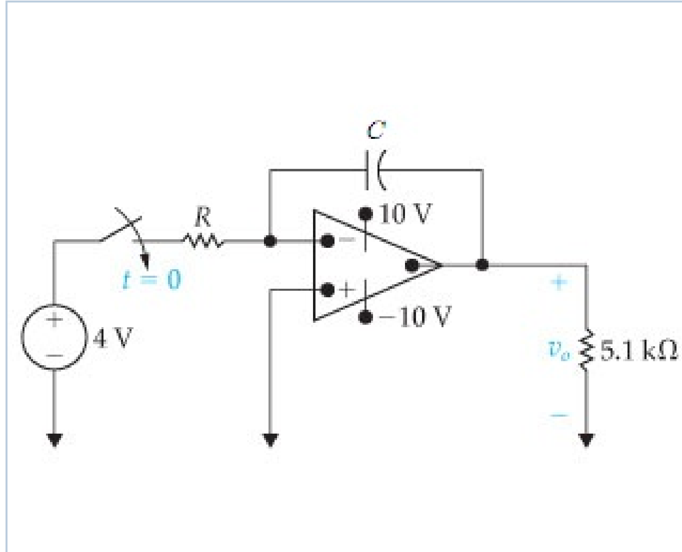
Problem 7.90 PSpice|Multisim

The energy stored in the capacitor in the circuit is zero at the instant the switch is closed. The ideal operational amplifier reaches saturation in 18 ms .



Part A

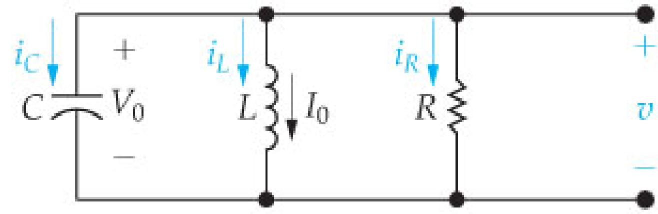
What is the numerical value of R in kilo-ohms, if C = 310 nF ?

ANSWER:

R = ______ $\mathrm{k\Omega}$

Problem 8.2 PSpice|Multisim

The circuit elements in the circuit in are R = 100 Ω, C = 5 μF, and L = 200 mH. The initial inductor current is -0.3 A, and the initial capacitor voltage is 25 V.



Part A

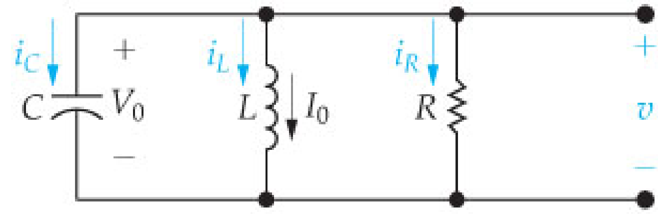
Find the expression for $v(t)$ for $t \geq 0$.

ANSWER:

- $70,000te^{-1000t} + 50e^{-1000t}$ V
- $35,000te^{-1000t} - 50e^{-1000t}$ V
- $70,000te^{-1000t} + 25e^{-1000t}$ V
- $70,000te^{-1000t} - 50e^{-1000t}$ V
- $35,000te^{-1000t} + 25e^{-1000t}$ V
- $35,000te^{-1000t} + 50e^{-1000t}$ V
- $70,000te^{-1000t} - 25e^{-1000t}$ V
- $35,000te^{-1000t} - 25e^{-1000t}$ V

Problem 8.7

The voltage response for the circuit in is known to be
$v(t) = D_1 te^{-80t} + D_2 e^{-80t}, \ t \geq 0,$
where t is in seconds. The initial current in the inductor (I_0) is -25 mA, and the initial voltage on the capacitor (V_0) is 5 V. The resistor has a value of 50 Ω.



Part A

Find the value of L.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

L =

Part B

Find the value of C.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

C =

Part C

Find the value of D_1.

Express your answer using three significant figures.

ANSWER:

D_1 = $\mathrm{V/s}$

Part D

Find the value of D_2.

Express your answer using three significant figures.

ANSWER:

D_2 = ______ V

Part E

Find $i_C(t)$ for $t \geq 0^+$.

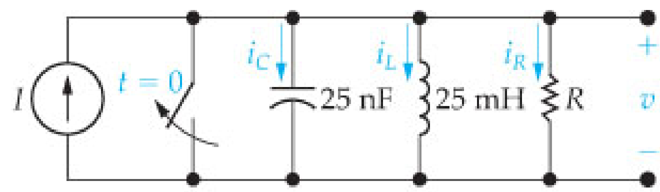
Express your answer in terms of t, where t is in milliseconds.

ANSWER:

i_C = ______ mA

Problem 8.24 PSpice|Multisim

The initial energy stored in the circuit in the figure is zero. At $t = 0$, a dc current source of 24 mA is applied to the circuit. The value of the resistor is 400 Ω.



