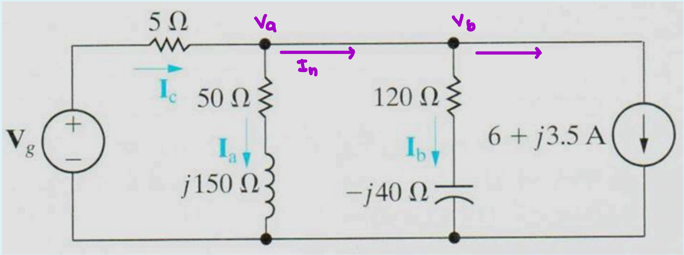
1



P9.40_7ed

Given the phasor current $\mathbf{I}_a = 2$ at angle 0° A (magnitude 2 with angle 0 degrees Amps).

Find the following phasor values:

$\mathbf{I}_b$ = Magnitude 2.5 ✔ with Angle 90 ✔ ° (Degrees) Amps

$\mathbf{I}_c$ = Magnitude 10 ✔ with Angle 36.87 ✔ ° (Degrees) Amps

$\mathbf{V}_g$ = Magnitude 358.47 ✔ with Angle 67.01 ✔ ° (Degrees) Volts

$I_a = 2\angle 0^\circ\text{ A} \approx 2 + j0$

$V_a = I_a(50 + j150)$ $\quad V_b = V_a = 100 + j300$

$= 2(50 + j150)$

$= 100 + j300$

(a) $V_b = I_b(120 - j40)$

$I_b = \dfrac{100 + j300}{120 - j40} \cdot \dfrac{120 + j40}{120 + j40} = \dfrac{12K + j40K - 12K}{14.4K + 1.6K}$

$= \dfrac{j40K}{16K} = j2.5 \approx \boxed{2.5\angle 90^\circ\text{ A}}$

(b) $I_n = I_b + (6 + j3.5)$

$I_c = I_a + I_n = I_a + I_b + (6 + j3.5)$

$= (2) + (j2.5) + (6 + j3.5)$

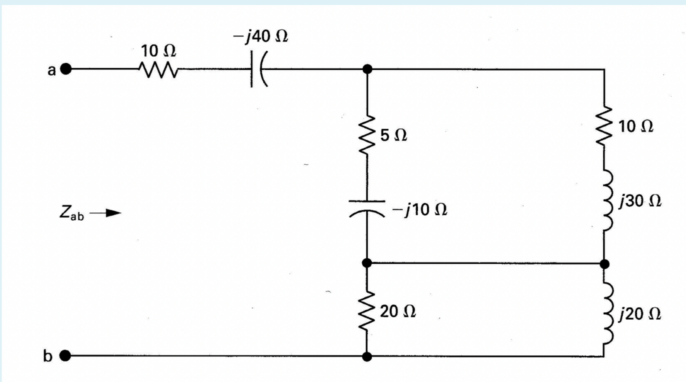
$I_c = 8 + j6 \approx \boxed{10\angle 36.87^\circ}$

(c) $I_c = \dfrac{V_g - V_a}{5} \longrightarrow V_g = 5I_c + V_a$

$V_g = 5(8 + j6) + (100 + j300)$

$= 140 + j330 \approx \boxed{358.47\angle 67.01^\circ}$

2

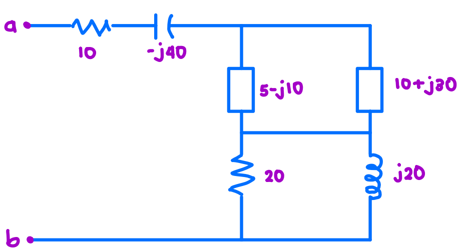


P9.23_6ed

Find the impedance Zab in this circuit.

