

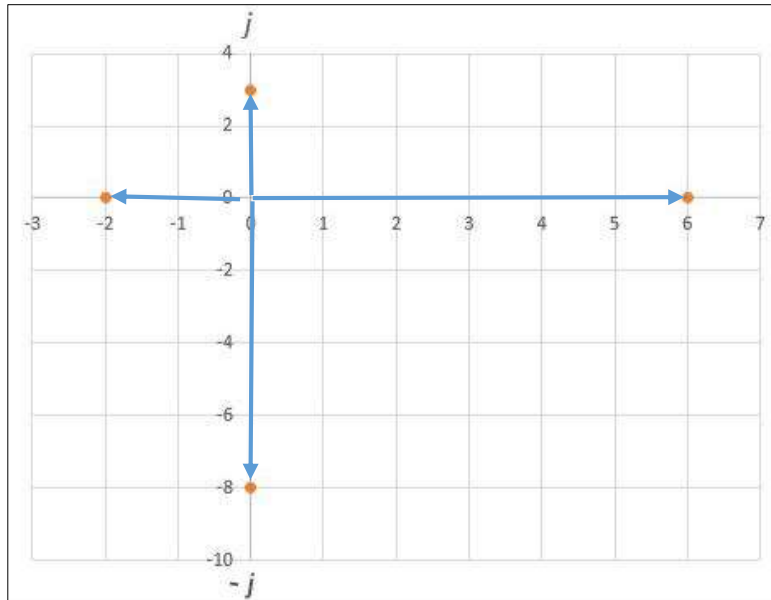
Cálculos del Capítulo N° 15:

Parte 1: CIRCUITOS EN SERIE

SECCIÓN 15-1 El sistema de los números complejos

1. Localice los siguientes en el plano complejo:

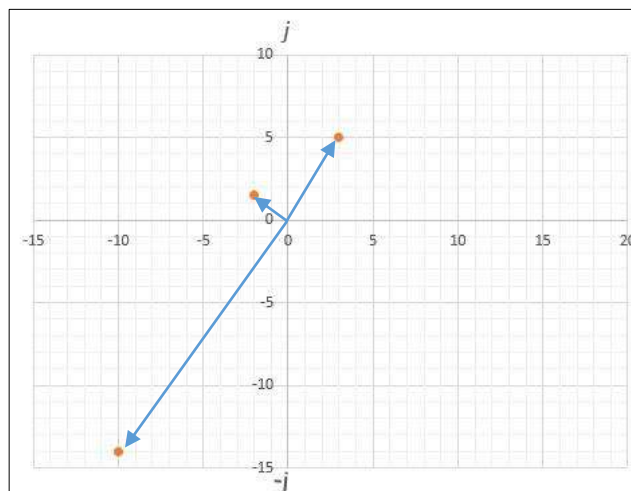
- (a) $+6$
- (b) -2
- (c) $+j3$
- (d) $-j8$



3. A continuación, se describen puntos localizados en el plano complejo. Expresé cada uno 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 .
- (b) 2 unidades a la izquierda del origen sobre el eje real, y 1.5 unidades hacia arriba sobre el eje j .
- (c) 10 unidades a la izquierda del origen sobre el eje real, y 14 unidades hacia abajo sobre el eje $-j$.

