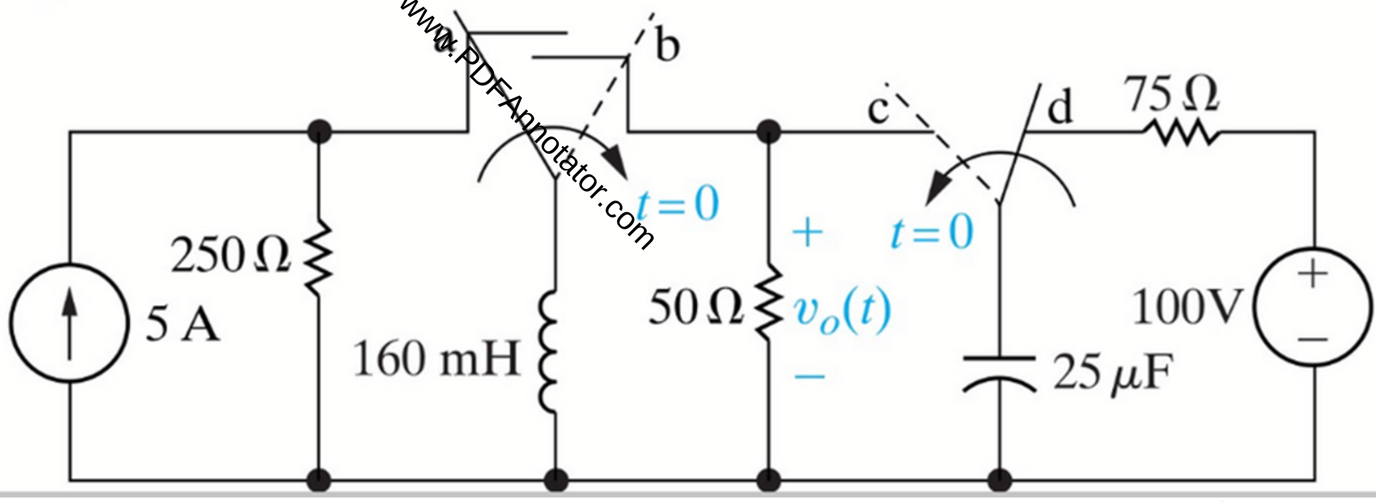
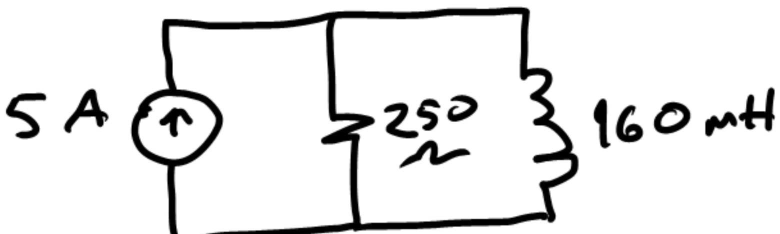
peak values occur.

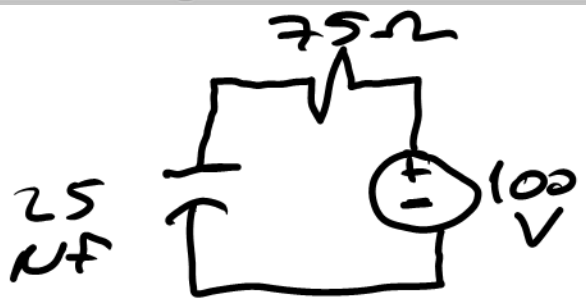
8.11 The two switches in the circuit seen in Fig. P8.11 operate synchronously. When switch 1 is in position a, switch 2 is in position d. When switch 1 moves to position b, switch 2 moves to position c. Switch 1 has been in position a for a long time. At $t = 0$, the switches move to their alternate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

PSPICE
MULTISIM

Figure P8.11







$i_L(0^-) = 5A$

$V_c(0^-) = 100V$

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{160\times10^{-3}\cdot 25\times10^{-6}}} = 500\,\text{rad/s}$$

$$\alpha = \frac{1}{2RC} = \frac{1}{2\cdot 50\cdot 25\times10^{-6}} = 400\,\text{rad/s}$$

$\omega_0^2 > \alpha^2 \rightarrow$ under damped

$$\boxed{\omega_d = \sqrt{\omega_0^2 - \alpha^2} = 300 \text{ rad/s}} \quad \boxed{B_1 = V_0 = 100V}$$

$$i_C(0) = -i_L(0) - i_R(0) = -5 - \frac{100}{50} = -7$$

$$-\alpha B_1 + \omega_d B_2 = \frac{1}{C} \cdot i_C(0)$$

$$-400 \cdot 100 + 300 \cdot B_2 = \frac{1}{25 \cdot 10^{-6}} \cdot -7 \Rightarrow \boxed{B_2 = -800}$$

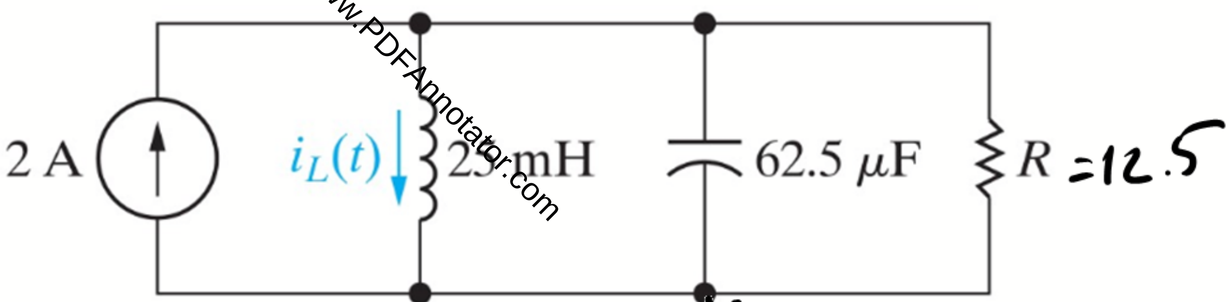
$$v_0(t) = e^{-\alpha \cdot t} \cdot [B_1 \cdot \cos(\omega_d \cdot t) + B_2 \cdot \sin(\omega_d \cdot t)]$$