Zab = 30 ✔ +j -40 ✔ Ω (Ohms) in rectangular form

Zab = Mag 50 ✔ and Angle -53.13 ✔ ° (Degrees) Ω (Ohms) in polar form



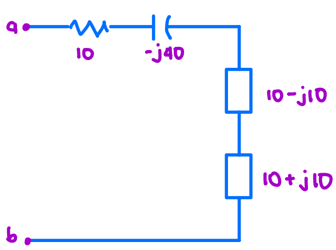
$5 - j10 \parallel 10 + j30 = \dfrac{(5 - j10)(10 + j30)}{(5 - j10) + (10 + j30)} = \dfrac{50 + j150 + 300}{15 + j20}$

$= \dfrac{350 + j50}{15 + j20} \cdot \dfrac{15 - j20}{15 - j20} = \dfrac{5250 - j6250 + 1000}{225 + 400}$

$= \dfrac{6250 - j6250}{625} = 10 - j10$

$20 \parallel j20 = \dfrac{(20)(j20)}{20 + j20} = \dfrac{j400}{20 + j20} \cdot \dfrac{20 - j20}{20 - j20} = \dfrac{j8000 + 8000}{400 + 400}$

$= 10 + j10$

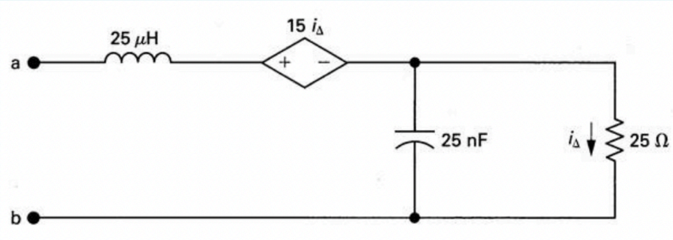


$Z_{ab} = 10 - j40 + (10 - j10) + (10 + j10)$

$= \boxed{30 - j40}$

polar form: $Z_{ab} = \boxed{50\angle -53.13^\circ}$

3

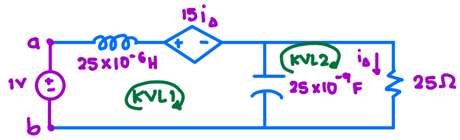


P9.18_6ed

Given: ω (omega) = 1.6 x 10^6 rad/sec

Find the circuits impedance at the terminals ab.

Z_{ab} = Magnitude 28.28 with Angle 45 ° (Degrees) Ω (Ohm)



$\omega = 1.6\times10^6$ rad/s

$Z_L = j\omega L = j(1.6\times10^6)(25\times10^{-6})$

$= j40$

$Z_C = -\dfrac{j}{\omega C} = \dfrac{-j}{(1.6\times10^6)(25\times10^{-9})} = -j25$

$V = ZI$

KVL1: $-1 + j40 I_1 + 15 I_\Delta - j25(I_1 - I_2) = 0$ $\quad I_\Delta = I_2$	KVL2: $-(-j25)(I_1 - I_2) + 25 I_2 = 0$
$-1 + j40 I_1 + 15 I_2 - j25 I_1 + j25 I_2 = 0$	$j25 I_1 - j25 I_2 + 25 I_2 = 0$
$[\, j15 I_1 + (15 + j25) I_2 = 1 \,]\ 1/5$	$25[\, jI_1 + (1-j) I_2 \,] = 0$
$j3 I_1 + (3 + j5) I_2 = 1/5$	$jI_1 + (1-j) I_2 = 0$

$[\, jI_1 + (1-j) I_2 = 0 \,]\ 3$

$(-)\ \ j3 I_1 + (3+j5) I_2 = 1/5$

$-8j I_2 = -1/5$

$I_2 = \dfrac{1}{j40}$

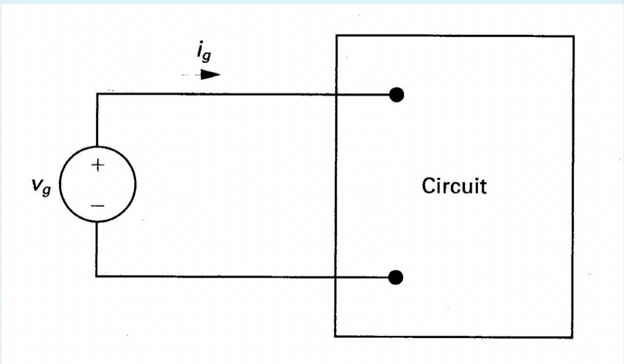
$I_1 = \dfrac{-(1-j)(1/j40)}{j} = \dfrac{1-j}{40} = 0.025 - j0.025$

$Z_{ab} = \dfrac{V}{I_1} = \dfrac{1}{0.025 - j0.025} = \dfrac{0.025 + j0.025}{\frac{1}{1600} + \frac{1}{1600}} = 20 + j20$

$Z_{ab} = 20\sqrt{2} \angle 45°$

$\approx 28.28 \angle 45°$

4



P9.29_6ed

Given:

v_g = 150 cos(8,000 π t + 20°) V

i_g = 30 sin(8,000 π t + 38°) A

a) What is the impedance seen by the source?

