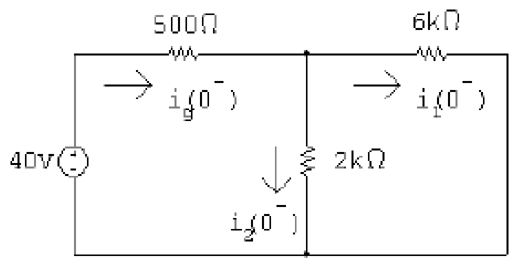
EENG 281 Homework #8 Solutions
Fall 2013

P 7.4 [a] $t < 0$



$2\,\text{k}\Omega \| 6\,\text{k}\Omega = 1.5\,\text{k}\Omega$

Find the current from the voltage source by combining the resistors in series and parallel and using Ohm's law:

$$i_g(0^-) = \frac{40}{(1500 + 500)} = 20\,\text{mA}$$

Find the branch currents using current division:

$$i_1(0^-) = \frac{2000}{8000}(0.02) = 5\,\text{mA}$$

$$i_2(0^-) = \frac{6000}{8000}(0.02) = 15\,\text{mA}$$

[b] The current in an inductor is continuous. Therefore,

$$i_1(0^+) = i_1(0^-) = 5\,\text{mA}$$

$$i_2(0^+) = -i_1(0^+) = -5\,\text{mA} \qquad \text{(when switch is open)}$$

[c] $\tau = \dfrac{L}{R} = \dfrac{0.4 \times 10^{-3}}{8 \times 10^3} = 5 \times 10^{-5}\,\text{s}; \qquad \dfrac{1}{\tau} = 20{,}000$

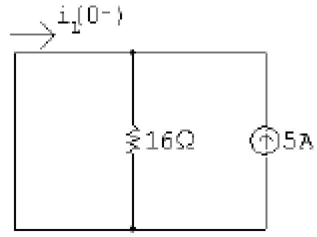
$$i_1(t) = i_1(0^+)e^{-t/\tau} = 5e^{-20{,}000t}\,\text{mA}, \qquad t \geq 0$$

[d] $i_2(t) = -i_1(t) \qquad \text{when} \quad t \geq 0^+$

$$\therefore \quad i_2(t) = -5e^{-20{,}000t}\,\text{mA}, \qquad t \geq 0^+$$

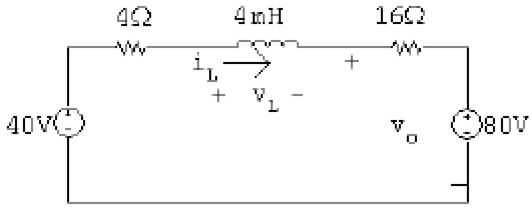
[e] The current in a resistor can change instantaneously. The switching operation forces $i_2(0^-)$ to equal 15 mA and $i_2(0^+) = -5\,\text{mA}$.

P 7.35 **[a]** $t < 0$



$$i_L(0^-) = -5\,\text{A}$$

$t > 0$



$$i_L(\infty) = \frac{40 - 80}{4 + 16} = -2\,\text{A}$$

$$\tau = \frac{L}{R} = \frac{4 \times 10^{-3}}{4 + 16} = 200\,\mu\text{s}; \qquad \frac{1}{\tau} = 5000$$

$$i_L = i_L(\infty) + [i_L(0^+) - i_L(\infty)]e^{-t/\tau}$$

$$= -2 + (-5 + 2)e^{-5000t} = -2 - 3e^{-5000t}\,\text{A}, \qquad t \geq 0$$

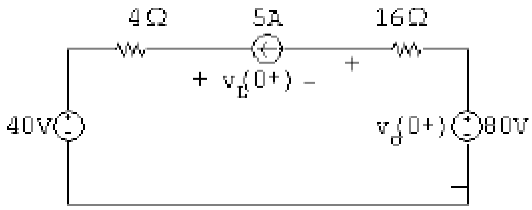
$$v_o = 16i_L + 80 = 16(-2 - 3e^{-5000t}) + 80 = 48 - 48e^{-5000t}\,\text{V}, \qquad t \geq 0$$

[b] $v_L = L\dfrac{di_L}{dt} = 4 \times 10^{-3}(-5000)[-3e^{-5000t}] = 60e^{-5000t}\,\text{V}, \qquad t \geq 0^+$

$$v_L(0^+) = 60\,\text{V}$$

From part (a) $\qquad v_o(0^+) = 0\,\text{V}$

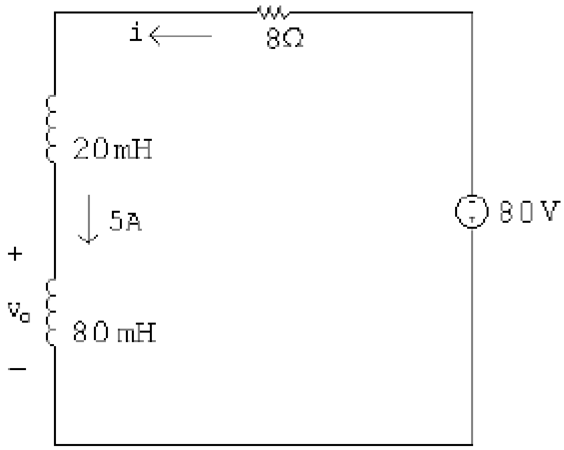
Check: at $t = 0^+$ the circuit is:



$$v_L(0^+) = 40 + (5\,\text{A})(4\,\Omega) = 60\,\text{V}, \qquad v_o(0^+) = 80 - (16\,\Omega)(5\,\text{A}) = 0\,\text{V}$$