- (a) $3 + j5$
- (b) $-2 + j1.5$
- (c) $-10 - j14$



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

(a) $40 - j40$

(b) $50 - j200$

(c) $35 - j20$

(d) $98 + j45$

a. $40 - j40$

$$c \angle \pm \theta$$

$$c = \sqrt{A^2 + B^2}$$

$$A = 40$$

$$B = -40$$

$$c = \sqrt{(40)^2 + (-40)^2} = 40\sqrt{2} = 56.56$$

$$\theta = \tan^{-1}\left(\frac{\pm B}{A}\right)$$

$$\theta = \tan^{-1}\left(\frac{-40}{40}\right)$$

$$\theta = \tan^{-1}(-1)$$

$$\theta = -45^\circ$$

$$40\sqrt{2} \angle -45^\circ$$

b. $50 - j200$

$$c \angle \pm \theta$$

$$c = \sqrt{A^2 + B^2}$$

$$A = 50$$

$$B = -200$$

$$c = \sqrt{(50)^2 + (-200)^2} = 50\sqrt{17} = 206.15$$

$$\theta = \tan^{-1}\left(\frac{\pm B}{A}\right)$$

$$\theta = \tan^{-1}\left(\frac{-200}{50}\right)$$

$$\theta = \tan^{-1}(-4)$$

$$\theta = -75.96^\circ$$

$$50\sqrt{17} \angle -75.96^\circ$$

c. $35 - j20$

$$c \angle \pm \theta$$

$$c = \sqrt{A^2 + B^2}$$

$$A = -20$$

$$B = -20$$

$$c = \sqrt{(35)^2 + (-20)^2} = 5\sqrt{65} = 40.31$$

$$\theta = \tan^{-1}\left(\frac{\pm B}{A}\right)$$

$$\theta = \tan^{-1}\left(\frac{-20}{35}\right)$$

$$\theta = \tan^{-1} \left(\frac{-4}{7} \right)$$

$$\theta = -29.7^\circ$$

$$5\sqrt{65} \angle -29.7^\circ$$

d. $98 + j45$

$$c \angle \pm \theta$$

$$c = \sqrt{A^2 + B^2}$$

$$A = 98$$

$$B = 45$$

$$c = \sqrt{(98)^2 + (45)^2} = 107.84$$

$$\theta = \tan^{-1} \left(\frac{\pm B}{A} \right)$$

$$\theta = \tan^{-1} \left(\frac{45}{98} \right)$$

$$\theta = 24.7^\circ$$

$$107.84 \angle 24.7^\circ$$

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

(a) $10 \angle 120^\circ$

(b) $32 \angle 85^\circ$

(c) $5 \angle 310^\circ$

(a) $10 \angle -240^\circ$

(b) $32 \angle -275^\circ$

(c) $5 \angle -50^\circ$

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

(a) $10 \angle 120^\circ$

(b) $32 \angle 85^\circ$

(c) $5 \angle 310^\circ$

(a) Segundo Cuadrante

(b) Primer Cuadrante

(c) Tercer Cuadrante

7. Sumar los siguientes conjuntos de números complejos:

(a) $9 + j5$ y $5 + j8$

(b) $3.5 - j4$ y $2.2 + j6$

(c) $-18 + j23$ y $30 - j15$

(d) $12 \angle 45^\circ$ y $20 \angle 32^\circ$

(e) $38 \angle 75^\circ$ y $1 + j1.8$

(f) $50 - j39$ y $60 \angle -30^\circ$

$$(a) \quad 9 + j5 \text{ y } 5 + j8$$

$$= (9 + 5) + j(5 + 8) = \mathbf{14 + j13}$$

$$(b) \quad 3.5 - j4 \text{ y } 2.2 + j6$$

$$= (3.5 + 2.2) + j(-4 + 6) = \mathbf{5.7 + j2}$$

$$(c) \quad -18 + j23 \text{ y } 30 - j15$$

$$= (-18 + 30) + j(23 - 15) = 22 + j8$$

$$(d) \quad 12\angle 45^\circ \text{ y } 20\angle 32^\circ$$

No se puede sumar números complejos de forma polar, por ende, se transforman de números complejos de forma polar a forma rectangular

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = 12 \cos 45^\circ = \mathbf{6\sqrt{2}}$$

$$B = 12 \sin 45^\circ = \mathbf{6\sqrt{2}}$$

$$A + jB = \mathbf{6\sqrt{2} + j6\sqrt{2}}$$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = 20 \cos 32^\circ = \mathbf{17}$$

$$B = 20 \sin 32^\circ = \mathbf{10.6}$$

$$A + jB = \mathbf{17 + j10.6}$$

$$- \quad 6\sqrt{2} + j6\sqrt{2} \text{ y } 17 + j10.6$$

$$= (6\sqrt{2} + 17) + j(6\sqrt{2} + 10.6) = 25.5 + j19$$

$$(e) \quad 38\angle 75^\circ \text{ y } 1 + j1.8$$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = 38 \cos 75^\circ = \mathbf{9.83}$$

$$B = 38 \sin 75^\circ = \mathbf{36.7}$$

$$A + jB = \mathbf{9.83 + j36.7}$$

$$- \quad 9.83 + j36.7 \text{ y } 1 + j1.8$$

$$= (9.83 + 1) + j(36.7 + 1.8) = 10.83 + j38.5$$

$$(f) \quad 50 - j39 \text{ y } 60\angle -30^\circ$$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = 60 \cos 30^\circ = \mathbf{30\sqrt{3}}$$

$$B = 60 \sin 30^\circ = \mathbf{30}$$

$$A + jB = \mathbf{30\sqrt{3} + j30}$$

$$\begin{aligned}
 & - 50 - j39 \text{ y } 30\sqrt{3} + j30 \\
 & = (50 + 30\sqrt{3}) + j(-39 + 30) = 102 - j9
 \end{aligned}$$

8. Multiplique los siguientes números:

- (a) $4.5\angle 48^\circ$ y $3.2\angle 90^\circ$
- (b) $120\angle -220^\circ$ y $95\angle 200^\circ$
- (c) $-3\angle 150^\circ$ y $4 - j3$
- (d) $67 + j84$ y $102\angle 40^\circ$
- (e) $15 - j10$ y $-25 - j30$
- (f) $0.8 + j0.5$ y $1.2 - j1.5$

(a) $4.5\angle 48^\circ$ y $3.2\angle 90^\circ$

$$(4.5) * (3.2)\angle (48^\circ + 90^\circ) = 14.4\angle 138^\circ$$

(b) $120\angle -220^\circ$ y $95\angle 200^\circ$

$$(120) * (95)\angle (-220^\circ + 200^\circ) = 11400\angle -20^\circ$$

(c) $-3\angle 150^\circ$ y $4 - j3$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = -3 \cos 150^\circ = \mathbf{2.6}$$

$$B = -3 \sin 150^\circ = -1.5$$

$$A + jB = \mathbf{2.6 - j1.5}$$

- $2.6 - j1.5$ y $4 - j3$

$$(2.6 - j1.5) * (4 - j3) = 10.4 - j7.8 + 4.5 - j6 = 14.9 - j13.8$$

(d) $67 + j84$ y $102\angle 40^\circ$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = 102 \cos 40^\circ = \mathbf{78.13}$$

$$B = 102 \sin 40^\circ = \mathbf{65.56}$$

$$A + jB = \mathbf{78.13 - j65.56}$$

- $67 + j84$ y $78.13 - j65.56$

$$(67 + j84) * (78.13 - j65.56)$$

$$= 5234.71 - j4392.52 - 5507.04 + j6562.92$$

$$= -272.33 + j2170.4$$

(e) $15 - j10$ y $-25 - j30$

$$(15 - j10) * (-25 - j30) = -375 - j450 + 300 + j300 = -75 - j150$$

(f) $0.8 + j0.5$ y $1.2 - j1.5$

$$(0.8 + j0.5) * (1.2 - j1.5) = 0.96 - j1.2 - 0.75 + j0.6 = 0.21 - j0.6$$

9. Realice las siguientes operaciones:

(a) $\frac{2.5\angle 65^\circ - 1.8\angle -23^\circ}{1.2\angle 37^\circ}$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = 2.5 \cos 65^\circ = \mathbf{1.05}$$

$$B = 2.5 \sin 65^\circ = \mathbf{2.26}$$

$$A + jB = \mathbf{1.05 + j2.26}$$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = -18 \cos -23^\circ = \mathbf{-16.57}$$