Insert everything

$$V_0(t) = e^{-400t} \cdot [100\cos(300t) - 800\sin(300t)] V$$

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



$i_L(0^-) = 1A \quad V_c(0^-) = 50V$

$$w_0 = \frac{1}{\sqrt{L.C}} = \frac{1}{\sqrt{25\times10^{-3}\times 62.5\times10^{-6}}} = 800 \text{ rad/s}$$

$$\alpha = \frac{1}{2RC} = \frac{1}{2.12{,}5.62{,}5.10^{-6}} = 640 \text{ rad/s}$$

$w_0^2 > \alpha^2$ Underdamped

$$w_d = \sqrt{w_0^2 - \alpha^2} = 480 \text{ rad/s}$$

$$i_L(0) = e^{-\alpha 0}.[B_1' \cos(w_d.0) + B_2' \sin(w_d.0)] + I_f$$

$$= B_1' + I_f \Rightarrow 1 = B_1' + 2 \Rightarrow B_1' = -1$$

$$\frac{V(0)}{L} = -B_1'\alpha + B_2' w_d \rightarrow \frac{50}{25\times10^{-3}} = 640 + 480B_2'$$

$$\Rightarrow B_2' = 2{,}833$$

$$i_L(t) = e^{-640t}.[-1\cos(480t) + 2{,}833(480t)] + 2A$$

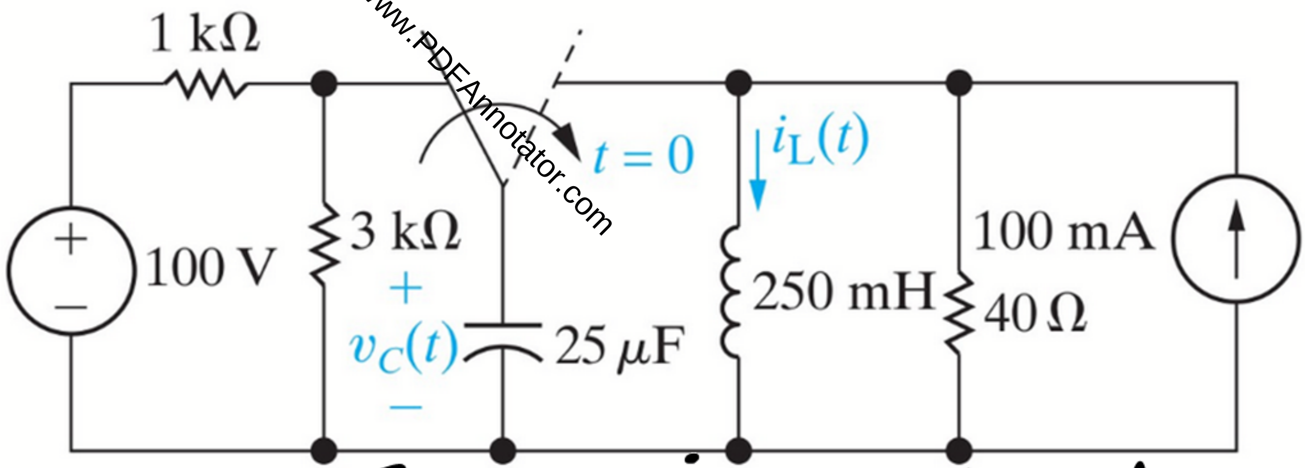
8.35 The switch in the circuit in Fig. P8.35 has been in the left position for a long time before moving to the right position at $t = 0$. Find

PSPICE
MULTISIM

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

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

Figure P8.35



$V_0 = \frac{3}{4} \cdot 100 = 75$ $\qquad i_0 = 100\,mA = 0,1A$

$$w_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{250\times10^{-3}\times25\times10^{-6}}} = 400\,rad/s$$

$$\alpha = \frac{1}{2RC} = \frac{1}{2\cdot40\cdot25\times10^{-6}} = 500\,rad/s$$

$\alpha^2 > w_0^2$ overdamped

$$s_1, s_2 = -\alpha \pm \sqrt{\alpha^2 - w_0^2} = -500 \pm \sqrt{500^2 - 400^2}$$

$$s_1 = -200, \; s_2 = -800$$

<u>1st eq. for $t=0$</u>

$A_1' + A_2' + 0,1 = 0,1$

$A_1' + A_2' = 0 \;/\times 50 \;+\; -50A_1' - 200A_2' = 75 \Rightarrow A_1' = \frac{1}{2}$

$A_2 = -\frac{1}{2}$

<u>2nd eq. for $t=0$</u>

$250\times10^{-3}(-200A_1' - 800A_2') = 75$

$i_L(t) = A_1' e^{s_1 t} + A_2 e^{s_2 t} + I_F$ (insert everything)

$i_L(t) = \dfrac{e^{-200t} - e^{-800t}}{2} + 0{,}1\,A$ a

$v_c(t) = L\left(s_1 A_1 e^{s_1 t} + s_2 A_2 e^{s_2 t}\right)$ (insert everything)

