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CSE231

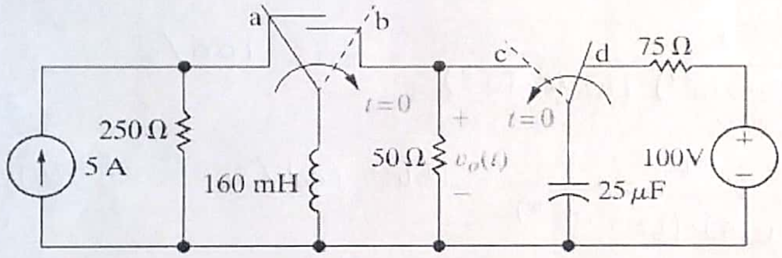
- Homework 3 -

31.12.2020

8.11

8.11 PSPICE MULTISIM The two switches in the circuit seen in Fig. P8.11 operate synchronously. When switch 1 is in position a, switch 2 is in position d. When switch 1 moves to position b, switch 2 moves to position c. Switch 1 has been in position a for a long time. At $t = 0$, the switches move to their alternate positions. Find $v_o(t)$ for $t \geq 0$.

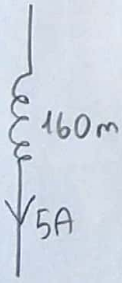
Figure P8.11

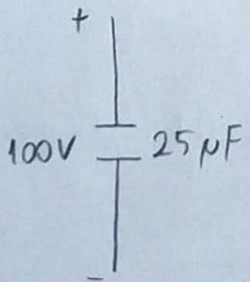


$t<0$

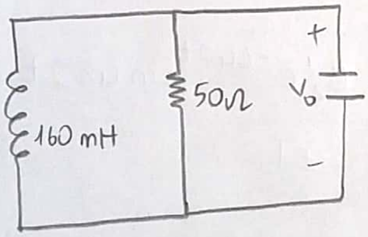
$V_o = 100V$

$I_o = 5A$





$t>0$



$$\alpha = \frac{1}{2RC} = \frac{1}{2\cdot 50\cdot(25\cdot 10^{-6})} = 400 \text{ rad/s}$$

$$w_0 = \sqrt{\frac{1}{LC}} = \sqrt{\frac{1}{(160\cdot 10^{-3})\cdot(25\cdot 10^{-6})}} = 500$$

$\boxed{\alpha^2 < w_0^2}$ → underdamped response

$$w_d = \sqrt{500^2 - 400^2} = 300$$

$$\boxed{V_o = B_1 e^{-400t} \cos 300t + B_2 e^{-400t} \sin 300t}$$

$V_o(0) = B1 = 100$

$$\frac{dV_o(0)}{dt} = -\alpha B_1 + W_d B_2 = \frac{1}{C}\left(-I_o - \frac{V_o}{R}\right)$$

$$\Rightarrow -400\cdot 100 + 300 B_2 = \frac{1}{25\cdot 10^{6}}\cdot\left(-5 - \frac{100}{50}\right)$$

$B_2 = -800$

Result

$t \geq 0$

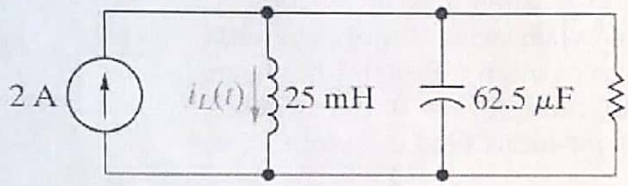
$$\boxed{V_o = 100e^{-400t}\cdot\cos 300t - 800e^{-400t}\cdot\sin 30t}$$

Volt

8.27

8.27 PSPICE MULTISIM Assume that at the instant the 2A dc current source is applied to the circuit in Fig. P8.27, the initial current in the 25 mH inductor is 1 A, and the initial voltage on the capacitor is 50 V (positive at the upper terminal). Find the expression for $i_L(t)$ for $t \geq 0$ if R equals 12.5 Ω.