$$B = -18 \sin -23^\circ = \mathbf{7.03}$$

$$A + jB = \mathbf{-16.57 + j7.03}$$

$$\begin{aligned} - & \quad 1.05 + j2.26 \text{ y } -16.57 + j7.03 \\ & = (1.05 - 16.57) + j(2.26 + 7.03) = -15.52 + j9.29 \end{aligned}$$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = 1.2 \cos 37^\circ = \mathbf{0.96}$$

$$B = 1.2 \sin 37^\circ = \mathbf{0.72}$$

$$A + jB = \mathbf{0.96 + j0.72}$$

$$\begin{aligned} \frac{-16.57 + j7.03}{0.96 + j0.72} &= \frac{(-16.57 + j7.03) * (0.96 - j0.72)}{(0.96 + j0.72) * (0.96 - j0.72)} \\ &= \frac{-15.9 + j18.68 - 5.06}{0.96 - 0.72} = \frac{-15.96 + j18.68}{0.24} \\ &= 66.5 + j77.83 \end{aligned}$$

$$\text{(b)} \quad \frac{(100 \angle 15^\circ)(85 - j150)}{25 + j45}$$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = 100 \cos 15^\circ = \mathbf{96.6}$$

$$B = 100 \sin 15^\circ = \mathbf{25.88}$$

$$A + jB = \mathbf{96.6 + j25.88}$$

$$\begin{aligned} - & \quad 96.6 + j25.88 \text{ y } 85 - j150 \\ & = (96.6 + 85) + j(25.88 - 150) = 181.6 - j124.12 \\ \frac{181.6 - j124.12}{25 + j45} &= \frac{(181.6 - j124.12) * (25 - j45)}{(25 + j45) * (25 - j45)} = \frac{4540 - j10548.6 + 5585.4}{25 - 45} \\ &= \frac{10125.4 - j10548.6}{-20} = -506.27 + j527.43 \end{aligned}$$

$$\text{(c)} \quad \frac{(250 \angle 90^\circ + 175 \angle 75^\circ)(50 - j100)}{(125 + j90)(35 \angle 50^\circ)}$$

$$A = C \cos \theta$$

$$B = C \sin \theta$$

$$A = 250 \cos 90^\circ = \mathbf{0}$$

$$B = 250 \sin 90^\circ = \mathbf{250}$$

$$A + jB = \mathbf{0 + j250}$$

$$\begin{aligned}
 A &= C \cos \theta \\
 B &= C \sin \theta \\
 A &= 175 \cos 75^\circ = \mathbf{45.3} \\
 B &= 175 \sin 75^\circ = \mathbf{169.03} \\
 A + jB &= \mathbf{45.3 + j169.03}
 \end{aligned}$$

$$\begin{aligned}
 - \quad & 0 + j250 + 45.3 + j169.03 = 45.3 + j214.33 \\
 - \quad & (45.3 + j214.33) * (50 - j100) = 23598 + j6186.5
 \end{aligned}$$

$$\begin{aligned}
 A &= C \cos \theta \\
 B &= C \sin \theta \\
 A &= 35 \cos 50^\circ = \mathbf{22.5} \\
 B &= 35 \sin 50^\circ = \mathbf{26.8} \\
 A + jB &= \mathbf{22.5 + j26.8}
 \end{aligned}$$

$$- \quad (125 + j90) * (22.5 + j26.8) = 5224.5 + j5375$$

$$\begin{aligned}
 &= \frac{23598 + j6186.5}{5224.5 + j5375} = \frac{(23598 + j6186.5) * (5224.5 - j5375)}{(5224.5 - j5375) * (5224.5 + j5375)} \\
 &= \frac{90035313.5 - j94517880.75}{5224.5^2 - 5375^2} \\
 &= \frac{90035313.5 - j94517880.75}{-150.5} = -598241.3 + j628025.8
 \end{aligned}$$

$$\text{(d)} \quad \frac{(1.5)^2(3.8)}{1.1} + j\left(\frac{8}{4} - j\frac{4}{2}\right)$$

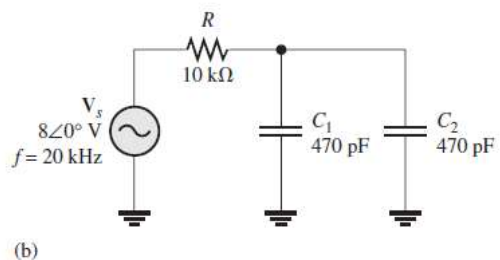
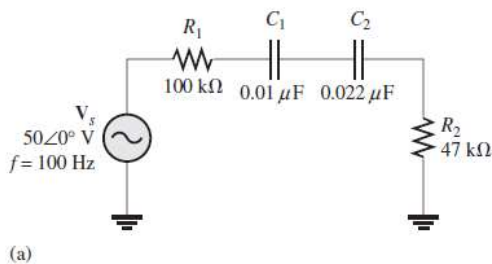
$$7.77 + j2 - 2 = 5.77 + j2$$

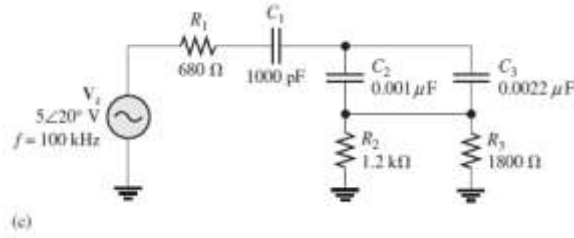
SECCIÓN 15-2 Respuesta sinusoidal de circuitos RC en serie