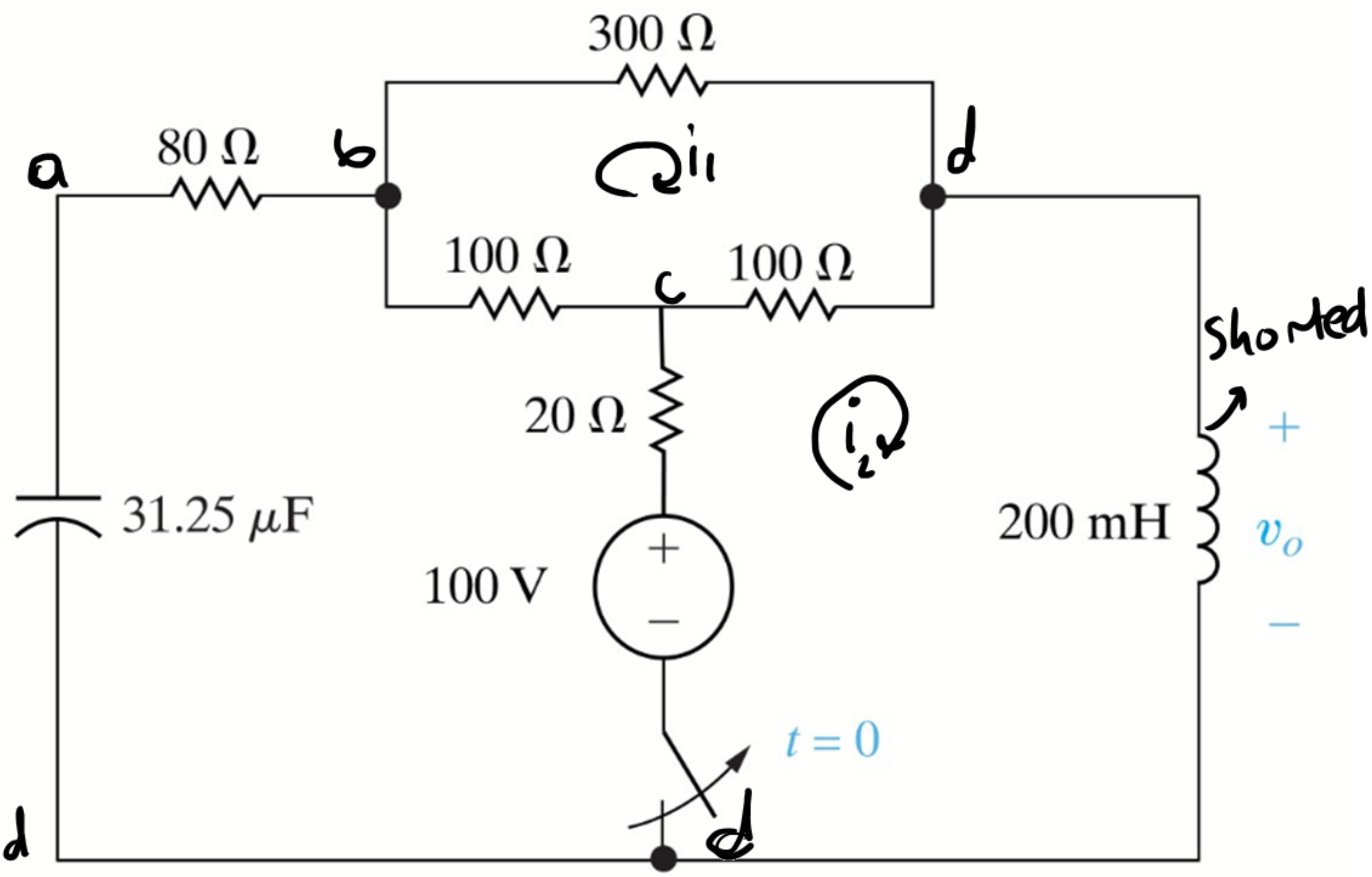
$v_c(t) = 250\times10^{-3}\cdot\left(-200\cdot 0{,}5\cdot e^{-200t} - 800\cdot 0{,}5\cdot e^{-800t}\right)$

$= 0{,}25\cdot\left(-100e^{-200t} - 400e^{-800t}\right) = \underline{-25e^{-200t} - 100e^{-800t}\ V}$

b

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



$$\left.\begin{aligned} 300 i_1 + 100(i_1 - i_2) + 100 i_1 &= 0 \\ -100V + 20 i_2 + 100(i_2 - i_1) &= 0 \end{aligned}\right\} \quad \begin{aligned} i_1 &= 0{,}2A \\ i_2 &= 1A \end{aligned}$$

$* \; V_c(0) = V_{ad} = V_{cd} = -100 + 20.1 + 100.0{,}2 = \underline{-60V}$

$R_{eq}(t>0) = (300 \,//\, (100+100)) + 80 = 200\,\Omega$

$\alpha = \dfrac{200}{2.0{,}2} = 500 \text{ rad/s}$

$w_0 = \dfrac{1}{\sqrt{0{,}2 \times 31{,}25 \times 10^{-6}}} = 400 \text{ rad/s}$

$\alpha^2 > w_0^2$ overdamped

$* \; s_1, s_2 = -500 \pm \sqrt{500^2 - 400^2} \Rightarrow \begin{aligned} s_1 &= -200 \\ s_2 &= -800 \end{aligned}$

$i_0 = i_2 = 1 = A_1 + A_2 \quad (1)$

$L \cdot \dfrac{d i_L(0)}{dt} = V_c(0) = -60 = (A_1 \cdot -200 + A_2 \cdot -800) \cdot 0{,}2$

$3 = -2A_1 - 8A_2 \quad (2) \qquad 2.(1) + (2) \Rightarrow A_1 = \dfrac{1}{6}, \; A_2 = \dfrac{5}{6}$

$V_o(t) = \underline{L . \dfrac{d i_L(0)}{dt}} = (A_1 s_1 . e^{s_1 t} + A_2 s_2 e^{s_2 t}) . L$