$Z_{circuit}$ = Mag 5 with Angle 72 ° (Degrees) Ω (Ohm)

b) By how many microseconds is the current out of phase with the voltage?

t_{phase} = 50 µs (micro sec)

(a) $V_g = 150\cos(8000\pi t + 20°)\,V$ $\qquad V = 150\angle 20°$

$i_g = 30\sin(8000\pi t + 38°)\,A$ $\qquad I = 30\angle -52°$

$= 30\cos[90 - (8000\pi t + 38°)]$

$= 30\cos(-8000\pi t + 52°)$ $\qquad V = ZI$

$= 30\cos(8000\pi t - 52°)$ $\qquad Z = \dfrac{V}{I} = \dfrac{150\angle 20°}{30\angle -52°} = 5\angle 72°$

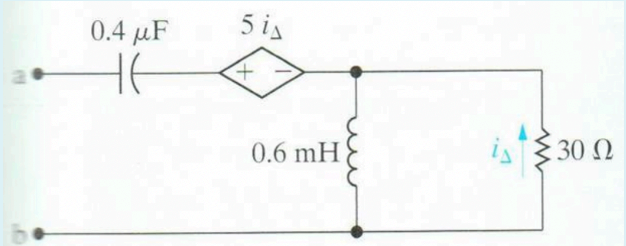
(b) $\omega = 8000\pi$ $\qquad T = \dfrac{2\pi}{\omega} = \dfrac{2\pi}{8000\pi} = 2.5\times10^{-4}$ s

2.5×10^{-4} s $\longrightarrow 360°$ $\qquad \dfrac{t}{72°} = \dfrac{2.5\times10^{-4}}{360°}$

$t \longrightarrow 72°$

$t = 5\times10^{-5}$ s ≈ 50 µs

5

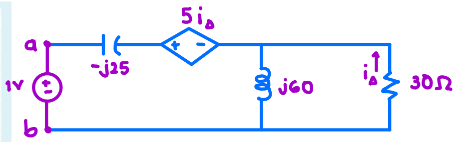


P9.29_7ed

Find the Thévenin impedance seen looking into the terminals ab of this circuit.

The frequency of operation is 100 krad/sec (kilo rad/sec).

Z_{Th} = 20 + j -15 Ω (Ohm)



$\omega = 100$ krad/s

$Z_C = -\frac{j}{\omega C} = \frac{-j}{(100k)(0.4\times10^{-6})} = -j25$

$Z_L = j\omega L = j(100k)(0.6\times10^{-3})$

$= j60$

CURRENT DIVISION RULE:

$I_2 = \frac{R_1}{R_1+R_2} I \qquad I_\Delta = -I_2$

$I_\Delta = -\frac{j60}{j60+30} I = \frac{-j1800-3600}{4500} I = -(0.8+j0.4)I$

$V = ZI$

KVL: $-1 - j25I + 5I_\Delta + (j60 \parallel 30)I = 0$

$-1 - j25I - 5(0.8+j0.4)I + (24+j12)I = 0$

$(20-j15)I = 1$

$I = \frac{1}{20-j15} = \frac{20+j15}{625} = \frac{4+j3}{125}$

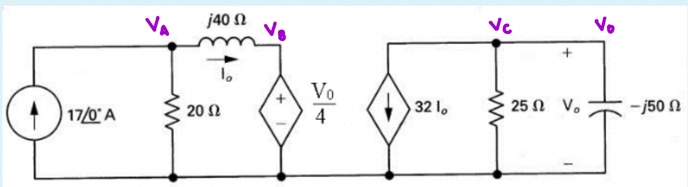
$Z_{TH} = \frac{V}{I} = \frac{1}{\frac{4+j3}{125}} = \frac{125}{4+j3}\cdot\frac{4-j3}{4-j3} = \frac{500-j375}{25} = \boxed{20-j15}$

$j60 \parallel 30 = \frac{(j60)(30)}{j60+30}$

$= \frac{j1800}{30+j60}\cdot\frac{30-j60}{30-j60}$

$= \frac{j54k+108k}{4.5k} = 24+j12$

6



P9.56_6ed

Use the node-voltage method to find the follow phasor values.