P 7.43 For $t < 0$, $\quad i_{80\text{mH}}(0) = 50\,\text{V}/10\,\Omega = 5\,\text{A}$

For $t > 0$, after making a Thévenin equivalent we have



$$i = \frac{V_s}{R} + \left(I_o - \frac{V_s}{R}\right) e^{-t/\tau}$$

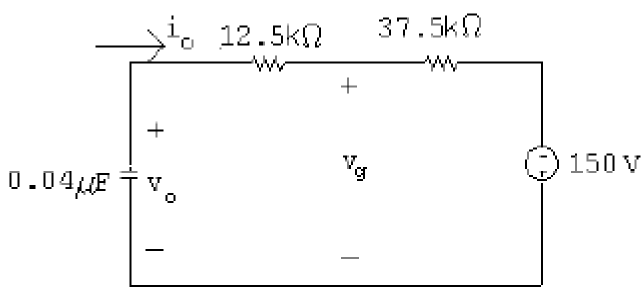
$$\frac{1}{\tau} = \frac{R}{L} = \frac{8}{100 \times 10^{-3}} = 80$$

$$I_o = 5\,\text{A}; \qquad I_f = \frac{V_s}{R} = \frac{-80}{8} = -10\,\text{A}$$

$$i = -10 + (5 + 10)e^{-80t} = -10 + 15e^{-80t}\,\text{A}, \qquad t \geq 0$$

$$v_o = 0.08\frac{di}{dt} = 0.08(-1200e^{-80t}) = -96e^{-80t}\,\text{V}, \qquad t \geq 0^+$$

P 7.52 [a] $v_o(0^-) = v_o(0^+) = 120\,\text{V}$



$$v_o(\infty) = -150\,\text{V}; \qquad \tau = 2\,\text{ms}; \qquad \frac{1}{\tau} = 500$$

$$v_o = -150 + (120 - (-150))e^{-500t}$$

$$v_o = -150 + 270e^{-500t}\,\text{V}, \qquad t \geq 0$$

[b] $i_o = -0.04 \times 10^{-6}(-500)[270e^{-500t}] = 5.4e^{-500t}\,\text{mA}, \qquad t \geq 0^+$

[c] $v_g = v_o - 12.5 \times 10^3 i_o = -150 + 202.5e^{-500t}\,\text{V}$

[d] $v_g(0^+) = -150 + 202.5 = 52.5\,\text{V}$

Checks:

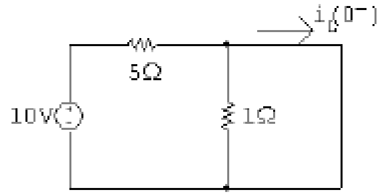
$$v_g(0^+) = i_o(0^+)[37.5 \times 10^3] - 150 = 202.5 - 150 = 52.5\,\text{V}$$

$$i_{50k} = \frac{v_g}{50\text{k}} = -3 + 4.05e^{-500t}\,\text{mA}$$

$$i_{150k} = \frac{v_g}{150\text{k}} = -1 + 1.35e^{-500t}\,\text{mA}$$

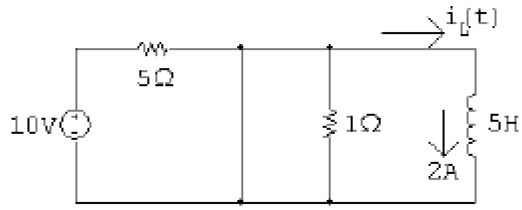
$$-i_o + i_{50k} + i_{150k} + 4 = 0 \qquad \text{(ok)}$$

P 7.70 $t < 0$:



$$i_L(0^-) = 10\,\mathrm{V}/5\,\Omega = 2\,\mathrm{A} = i_L(0^+)$$

$0 \leq t \leq 5$:

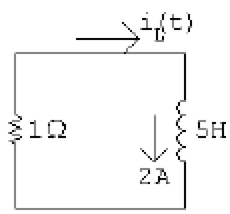


$$\tau = 5/0 = \infty$$

$$i_L(t) = 2e^{-t/\infty} = 2e^{-0} = 2$$

$$i_L(t) = 2\,\mathrm{A} \quad 0 \leq t \leq 5\,\mathrm{s}$$

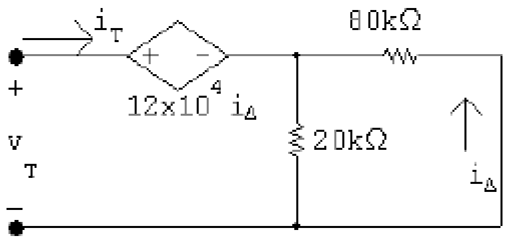
$5 \leq t < \infty$:



$$\tau = \frac{5}{1} = 5\,\mathrm{s}; \qquad 1/\tau = 0.2$$

$$i_L(t) = 2e^{-0.2(t-5)}\,\mathrm{A}, \quad t \geq 5\,\mathrm{s}$$

P 7.84 $t > 0$:



$$v_T = 12 \times 10^4 i_\Delta + 16 \times 10^3 i_T$$

$$i_\Delta = -\frac{20}{100} i_T = -0.2 i_T$$

$$\therefore \quad v_T = -24 \times 10^3 i_T + 16 \times 10^3 i_T$$

$$R_{\text{Th}} = \frac{v_T}{i_T} = -8\,\text{k}\Omega$$

$$\tau = RC = (-8 \times 10^3)(2.5 \times 10^{-6}) = -0.02 \quad 1/\tau = -50$$

$$v_c = 20e^{50t}\,\text{V}; \qquad 20e^{50t} = 20{,}000$$

$$50t = \ln 1000 \quad \therefore \qquad t = 138.16\,\text{ms}$$