Figure P8.27



$$w_o = \sqrt{\frac{1}{LC}} = \sqrt{\frac{1}{(25\cdot10^{-3})\cdot(62{,}5\cdot10^{-6})}} = 800 \text{ rad/s}$$

$$\alpha = \frac{1}{2RC} = \frac{1}{2\cdot(12{,}5)\cdot(62.5\cdot10^{-6})} = 640 \text{ rad/s}$$

$\alpha^2 < w_o^2$ under damped response

$$w_d = \sqrt{800^2 - 640^2} = 480 \qquad I_f = 2A$$

$$\boxed{i_L = 2 + B_1' e^{-640t}\cdot\cos 480t + B_2' e^{-640t}\cdot\sin 480t}$$

$i_L(0) = 2 + B_1' = 1 \longrightarrow B_1' = -1$

$$\frac{di_L}{dt}(0) = -\alpha B_1' + w_d B_2' = \frac{V_o}{L}$$

$$-640(-1) + 480 B_2' = \frac{50}{25\cdot10^{-3}} \longrightarrow B_2' = 2.83$$

$t \geq 0$

$$\boxed{i_L(t) = 2 - e^{-640t}\cdot\cos 480t + 2.83\cdot e^{-640t}\cdot\sin 480t} \text{ Amper}$$

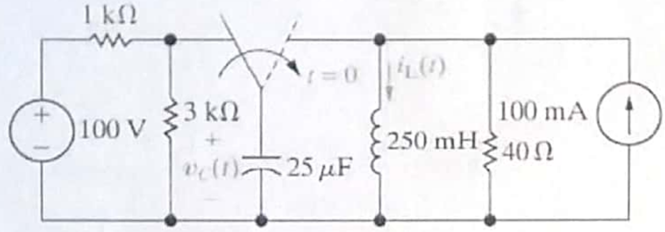
$\boxed{8.35}$

8.35 The switch in the circuit in Fig. P8.35 has been in the left position for a long time before moving to the right position at $t = 0$. Find

a) $i_L(t)$ for $t \geq 0$,

b) $v_C(t)$ for $t \geq 0$.

Figure P8.35

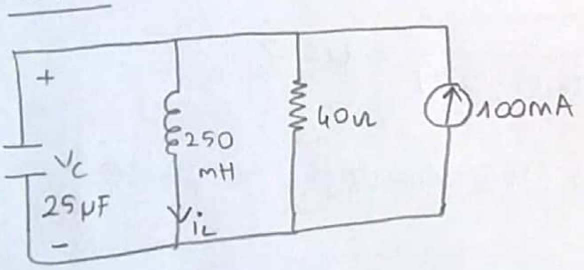


$t<0$

$V_o = V_o(0^-) = V_o(0^+) = \frac{3000}{4000} 100 = 75V$

$I_o = i_L(0^-) = i_L \cdot (0^+) = 100$ mA

$t>0$



$\alpha = \frac{1}{2RC} = \frac{1}{2(40)(25\cdot 10^{-6})} = 500$ rad/s

$w_0 = \sqrt{\frac{1}{LC}} = \sqrt{\frac{1}{(250\cdot 10^{-3})\cdot(25\cdot 10^{-6})}} = 400$