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

SECCIÓN 15-2 Respuesta sinusoidal de circuitos RC en serie

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





(a) El a

$$x_{C1} = \frac{1}{2\pi f C} = \frac{1}{2\pi * 0.1 * 0.01} = 159.15 k\Omega$$

$$x_{C2} = \frac{1}{2\pi f C} = \frac{1}{2\pi * 0.1 * 0.022} = 72.34 k\Omega$$

$$Z = R_1 - jx_{C1} - jx_{C2} + R_2$$

$$Z = 100 k\Omega - j59.15 k\Omega - j72.34 k\Omega + 47 k\Omega$$

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

$$Z = \sqrt{(147)^2 + (231.49)^2} < \tan\left(\frac{231.49}{147}\right)$$

$$Z = 274.22 < -57.58 k\Omega$$

(b) El b

$$x_{C1} = \frac{1}{2\pi f C} = \frac{1}{2\pi * 20 kHz * 4.7 \times 10^{-7} \mu F} = 16931.37 k\Omega$$

$$x_C = \frac{16931.37}{2} = 8465.68 k\Omega$$

$$Z = R_1 - jx_C$$

$$Z = 10 k\Omega - j8465.68 k\Omega$$

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

$$Z = \sqrt{(10)^2 + (8465.68)^2} < \tan\left(\frac{8465.68}{10}\right)$$

$$Z = 8465.68 < -89.93 k\Omega$$

(c) El c

$$x_{C1} = \frac{1}{2\pi f C} = \frac{1}{2\pi * 100 kHz * 0.001 \mu F} = 1.59 k\Omega$$

$$x_{C2} = \frac{1}{2\pi f C} = \frac{1}{2\pi * 100 kHz * 0.001 \mu F} = 1.59 k\Omega$$

$$x_{C3} = \frac{1}{2\pi f C} = \frac{1}{2\pi * 100 kHz * 0.0022 \mu F} = 0.72 k\Omega$$

$$Z = R_1 - jx_{C1} - jx_{C2} \parallel x_{C3} + R_2 \parallel R_3$$

$$Z = 0.68 k\Omega - j1.59 k\Omega - j \frac{(1.59) * (0.72)}{1.59 + 0.72} k\Omega + \frac{(1.2)(1.8)}{1.2 + 1.8} k\Omega = 1.4 k\Omega - j2.05 k\Omega$$

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

$$Z = \sqrt{(1.4)^2 + (2.05)^2} < \tan\left(\frac{2.05}{1.4}\right)$$

$$Z = 2.48 < -55.56 \text{ k}\Omega$$

12. Repita el problema 23 con $C=0.0047 \mu F$.

$$x_{c1} = \frac{1}{2\pi f C} = \text{Reactancia } v(k\Omega)$$

$$a) \frac{1}{2\pi * 100 * 0.0047} = 338.62 \text{ k}\Omega$$

$$z = 56 - j338.62$$

$$b) \frac{1}{2\pi * 500 * 0.0047} = 67.72 \text{ k}\Omega$$

$$z = 56 - j67.72$$

$$c) \frac{1}{2\pi * 1000 * 0.0047} = 33.862 \text{ k}\Omega$$

$$z = 56 - j338.6267.72$$

$$d) \frac{1}{2\pi * 2500 * 0.0047} = 13.54 \text{ k}\Omega$$

$$z = 56 - j67.72$$

13. Expresé la corriente en forma polar para cada circuito de la figura 15-84.

A)

$$C = \frac{1}{\frac{1}{0.01} + \frac{1}{0.022}} = 0.006875 \mu F$$

$$X_C = \frac{1}{2\pi * 100 \text{ Hz} * 0.006875 \mu F} = 231.49 \text{ K}\Omega$$

$$Z = \sqrt{(100 \text{ K}\Omega)^2 + (231.49)^2} < -\tan^{-1}\left(\frac{231.49 \text{ K}\Omega}{100 \text{ K}\Omega}\right)$$

$$Z = 252.17 < -74.04 \text{ K}\Omega$$

$$I = \frac{V}{Z} = \frac{50 < 0^\circ V}{252.17 < -74.04 \text{ K}\Omega} = 0.20 < 74.04 \text{ mA}$$

B)

$$Z = \sqrt{(1 \text{ K}\Omega)^2 + (0.68)^2} < -\tan^{-1}\left(\frac{1 \text{ K}\Omega}{0.68 \text{ K}\Omega}\right)$$

$$Z = 1.20 < -61.98 \text{ K}\Omega$$

$$I = \frac{V}{Z} = \frac{5 < 0^\circ V}{1.20 < -61.98 \text{ K}\Omega} = 4.17 < 61.98 \text{ mA}$$

14. Expresé la corriente en forma polar para cada circuito de la figura 15-84.

A)

$$C = \frac{1}{\frac{1}{0,01} + \frac{1}{0,022}} = 0,006875\mu f$$

$$R_{fq} = 100K\Omega + 47K\Omega = 147K\Omega$$

$$X_c = \frac{1}{2\pi(100Hz)(0,006875\mu f)} = 231,49K\Omega$$

$$Z = \sqrt{(147K\Omega)^2 + (231,49)^2} < -\tan^{-1}\left(\frac{231,49K\Omega}{147K\Omega}\right)$$

$$Z = 247,22 < -63,98K\Omega$$

$$I = \frac{V}{Z} = \frac{50 < 0^\circ V}{274,22 < -63,98K\Omega} = 0.188 < 63,98mA$$

B)

$$C_{eq} = 0,00047\mu f + 0,00047\mu f$$

$$C_{eq} = 0,00094\mu f$$

$$X_c = \frac{1}{2\pi(20KHz)(0,00094\mu f)} = 8,46K\Omega$$

$$Z = \sqrt{(10K\Omega)^2 + (8,46K\Omega)^2} < -\tan^{-1}\left(\frac{8,46K\Omega}{10K\Omega}\right)$$

$$Z = 13,098 < -44,70^\circ K\Omega$$

$$I = \frac{V}{Z} = \frac{8 < 0^\circ V}{13,098 < -44,70^\circ K\Omega} = 0,61 < 44,70^\circ mA$$

c)

$$C_{eq1} = 0,001\mu f + 0,0022\mu f = 0,0032\mu f$$

$$C_{eq2} = \frac{1}{\frac{1}{0,0032} + \frac{1}{0,001}} = 0,000762\mu f$$

$$R_{eq1} = \frac{1}{\frac{1}{1,2} + \frac{1}{1,6}} = 0,72K\Omega$$

$$R_{eq2} = 0,72 + 0,66 = 1,4K\Omega$$

$$X_c = \frac{1}{2\pi(100KHz)(0,000762\mu f)} = 2,08K\Omega$$

$$Z = \sqrt{(1,4K\Omega)^2 + (2,08K\Omega)^2} < -\tan^{-1}\left(\frac{2,08K\Omega}{1,4K\Omega}\right)$$

$$Z = 2,50 \angle -62,28^\circ$$

$$I = \frac{V}{Z} = \frac{5 \angle 20^\circ}{2,50 \angle -62,28^\circ} = 2 \angle 82,28^\circ \text{ mA}$$

15. 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.

