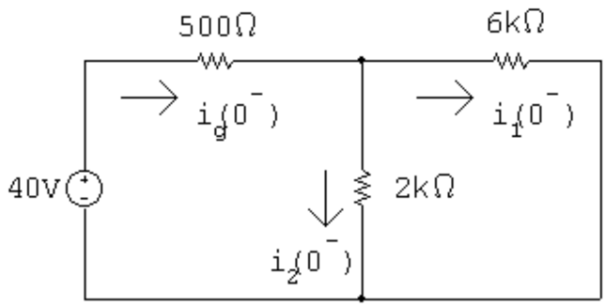
P 7.1 [a] $t < 0$:



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

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

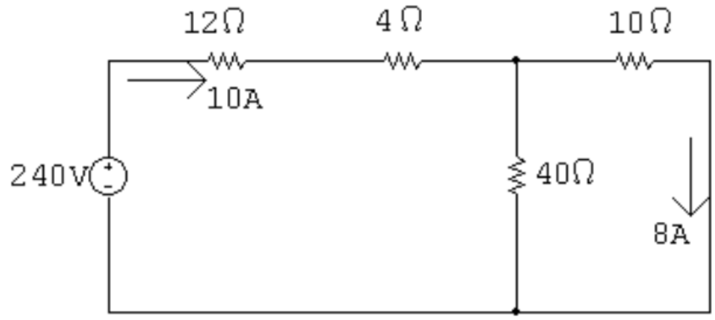
$$i_1(t) = i_1(0^+)e^{-t/\tau} = 5e^{-20{,}000t}\,\text{mA}, \qquad t \geq 0.$$

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

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

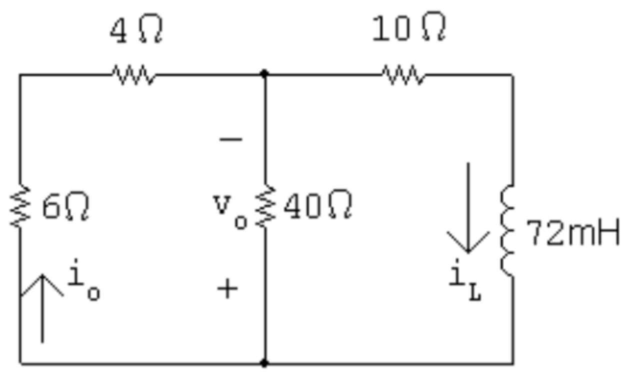
[e] The current in a resistor can change instantaneously. The switching operation forces $i_2(0^-)$ to equal 15 mA and $i_2(0^+) = -5$ mA.

P 7.5 $\quad t < 0$:



$i_L(0^+) = 8\,\text{A}.$

$t > 0$:



$$R_e = \frac{(10)(40)}{50} + 10 = 18\,\Omega;$$

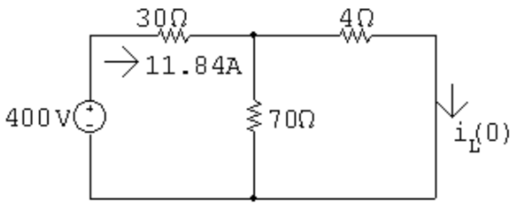
$$\tau = \frac{L}{R_e} = \frac{0.072}{18} = 4\,\text{ms}; \qquad \frac{1}{\tau} = 250;$$

$$\therefore \quad i_L = 8e^{-250t}\,\text{A}.$$

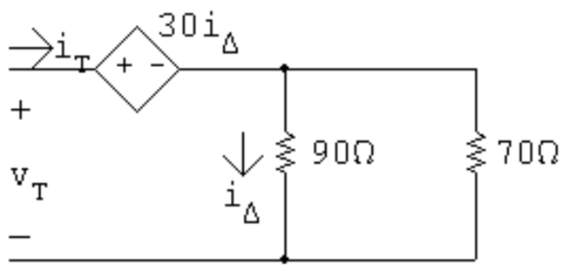
$$\therefore \quad v_o = -10 i_L - 0.072\frac{di_L}{dt} = -80e^{-250t} + 144e^{-250t}$$