$\boxed{\alpha^2 > w_0^2}$ → overdamped response

$\boxed{S_{1,2} = -\alpha \mp \sqrt{\alpha^2 - w_0^2}}$

$S_{1,2} = -500 \mp \sqrt{500^2 - 400^2}$

$= -200, -800$

a) $i_L = I_f + A_1 e^{-200t} + A_2 e^{-800t}$

$I_f = 100$ mA

$i_L(0) = 0.1 + A_1 + A_2 = 0.1$

$\Rightarrow \boxed{A_1 + A_2 = 0}$

$\frac{di_L}{dt}(0) = -200A_1 - 800A_2 = \frac{V_0}{L}$

$= \frac{75}{(0.25)} = 300$

$A_1 = 0.5$ $\quad$ $A_2 = -0.5$

$t \geq 0$

$\boxed{i_L(t) = 0.1 + 0.5e^{-200t} - 0.5e^{-800t} \text{ Amper}}$

b) $V_C(t) = V_L(t) = L \cdot \frac{di_L}{dt}$

$= (0.25)\cdot(-100e^{-200t} + 400e^{-800t})$

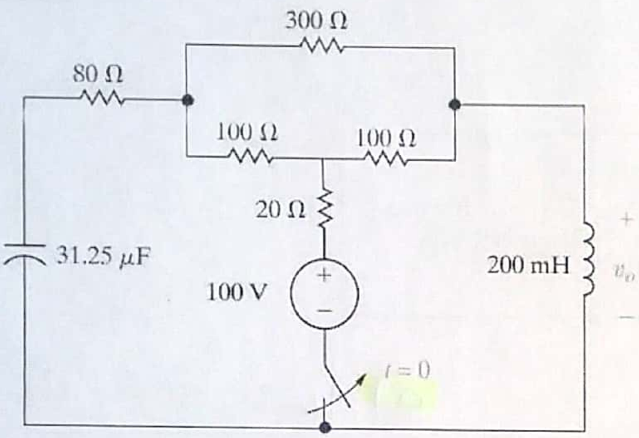
$t \geq 0$

$\boxed{V_C(t) = -25e^{-200t} + 100e^{-800t} \text{ Volt}}$

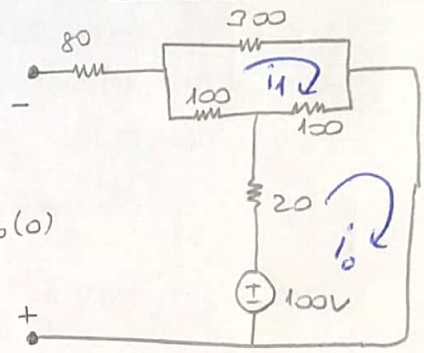
$\boxed{8.47}$

8.47 The switch in the circuit shown in Fig. P8.47 has been closed for a long time. The switch opens at $t = 0$. Find $v_o(t)$ for $t \geq 0^+$.

Figure P8.47



$t<0$

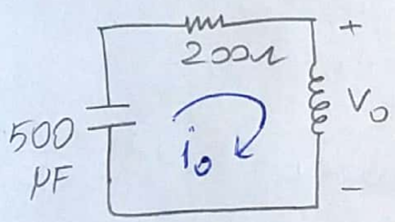


$$500 i_1 - 100 i_0 = 0$$
$$-100 i_1 + 120 i_0 = 100$$

$\boxed{i_1 = 0.2\,A}$ $\boxed{i_0 = 1\,A}$

$\boxed{V_o = -100 + 20 i_0 + 100 i_1 = -60\,V}$

$t>0$



$$\alpha = \frac{R}{2L} = \frac{200}{2(0.2)} = 500$$

$$w_0 = \sqrt{\frac{1}{LC}} = \sqrt{\frac{1}{(0.2)\cdot(36.25\cdot 10^{-6})}} = 400$$

$\boxed{\alpha^2 > w_0^2} \longrightarrow$ overdamped response

$$S_{1,2} = -\alpha \mp \sqrt{\alpha^2 - w_0^2}$$
$$= -500 \mp \sqrt{500^2 - 400^2}$$

$S_{1,2} = -200, -800$ rad/s

$t \geq 0$

$V_o(t) = -6.67 e^{-200t} - 133.33 e^{-800t}$ Vol

$$i_o = A_1 e^{-200t} + A_2 e^{-800t}$$

$$i_o(0) = A_1 + A_2 = 1$$

$$\frac{di_o}{dt}(0) = -200A_1 - 800A_2 = \frac{1}{L}(-V_o - R I_o) = -700$$

$A_1 = 166.67$ mA

$A_2 = 833.33$ mA

$t \geq 0$

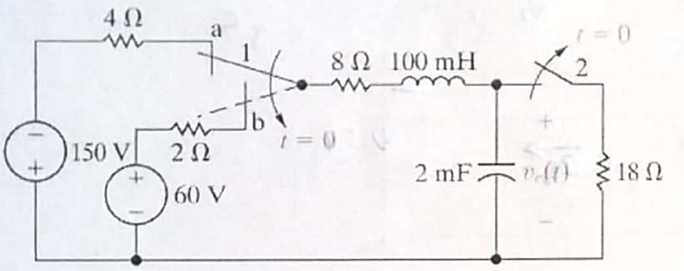
$\boxed{i_o(t) = 166.67 \cdot e^{-200t} + 833.33 e^{-800t} \text{ mA}}$

$$V_o(t) = L \cdot \frac{di_o}{dt} = (0.2) \cdot \left[(-200) \cdot 0.16667 e^{-200t} + (-800) \cdot 0.83333 e^{-800t}\right]$$