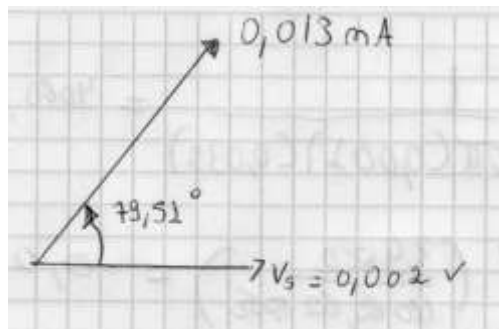
$$R_{eq1} = \frac{1}{0,1 + 0,1} = 0,05 \text{ K}\Omega$$

$$X_c = \frac{1}{2\pi(15 \text{ KHz})(0,068 \mu\text{f})} = 0,15 \text{ K}\Omega$$

$$Z = \sqrt{(0,05 \text{ K}\Omega)^2 + (0,15 \text{ K}\Omega)^2} \angle -\tan^{-1}\left(\frac{0,15 \text{ K}\Omega}{0,05 \text{ K}\Omega}\right)$$

$$Z = 0,15 \angle -79,51^\circ$$

$$I = \frac{V}{Z} = \frac{0,002 \angle 20^\circ}{0,15 \angle -79,51^\circ} = 0,013 \angle 79,51^\circ \text{ mA}$$



16. ¿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?

$$Z = \frac{V}{I} = \frac{10}{10} = 1$$

$$X_c = \frac{1}{2\pi(10)(0,027)} = 0,58 \text{ K}\Omega$$

$$Z = \sqrt{(R \text{ K}\Omega)^2 + (X_c \text{ K}\Omega)^2}$$

$$1 - X_c^2 = R^2$$

$$R^2 = 1 - 0,58^2$$

$$R = 0,81 \text{ K}\Omega$$

$$\theta = -\tan^{-1}\left(\frac{0,58 \text{ K}\Omega}{0,81 \text{ K}\Omega}\right)$$

$$\theta = -39,56 = 39,56$$

17. 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)

$$X_c = \frac{1}{2\pi(0,001)(0,039)} = 4060,62\text{K}\Omega$$

$$\phi = -\tan^{-1}\left(\frac{39\text{K}\Omega}{4060,62}\right) = -0,06^\circ$$

B)

$$X_c = 40,60\text{K}\Omega$$

$$\phi = -6,066^\circ$$

C)

$$X_c = 4,08\text{K}\Omega$$

$$\phi = -48,56^\circ$$

D)

$$X_c = 0,40\text{K}\Omega$$

$$\phi = -93,49$$

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

A)

$$X_c = \frac{1}{2\pi(0,001)(10)} = 15,91\text{K}\Omega$$

$$\phi = -\tan^{-1}\left(\frac{15,91\text{K}\Omega}{0,01\text{K}\Omega}\right) = -99,85^\circ$$

B)

$$X_c = 0,15\text{K}\Omega$$

$$\phi = -95,78^\circ$$

C)

$$X_c = 0,0159\text{K}\Omega$$

$$\phi = -64,26^\circ$$

D)

$$X_c = 0,0015K\Omega$$

$$\phi = -9.47$$

- 19.** Trace el diagrama fasorial de voltaje para el circuito de la figura 15-91 para una frecuencia de 5 kHz con V_s 1 V rms.

$$F=5KHz$$

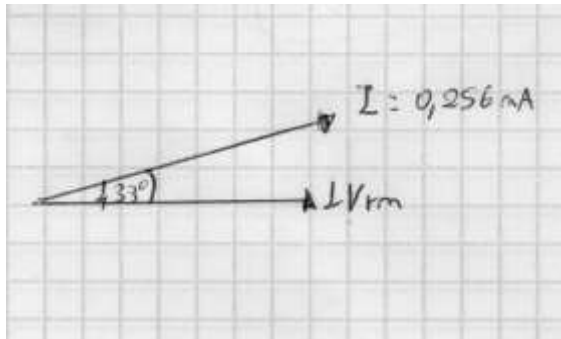
$$V_s=1V_{rms}$$

$$X_c = \frac{1}{2\pi(5KHz)(0,39\mu f)} = 0.0816K\Omega$$

$$Z = \sqrt{(3.9K\Omega)^2 + (0.0816K\Omega)^2} < -\tan^{-1}\left(\frac{0.0816K\Omega}{3.9K\Omega}\right)$$

$$Z = 3.90 < -1.33^\circ$$

$$I = \frac{V}{Z} = \frac{1 < 0^\circ}{3.9 < -1.33^\circ} = 0.256 < 1,33^\circ mA$$