V_0 = 1280 + j 320 Volts

I_0 = -1.4 + j -1.2 Amps

NODE V_A: $\left[\frac{V_A}{20} + \frac{V_A-V_B}{j40} = 17\right] j40$

$j2V_A + V_A - V_B = j680$

$(1+j2)V_A - V_B = j680$

$\left[(1+j2)V_A - \frac{V_o}{4} = j680\right] 4$

$(4+j8)V_A - V_o = j2720$

NODE V_C: $\left[32I_o + \frac{V_C}{25} - \frac{V_C}{j50} = 0\right] j50$

$j1600 I_o + j2V_C - V_C = 0$

$j1600 I_o + (-1+j2)V_o = 0$

$j1600\left[\frac{V_A-V_B}{j40}\right] + (-1+j2)V_o = 0$

$40V_A - 40V_B + (-1+j2)V_o = 0$

$40V_A - 40\left(\frac{V_o}{4}\right) + (-1+j2)V_o = 0$

$40V_A - 10V_o + (-1+j2)V_o = 0$

$V_A = \frac{11-j2}{40} V_o$

$(4+j8)\left[\frac{11-j2}{40} V_o\right] - V_o = j2720$

$\frac{1}{10}(1+j2)(11-j2)V_o - V_o = j2720$

$\frac{1}{10}(11+j20+4)V_o - V_o = j2720$

$\frac{1}{10}(15+j20)V_o - V_o = j2720$

$(1.5+j2)V_o - V_o = j2720$

$(0.5+j2)V_o = j2720$

$V_o = \frac{j2720}{0.5+j2}\cdot\frac{0.5-j2}{0.5-j2} = \frac{5440+j1360}{4.25}$

$\boxed{V_o = 1280+j320 \text{ V}}$

$= \left(\frac{11}{40} - j0.05\right)(1280+j320)$

$= 352 + j24 + 16 = 368+j24$

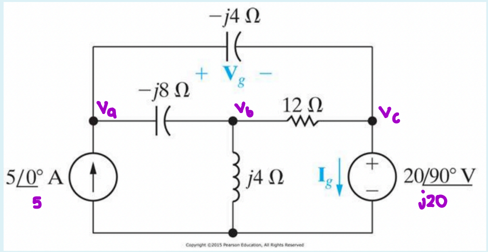
$I_o = \frac{V_A-V_B}{j40} = \frac{\frac{11-j2}{40}V_o - V_o/4}{j40} = \frac{(11-j2)V_o - 10V_o}{j40\cdot40} = \frac{1-j2}{j40\cdot40} V_o$

$I_o = \left(\frac{1}{j40\cdot40} - \frac{1}{20\cdot40}\right) V_o$

$= (-1.25\times10^{-3} - j6.25\times10^{-4})(1280+j320)$

$= -1.6 - j1.2 + 0.2 = \boxed{-1.4-j1.2}$

7



P9.55_10ed

Use the node-voltage method to find $\mathbf{V}_g$.

$\mathbf{V}_g$ = -2.665 ✔ +j -18.668 ✔ Volts

NODE V_a: $\left[\frac{V_a - V_c}{-j4} + \frac{V_a - V_b}{-j8} = 5 \right] -j8$

$2V_a - 2V_c + V_a - V_b = -j40$

$3V_a - 2(j20) - V_b = -j40$

$3V_a - V_b = 0$

$V_b = 3V_a$

NODE V_b: $\left[\frac{V_b - V_a}{-j8} + \frac{V_b}{j4} + \frac{V_b - V_c}{12} = 0 \right] j24$