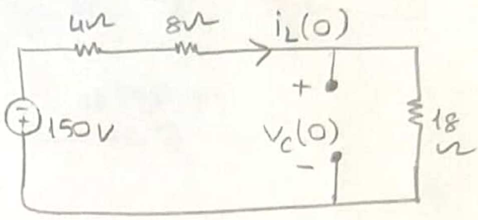
8.54

8.54 PSPICE MULTISIM The two switches in the circuit seen in Fig. P8.55 operate synchronously. When switch 1 is in position a, switch 2 is closed. When switch 1 is in position b, switch 2 is open. Switch 1 has been in position a for a long time. At $t = 0$, it moves instantaneously to position b. Find $v_c(t)$ for $t \geq 0$.

Figure P8.54



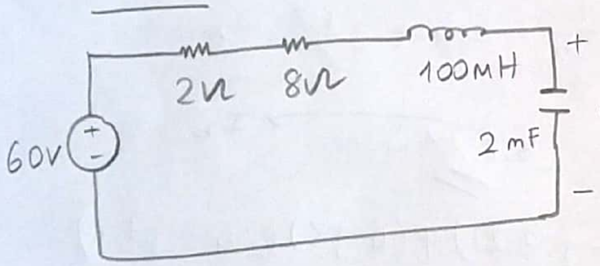
$t<0$



$$i_L(0) = \frac{-150}{30} = -5\text{A}$$

$$V_c(0) = 18\, i_L(0) = -90\text{V}$$

$t>0$



$$\alpha = \frac{R}{2L} = \frac{10}{2\cdot(0.1)} = 50 \text{ rad/s}$$

$$W_o = \sqrt{\frac{1}{LC}} = \sqrt{\frac{1}{(0.1)\cdot(2\cdot10^{-3})}} = \sqrt{5000}$$

$W_o^2 > \alpha^2 \rightarrow$ underdamped

$$S_{1,2} = -\alpha \mp \sqrt{\alpha^2 - W_o^2} = -50 \mp j50$$

$$V_c = 60 + B_1' e^{-50t} \cos 50t + B_2' e^{-50t} \cdot \sin 50t$$

$$V_c(0) = -90 = 60 + B_1' \Rightarrow B_1' = -150$$

$$C \cdot \frac{dV_c}{dt}(0) = -5 \rightarrow \frac{dV_c}{dt}(0) = \frac{-5}{2\cdot10^{-3}} = -2500$$

$$\frac{dV_c}{dt}(0) = -50B_1' + 50\cdot B_2' = -2500 \Rightarrow B_2' = -200$$

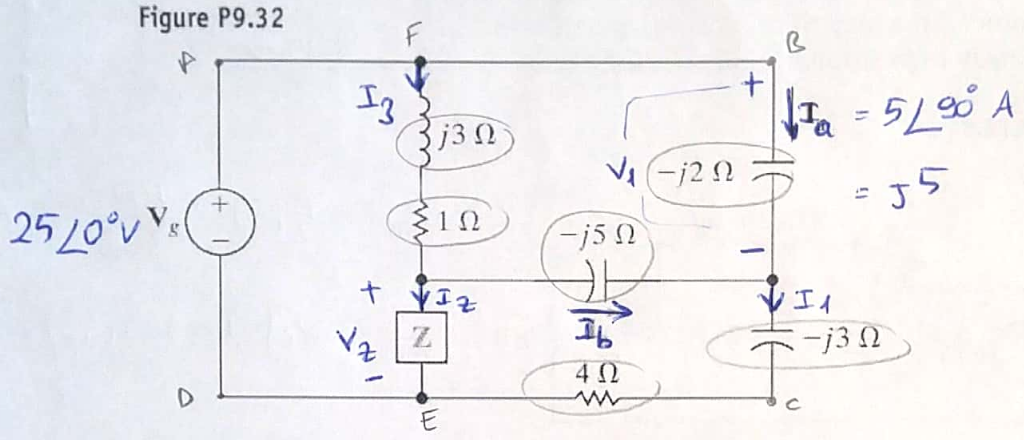
$t \geq 0$.