Part A

Find $v(t)$ for $t \geq 0$;

ANSWER:

- $32(e^{-20{,}000t} + e^{-40{,}000t})$ V
- $16(e^{-20{,}000t} - e^{-80{,}000t})$ V
- $16(e^{-20{,}000t} - e^{-40{,}000t})$ V
- $32(e^{-20{,}000t} - e^{-80{,}000t})$ V
- $16(e^{-20{,}000t} + e^{-80{,}000t})$ V
- $16(e^{-20{,}000t} + e^{-40{,}000t})$ V
- $32(e^{-20{,}000t} + e^{-80{,}000t})$ V
- $32(e^{-20{,}000t} - e^{-40{,}000t})$ V

Part B

Find $i_R(t)$ for $t \geq 0$;

ANSWER:

- $40(e^{-20,000t} - 2e^{-80,000t})$ mA
- $40(e^{-20,000t} + 2e^{-80,000t})$ mA
- $20(e^{-20,000t} - e^{-80,000t})$ mA
- $20(e^{-20,000t} - 2e^{-80,000t})$ mA
- $20(e^{-20,000t} + 2e^{-80,000t})$ mA
- $20(e^{-20,000t} + e^{-80,000t})$ mA
- $40(e^{-20,000t} - e^{-80,000t})$ mA
- $40(e^{-20,000t} + e^{-80,000t})$ mA

Part C

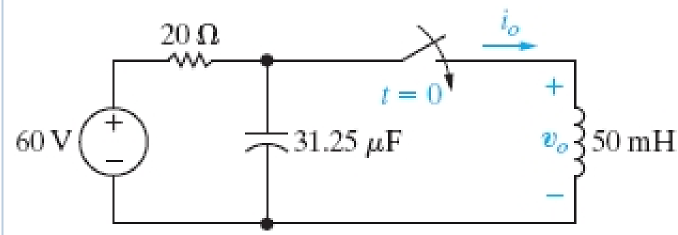
Find $i_C(t)$ for $t \geq 0$;

ANSWER:

- $-8e^{-20,000t} + 32e^{-80,000t}$ mA
- $-8e^{-20,000t} - 32e^{-80,000t}$ mA
- $-8e^{-20,000t} + 16e^{-80,000t}$ mA
- $-4e^{-20,000t} - 32e^{-80,000t}$ mA
- $-4e^{-20,000t} + 16e^{-80,000t}$ mA
- $-8e^{-20,000t} - 16e^{-80,000t}$ mA
- $-4e^{-20,000t} + 32e^{-80,000t}$ mA
- $-4e^{-20,000t} - 16e^{-80,000t}$ mA

Problem 8.31 PSpice|Multisim

The switch in the circuit in has been open for a long time before closing at t = 0.



Part A

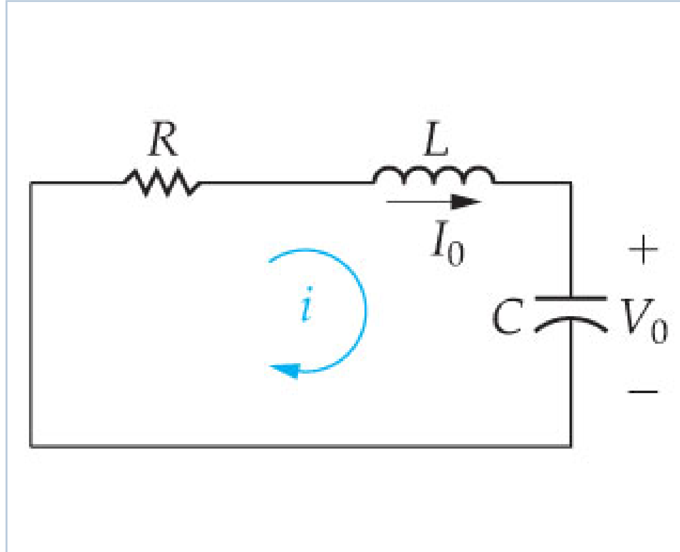
Find $i_o(t)$ for $t \geq 0$.

ANSWER:

- $3 - 1200te^{-800t} + 6e^{-800t}$ A
- $3 - 1200te^{-800t} - 6e^{-800t}$ A
- $6 - 1200te^{-800t} - 3e^{-800t}$ A
- $3 - 1200te^{-800t} + 3e^{-800t}$ A
- $6 - 1200te^{-800t} + 6e^{-800t}$ A
- $3 - 1200te^{-800t} - 3e^{-800t}$ A
- $6 - 1200te^{-800t} + 3e^{-800t}$ A
- $6 - 1200te^{-800t} - 6e^{-800t}$ A

Problem 8.39

The current in the circuit in the followin figure is known to be
$i = B_1 e^{-2000t} \cos 1500t + B_2 e^{-2000t} \sin 1500t, t \geq 0.$
The capacitor has a value of 80 nF; the initial value of the current is 6 mA ; and the initial voltage on the capacitor is -21 V .



Part A

Find the value of R .

Express your answer with the appropriate units.

ANSWER:

R =

Part B

Find the value of L .

Express your answer with the appropriate units.

ANSWER:

L =

Part C

Find the value of B_1 .

Express your answer with the appropriate units.

ANSWER:

B_1 =

Part D

Find the value of B_2.

Express your answer with the appropriate units.

