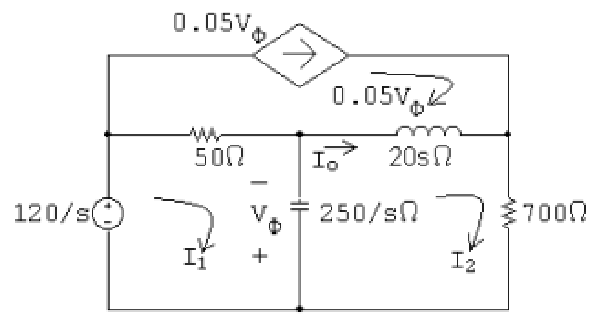
EENG382 HW05 – AUTHOR'S SOLUTIONS

NOTE: I have not yet verified that the author's solutions are, in fact, correct.

Prob 13.31

P 13.31 **[a]**



$$\frac{120}{s} = 50(I_1 - 0.05V_\phi) + \frac{250}{s}(I_1 - I_2)$$

$$\frac{250}{s} = 50I_1 - 2.5\left(\frac{250}{s}\right)(I_2 - I_1) + \frac{250}{s}I_1 - \frac{250}{s}I_2$$

Simplfying,

$$(50s + 875)I_1 - 875I_2 = 120$$

$$250(s - 1)I_1 + (20s^2 + 450s + 250)I_2 = 0$$

$$\Delta = \begin{vmatrix} (50s + 875) & -875 \\ 250(s - 1) & (20s^2 + 450s + 250) \end{vmatrix} = 1000s(s^2 + 40s + 625)$$

$$N_1 = \begin{vmatrix} 120 & -875 \\ 0 & (20s^2 + 450s + 250) \end{vmatrix} = 1200(2s^2 + 45s + 25)$$

$$N_2 = \begin{vmatrix} (50s + 875) & 120 \\ 250(s - 1) & 0 \end{vmatrix} = -30{,}000(s - 1)$$

$$I_1 = \frac{N_1}{\Delta} = \frac{1200(2s^2 + 45s + 25)}{s(s^2 + 40s + 625)}$$

$$I_2 = \frac{N_2}{\Delta} = \frac{-30{,}000(s - 1)}{s(s^2 + 40s + 625)}$$

Prob 13.31 (Cont'd)

$$I_o = I_2 - 0.05V_\phi = I_2 - 0.05\left[\frac{250}{s}(I_2 - I_1)\right]$$

$$I_2 - I_1 = \frac{-2400(s+35)}{s(s^2+40s+625)}$$

$$\frac{250}{s}(I_2 - I_1) = \frac{-600{,}000(s+35)}{s(s^2+40s+625)}$$

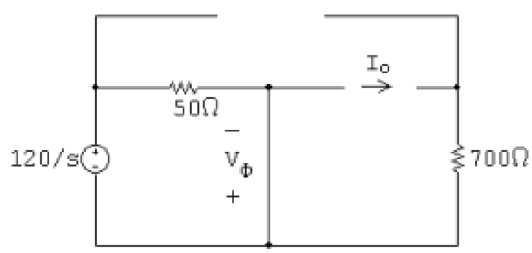
$$\therefore \qquad I_o = \frac{-30{,}000(s-1)}{s(s^2+40s+625)} + \frac{30{,}000(s+35)}{s(s^2+40s+625)} = \frac{1080}{s(s^2+40s+625)}$$

[b] $sI_o = \dfrac{1080}{(s^2+40s+625)}$

$$i_o(0^+) = \lim_{s\to\infty} sI_o = 0$$

$$i_o(\infty) = \lim_{s\to 0} sV_o = \frac{1080}{625} = 1728\,\text{mA}$$

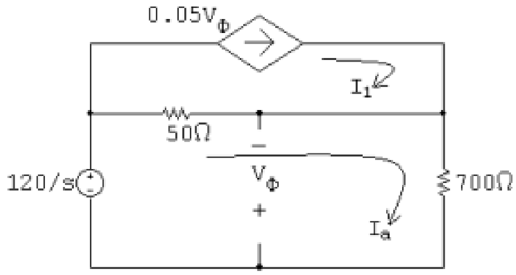
[c] At $t = 0^+$ the circuit is



$i(0^+) = 0$ (checks)

Prob 13.31 (Cont'd)

At $t = \infty$ the circuit is



$$120 = 50(i_a - i_1) + 700i_a$$

$$= 50(i_a - 0.05v_\phi) + 700i_a = 750i_a - 2.5v\phi$$

$$v_\phi = -700i_a \quad \therefore \quad 120 = 750i_a + 1750i_a = 2500i_a$$

$$i_a = \frac{120}{2500} = 48\,\text{mA}$$

$$v_\phi = -700i_a = -33.60\,\text{V}$$

$$i_o(\infty) = 48 \times 10^{-3} - 0.05(-33.60) = 48 \times 10^{-3} + 1.68 = 1728\,\text{mA (checks)}$$

[d] $$I_o = \frac{1080}{s(s^2 + 40s + 625)} = \frac{K_1}{s} + \frac{K_2}{s + 20 - j15} + \frac{K_2^*}{s + 20 + j15}$$

$$K_1 = \frac{1080}{625} = 1.728$$

$$K_2 = \frac{1080}{(-20 + j15)(j30)} = 1.44\underline{/126.87^\circ}$$

$$i_o(t) = [1728 + 2880e^{-20t}\cos(15t + 126.87^\circ)]u(t)\,\text{mA}$$

Check: $i_o(0^+) = 0\,\text{mA}$; $i_o(\infty) = 1728\,\text{mA}$

Prob 13.67

P 13.67 [**a**] $-1 \leq t \leq 4$:

$$v_o = \int_0^{t+1} 10\lambda\, d\lambda = 5\lambda^2 \Big|_0^{t+1} = 5t^2 + 10t + 5\,\text{V}$$