$$= 64e^{-250t}\,\text{A} \quad t \geq 0^+.$$

P 7.15 **[a]** $t < 0:$



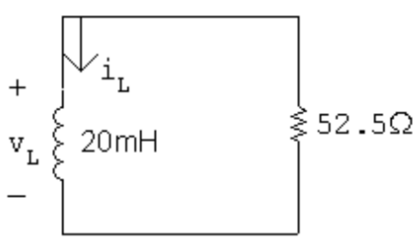
$$i_L(0^-) = i_L(0^+) = \frac{70}{70+4}(11.84) = 11.2\,\text{A}.$$



$$i_\Delta = \frac{70}{160} i_T = 0.4375 i_T;$$

$$v_T = 30 i_\Delta + i_T \frac{(90)(70)}{160} = 30(0.4375) i_T + \frac{(90)(70)}{160} i_T = 52.5 i_T;$$

$$\frac{v_T}{i_T} = R_{\text{Th}} = 52.5\,\Omega.$$

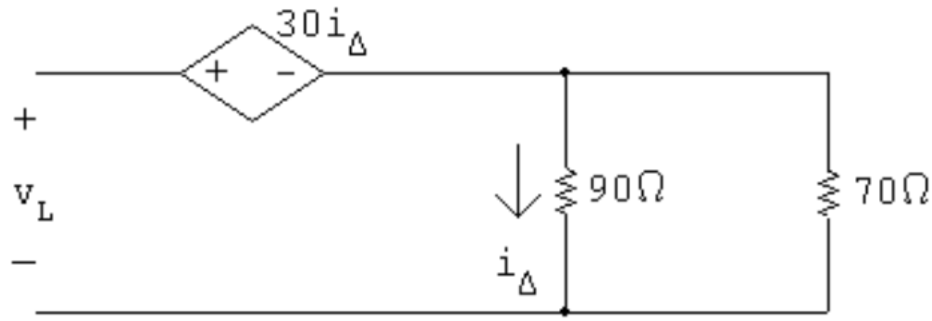


$$\tau = \frac{L}{R} = \frac{20 \times 10^{-3}}{52.5} = \quad \therefore \qquad \frac{1}{\tau} = 2625;$$

$$i_L = 11.2 e^{-2625t}\,\text{A}, \qquad t \geq 0.$$

[b] $v_L = L\dfrac{di_L}{dt} = 20 \times 10^{-3}(-2625)(11.2 e^{-2625t}) = -588 e^{-2625t}\,\text{V}, \quad t \geq 0^+.$

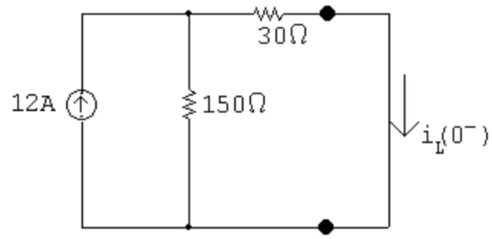
[c]



$$v_L = 30i_\Delta + 90i_\Delta = 120i_\Delta;$$

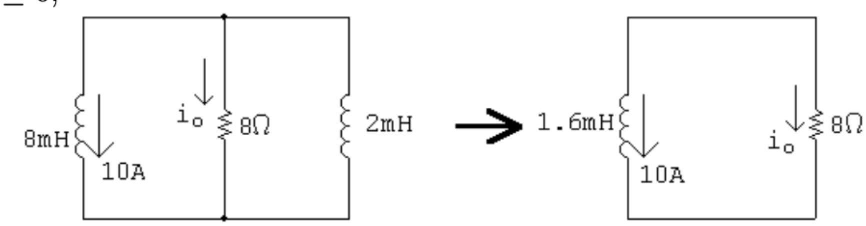
$$i_\Delta = \frac{v_L}{120} = -4.9e^{-2625t}\,\mathrm{A} \qquad t \geq 0^+.$$

P 7.18 **[a]** $t < 0$:



$$i_L(0^-) = \frac{150}{180}(12) = 10\,\text{A}.$$

$t \geq 0$;



$$\tau = \frac{1.6 \times 10^{-3}}{8} = 200 \times 10^{-6}; \qquad 1/\tau = 5000;$$

$$i_o = -10e^{-5000t}\,\text{A} \quad t \geq 0.$$

[b] $w_{\text{del}} = \frac{1}{2}(1.6 \times 10^{-3})(10)^2 = 80\,\text{mJ}.$

[c] $0.95w_{\text{del}} = 76\,\text{mJ};$

$$\therefore \quad 76 \times 10^{-3} = \int_0^{t_o} 8(100e^{-10{,}000t})\,dt;$$

$$\therefore \quad 76 \times 10^{-3} = -80 \times 10^{-3}e^{-10{,}000t}\Big|_0^{t_o} = 80 \times 10^{-3}(1 - e^{-10{,}000t_o});$$