ANSWER:

B_2 =

7.90 NODAL EQ AT NEG TERMINAL

$$\frac{v_n - 4V}{R} + C\frac{d}{dt}(v_n - v_0) = 0$$

POS TERM @ GROUND, $v_p = 0$

BUT $v_n = v_p \Rightarrow -\frac{4V}{R} - C\frac{dv_0(t)}{dt} = 0$

$$\frac{dv_0}{dt} = -\frac{4}{RC}$$

$$v_0(t) = \int_0^t \left(-\frac{4}{RC}\right)dx + v_0(0)$$

($v_0(0)$ = 0 BY INITIAL COND)

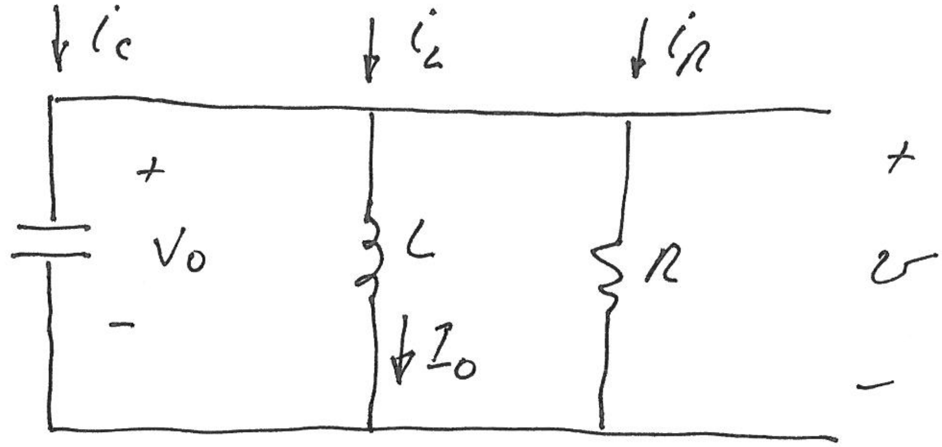
$$v_0(t) = -\frac{4}{RC}x\Big|_0^t$$

$$v_0(t) = -4t/RC$$

SATURATION (−10V) REACHED AT t = 18 ms

$$\frac{-4(0.018)}{R(310nF)} = -10 \Rightarrow R = 23.226k\Omega$$

8.2



$R = 100\ \Omega$ $\quad$ $I_0 = -0.3A$
$L = 200\ mH$ $\quad$ $V_0 = 25V$
$C = 5\mu F$

FIND $v(t)$; $t \geq 0$

$$\alpha = \frac{1}{2RC} = 1{,}000\ Np/s$$
$$\omega_0 = \frac{1}{\sqrt{LC}} = 1{,}000\ RAD/S$$
$\Rightarrow$ CRITICAL DAMPING

$$v(t) = D_1 t e^{-\alpha t} + D_2 e^{-\alpha t}$$

$$v(0) = D_2 = V_0 \quad (1)$$

$$i_C(0^+) = C \frac{dv(t)}{dt}\Big|_{t=0^+}$$

$$= C \frac{d}{dt}\left[D_1 t e^{-\alpha t} + D_2 e^{-\alpha t}\right]\Big|_{t=0^+}$$

$$i_c(0^+) = C\left[D_1 e^{-\alpha t} - \alpha D_1 t e^{-\alpha t} - \alpha D_2 e^{-\alpha t}\right]\Big|_{t=0^+}$$

$$i_c(0^+) = C(D_1 - \alpha D_2) \quad (2)$$

APPLY KCL AT NODE FOR $t = 0^+$:

$$i_c(0^+) + i_L(0^+) + i_R(0^+) = 0$$

$$i_c(0^+) + I_0 + V_0/R = 0$$

$$i_c(0^+) = -I_0 - V_0/R \quad (3)$$

COMBINE EQ'S (1), (2), & (3):

