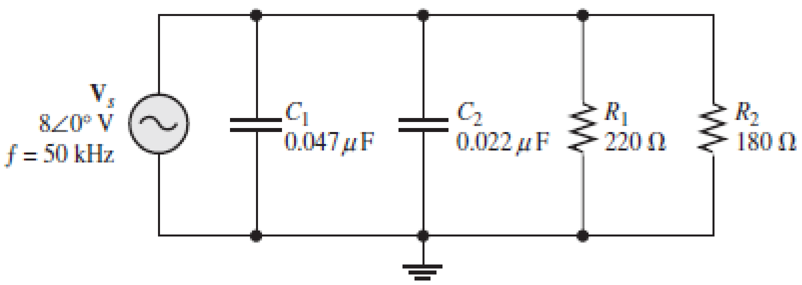
$$Z = \frac{R\ X_c}{\sqrt{(R)^2 + (X_c)^2}}$$

$$Z = 72\ \Omega$$

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

$$\Theta = 84.49°$$

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?



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

$$X_c = 67.73\ \Omega$$

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

$$X_c = 144.68\ \Omega$$

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

$$I_{c1} = 118 < 90°\ mA$$

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

$$I_{c1} = 55 < 90°\ mA$$

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

$$I_{R1} = 36.4 < 90°\ mA$$

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

$$I_{R1} = 44.4 < 90° \, mA$$

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

$$I_T = 190.9 < 64.96° \, mA$$

$$\Theta = \Theta_v - \Theta_i$$

$$\Theta = 0° \; - 64.96°$$

$$\Theta = -64.96°$$