$-3V_b + 3V_a + 6V_b + j2V_b - j2V_c = 0$

$3V_a + (3 + j2)V_b = j2(j20)$

$3V_a + (3+j2)V_b = -40$

$3V_a + (3+j2)(3V_a) = -40$

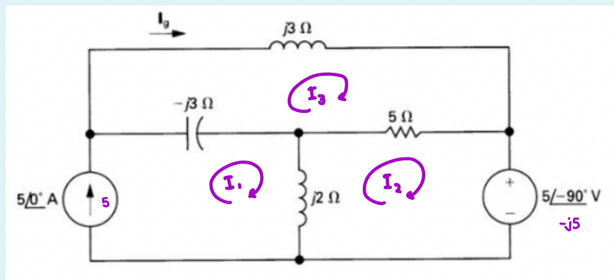
$[(12 + j6)V_a = -40]\ 1/2$

$V_a = \frac{-20}{6+j3} \cdot \frac{6-j3}{6-j3} = \frac{-120 + j60}{45} = -\frac{8}{3} + j\frac{4}{3}$

$V_g = V_a - V_c = -\frac{8}{3} + j4/3 - j20$

$= -\frac{8}{3} - j\frac{56}{3} \approx \boxed{-2.67 - j18.67}$

8



P9.45_6ed

Use the mesh-current method to find $\mathbf{I}_g$.

$\mathbf{I}_g$ = 0 ✔ +j -3 ✔ A

$I_1 = 5$ A

I_2: $-j2(I_2 - I_1) - 5(I_2 - I_3) + j5 = 0$

$-j2I_2 + j2(5) - 5I_2 + 5I_3 + j5 = 0$

$(-5 - j2)I_2 + 5I_3 = -j15$

I_3: $-j3I_3 - 5(I_3 - I_2) + j3(I_3 - I_1) = 0$

$\cancel{-j3I_3} - 5I_3 + 5I_2 + \cancel{j3I_3} - j3(5) = 0$

$5I_2 - 5I_3 = j15$

$5I_2 - 5I_3 = j15$

$(+)\ (-5 - j2)I_2 + 5I_3 = -j15$

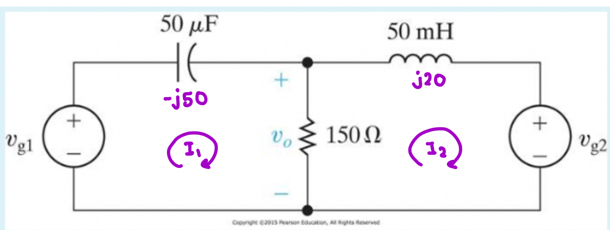
$-j2I_2 + 0 = 0$

$I_2 = 0$

$I_3 = (-j15 + 5I_2)\ 1/5 = -j3 + 0 = -j3$

$I_g = I_3 = \boxed{-j3 \text{ A}}$

9



P9.61_10ed

Given: v_{g1} = 25 sin (400 t + 143.12°) V and v_{g2} = 18.03 cos (400 t + 33.69°) V

Use the mesh-current method to find the steady-state voltage of $v_o(t)$.

$v_o(t)$ = 15 ✔ cos (400 t + 0.005 ✔ °) (Degrees) V

$V_{g1} = 25 \sin(400t + 143.12^\circ)$ V

$= 25 \cos(400t + 53.12^\circ)$ V

$= 25 \angle 53.12^\circ \approx 15 + j20$

$V_{g2} = 18.03 \cos(400t + 33.69^\circ)$ V

$= 18.03 \angle 33.69^\circ \approx 15 + j10$

$Z_L = j\omega L = j(400)(50 \times 10^{-3})$

$= j20$

$Z_C = \frac{-j}{\omega C} = \frac{-j}{(400)(50 \times 10^{-6})} = -j50$

I_1: $-V_{g1} - j50I_1 + 150(I_1 - I_2) = 0$

$-(15 + j20) - j50I_1 + 150I_1 - 150I_2 = 0$

$(150 - j50)I_1 - 150I_2 = 15 + j20$

I_2: $150(I_2 - I_1) + j20I_2 + V_{g2} = 0$

$150I_2 - 150I_1 + j20I_2 = -(15 + j10)$

$-150I_1 + (150 + j20)I_2 = -15 - j10$

$\left.\begin{matrix} (150 - j50)I_1 - 150I_2 = 15 + j20 \\ -150I_1 + (150 + j20)I_2 = -15 - j10 \end{matrix}\right]$ $\begin{matrix} I_1 = -0.4 \\ I_2 = -0.5 \end{matrix}$