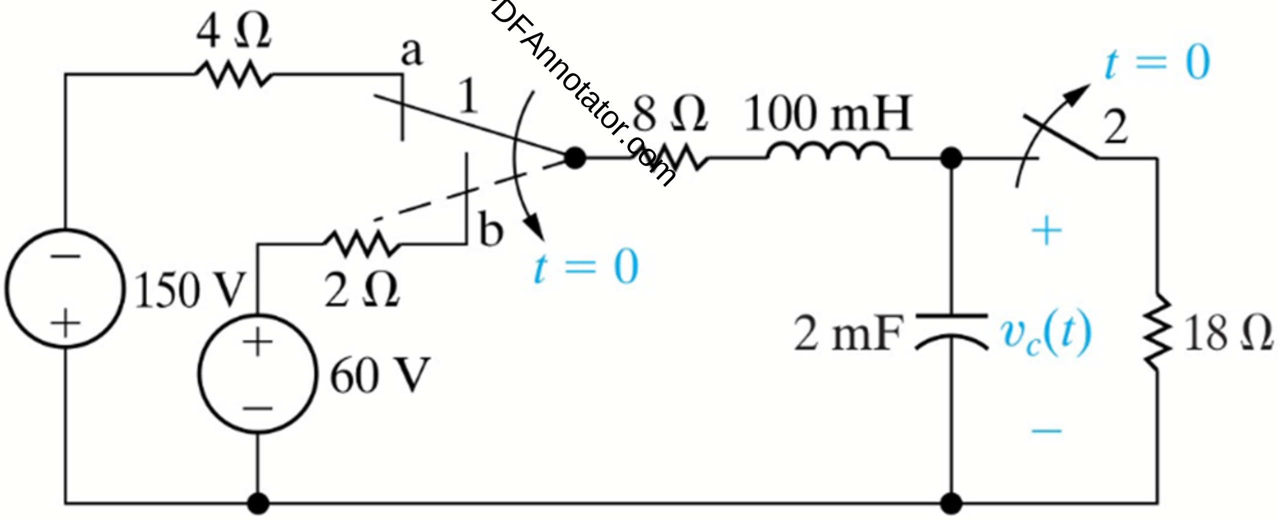
$= \left(\dfrac{-200 . e^{-200t} - 5.800 e^{-800t}}{6} \right) . 0{,}2$

$= 6{,}67 . e^{-200t} - 133 . e^{-800t} \; V$

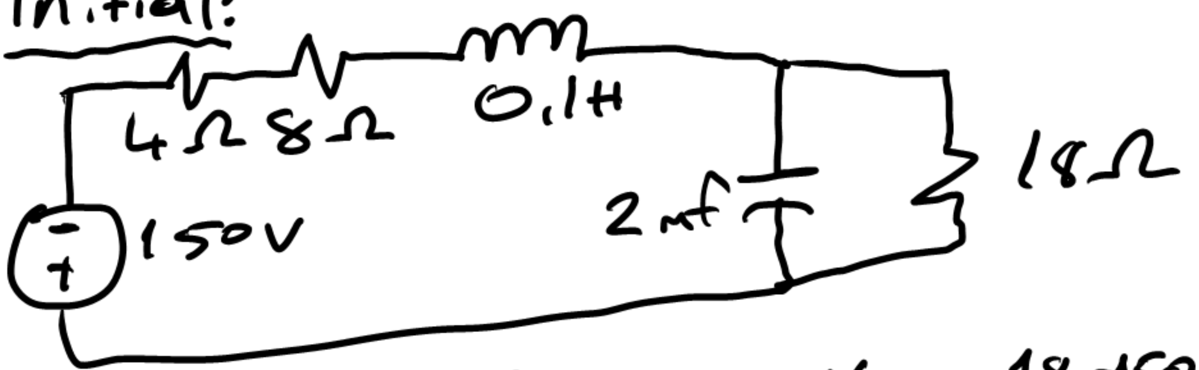
8.54 The two switches in the circuit seen in Fig. P8.55 operate synchronously. When switch 1 is in position a, switch 2 is closed. When switch 1 is in position b, switch 2 is open. Switch 1 has been in position a for a long time. At $t = 0$, it moves instantaneously to position b. Find $v_c(t)$ for $t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

PSPICE
MULTISIM

Figure P8.54

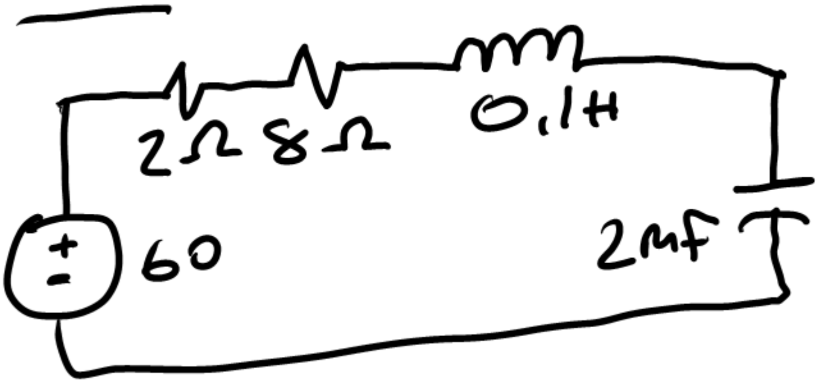


initial:



$-150 = 30 \cdot i_L(0) \Rightarrow i_L(0) = -5A$ $\quad V_c(0) = \frac{18}{30} \cdot -150 = -90V$

t>0:



$R_{eq} = 10\Omega$

$$w_0 = \frac{1}{\sqrt{0{,}1 \times 2 \times 10^{-3}}} = 70{,}71 \text{ rad/s}$$

$$\alpha = \frac{10}{2 \cdot 0{,}1} = 50 \text{ rad/s}$$

$w_0^2 > \alpha^2$ underdamped

$$\boxed{w_d = \sqrt{70{,}71^2 - 50^2} = 50 \text{ rad/s}}$$

$$v_C(0) = B_1' + V_f = -90 = B_1' + 60 \Rightarrow \boxed{B_1' = -150}$$

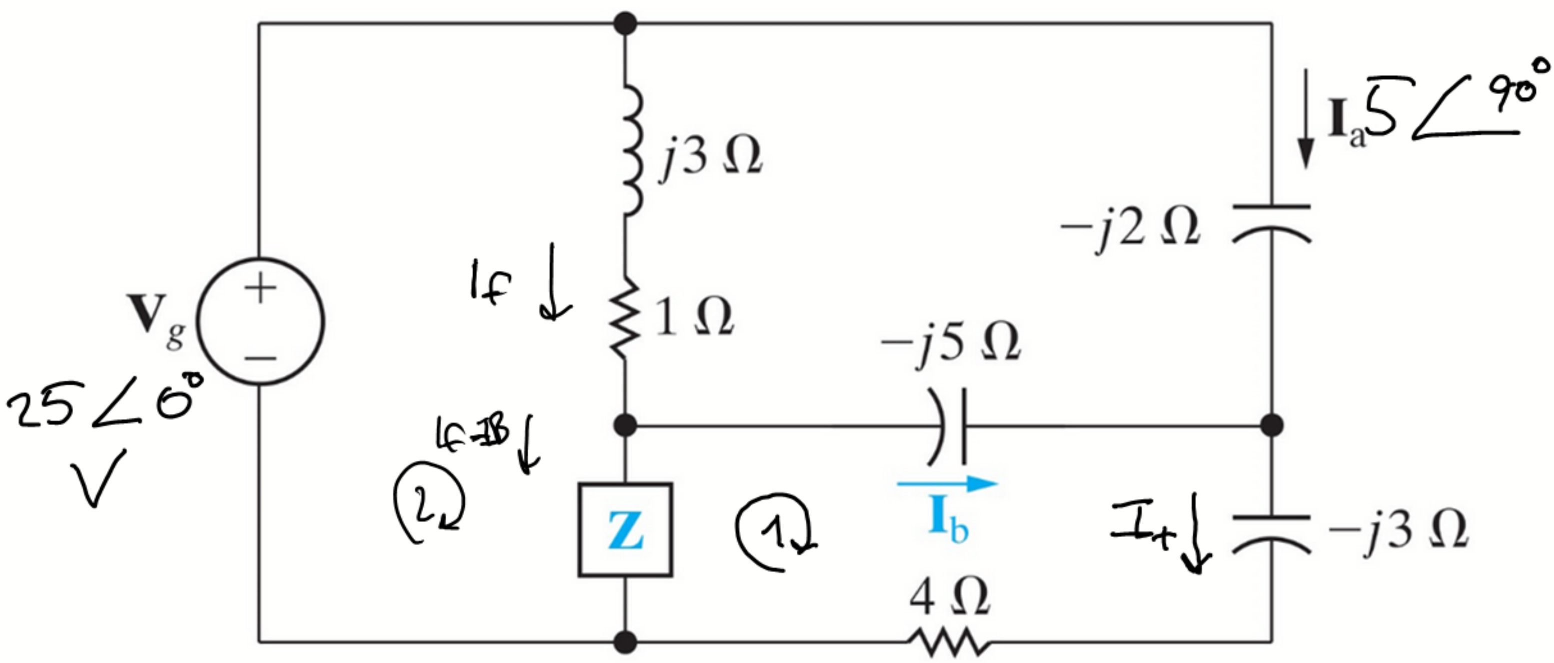
$$\frac{i(0)}{C} = -B_1' \cdot \alpha + B_2' \cdot w_d \Rightarrow \frac{-5}{2 \times 10^{-3}} = 150 \cdot 50 + B_2' \cdot 50$$

$$\boxed{\Rightarrow B_2' = -200}$$

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

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



$V_{-j2\Omega} = 5\angle 90° \cdot -j2\Omega = 5\cos(90) + 5\sin(90)j) \cdot -j2\Omega$

$= j5 \cdot -j2 = -10j^2 = \underline{10V}$

KVL AT OUTER LOOP:

$-25 + 10 + (4-j3) \cdot I_t = 0 \Rightarrow I_t = \frac{15}{4-j3} \cdot \frac{4+j3}{4+j3} = 2{,}4 + 1{,}8j\,A$

$I_b = I_t - I_a = 2{,}4 + 1{,}8j - 5j = \underline{2{,}4 - 3{,}2j\,A}$

KVL AT LOOP 1:

$-V_z + I_b \cdot (-j5) + I_t \cdot (-j3 + 4) = 0$

$\Rightarrow V_z = \underbrace{(2{,}4 - 3{,}2j) \cdot (-j5)}_{-12j-16} + \underbrace{(2{,}4 + 1{,}8j)(-j3+4)}_{15}$

$\Rightarrow V_z = -12j - 1$

KVL AT LOOP 2:

$-25 + (1+j3) I_f + (-12j - 1) = 0$

$I_f = \frac{12j + 26}{3j+1} \cdot \frac{3j-1}{3j-1} = \frac{-36 - 12j + 78j - 26}{-9-1} = \frac{66j - 62}{-10}$