$4 \leq t \leq 9$:

$$v_o = \int_{t-4}^{t+1} 10\lambda\, d\lambda = 5\lambda^2 \Big|_{t-4}^{t+1} = 50t - 75\,\text{V}$$

$9 \leq t \leq 14$:

$$v_o = 10\int_{t-4}^{10} \lambda\, d\lambda + 10\int_{10}^{t+1} 10\, d\lambda$$

$$= 5\lambda^2 \Big|_{t-4}^{10} + 100\lambda \Big|_{10}^{t+1} = -5t^2 + 140t - 480\,\text{V}$$

$14 \leq t \leq 19$:

$$v_o = 100\int_{t-4}^{t+1} d\lambda = 500\,\text{V}$$

$19 \leq t \leq 24$:

$$v_o = \int_{t-4}^{20} 100\lambda\, d\lambda + \int_{20}^{t+2} 10(30 - \lambda)\, d\lambda$$

$$= 100\lambda \Big|_{t-2}^{20} + 300\lambda \Big|_{20}^{t+1} - 5\lambda^2 \Big|_{20}^{t+2}$$

$$= -5t^2 + 190t - 1305\,\text{V}$$

$24 \leq t \leq 29$:

$$v_o = 10\int_{t-4}^{t+1} (30 - \lambda)\, d\lambda = 300\lambda \Big|_{t-4}^{t+1} - 5\lambda^2 \Big|_{t-4}^{t+1}$$

$$= 1575 - 50t\,\text{V}$$

$29 \leq t \leq 34$:

$$v_o = 10\int_{t-4}^{30} (30 - \lambda)\, d\lambda = 300\lambda \Big|_{t-4}^{30} - 5\lambda^2 \Big|_{t-2}^{30}$$

$$= 5t^2 - 340t + 5780\,\text{V}$$

Prob 13.67 (Cont'd)

Summary:

$v_o = 0 \qquad -\infty \leq t \leq -1$

$v_o = 5t^2 + 10t + 5\,\mathrm{V} \qquad -1 \leq t \leq 4$

$v_o = 50t - 75\,\mathrm{V} \qquad 4 \leq t \leq 9$

$v_o = -5t^2 + 140t - 480\,\mathrm{V} \qquad 9 \leq t \leq 14$

$v_o = 500\,\mathrm{V} \qquad 14 \leq t \leq 19$

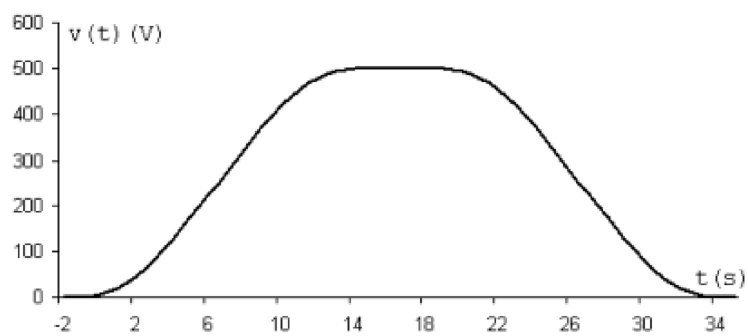
$v_o = -5t^2 + 190t - 1305\,\mathrm{V} \qquad 19 \leq t \leq 24$

$v_o = 1575 - 50t\,\mathrm{V} \qquad 24 \leq t \leq 29$

$v_o = 5t^2 - 340t + 5780\,\mathrm{V} \qquad 29 \leq t \leq 34$

$v_o = 0 \qquad 34 \leq t \leq \infty$

[b]



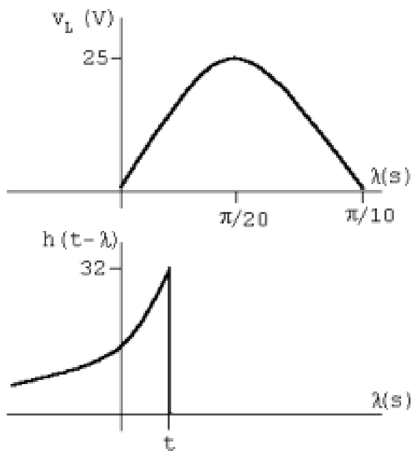
Prob 13.71

P 13.71 $v_i = 25\ \sin 10\lambda\,[u(\lambda) - u(\lambda - \pi/10)]$

$$H(s) = \frac{32}{s+32}$$

$$h(\lambda) = 32e^{-32\lambda}$$

$$h(t-\lambda) = 32e^{-32(t-\lambda)} = 32e^{-32t}e^{32\lambda}$$



$$v_o = 800e^{-32t}\int_0^t e^{32\lambda}\sin 10\lambda\,d\lambda$$

$$= 800e^{-32t}\left[\frac{e^{32\lambda}}{32^2+10^2}(32\sin 10\lambda - 10\cos 10\lambda\ \Big|_0^t\right]$$

$$= \frac{800e^{-32t}}{1124}[e^{32t}(32\sin 10t - 10\cos 10t) + 10]$$

$$= \frac{800}{1124}[32\sin 10t - 10\cos 10t + 10e^{-32t}]$$

$v_o(0.075) = 10.96\,\mathrm{V}$