Circuits II

Ch13 Additional Problems Solution

AP 13.2 [a] $Z = 2000 + \dfrac{1}{Y} = 2000 + \dfrac{4 \times 10^7 s}{s^2 + 80{,}000s + 25 \times 10^8}$

$$= \frac{2000(s^2 + 10^5 s + 25 \times 10^8)}{s^2 + 80{,}000s + 25 \times 10^8} = \frac{2000(s + 50{,}000)^2}{s^2 + 80{,}000s + 25 \times 10^8}$$

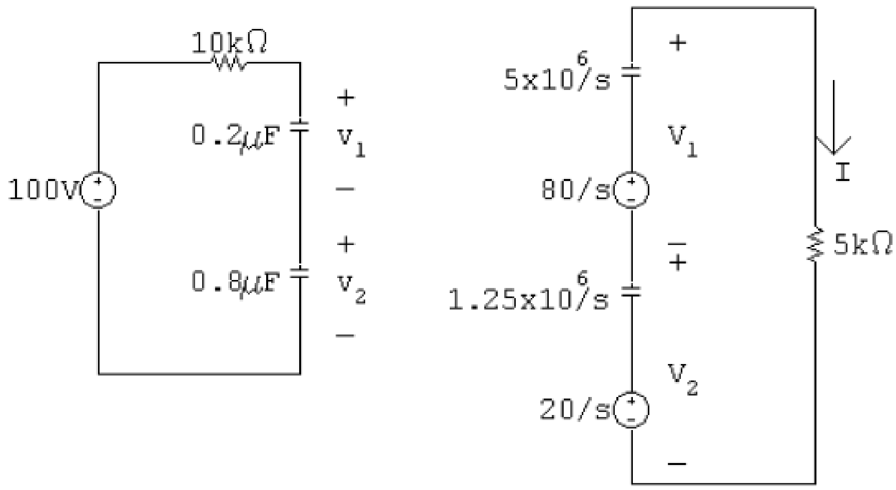
[b] $-z_1 = -z_2 = -50{,}000 \text{ rad/s}$

$-p_1 = -40{,}000 - j30{,}000 \text{ rad/s}$

$-p_2 = -40{,}000 + j30{,}000 \text{ rad/s}$

AP 13.3 [a] At $t = 0^-$, $\quad 0.2v_1 = (0.8)v_2; \quad v_1 = 4v_2; \quad v_1 + v_2 = 100\,\text{V}$

Therefore $\quad v_1(0^-) = 80V = v_1(0^+); \quad v_2(0^-) = 20V = v_2(0^+)$



$$I = \frac{(80/s) + (20/s)}{5000 + [(5 \times 10^6)/s] + (1.25 \times 10^6/s)} = \frac{20 \times 10^{-3}}{s + 1250}$$

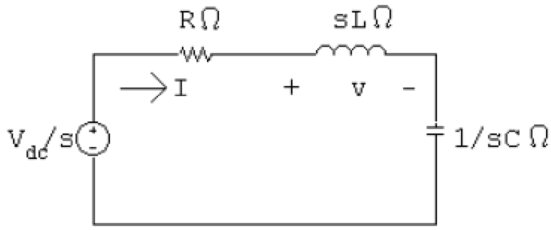
$$V_1 = \frac{80}{s} - \frac{5 \times 10^6}{s}\left(\frac{20 \times 10^{-3}}{s + 1250}\right) = \frac{80}{s + 1250}$$

$$V_2 = \frac{20}{s} - \frac{1.25 \times 10^6}{s}\left(\frac{20 \times 10^{-3}}{s + 1250}\right) = \frac{20}{s + 1250}$$

[b] $i = 20e^{-1250t}u(t)\,\text{mA}; \qquad v_1 = 80e^{-1250t}u(t)\,\text{V}$

$v_2 = 20e^{-1250t}u(t)\,\text{V}$

AP 13.4 [a]



$$I = \frac{V_{\mathrm{dc}}/s}{R + sL + (1/sC)} = \frac{V_{\mathrm{dc}}/L}{s^2 + (R/L)s + (1/LC)}$$

$$\frac{V_{\mathrm{dc}}}{L} = 40; \qquad \frac{R}{L} = 1.2; \qquad \frac{1}{LC} = 1.0$$

$$I = \frac{40}{(s + 0.6 - j0.8)(s + 0.6 + j0.8)} = \frac{K_1}{s + 0.6 - j0.8} + \frac{K_1^*}{s + 0.6 + j0.8}$$

$$K_1 = \frac{40}{j1.6} = -j25 = 25\underline{/-90^\circ}; \qquad K_1^* = 25\underline{/90^\circ}$$