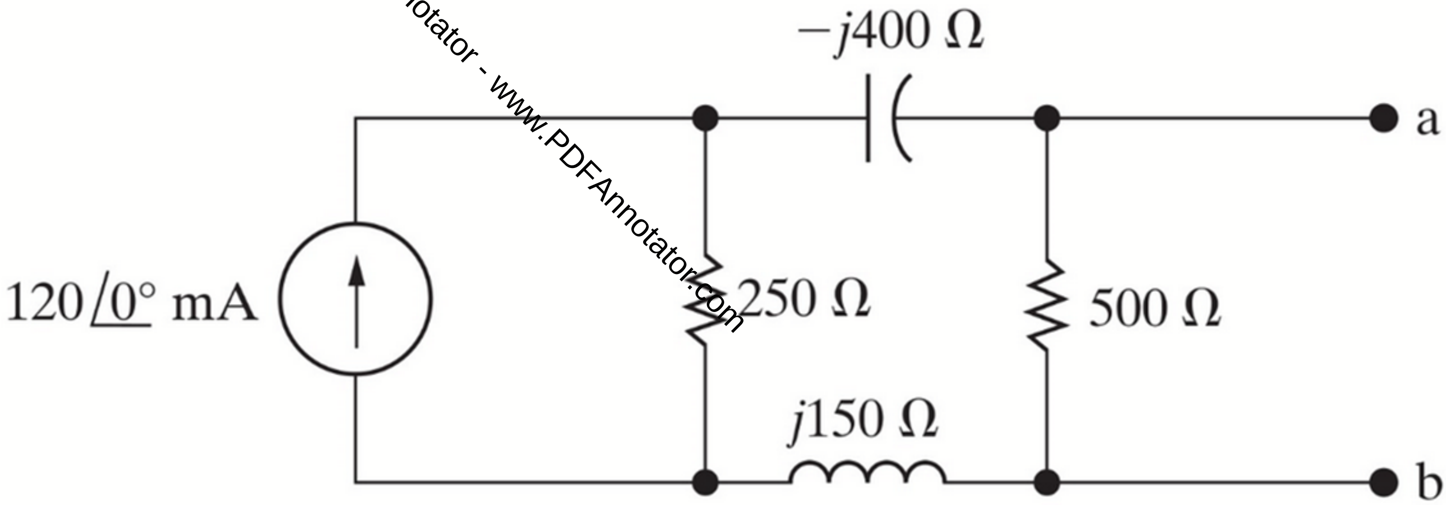
$= 6{,}6j - 6{,}2\,A$

$I_z = I_f - I_b = -3{,}4j + 3{,}8\,A$

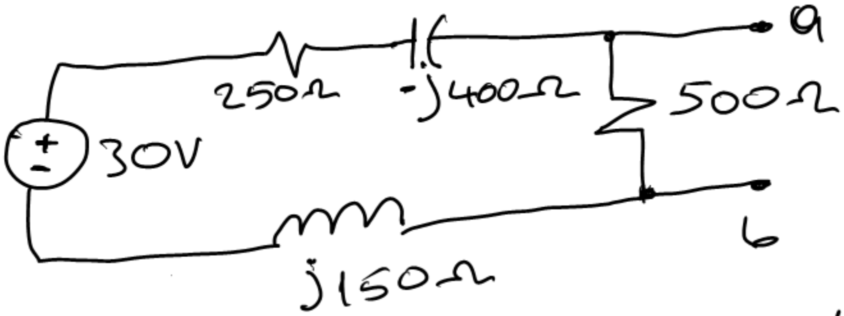
$Z = \frac{-12j - 1}{-3{,}4j + 3{,}8} \cdot \frac{-3{,}4j - 3{,}8}{-3{,}4j - 3{,}8} = 1{,}42 - 1{,}88j\,\Omega$

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



$V = 120\,mA \cdot 250\,\Omega \Rightarrow V = 30\,V$



$V_{ab} = V_{Th}$

$$V_{Th} = 30 \cdot \frac{500}{500+250+j150-j400} = \frac{15000}{750-250j} = \frac{60}{3-j} \cdot \frac{-3-j}{-3-j}$$

