EENG382 HW10 – AUTHOR'S SOLUTIONS

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

Prob 17.23

P 17.23 **[a]** From the solution to Problem 17.22

$$H(\omega) = \frac{2}{j\omega + 2}$$

Now,

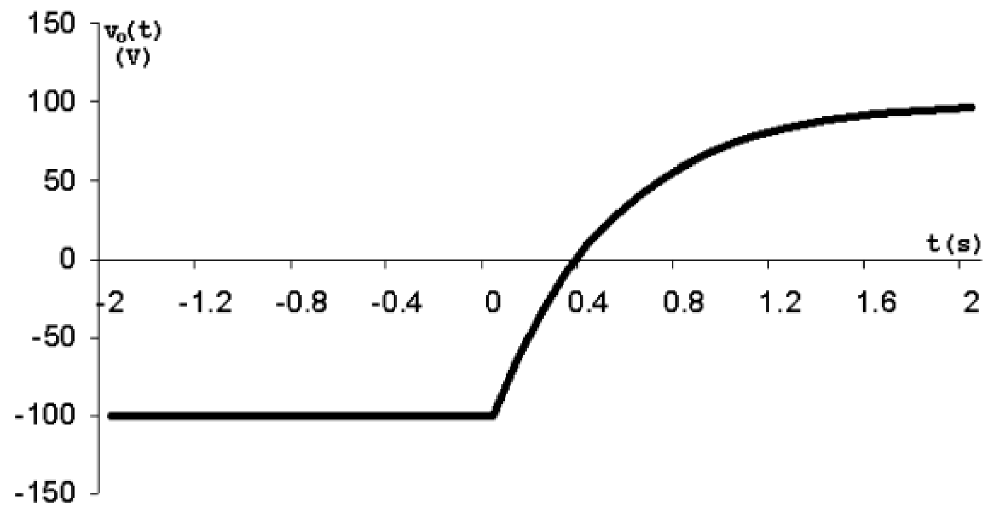
$$V_g(\omega) = \frac{200}{j\omega}$$

Then,

$$V_o(\omega) = H(\omega)V_g(\omega) = \frac{400}{j\omega(j\omega + 2)} = \frac{K_1}{j\omega} + \frac{K_2}{j\omega + 2} = \frac{200}{j\omega} - \frac{200}{j\omega + 2}$$

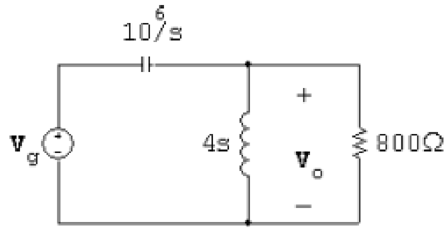
$$\therefore \qquad v_o(t) = 100\text{sgn}(t) - 200e^{-2t}u(t)\text{ V}$$

[b]



Prob 17.32

P 17.32 [**a**]



$$\frac{(V_o - V_g)s}{10^6} + \frac{V_o}{4s} + \frac{V_o}{800} = 0$$

$$\therefore \quad V_o = \frac{s^2 V_g}{s^2 + 1250s + 25 \times 10^4}$$

$$\frac{V_o}{V_g} = H(s) = \frac{s^2}{(s + 250)(s + 1000)}$$

$$H(j\omega) = \frac{(j\omega)^2}{(j\omega + 250)(j\omega + 1000)}$$

$$v_g = 45e^{-500|t|}; \qquad V_g(\omega) = \frac{45{,}000}{(j\omega + 500)(-j\omega + 500)}$$

$$\therefore \quad V_o(\omega) = H(j\omega)V_g(\omega) = \frac{45{,}000(j\omega)^2}{(j\omega + 250)(j\omega + 500)(j\omega + 1000)(-j\omega + 500)}$$

$$= \frac{K_1}{j\omega + 250} + \frac{K_2}{j\omega + 500} + \frac{K_3}{j\omega + 1000} + \frac{K_4}{-j\omega + 500}$$

$$K_1 = \frac{45{,}000(-250)^2}{(250)(750)(750)} = 20$$

$$K_2 = \frac{45{,}000(-500)^2}{(-250)(500)(1000)} = -90$$

$$K_3 = \frac{45{,}000(-1000)^2}{(-750)(-500)(1500)} = 80$$

$$K_4 = \frac{45{,}000(500)^2}{(750)(1000)(1500)} = 10$$

$$\therefore \quad v_o(t) = [20e^{-250t} - 90e^{-500t} + 80e^{-1000t}]u(t) + 10e^{500t}u(-t)\,\text{V}$$

Prob 17.32 (Cont'd)