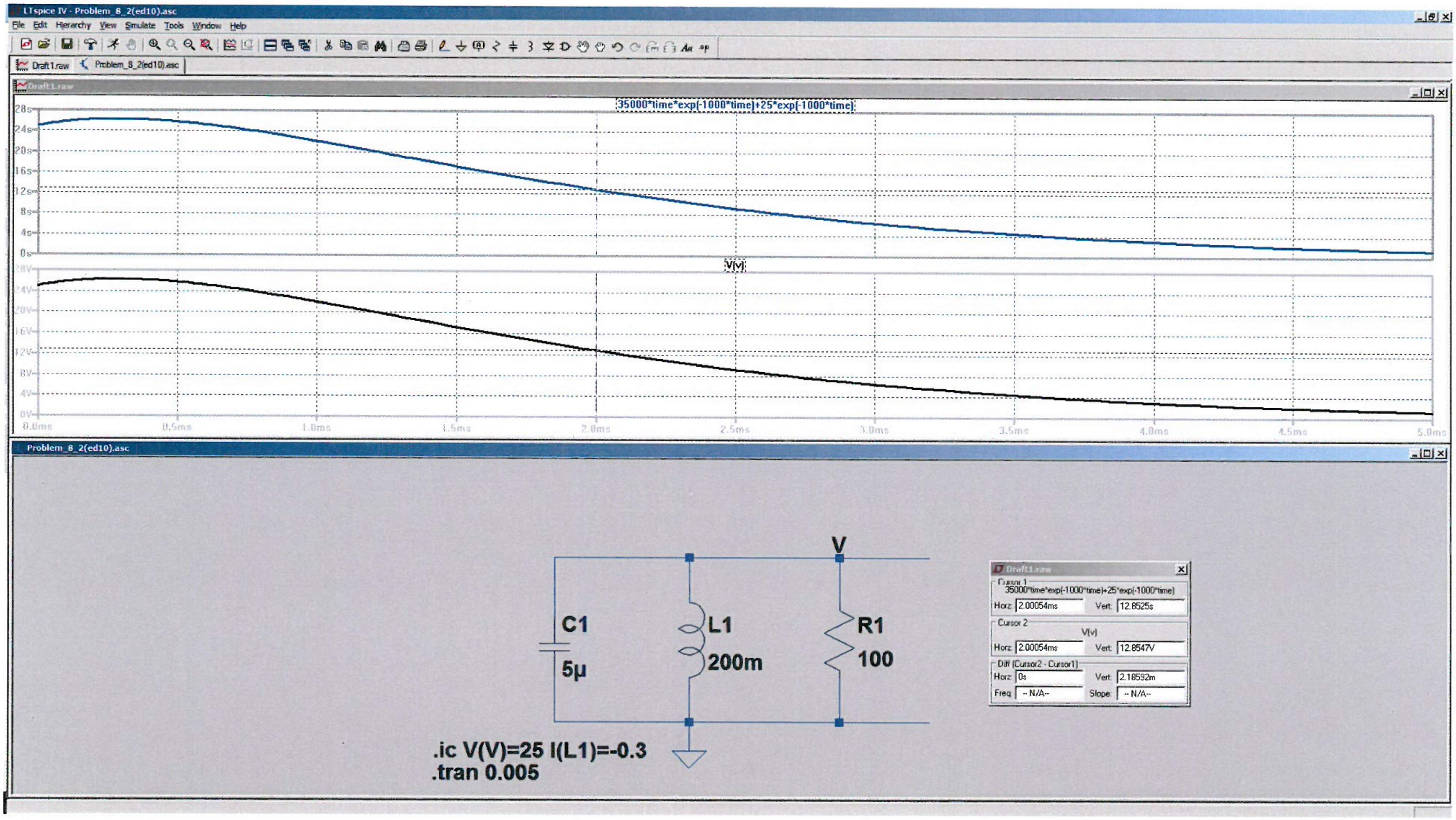
$$C(D_1 - \alpha V_0) = -I_0 - V_0/R$$

$$D_1 = \alpha V_0 - \frac{1}{C}(I_0 + V_0/R)$$

$$D_1 = 35{,}000 \text{ V/s}$$

$$v(t) = 35{,}000\, t e^{-1{,}000 t} + 25 e^{-1{,}000 t}; \quad t \geq 0$$

Problem 8.2 (10^{th} edition)



Note units of seconds on ordinate of top plot.

8.7 $v(t) = D_1 t e^{-80t} + D_2 e^{-80t}; \quad t \geq 0$

$I_0 = -25\,mA, \quad V_0 = 5V, \quad R = 50\,\Omega$

a) L? CRITICAL DAMPING // RLC

$$\alpha = \frac{1}{2RC} = \omega_0 = \frac{1}{\sqrt{LC}}$$

IN SOLN, $s_{1,2} = -\alpha = -80$

$$\frac{1}{2RC} = 80 \Rightarrow C = \frac{1}{2R \times 80} = 125\mu F$$

$$\omega_0^2 = \alpha^2 = \frac{1}{LC} \Rightarrow L = \frac{1}{(80)^2 C}$$

$L = 1.25\,H$ //

b) C? FROM PART a, $C = 125\mu F$ //

c) $D_2 = v(0^+) = V_0 \Rightarrow D_2 = 5V$ //

$$\frac{i_c(0)}{C} = D_1 - \alpha D_2 \longrightarrow D_1 = \frac{i_c(0)}{C} + \alpha D_2$$

KCL AT TOP NODE:

$$\frac{v(0)}{R} + I_0 + i_c(0) = 0$$

$$i_c(0) = -I_0 - v(0)/R$$

$$i_c(0) = 25mA - D_2/50$$

$$= 25mA - 5/50 = -75mA$$

$$D_1 = \frac{-75mA}{125\mu F} + 80D_2 = -200\ V/s$$ //

d) D_2? FROM PART c, $D_2 = 5V$ //

e) $i_c(t);\ t \geq 0^+$?

$$i_c(t) = c\frac{dv}{dt}$$

$$= c\frac{d}{dt}(D_1 t e^{-80t} + D_2 e^{-80t})$$

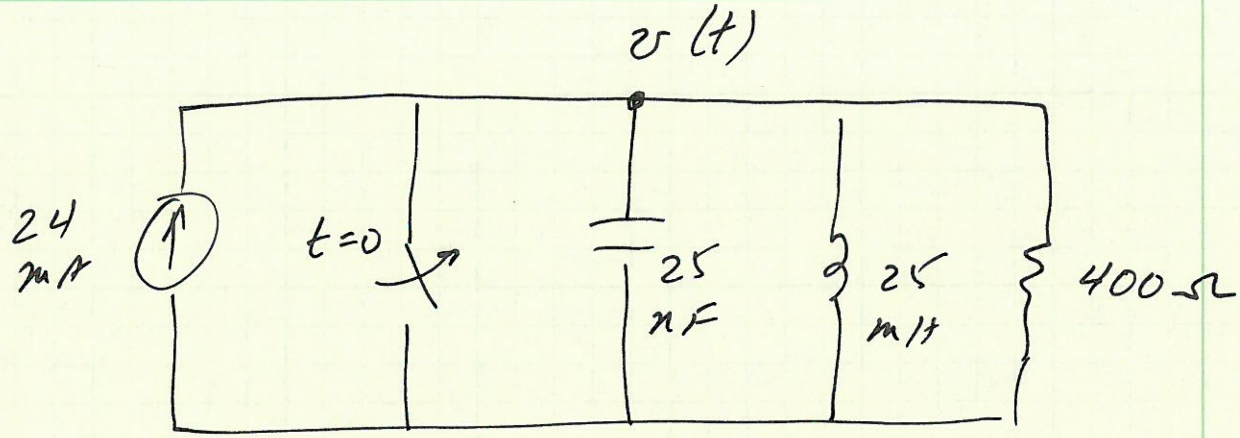
$$= c(D_1 e^{-80t} - 80D_1 t e^{-80t} - 80D_2 e^{-80t})$$