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

$$Z = \frac{(1,2 < 0^\circ)(2K\Omega < 0^\circ)}{\sqrt{(1,2)^2 + (2)^2}} < -\tan^{-1}\left(\frac{1,2}{2}\right)$$

$$Z = \frac{2,4}{2,33} < -\tan^{-1}\left(\frac{3}{5}\right)$$

$$Z = 1,03 < -34,40^\circ$$

- 21.** Repita el problema 41 para las siguientes frecuencias:

$$C_{eq} = 0.32 \mu F$$

$$R_{eq} = 1.48K\Omega$$

A)

$$X_C = \frac{1}{2\pi \cdot 1.5 \cdot 0.032 \mu F} = 0.33 K\Omega$$

$$Z = \frac{0.488}{1.51} < -\tan^{-1} \left(\frac{1.48 K\Omega}{0.33 K\Omega} \right)$$

$$Z = 0.323 < -86.03 K\Omega$$

B)

$$X_C = \frac{1}{2\pi \cdot 3 \cdot 0.032 \mu F} = 0.16 K\Omega$$

$$Z = \frac{0.236}{1.48} < -\tan^{-1} \left(\frac{1.48 K\Omega}{0.16 K\Omega} \right)$$

$$Z = 0.16 < -93.14 K\Omega$$

C)

$$X_C = \frac{1}{2\pi \cdot 5 \cdot 0.032 \mu F} = 0.099 K\Omega$$

$$Z = \frac{0.146}{1.483} < -\tan^{-1} \left(\frac{1.48 K\Omega}{0.99 K\Omega} \right)$$

$$Z = 0.098 < -62.46 K\Omega$$

D)

$$X_C = \frac{1}{2\pi \cdot 10 \cdot 0.032 \mu F} = 0.049 K\Omega$$

$$Z = \frac{0.072}{1.480} < -\tan^{-1} \left(\frac{1.48 K\Omega}{0.049 K\Omega} \right)$$

$$Z = 0.048 < -79.64 K\Omega$$

22. 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?

$$I_{R1} = \frac{V_S}{R_1} = \frac{8V}{0.22 \mu F} = 36.36 mA$$

$$I_{R2} = \frac{V_S}{R_2} = \frac{8V}{0.18 \mu F} = 44.44 mA$$

$$I_{C1, C2} = I_{tot} ; R_{eq} = 0.4 K\Omega ; C_{eq} = 0.00103 \mu F$$

$$G = \frac{I}{R} = \frac{1}{0.4} = 2.5$$

$$X_C = \frac{1}{2\pi \cdot 50 \cdot 0.00103 \mu F} = 3.09 K\Omega$$

$$Bc = \frac{1}{Xc} = \frac{1}{3.09}$$

$$Y = \sqrt{2.5^2 + \frac{1}{3.09^2}} < \tan^{-1}\left(\frac{1}{7.72}\right)$$

$$Y = 2.52 < 8.20us$$

$$I = V * Y = (8 < 0)(2.52 < 8.20)$$

$$I_{tot} = 20.16 < 8.20mA$$

23. Repita el problema 45 con R 5.6 k Ω , C1 0.047 mF, C2 0.022 mF, y f 500 Hz.

$$C_{eq} = C1 \parallel C2 = 0,069\mu f$$

$$X_c = \frac{1}{2\pi(0,5)(0,069)} = 4,61K\Omega$$

$$Z = \frac{25,81}{7,25} = 3,55K\Omega < -\tan^{-1}\left(\frac{5,6}{4,61}\right)$$

$$I_r = \frac{V_s}{R} = \frac{100}{5,6} = 17,85mA$$

$$I_c = \frac{V_s}{X_c} = \frac{100}{4,61} = 21,69mA$$

$$Z = \frac{1}{y} \quad Y = \frac{1}{z} \quad Y = \frac{1}{3,55 < -56,15^\circ}$$

$$I_{tot} = V_o y = (100 < 0^\circ) \left(\frac{1}{3,55 < -56,15} \right) = 28,16 < 56,15^\circ mA$$

24. 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.

Para ángulos

$$I = V * Y$$

$$30 = 0 + \theta y$$

$$1. \theta y = 30$$

$$2. \theta y = \tan^{-1} \frac{Bc}{G}$$

$$1 \text{ y } 2$$

$$3. \tan^{-1} \frac{Bc}{G} = 30$$

$$\frac{Bc}{G} = x; \quad \tan^{-1}(x) = 30$$

$$x = \tan(30) = 0.5$$

25. Encuentre la corriente a través de cada rama y la corriente total en la figura 15-100. Exprese las corrientes en forma polar. Trace el diagrama fasorial de corriente.

$$G = \frac{1}{R_{eq}} = \frac{1}{\frac{1}{R_1} + \frac{1}{47}} = \frac{47 + R_1}{47R_1}$$

$$X_c = \frac{1}{2\pi(1)(0,01)} = 15,91K\Omega; \quad B_c = \frac{1}{15.91}$$

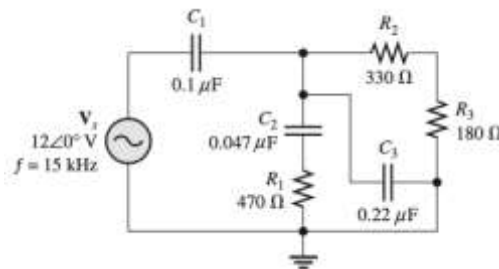
$$\frac{B_c}{G} = \frac{47R_1}{747.77 + 15.91R_1} = 0.50$$

$$4700R_1 = 37388.5 + 795.5R_1$$

$$3904.5R_1 = 37388.5$$

$$R_1 = 9.57K\Omega$$

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



$$R_1 = 330\Omega + 180\Omega = 510\Omega$$

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

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

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

$$Z_1 = \frac{1}{\frac{1}{510} - \frac{j}{48.228}} = 4.5202 - j47.80$$

$$Z_2 = 470 - j225.751$$

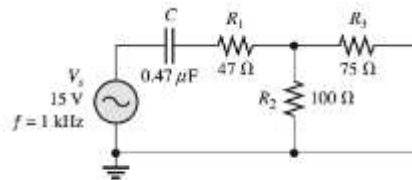
$$Z_3 = \frac{1}{\frac{1}{4.5202 - j47.80} + \frac{1}{470 - j225.751}} = 7.7078 - 45.051j$$