[b] $i = 50e^{-0.6t}\cos(0.8t - 90^\circ) = [50e^{-0.6t}\sin 0.8t]u(t)\,\mathrm{A}$

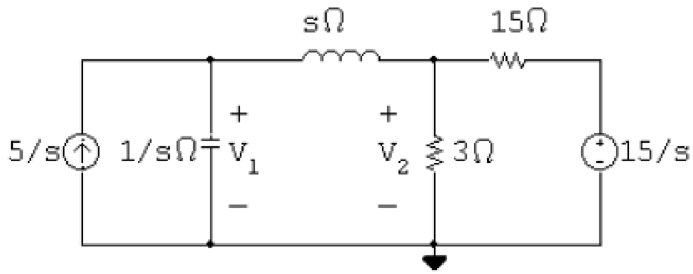
[c] $$V = sLI = \frac{160s}{(s + 0.6 - j0.8)(s + 0.6 + j0.8)}$$

$$= \frac{K_1}{s + 0.6 - j0.8} + \frac{K_1^*}{s + 0.6 + j0.8}$$

$$K_1 = \frac{160(-0.6 + j0.8)}{j1.6} = 100\underline{/36.87^\circ}$$

[d] $v(t) = [200e^{-0.6t}\cos(0.8t + 36.87^\circ)]u(t)\,\mathrm{V}$

AP 13.5 [a]



The two node voltage equations are

$$\frac{V_1 - V_2}{s} + V_1 s = \frac{5}{s} \quad \text{and} \quad \frac{V_2}{3} + \frac{V_2 - V_1}{s} + \frac{V_2 - (15/s)}{15} = 0$$

Solving for V_1 and V_2 yields

$$V_1 = \frac{5(s+3)}{s(s^2 + 2.5s + 1)}, \qquad V_2 = \frac{2.5(s^2+6)}{s(s^2 + 2.5s + 1)}$$

[b] The partial fraction expansions of V_1 and V_2 are

$$V_1 = \frac{15}{s} - \frac{50/3}{s+0.5} + \frac{5/3}{s+2} \quad \text{and} \quad V_2 = \frac{15}{s} - \frac{125/6}{s+0.5} + \frac{25/3}{s+2}$$

It follows that

$$v_1(t) = \left[15 - \frac{50}{3}e^{-0.5t} + \frac{5}{3}e^{-2t}\right] u(t)\,\text{V} \quad \text{and}$$

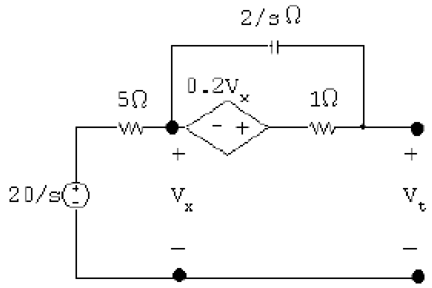
$$v_2(t) = \left[15 - \frac{125}{6}e^{-0.5t} + \frac{25}{3}e^{-2t}\right] u(t)\,\text{V}$$

[c] $v_1(0^+) = 15 - \frac{50}{3} + \frac{5}{3} = 0$

$$v_2(0^+) = 15 - \frac{125}{6} + \frac{25}{3} = 2.5\,\text{V}$$

[d] $v_1(\infty) = 15\,\text{V}; \qquad v_2(\infty) = 15\,\text{V}$

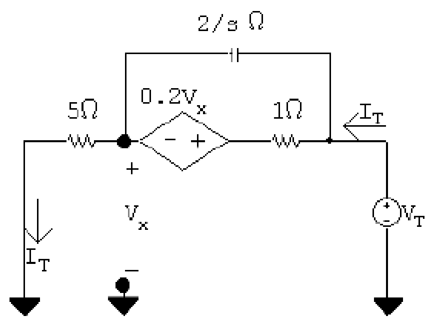
AP 13.6 [a]