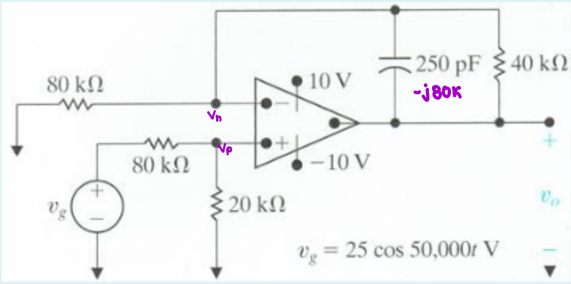
$V_o = 150(I_1 - I_2)$

$= 150(-0.4 + 0.5)$

$= 15 + j0$

$\approx \boxed{15 \angle 0^\circ}$

10.



P9.81_7ed

The operational amplifier is ideal.

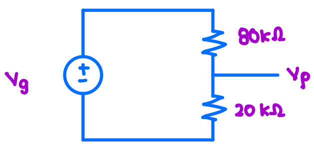
Given $v_g(t) = 25 \cos(50{,}000\ t)$ V

a) Find the steady-state output $v_0(t)$.

$v_0(t) =$ 7.07 ✔ cos(50,000 t + -8.13 ✔ °) (Degrees) Volts

b) How large can the amplitude of $v_g(t)$ be before the amplifier saturates?

$|v_0(t)_{max}| \le$ 35.35 ✔ Volts



VOLTAGE DIVISION:

$$V_p = \frac{V_g(20k)}{20k + 80k}$$

$$= 0.2V_g = 5V = V_n$$

$$Z_C = \frac{-j}{\omega C} = \frac{-j}{(50k)(250\times10^{-12})} = -j80k$$

$$-j80k \,/\!/\, 40k\Omega = \frac{(-j80k)(40k)}{-j80k + 40k} = \frac{-j3200k^2}{40k(1-j2)} = \frac{-j80k}{1-j2} \cdot \frac{1+j2}{1+j2}$$

$$= \frac{-j80k + 160k}{5} = 32k - j16k$$

(a) NODE V_n: $\frac{V_n}{80k} + \frac{V_n - V_o}{32k - j16k} = 0$

$$\frac{5}{80k} + \frac{5 - V_o}{32k - j16k} = 0$$

$$5 - V_o = -\frac{5}{80k}(32k - j16k)$$

$$V_o = \frac{\cancel{16k}(2-j1)}{\cancel{16k}} + 5 = 2 - j1 + 5$$

$$= 7 - j1$$

$$V_o = \boxed{7\angle -8.13^\circ}$$

(b) $|V_o(t)| \le 10$ V

$$|(0.28 - j0.04)V_g| \le 10$$

$$\left|\sqrt{2}/5\ V_g\right| \le 10$$

$$\boxed{V_g \le 25\sqrt{2} \approx 35.35}$$

$$\frac{V_n}{80k} + \frac{V_n - V_o}{32k - j16k} = 0$$

$$\frac{0.2V_g}{80k} + \frac{0.2V_g - V_o}{32k - j16k} = 0$$

$$\left(\frac{1}{80k} + \frac{1}{32k - j16k}\right) 0.2V_g = \frac{V_o}{32k - j16k}$$

$$\frac{0.2}{\cancel{16k}}\left[\frac{1}{5} + \frac{1}{2-j1}\right]V_g = \frac{V_o}{\cancel{16k}(2-j1)}$$

$$0.2\left[\frac{5 + 2 - j1}{5(2-j1)}\right]V_g = \frac{V_o}{2-j1}$$

$$\frac{(0.2)(7-j1)\cancel{(2-j1)}}{5\cancel{(2-j1)}}V_g = V_o$$

$$0.04(7 - j1)V_g = V_o$$

$$0.28 - j0.04\ V_g = V_o$$