$$V_c(t) = 60 - 150e^{-50t} \cdot \cos 50t - 200e^{-50t} \cdot \sin 50t \text{ Volt}$$

9.32

9.32 Find $\mathbf{I}_b$ and Z in the circuit shown in Fig. P9.32 if $\mathbf{V}_g = 25\,\angle 0^\circ$ V and $\mathbf{I}_a = 5\,\angle 90^\circ$ A.

Figure P9.32



$V_1 = j5 \cdot (-j2) = 10\ V$

ABCD mesh

$\boxed{-25 + 10 + (4 - j3) I_1 = 0} \Rightarrow I_1 = \frac{15}{4 - j3} = \boxed{2.4 + j1.8}$ Amper

$I_b = I_1 - j5 = (2.4 + j1.8) - j5 = \boxed{2.4 - j3.2}$ Amper $\rightarrow I_b$

$V_z = -j5 I_2 + (4 - j3) I_1 = -j5\,((2.4) - j.(3.2)) + (4 - j3)(2.4 + j1.8)$

$= -1 - j12$ Volt

AFED mesh

$\boxed{-25 + (j3 + 1) I_3 + \underbrace{(-1 - j12)}_{V_z} = 0} \Rightarrow I_3 = 6.2 - j.(6.6)$ Amper

$I_z = I_3 - I_2 = (6.2 - j(6.6)) - (2.4 - j3.2)$

$= (3.8) - j.(3.4)$ Amper

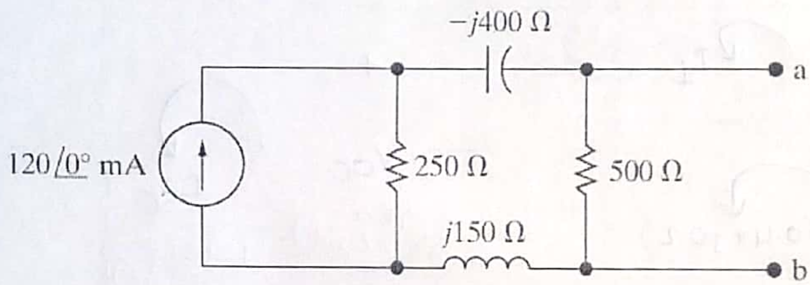
Z ?

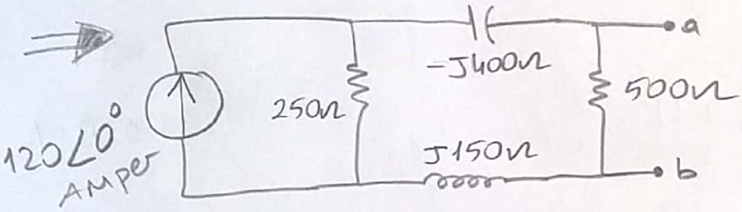
$Z = \frac{V_z}{I_z} = \frac{-1 - j12}{(3.8) - j(3.4)} = \boxed{1.42 - j(1.88)\ \Omega}$

9.45

9.45 Use source transformations to find the Thévenin equivalent circuit with respect to the terminals a,b for the circuit shown in Fig. P9.45.