$$= c(D_1 - 80D_2 - 80D_1 t)e^{-80t}$$

$$= (2t - 0.075)e^{-80t}\ A;\ t \text{ IN SEC}$$

$$= (0.002t - 0.075)e^{-0.08t}\ A;\ t \text{ IN ms}$$

$$i_c(t) = (2t - 75)e^{-0.08t}\ mA,\ t \text{ IN ms}$$



NO INITIAL ENERGY IN CKT

$\alpha = \frac{1}{2RC}$ $\omega_0 = \frac{1}{\sqrt{LC}}$

$= 50{,}000/s$ $= 40{,}000$ RAD/S

$s_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2} = -20{,}000/s$

$s_2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2} = -80{,}000/s$

UNDERDAMPED $\Rightarrow$ RESPONSE OF FORM

$v(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$

INITIAL CONDITION: $v(0) = 0 \Rightarrow A_1 + A_2 = 0$

INITIAL CONDITION:

$$C \frac{dv}{dt}\bigg|_{t=0^+} = i_C(0^+) = C(A_1 s_1 + A_2 s_2)$$

KCL AT UPPER NODE (AT $t=0^+$):

$$-24\,mA + i_C(0^+) + i_L(0^+) + \frac{v(0^+)}{4R} = 0$$

$i_L(0^+)$: INDUCTOR CURRENT CANNOT CHANGE INSTANTANEOUSLY $\Rightarrow i_L(0^+)=0$

$v(0^+)$: FROM NO INITIAL ENERGY, $v(0^+)=0$

$\therefore\ i_C(0^+) = 24\,mA$

$$24\,mA = C(A_1 s_1 + A_2 s_2)$$

BUT $A_2 = -A_1$

$$\frac{24\,mA}{25\,nF} = -20{,}000A_1 + 80{,}000A_1 = +60{,}000A_1$$

$$A_1 = \frac{24\,mA}{(25\,nF)(+60{,}000)} = +16\,V$$

$$v(t) = +16e^{-20{,}000t} - 16e^{-80{,}000t}\ V;\ t \geq 0$$

FOR t IN ms,

a) $v(t) = +16(e^{-20t} - e^{-80t})\ V;\ t \geq 0$

b) $i_R(t) = \dfrac{v(t)}{R} = +40(e^{-20t} - e^{-80t})\,\text{mA};\ t \geq 0$

t IN ms

c) $i_c(t) = C\dfrac{dv}{dt}$

$= 25\text{nF}\dfrac{d}{dt}\left[+16(e^{-20,000t} - e^{-80,000t})\right]$

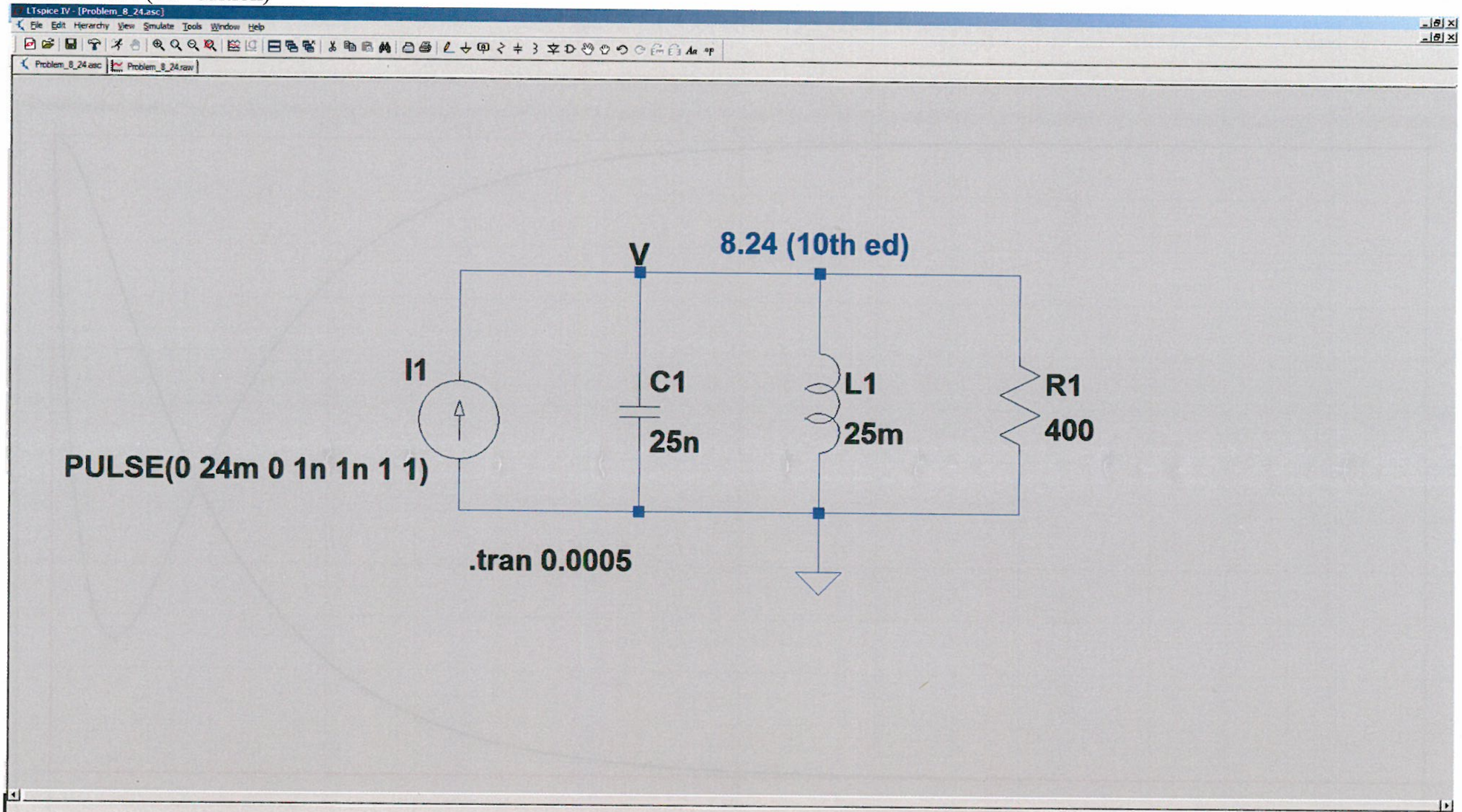
$= 25\text{nF}\left[+16(-20,000)e^{-20,000t} - 16(-80,000)e^{-80,000t}\right]$

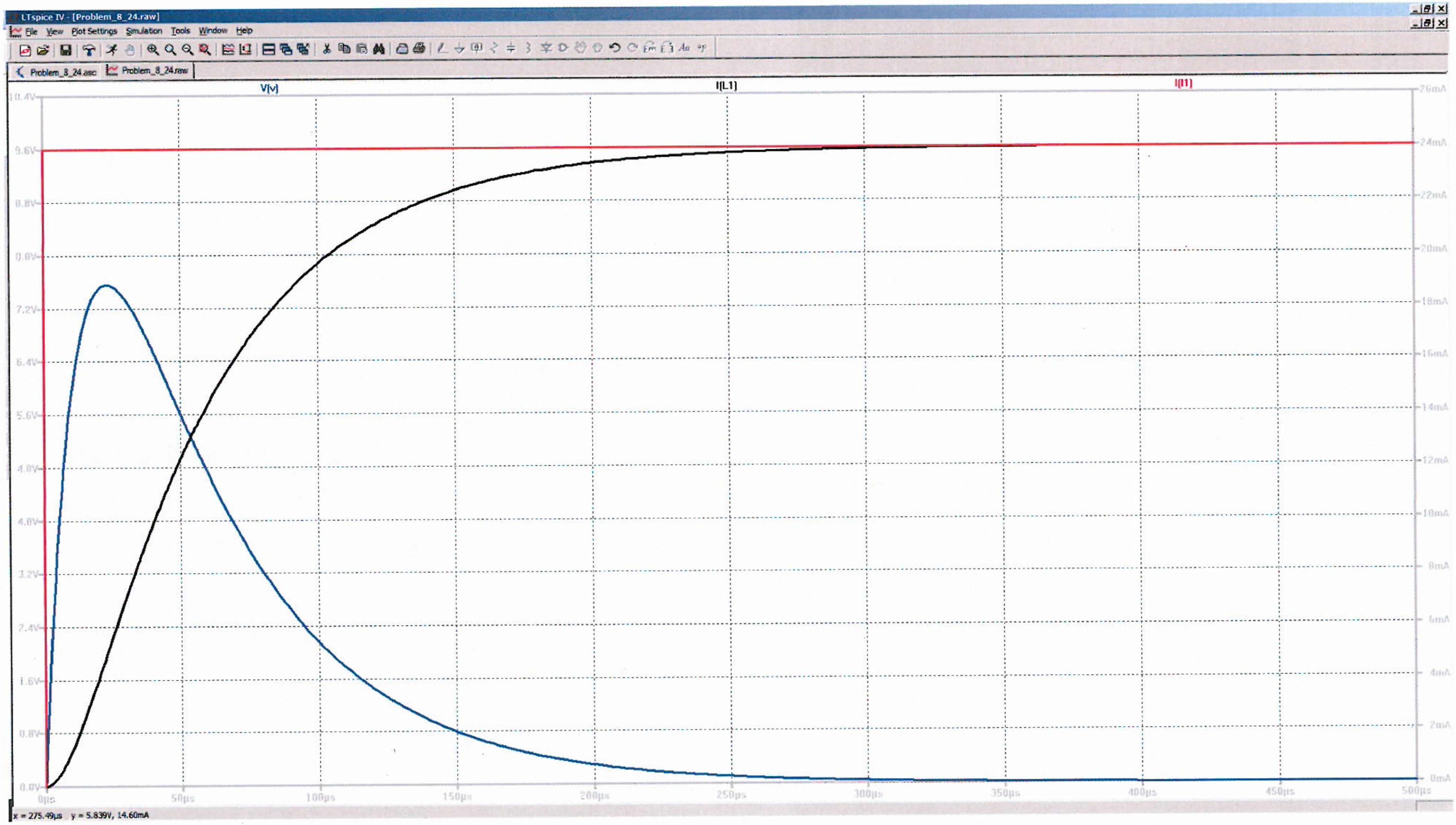
$= (-8e^{-20,000t} + 32e^{-80,000t})\,\text{mA};\ t \geq 0$