[b] $v_o(0^-) = 10\,\text{V}; \qquad V_o(0^+) = 20 - 90 + 80 = 10\,\text{V}$

$v_o(\infty) = 0\,\text{V}$

[c] $I_L = \dfrac{V_o}{4s} = \dfrac{0.25sV_g}{(s+250)(s+1000)}$

$$H(s) = \frac{I_L}{V_o} = \frac{0.25s}{(s+250)(s+1000)}$$

$$H(j\omega) = \frac{0.25(j\omega)}{(j\omega+250)(j\omega+1000)}$$

$$I_L(\omega) = \frac{0.25(j\omega)(45{,}000)}{(j\omega+250)(j\omega+500)(j\omega+1000)(-j\omega+500)}$$

$$= \frac{K_1}{j\omega+250} + \frac{K_2}{j\omega+500} + \frac{K_3}{j\omega+1000} + \frac{K_4}{-j\omega+500}$$

$$K_4 = \frac{(0.25)(500)(45{,}000)}{(750)(1000)(1500)} = 5\,\text{mA}$$

$$i_L(t) = 5e^{500t}u(-t); \qquad \therefore \quad i_L(0^-) = 5\,\text{mA}$$

$$K_1 = \frac{(0.25)(-250)(45{,}000)}{(250)(750)(750)} = -20\,\text{mA}$$

$$K_2 = \frac{(0.25)(-500)(45{,}000)}{(-250)(500)(1000)} = 45\,\text{mA}$$

$$K_3 = \frac{(0.25)(-1000)(45{,}000)}{(-750)(-500)(1500)} = -20\,\text{mA}$$

$$\therefore \quad i_L(0^+) = K_1 + K_2 + K_3 = -20 + 45 - 20 = 5\,\text{mA}$$

Checks, i.e., $\quad i_L(0^+) = i_L(0^-) = 5\,\text{mA}$

At $t = 0^-$:

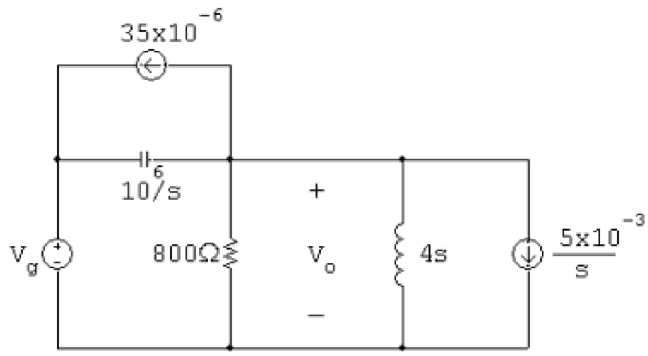
$$v_C(0^-) = 45 - 10 = 35\,\text{V}$$

At $t = 0^+$:

$$v_C(0^+) = 45 - 10 = 35\,\text{V}$$

Prob 17.32 (Cont'd)

[d] We can check the correctness of out solution for $t \geq 0^+$ by using the Laplace transform. Our circuit becomes



$$\frac{V_o}{800} + \frac{V_o}{4s} + \frac{(V_o - V_g)s}{10^6} + 35 \times 10^{-6} + \frac{5 \times 10^{-3}}{s} = 0$$

$$\therefore \quad (s^2 + 1250s + 24 \times 10^4)V_o = s^2 V_g - (35s + 5000)$$

$$v_g(t) = 45e^{-500t}u(t)\,\text{V}; \qquad V_g = \frac{45}{s + 500}$$

$$\therefore \quad (s + 250)(s + 1000)V_o = \frac{45s^2 - (35s + 5000)(s + 500)}{(s + 500)}$$

$$\therefore \quad V_o = \frac{10s^2 - 22{,}500s - 250 \times 10^4}{(s + 250)(s + 500)(s + 1000)}$$

$$= \frac{20}{s + 250} - \frac{90}{s + 500} + \frac{80}{s + 1000}$$

$$\therefore \quad v_o(t) = [20e^{-250t} - 90e^{-500t} + 80e^{-1000t}]u(t)\,\text{V}$$

This agrees with our solution for $v_o(t)$ for $t \geq 0^+$.

Prob 17.36

P 17.36 $V_o(s) = \frac{10}{s} + \frac{30}{s+20} - \frac{40}{s+30} = \frac{600(s+10)}{s(s+20)(s+30)}$

$$V_o(s) = H(s) \cdot \frac{15}{s}$$

$$\therefore \qquad H(s) = \frac{40(s+10)}{(s+20)(s+30)}$$

$$\therefore \qquad H(\omega) = \frac{40(j\omega+10)}{(j\omega+20)(j\omega+30)}$$

$$\therefore \qquad V_o(\omega) = \frac{30}{j\omega} \cdot \frac{40(j\omega+10)}{(j\omega+20)(j\omega+30)} = \frac{1200(j\omega+10)}{j\omega(j\omega+20)(j\omega+30)}$$

$$v_o(\omega) = \frac{20}{j\omega} + \frac{60}{j\omega+20} - \frac{80}{j\omega+30}$$

$$v_o(t) = 10\text{sgn}(t) + [60e^{-20t} - 80e^{-30t}]u(t)\,\text{V}$$