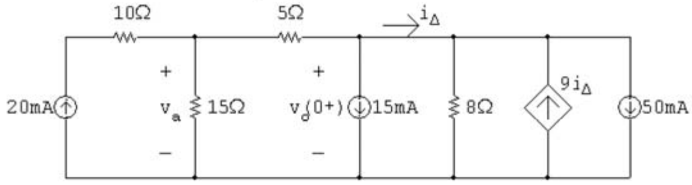
P 7.41 $t > 0$; calculate $v_o(0^+)$



$$\frac{v_a}{15} + \frac{v_a - v_o(0^+)}{5} = 20 \times 10^{-3}$$

$$\therefore \quad v_a = 0.75 v_o(0^+) + 75 \times 10^{-3}$$

$$15 \times 10^{-3} + \frac{v_o(0^+) - v_a}{5} + \frac{v_o(0^+)}{8} - 9i_\Delta + 50 \times 10^{-3} = 0$$

$$13v_o(0^+) - 8v_a - 360 i_\Delta = -2600 \times 10^{-3}$$

$$i_\Delta = \frac{v_o(0^+)}{8} - 9i_\Delta + 50 \times 10^{-3}$$

$$\therefore \quad i_\Delta = \frac{v_o(0^+)}{80} + 5 \times 10^{-3}$$

$$\therefore \quad 360 i_\Delta = 4.5 v_o(0^+) + 1800 \times 10^{-3}$$

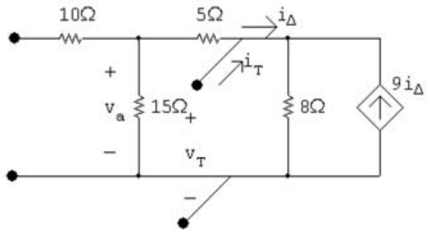
$$8v_a = 6v_o(0^+) + 600 \times 10^{-3}$$

$$\therefore \quad 13v_o(0^+) - 6v_o(0^+) - 600 \times 10^{-3} - 4.5v_o(0^+) -$$
$$1800 \times 10^{-3} = -2600 \times 10^{-3}$$

$$2.5v_o(0^+) = -200 \times 10^{-3}; \qquad v_o(0^+) = -80\,\text{mV}$$

$$v_o(\infty) = 0$$

Find the Thévenin resistance seen by the 4 mH inductor:



$$i_T = \frac{v_T}{20} + \frac{v_T}{8} - 9i_\Delta$$

$$i_\Delta = \frac{v_T}{8} - 9i_\Delta \qquad \therefore \quad 10i_\Delta = \frac{v_T}{8}; \qquad i_\Delta = \frac{v_T}{80}$$

$$i_T = \frac{v_T}{20} + \frac{10v_T}{80} - \frac{9v_T}{80}$$

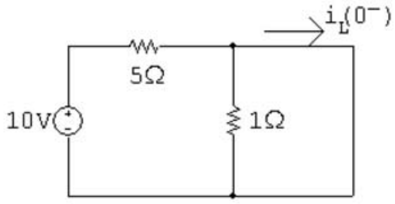
$$\frac{i_T}{v_T} = \frac{1}{20} + \frac{1}{80} = \frac{5}{80} = \frac{1}{16}\,\text{S}$$

$$\therefore \quad R_{Th} = 16\Omega$$

$$\tau = \frac{4 \times 10^{-3}}{16} = 0.25\,\text{ms}; \qquad 1/\tau = 4000$$

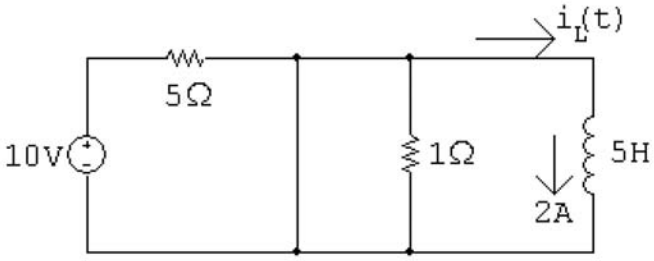
$$\therefore \quad v_o = 0 + (-80 - 0)e^{-4000t} = -80e^{-4000t}\,\text{mV}, \qquad t \geq 0^+$$

P 7.70 $t < 0$:



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

$0 \le t \le 5$:

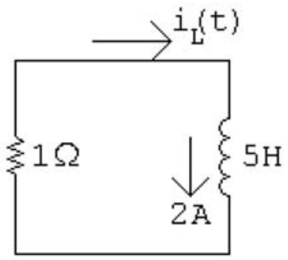


$$\tau = 5/0 = \infty$$

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

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

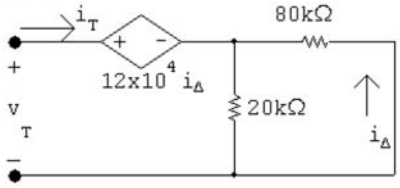
$5 \le t < \infty$:



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

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

P 7.84 $t > 0$:



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

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

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

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

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

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

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

P 8.10 $\alpha = 500/2 = 250$

$$R = \frac{1}{2\alpha C} = \frac{10^6}{(500)(2.5)} = 800\,\Omega$$

$$v(0^+) = -11 + 20 = 9\,\text{V}$$

$$i_R(0^+) = \frac{9}{800} = 11.25\,\text{mA}$$

$$\frac{dv}{dt} = 1100e^{-100t} - 8000e^{-400t}$$

$$\frac{dv(0^+)}{dt} = 1100 - 8000 = -6900\,\text{V/s}$$

$$i_C(0^+) = 2.5 \times 10^{-6}(-6900) = -17.25\,\text{mA}$$

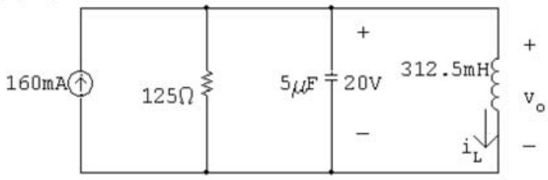
$$i_L(0^+) = -[i_R(0^+) + i_C(0^+)] = -[11.25 - 17.25] = 6\,\text{mA}$$

P 8.27 $t < 0$:

$$v_o(0^-) = v_o(0^+) = \frac{625}{781.25}(25) = 20\,\text{V}$$

$$i_L(0^-) = i_L(0^+) = 0$$

$t > 0$:



$$-160 \times 10^{-3} + \frac{20}{125} + i_C(0^+) + 0 = 0; \qquad \therefore\ i_C(0^+) = 0$$

$$\frac{1}{2RC} = \frac{1}{2(125)(5 \times 10^{-6})} = 800\,\text{rad/s}$$

$$\omega_o^2 = \frac{1}{LC} = \frac{1}{(312.5 \times 10^{-3})(5 \times 10^{-6})} = 64 \times 10^4$$

$$\therefore\ \alpha^2 = \omega_o^2 \quad \text{critically damped}$$

[a] $v_o = V_f + D_1' te^{-800t} + D_2' e^{-800t}$

$V_f = 0$

$$\frac{dv_o(0)}{dt} = -800D_2' + D_1' = 0$$

$v_o(0^+) = 20 = D_2'$

$D_1' = 800D_2' = 16{,}000\,\text{V/s}$

$\therefore\ v_o = 16{,}000te^{-800t} + 20e^{-800t}\,\text{V}, \quad t \geq 0^+$

[b] $i_L = I_f + D_3' te^{-800t} + D_4' e^{-800t}$

$$i_L(0^+) = 0; \qquad I_f = 160\,\text{mA}; \qquad \frac{di_L(0^+)}{dt} = \frac{20}{312.5 \times 10^{-3}} = 64\ \text{A/s}$$

$\therefore\ 0 = 160 + D_4'; \qquad D_4' = -160\,\text{mA};$

$-800D_4' + D_3' = 64; \qquad D_3' = -64\,\text{A/s}$

$\therefore\ i_L = 160 - 64{,}000te^{-800t} - 160e^{-800t}\,\text{mA} \qquad t \geq 0$

P 8.44 [a] $$\omega_o^2 = \frac{1}{LC} = \frac{10^9}{(125)(0.32)} = 25 \times 10^6$$

$$\alpha = \frac{R}{2L} = \omega_o = 5000\,\text{rad/s}$$

$\therefore\ R = (5000)(2)L = 1250\,\Omega$

[b] $i(0) = i_L(0) = 4\,\text{mA}$

$v_L(0) = 15 - (0.004)(1250) = 10\,\text{V}$

$$\frac{di}{dt}(0) = \frac{7.5}{0.125} = 80\ \text{A/s}$$

[c] $v_C = D_1 te^{-5000t} + D_2 e^{-5000t}$

$v_C(0) = D_2 = 15\,\text{V}$

$$\frac{dv_C}{dt}(0) = D_1 - 5000D_2 = \frac{i_C(0)}{C} = \frac{-i_L(0)}{C} = -12{,}500$$

$\therefore\ D_1 = 62{,}500\ \text{V/s}$

$v_C = 62{,}500te^{-5000t} + 15e^{-5000t}\,\text{V}, \qquad t \geq 0$