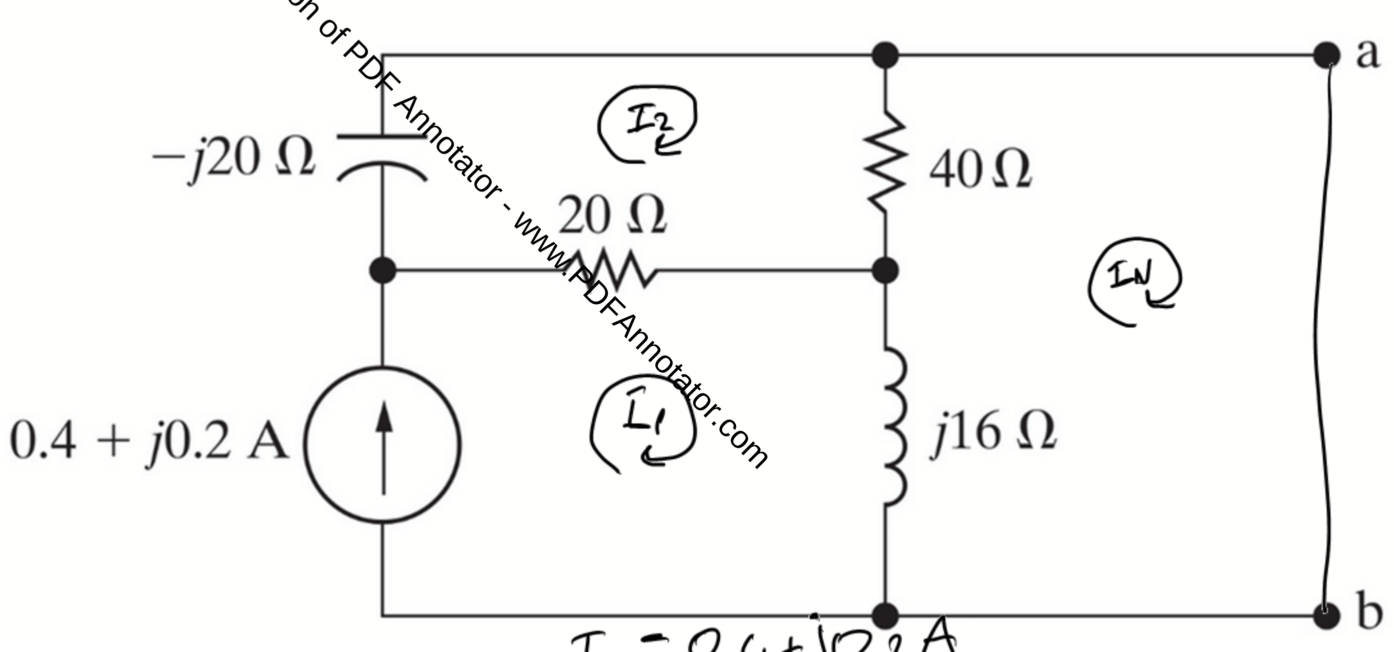
$$= \frac{-180-60j}{-10} = 18+6j\,V$$

$$Z_{Th} = \frac{(250-j250) \cdot 500}{750-j250} = \frac{500-500j}{3-j} \cdot \frac{-3-j}{-3-j} = \frac{1000j-2000}{-10}$$

$$= -100j + 200\,\Omega$$

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



$I_1 = 0{,}4 + j0{,}2\,A$

$I_2 \cdot (-20j) + (I_2 - I_n) \cdot 40 + (I_2 - 0{,}4 - 0{,}2j) \cdot 20 = 0$

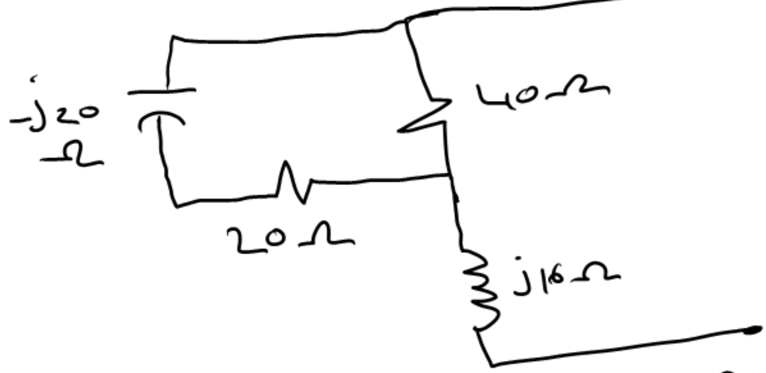
$I_2(60 - 20j) - 40 I_n - 8 - 4j = 0$ (1)

solved this with wolfram alpha

$\underline{I_n = 0{,}3 + 0{,}5j\,A}$

$(I_n - 0{,}4 - 0{,}2j) \cdot 16j + (I_n - I_2) \cdot 40 = 0$

$-40 I_2 + I_n(40 + 16j) - 6{,}4j + 3{,}2 = 0$ (2)



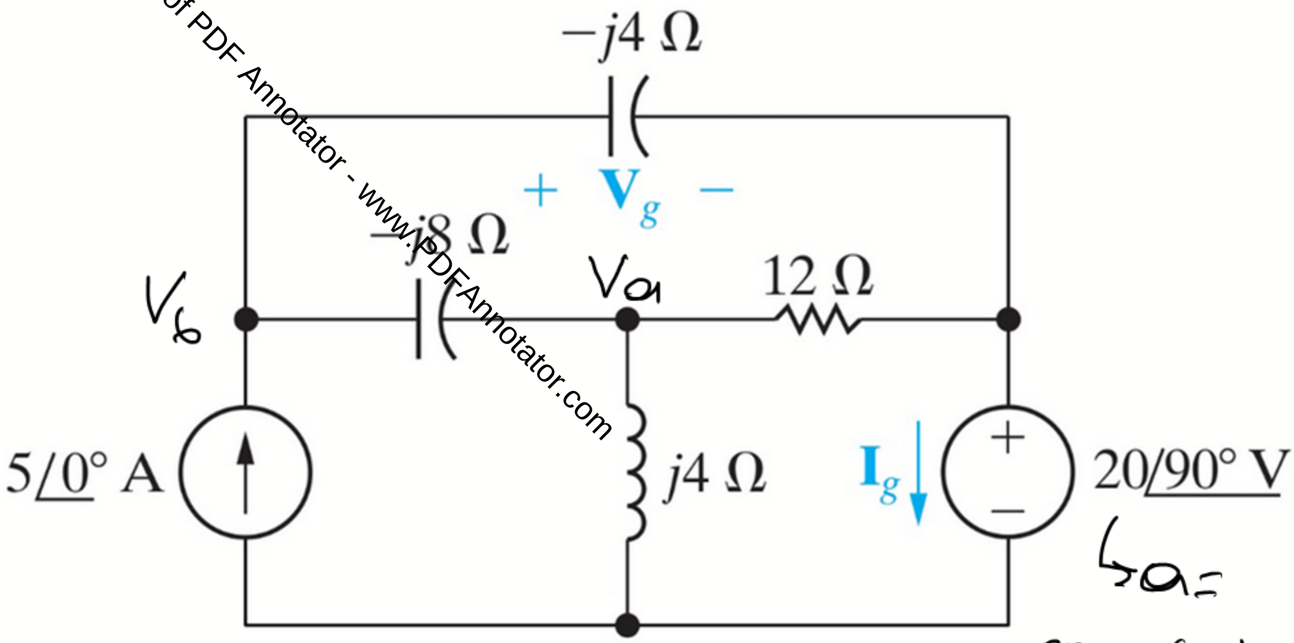
$Z_N = ((-j20 + 20) \| 40) + j16$

$\frac{(-j20 + 20) \cdot 40}{-j20 + 60} \; . \; j16$

$\underline{= 16 + 8j\,\Omega}$

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



$a =$

$20\cos(90) = 0$

$b = 20\sin(90) = 20$

$= 20j$

$$-5 + \left(\frac{V_b - V_a}{-j8}\right) + \frac{V_b - 20j}{-j4} = 0$$

$$\left(\frac{1}{-j8} + \frac{1}{-j4}\right)V_b + \frac{V_a}{j8} = \underbrace{-5+5}_{0} \quad (1)$$

$$\frac{V_a - V_b}{-j8} + \frac{V_a}{j4} + \frac{V_a - 20j}{12} = 0$$

$$\left(\frac{1}{-j8} + \frac{1}{j4} + \frac{1}{12}\right)V_a - \frac{V_b}{-j8} = \frac{5}{3}j \quad (2)$$