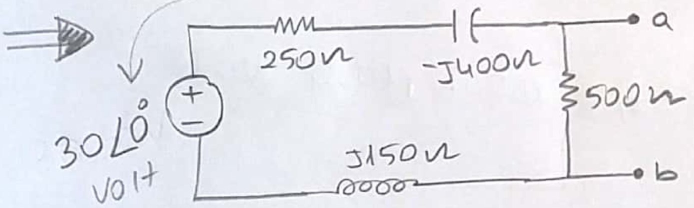
Figure P9.45



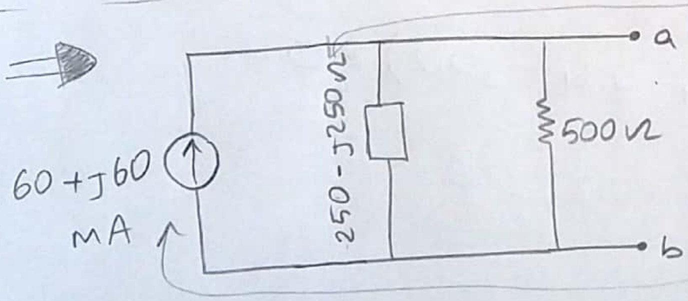


I R V

$(0.12\angle 0^\circ)\cdot(250) = 30\angle 0^\circ$ Volt

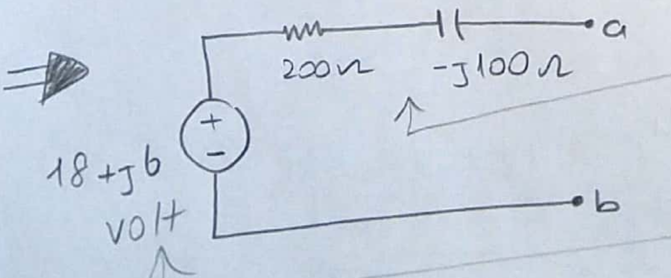


$250 - j400 + j150 = 250 - j250\,\Omega$



$$\frac{30\angle 0^\circ}{250 - j250} = 60 - j60 \text{ mA}$$

$(250 - j250) \parallel 500 = 200 - j100\,\Omega$

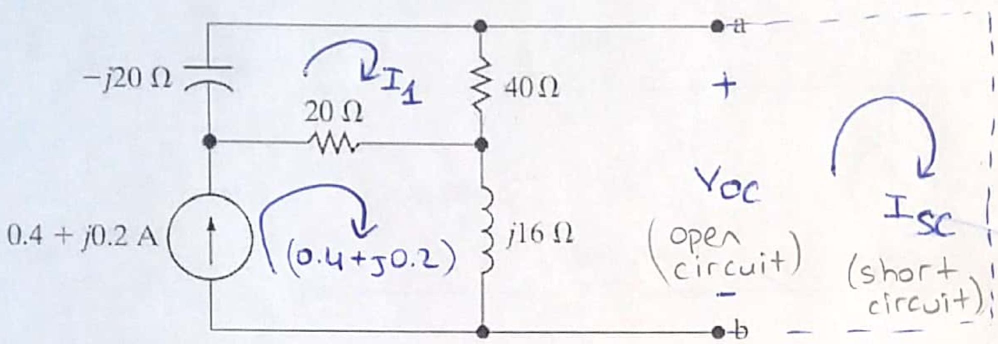


$(200 - j100)(0.06 - j0.06) = 18 - j6$ V

9.46

9.46 Find the Norton equivalent circuit with respect to the terminals a,b for the circuit shown in Fig. P9.46.

Figure P9.46



For Open Circuit:

$$-j20 I_1 + 40 I_1 + 20(I_1 - 0.4 - j0.2) = 0$$

$$I_1 = \frac{20\cdot(0.4 + j0.2)}{60 - j20} = 0.1 + j0.1 \text{ Amper}$$

$$V_{oc} = 40 I_1 + j16(0.4 + j0.2) = 0.8 + j10.4 \text{ Volt}$$

For short circuit:

MESH

$$-j20 I_1 + 40(I_1 - I_{sc}) + 20(I_1 - 0.4 - j0.2) = 0$$

$$40(I_{sc} - I_1) + j16(I_{sc} - 0.4 - j0.2) = 0$$

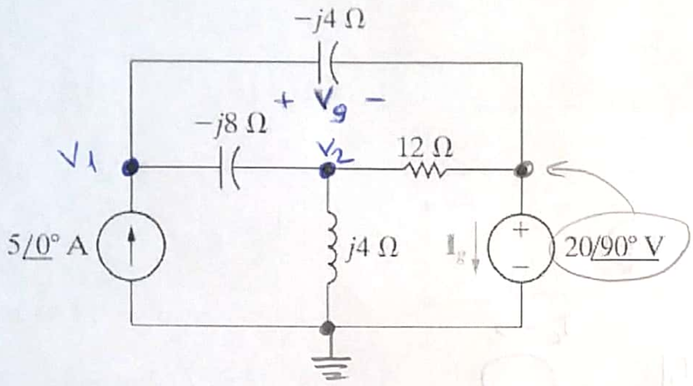
$$I_{sc} = 0.3 + j0.5 \text{ Amper}$$

$$Z_N = \frac{V_{oc}}{I_{sc}} = \frac{0.8 + j10.4}{0.3 + j0.5} = 16 + j8\ \Omega$$