$$\therefore \quad e^{-10{,}000t_o} = 0.05 \quad \text{so} \quad t_o = 299.57\,\mu\text{s};$$

$$\therefore \quad \frac{t_o}{\tau} = \frac{299.57 \times 10^{-6}}{200 \times 10^{-6}} = 1.498 \quad \text{so} \quad t_o \approx 1.498\tau.$$

P 7.22 [a] Calculate the initial voltage drop across the capacitor:

$$v(0) = (2.7\,\text{k}\|3.3\,\text{k})(40\,\text{mA}) = (1485)(40 \times 10^{-3}) = 59.4\,\text{V}.$$

The equivalent resistance seen by the capacitor is

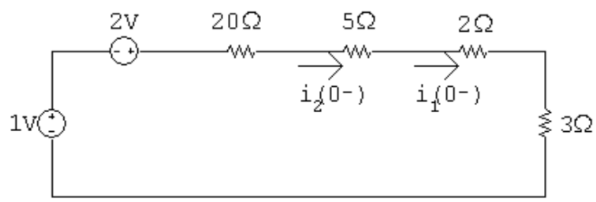
$$R_e = 3\,\text{k}\|(2.4\,\text{k} + 3.6\,\text{k}) = 3\,\text{k}\|6\,\text{k} = 2\,\text{k}\Omega;$$

$$\tau = R_eC = (2000)(0.5 \times 10^{-6}) = 1000\,\mu\text{s}; \qquad \frac{1}{\tau} = 1000;$$

$$v = v(0)e^{-t/\tau} = 59.4e^{-1000t}\,\text{V} \qquad t \geq 0.$$

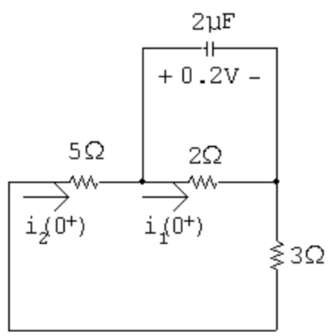
[b] $$i = \frac{v}{2.4\,\text{k} + 3.6\,\text{k}} = 9.9e^{-1000t}\,\text{mA}, \quad t \geq 0^+.$$

P 7.25 [a] $t < 0$:



$$i_1(0^-) = i_2(0^-) = \frac{3}{30} = 100\,\text{mA}.$$

[b] $t > 0$:



$$i_1(0^+) = \frac{0.2}{2} = 100\,\text{mA};$$

$$i_2(0^+) = \frac{-0.2}{8} = -25\,\text{mA}.$$

[c] Capacitor voltage cannot change instantaneously, therefore,

$$i_1(0^-) = i_1(0^+) = 100\,\text{mA}.$$

[d] Switching can cause an instantaneous change in the current in a resistive branch. In this circuit

$$i_2(0^-) = 100\,\text{mA} \quad \text{and} \quad i_2(0^+) = 25\,\text{mA}.$$

[e] $v_c = 0.2e^{-t/\tau}\,\text{V}, \qquad t \geq 0;$

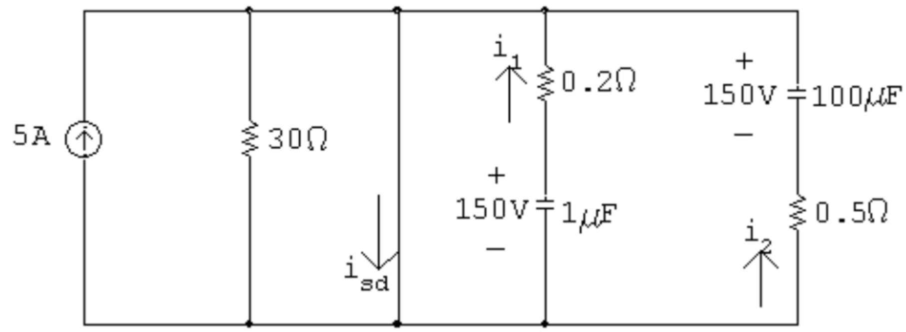
$$\tau = R_eC = 1.6(2 \times 10^{-6}) = 3.2\,\mu\text{s}; \qquad \frac{1}{\tau} = 312{,}500;$$