CHECK FOR $t=0$:

$i_c(0) = 24\,\text{mA}$ ✓

Problem 8.24 (10^{th} edition)

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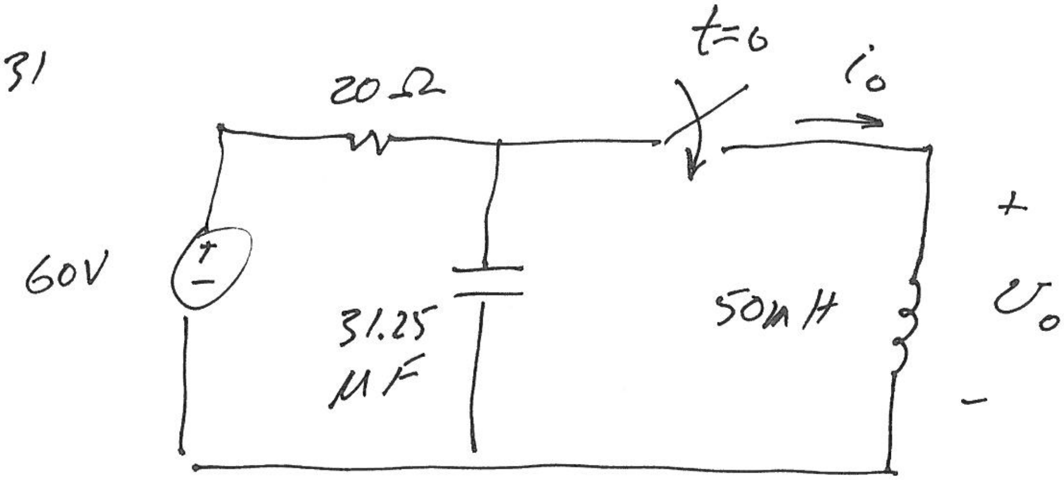
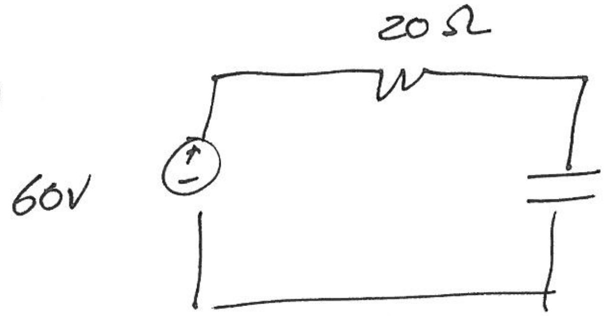
File View Plot Settings Simulation Tools Window Help
Problem_8_24.asc
Problem_8_24.raw
V(v)
I(L1)
I(I1)
10.4V
9.6V
8.8V
8.0V
7.2V
6.4V
5.6V
4.8V
4.0V
3.2V
2.4V
1.6V
0.8V
0.0V
26mA
24mA
22mA
20mA
18mA
16mA
14mA
12mA
10mA
8mA
6mA
4mA
2mA
0mA
0µs
50µs
100µs
150µs
200µs
250µs
300µs
350µs
400µs
450µs
500µs
x = 275.49µs y = 5.839V, 14.60mA

8.31



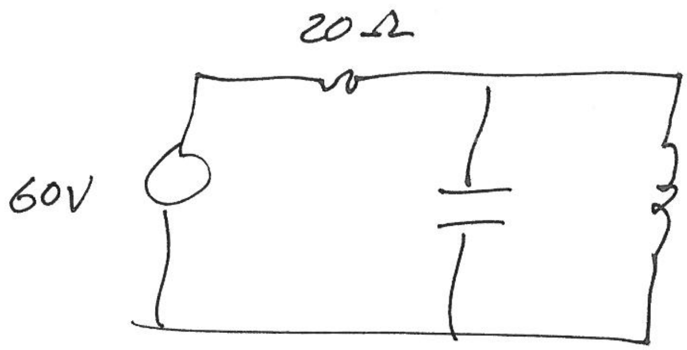
FIND $i_o(t)$

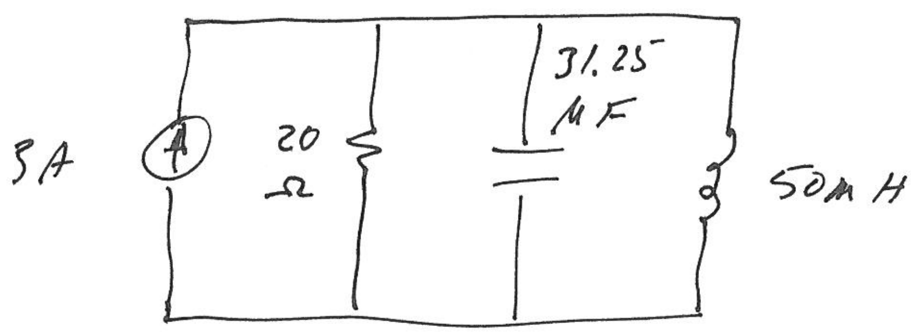
$t<0$



$v_c(0) = 60V$

$t \geq 0$





8.31, CONT'D.