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

- Por lo tanto decimos que es un circuito RC

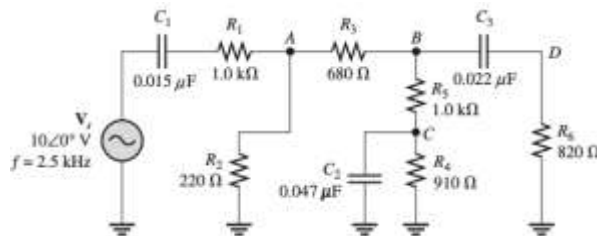
52. Para el circuito de la figura 15-101, determine lo siguiente:

- (a) I_{tot} (b) θ (c) V_{R1} (d) V_{R2} (e) V_{R3} (f) V_C



▲ FIGURA 15-101

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



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

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

$$z_1 = 47 - j338.627 = 341.8731 \angle -82.098^\circ$$

$$Z_{eq} = 42.841\Omega + 47 - j338.627 = 89.8471 - j338.27j = 350.3421 \angle -75.1411^\circ$$

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

$$V_{z1} = I \cdot Z_2 = 0.042815 \angle 75.1411^\circ \cdot 341.8731 \angle -82.098^\circ = 14.63 \angle -6.95^\circ (v)$$

$$V_{ra} = I \cdot R_a = 0.042815 \angle 75.1411^\circ \cdot 42.8471\Omega = 1.8344 \angle 75.1411^\circ (v)$$

$$V_{c1} = I \cdot C_1 = 0.042815 \angle 75.1411^\circ \cdot 338.627 \angle -90^\circ = 14.498 \angle -14.85^\circ (v)$$

$$V_{r1} = I \cdot C_1 = 0.042815 \angle 75.1411^\circ \cdot 47 = 2.01 \angle 75.14^\circ (v)$$

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

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

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

$$z4 = 1.0 - 4.244j$$

$$z2 = \frac{1}{\frac{1}{0.91} + \frac{1}{-j1.3545}} = 0.626 - 0.4212j$$

$$z1 = 0.82 - 2.893j$$

$$z3 = z2 + 1.0k\Omega = 0.626 - 0.4212j + 1.0 = 1.626 - 0.4212j$$

$$z5 = \frac{1}{\frac{1}{1.626 - 0.4212j} + \frac{1}{0.82 - 2.893j}} = 1.0028 - 0.7055j$$

$$z6 = z5 + 0.68k\Omega = 1.6828 - 0.7055j$$

$$z7 = \frac{1}{\frac{1}{1.6828 - 0.7055j} + \frac{1}{0.22k\Omega}} = 0.1976 - 8.2911j \cdot 10^{-3}$$

$$z_{eq} = z7 + z4 = 0.1976 - 8.2911j \cdot 10^{-3} + 1.0 - 4.244j = 1.1976 - 4.2522j = 8.775 \angle -75.497$$

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

$$V_{z7} = V_A = I_A \cdot Z7 = 1.1394 \angle 75.4978 \cdot 0.1977 \angle -2.4026 = 0.2253 \angle 73.095 \text{ (V)}$$

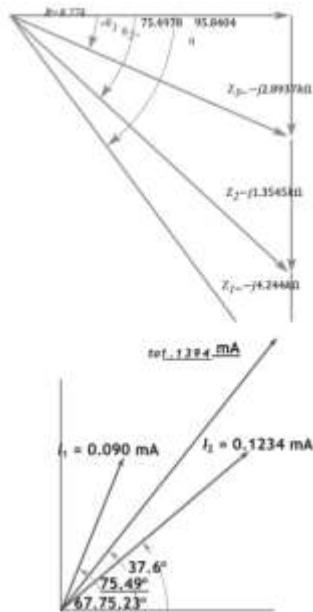
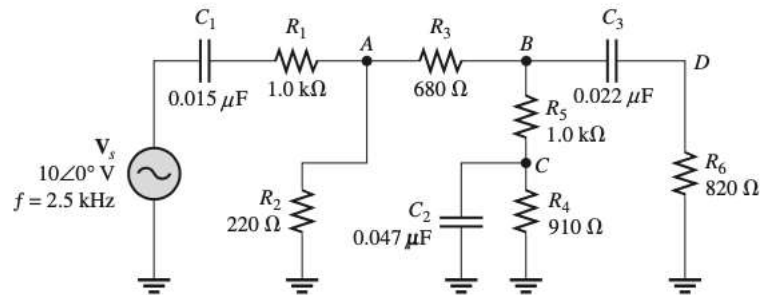
$$I_{z6} = \frac{V_{z7}}{z6} = \frac{0.2253 \angle 73.095}{1.8247 \angle -22.745} = 0.1234 \angle 95.8404 \text{ (mA)}$$

$$V_{z5} = V_B = V_D = I_{z6} \cdot Z5 = 0.1234 \angle 95.8404 \cdot 1.2261 \angle -35.127 = 0.1513 \angle 60.71 \text{ (V)}$$

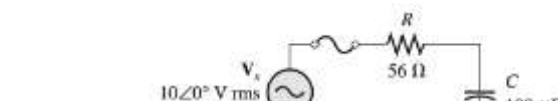
$$I_{z3} = \frac{V_{z5}}{z3} = \frac{0.1513 \angle 60.71}{1.6796 \angle -14.522} = 0.090 \angle 75.2327 \text{ (mA)}$$

$$V_{z2} = V_C = I_{z3} \cdot Z2 = 0.090 \angle 75.2327 \cdot 0.7545 \angle -33.934 = 0.0679 \angle 41.2983 \text{ (V)}$$

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



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



$$x_{C1} = \frac{-j}{2\pi(20\text{Hz})(100) \cdot 10^{-6}} = -j79.577\Omega$$

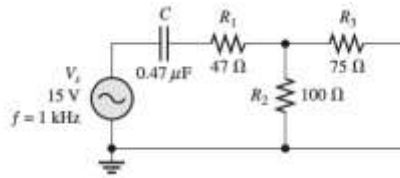
$$z_1 = 56 - 79.577j = 137.392 \angle -35.394^\circ$$