9.55

9.55 Use the node-voltage method to find the phasor voltage $\mathbf{V}_g$ in the circuit shown in Fig. P9.55.

Figure P9.55



For V_1 :

$$\boxed{-5\angle 0^\circ + \frac{V_1 - V_2}{-j8} + \frac{V_1 - 20\angle 90^\circ}{-j4} = 0}$$

For V_2 :

$$\boxed{\frac{V_2 - V_1}{-j8} + \frac{V_2}{j4} + \frac{V_2 - 20\angle 90^\circ}{12} = 0}$$

solve

$$\boxed{V_1 = \frac{-8}{3} + j\frac{4}{3}} \qquad \boxed{V_2 = -8 + j4}$$

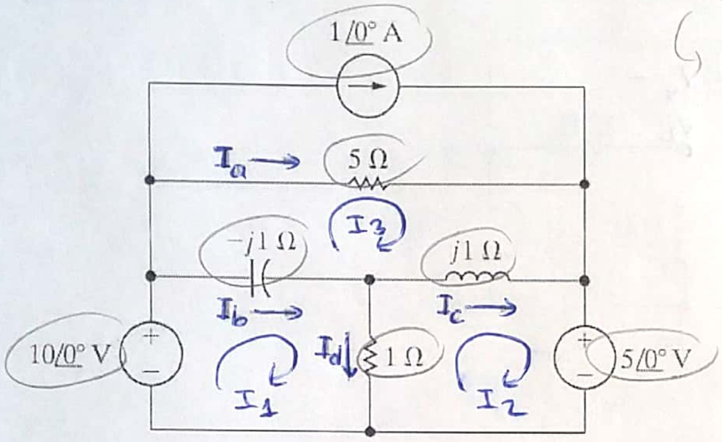
$$V_g = V_1 - 20\angle 90^\circ$$

$$\boxed{V_g = -\frac{8}{3} - j\frac{56}{3} \ V}$$

9.62

9.62 Use the mesh-current method to find the branch currents $\mathbf{I}_a$, $\mathbf{I}_b$, $\mathbf{I}_c$, and $\mathbf{I}_d$ in the circuit shown in Fig. P9.62.

Figure P9.62



$-10\angle 0° + (-j1)\cdot(I_1 - I_3) + 1\cdot(I_1 - I_2) = 0$

$\boxed{-10\angle 0° - jI_1 + jI_3 + I_1 - I_2 = 0}$

$-5\angle 0° + 1(I_2 - I_1) + j1(I_2 - I_3) = 0$

$\boxed{-5\angle 0° + I_2 - I_1 + jI_2 - jI_3 = 0}$

$-1\angle 0° + j1(I_3 - I_2) + (-j\cdot 1)\cdot(I_3 - I_1) = 0$

$\boxed{-1\angle 0 + jI_3 - jI_2 - jI_3 + jI_1 = 0}$

$$\boxed{\begin{aligned} -10\angle 0° + (1 - j\cdot 1)\, I_1 - 1\cdot I_2 + j\cdot 1\cdot I_3 &= 0 \\ -5\angle 0° - 1\, I_1 + (1 + j1)\, I_2 - j\cdot 1\, I_3 &= 0 \\ -1\angle 0° + j\cdot 1\cdot I_1 - j\cdot 1\cdot I_2 + I_3 &= 0 \end{aligned}}$$

solve

$I_1 = 11 + j10$ Amper

$I_2 = 11 + j5$ Amper

$I_3 = 6$ Amper

$I_a = I_3 - 1 = 5$ Amper //

$I_b = I_1 - I_3 = 5 + j10$ Amper //

$I_c = I_2 - I_3 = 5 + j5$ Amper //

$I_d = I_1 - I_2 = j5$ Amper //