PARALLEL RLC

$$s_i = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = 800 \text{ RAD/S}$$

$$\alpha = \frac{1}{2RC} = 800 \text{ NP/S}$$

$\Rightarrow$ CRITICAL DAMPING

$$i_o(t) = I_F + D_1 t e^{-\alpha t} + D_2 e^{-\alpha t}$$

$$I_F = 3A$$

$$v_o(0) = L \left. \frac{di_o(t)}{dt} \right|_{t=0}$$

$$= L \frac{d}{dt}\left(I_F + D_1 t e^{-\alpha t} + D_2 e^{-\alpha t}\right)\Big|_{t=0}$$

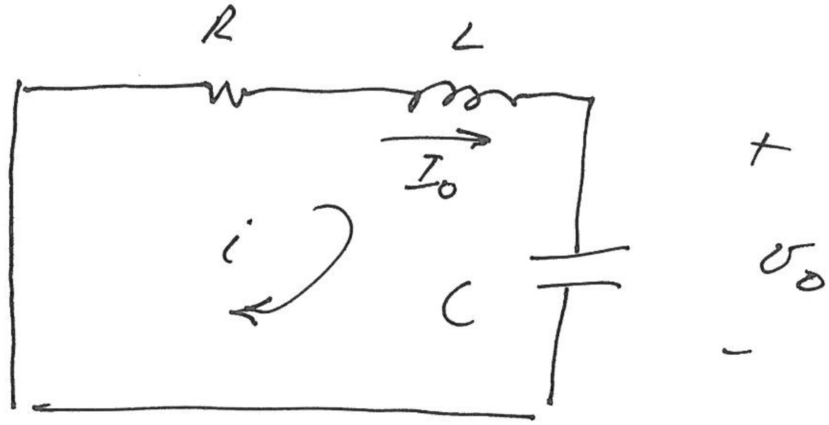
$$= L\left(-\alpha D_1 t e^{-\alpha t} + D_1 e^{-\alpha t} - \alpha D_2 e^{-\alpha t}\right)\Big|_{t=0}$$

$$v_o(0) = L(D_1 - \alpha D_2) = 60V$$

$$i_o(0) = 0 = I_F + D_2 \Rightarrow D_2 = -3A$$

$$D_1 = \frac{60V}{L} + \alpha D_2 = -1{,}200 \text{ A/S}$$

$$i_o(t) = 3 - 1{,}200te^{-800t} - 3e^{-800t}; \; t \geq 0$$



GIVEN: $i(t) = B_1 e^{-2{,}000t} \cos 1{,}500t$

$+ B_2 e^{-2{,}000t} \sin 1{,}500t$

THIS IS A NATURAL RESPONSE

$C = 80\,nF \qquad I_0 = 7.5\,mA$

$v_0(0) = -30V$

FIND: R, L, B_1 & B_2

SERIES RLC WITH UNDERDAMPED RESPONSE

$$\alpha = \frac{R}{2L} = 2{,}000\ Np/s$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$\omega_d = \sqrt{\omega_0^2 - \alpha^2} = 1{,}500\ RAD/s$$

$$\omega_0^2 - \alpha^2 = (1{,}500)^2$$

8.39, CONT'D.

$$\omega_0^2 = (1500)^2 + (2000)^2 = \frac{1}{LC}$$

$$L = \frac{1}{C[(1500)^2 + (2000)^2]}$$

$$\boxed{L = 2H}$$

$$\frac{R}{2L} = 2{,}000 \Rightarrow R = 2(2{,}000)L$$

$$\boxed{R = 8k\,\Omega}$$

$$i(0) = I_0 = B_1 \qquad \boxed{B_1 = 7.5mA}$$

MESH EQ AT $t=0$:

$$-I_0 R - L\frac{di}{dt}\Big|_{t=0} - V_0 = 0$$

NEED $\frac{di}{dt}\Big|_{t=0}$

$$\frac{di}{dt} = \frac{d}{dt}\left[e^{-2{,}000t}(B_1 \cos\omega_d t + B_2 \sin\omega_d t\right]$$

8.39, CONT'D.

$$\frac{di}{dt} = -2{,}000e^{-2{,}000t}(B_1 \cos\omega_d t + B_2 \sin\omega_d t)$$
$$+ e^{-2{,}000t}(-B_1 \omega_d \sin\omega_d t + B_2 \omega_d \cos\omega_d t)$$

$$\left.\frac{di}{dt}\right|_{t=0} = -2{,}000 B_1 + \omega_d B_2$$

NOW $L \left.\frac{di}{dt}\right|_{t=0} = -I_0 R - V_0$

$$B_2 = \frac{\frac{-I_0 R - V_0}{L} + 2{,}000 B_1}{1{,}500} = 0$$

$$\boxed{B_2 = 0}$$