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

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

$$Q_C = I_T^2 \cdot x_C = (0.0727 \angle 35.394^\circ)^2 \cdot 79.577 \angle -90^\circ = 0.4205 \angle -19.212^\circ \text{ var}$$

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



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

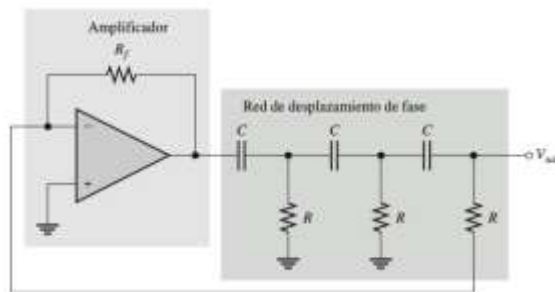
$$P_r = I_T^2 * R = (0.042815 \angle 75.1411)^2 * 89.8471 = 0.1647 \angle 150.28 (W)$$

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

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

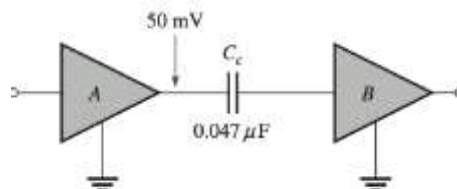
$$F_p = \cos(75.1411) = 0.2564$$

62. Calcule la frecuencia de oscilación para el circuito de la figura 15-62 si todos los capacitores son de $0.0022 \mu F$ y todos los resistores de $10 k\Omega$.



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

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 $10 k\Omega$, ¿qué tanto de la señal se pierde debido al capacitor de acoplamiento cuando la frecuencia es de 3 kHz?



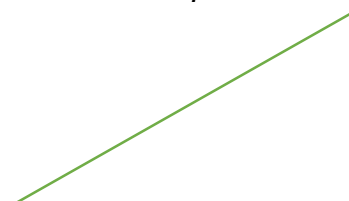
$$x_c = 1128.75 \Omega$$

$$I = \frac{v}{z_r} \quad I = \frac{50mV}{1063\Omega}$$

$$P = VI \quad P = 0.241 \mu W$$

$$z_r = \sqrt{10k^2 + 1128^2}$$

$$z_r = 10063 \Omega$$



$$\theta = \tan^{-1} \left(\frac{1128.75}{10000} \right) \quad \theta = 6.44^\circ$$

$$I = \frac{v}{z_T} = 5 \mu A$$

$$P = VI = 2,5 * 10^{-8} W$$

$$0.241 \mu W$$

$$6.44^\circ$$

$$0.24 \mu W$$

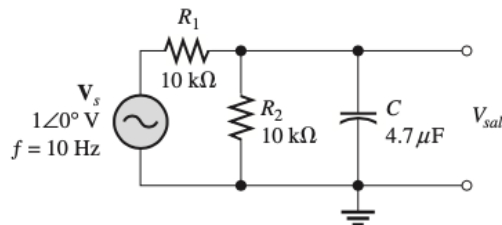
$$0.24 \mu W$$

$$\cos \theta = \frac{0.24}{P}$$

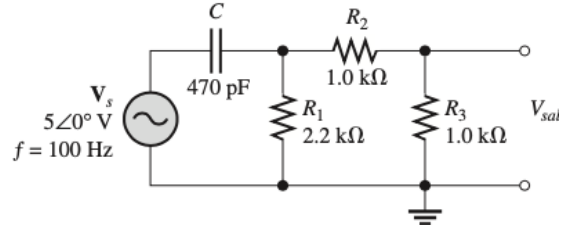
$$F_c = \frac{0.24}{0.241} = 0.99$$

Se pierde la señal del 0.1%

*66. Los capacitores de la figura 15-107 han desarrollado un resistencia de fuga de 2 kΩ. Determine los voltajes de salida en esta condición para cada circuito.



(a)



(b)

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

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

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

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

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

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

$$R_a = 2.0 k\Omega + 2.0 k\Omega = 4.0 k\Omega$$

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

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

$$I_T = \frac{V}{Z_1} = \frac{5 \angle 0}{33.88 \angle -87.750} = 0.1475 \angle 87.750 \text{ (ma)}$$

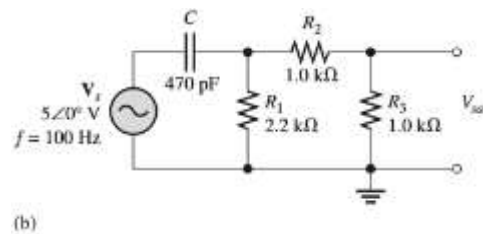
$$V_{rb} = I_T * r_b = 0.1475 \angle 87.750 \text{ (ma)} * 1.33 \text{ k}\Omega = 0.1962 \angle 87.750 \text{ (v)}$$

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

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

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) R_1 abierto (d) R_2 abierto (e) R_3 abierto



a) Nos da OV en la salida ya que no se energiza la fase.

b)

$$R_a = 1 + 1 = 2 \text{ k}\Omega$$

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

$$I_T = \frac{V_T}{R_T} = \frac{5}{1.0476} = 4.7728 \text{ (ma)}$$

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

c)

$$X_{C1} = \frac{-j}{2\pi(100\text{Hz})(470) * 10^{-10}} = -j33.8627 \text{ k}\Omega$$

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

$$I_T = \frac{V_T}{R_T} = \frac{5 \angle 0}{33.9217 \angle -86.6199} = 0.1473 \angle 86.61 \text{ (ma)}$$

d)

$$V_{salida} = I * 1 = 0.1473 \angle 86.61 * 1 = 0.1473 \text{ (v)}$$

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

e)

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

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

$$I_t = \frac{V_t}{z_t} = \frac{5 < 0}{3.2 - 33.8627j} = 0.1470 < 84.601(\text{ma})$$

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