With no load across terminals $a-b$ $\quad V_x = 20/s$:

$$\frac{1}{2}\left[\frac{20}{s} - V_{\text{Th}}\right]s + \left[1.2\left(\frac{20}{s}\right) - V_{\text{Th}}\right] = 0$$

therefore $\quad V_{\text{Th}} = \dfrac{20(s+2.4)}{s(s+2)}$



$V_x = 5I_T \quad$ and $\quad Z_{\text{Th}} = \dfrac{V_T}{I_T}$

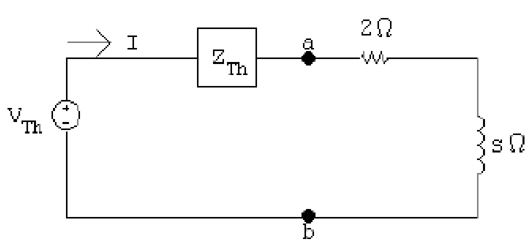
Solving for I_T gives

$$I_T = \frac{(V_T - 5I_T)s}{2} + V_T - 6I_T$$

Therefore

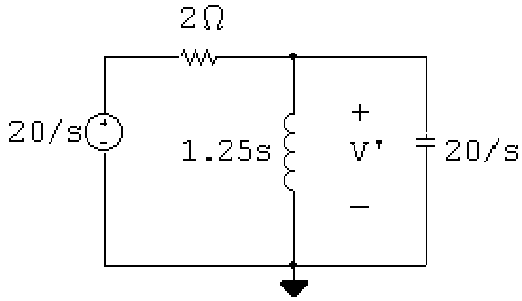
$14I_T = V_T s + 5sI_T + 2V_T; \qquad$ therefore $\quad Z_{\text{Th}} = \dfrac{5(s+2.8)}{s+2}$

[b]



$$I = \frac{V_{\text{Th}}}{Z_{\text{Th}} + 2 + s} = \frac{20(s+2.4)}{s(s+3)(s+6)}$$

AP 13.8 [a] The s-domain circuit with the voltage source acting alone is

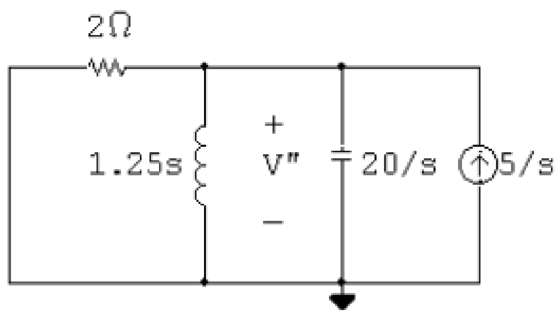


$$\frac{V' - (20/s)}{2} + \frac{V'}{1.25s} + \frac{V's}{20} = 0$$

$$V' = \frac{200}{(s+2)(s+8)} = \frac{100/3}{s+2} - \frac{100/3}{s+8}$$

$$v' = \frac{100}{3}[e^{-2t} - e^{-8t}]u(t)\,\mathrm{V}$$

[b] With the current source acting alone,



$$\frac{V''}{2} + \frac{V''}{1.25s} + \frac{V''s}{20} = \frac{5}{s}$$

$$V'' = \frac{100}{(s+2)(s+8)} = \frac{50/3}{s+2} - \frac{50/3}{s+8}$$

$$v'' = \frac{50}{3}[e^{-2t} - e^{-8t}]u(t)\,\mathrm{V}$$

[c] $v = v' + v'' = [50e^{-2t} - 50e^{-8t}]u(t)\,\mathrm{V}$

AP 13.9 [a] $\frac{V_o}{s+2} + \frac{V_o s}{10} = I_g;$ therefore $\frac{V_o}{I_g} = H(s) = \frac{10(s+2)}{s^2+2s+10}$

[b] $-z_1 = -2$ rad/s; $-p_1 = -1 + j3$ rad/s; $-p_2 = -1 - j3$ rad/s