$$v_c = 0.2e^{-312{,}000t}\,\text{V}, \qquad t \geq 0;$$

$$i_1 = \frac{v_c}{2} = 0.1e^{-312{,}000t}\,\text{A}, \qquad t \geq 0.$$

[f] $i_2 = \dfrac{-v_c}{8} = -25e^{-312{,}000t}\,\text{mA}, \qquad t \geq 0^+.$

P 7.34 [a] At $t = 0^-$ the voltage on each capacitor will be $150\,\text{V}(5 \times 30)$, positive at the upper terminal. Hence at $t \geq 0^+$ we have



$$\therefore \quad i_{sd}(0^+) = 5 + \frac{150}{0.2} + \frac{150}{0.5} = 1055\,\text{A}.$$

At $t = \infty$, both capacitors will have completely discharged.

$$\therefore \quad i_{sd}(\infty) = 5\,\text{A}.$$

[b] $i_{sd}(t) = 5 + i_1(t) + i_2(t)$;

$$\tau_1 = 0.2(10^{-6}) = 0.2\,\mu\text{s};$$

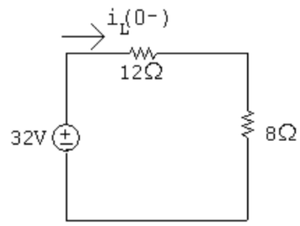
$$\tau_2 = 0.5(100 \times 10^{-6}) = 50\,\mu\text{s};$$

$$\therefore \quad i_1(t) = 750e^{-5\times 10^6 t}\,\text{A}, \qquad t \geq 0^+;$$

$$i_2(t) = 300e^{-20{,}000t}\,\text{A}, \qquad t \geq 0;$$

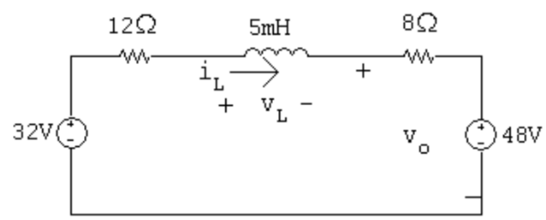
$$\therefore \quad i_{sd} = 5 + 750e^{-5\times 10^6 t} + 300e^{-20{,}000t}\,\text{A}, \qquad t \geq 0^+.$$

P 7.38 [a] $t < 0$:



$$i_L(0^-) = \frac{32}{20} = 1.6\,\text{A}.$$

$t > 0$:



$$i_L(\infty) = \frac{32 - 48}{12 + 8} = -0.8\,\text{A};$$

$$\tau = \frac{L}{R} = \frac{5 \times 10^{-3}}{12 + 8} = 250\,\mu\text{s}; \qquad \frac{1}{\tau} = 4000;$$

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

$$= -0.8 + (1.6 + 0.8)e^{-4000t} = -0.8 + 2.4e^{-4000t}\,\text{A}, \qquad t \geq 0.$$

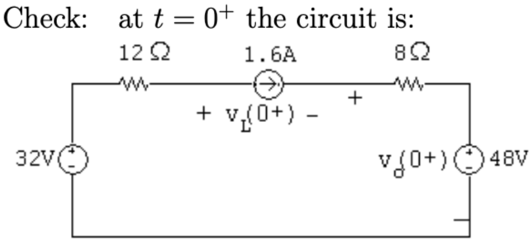
$$v_o = 8i_L + 48 = 8(-0.8 + 2.4e^{-4000t}) + 48 = 41.6 + 19.2e^{-4000t}\,\text{V}, \qquad t \geq 0.$$

[b] $v_L = L\dfrac{di_L}{dt} = 5 \times 10^{-3}(-4000)[2.4e^{-4000t}] = -48e^{-4000t}\,\text{V}, \qquad t \geq 0^+$

$v_L(0^+) = -48\,\text{V}.$

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

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



$v_o(0^+) = 48 + (8\,\Omega)(1.6\,\text{A}) = 60.8\,\text{V}; \qquad v_{\text{L}}(0^+) + v_o(0^+) = 12(-1.6) + 32;$

$\therefore \qquad v_{\text{L}}(0^+) = -19.2 + 32 - 60.8 = -48\,\text{V}.$