I solved this with wolframalpha. eq:

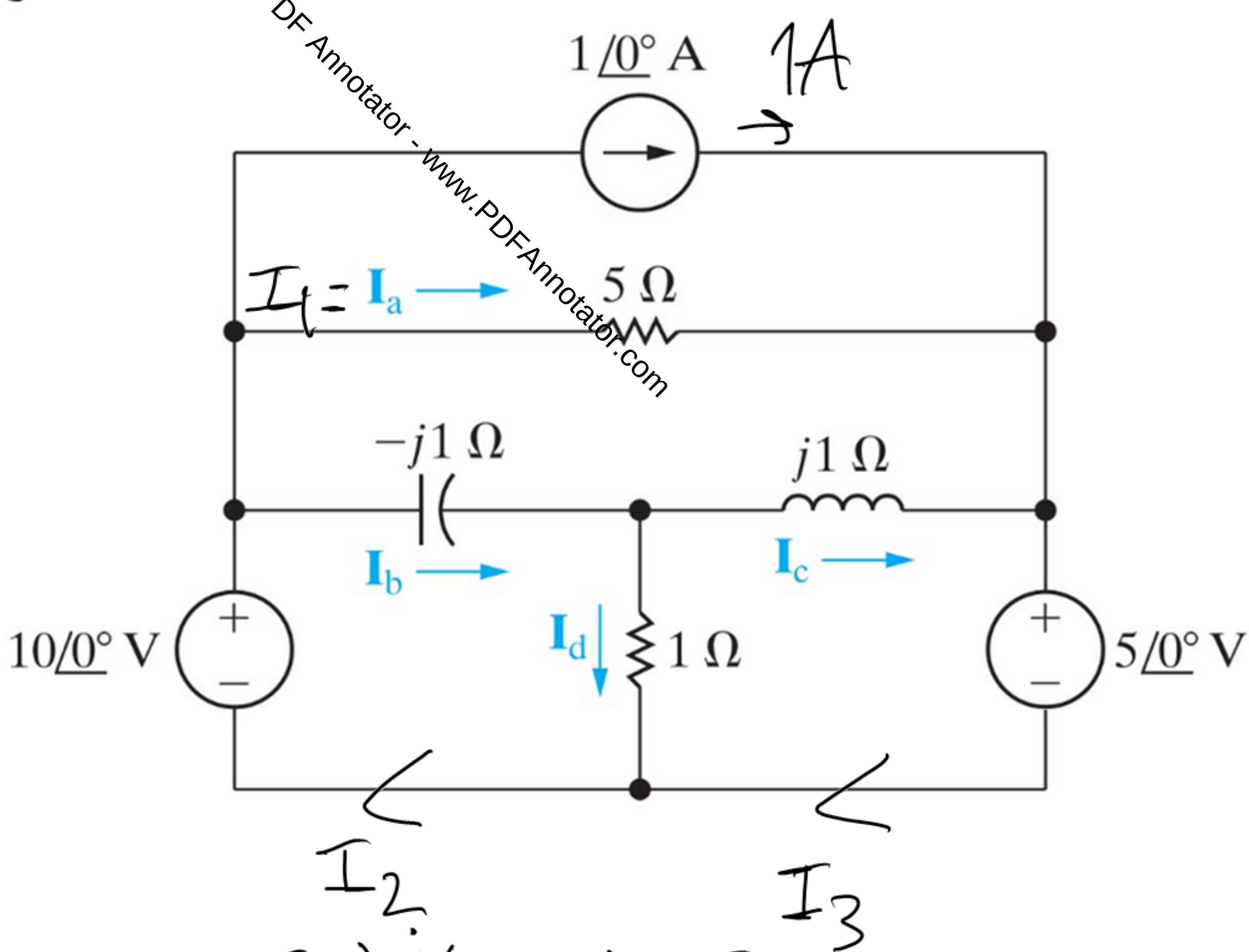
((1/(-i*8)+1/(-i*4))*x + y/(i*8) = 0,(1/(-i*8)+1/(i*4)+1/12)y + x/(8*i) = 5/3i

Result: Vb = -8/3 + 4j/3
Va = -8+4j

$$V_g = V_B - 20\angle 90^\circ V = -\frac{8}{3} + \frac{4j}{3} - 20j = -\frac{56}{3}j - \frac{8}{3}\ V$$

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



$5I_1 + j.(I_1 - I_3) - j(I_1 - I_2) = 0$

$-10 - j(I_2 - I_1) + (I_2 - I_3) = 0$

$5 + (I_3 - I_2) + j.(I_3 - I_1) = 0$

simplify all three

$5I_1 + jI_2 - jI_3 = 0$

$jI_1 + (-j+1)I_2 - I_3 = 10$

$-jI_1 - I_2 + (j+1)I_3 = -5$

$I_1 = 1A$

$I_2 = 6 + 10j\ A$

$I_3 = 6 + 5j\ A$

$I_a = I_1 = \underline{1A}$ $\quad I_c = -(I_1 + 1 - I_3) = \underline{4 + 5j}\ A$

$I_b = I_2 - I_1 - 1 = \underline{4 + 10j\ A}$ $\quad I_d = I_b - I_c = 5jA$