

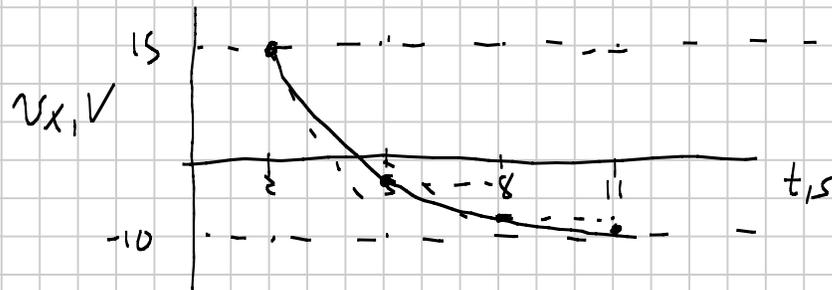
# EGE 224 SPRING 2013 TEST #

Note Title

I (1) R/W diff eq as  $3 \frac{dv_x}{dt} + v_x = -10$

$v_x(2^+) = 15$   $v_x(\infty) = -10$   $\tau = 3$   $t_0 = 2$

$v_x(t) = -10 + 25 e^{-(t-2)/3}$  for  $t > 2$



(2) from corner,  $K \frac{j\omega}{(j\omega+10)} \frac{(j\omega+10000)}{(j\omega+1000)^2}$

to get  $K$ , pick  $\omega$  left of first corner (orig,  $\omega=1$ )

$|H(1)| \approx \left| \frac{K j(1)}{10} \frac{10000}{1000^2} \right| = 10$  (20dB)

so  $K \frac{10^4}{10^2} = 10^1$   $K = 10^4$

$\frac{10^4 (j\omega)(j\omega+10000)}{(j\omega+10)(j\omega+1000)^2} \approx \frac{10^4 (j\omega)(1+j\omega/10000)}{(1+j\omega/10)(1+j\omega/1000)^2}$

(3)  $X(t) = \mathcal{L}^{-1} \left\{ \frac{3(s+3)}{s^2+11s+30} \right\} = \mathcal{L}^{-1} \left\{ \frac{3(s+3)}{(s+5)(s+6)} \right\} = \mathcal{L}^{-1} \left\{ \frac{-6}{s+5} + \frac{9}{s+6} \right\}$   
 $= (-6e^{-5t} + 9e^{-6t}) u(t)$

$Y(t) = \mathcal{L}^{-1} \left\{ \frac{6(s+3)}{s^2+10s+41} \right\} = \mathcal{L}^{-1} \left\{ \frac{6s+18}{(s+5)^2+(4)^2} \right\} = \mathcal{L}^{-1} \left\{ \frac{A(s+5)+B(4)}{(s+5)^2+(4)^2} \right\}$   
 $= \mathcal{L}^{-1} \left\{ \frac{6(s+5) - 3(4)}{(s+5)^2+(4)^2} \right\} = e^{-5t} (6 \cos(4t) - 3 \sin(4t)) u(t)$

$H(s) = \frac{Y(s)}{X(s)} = \frac{6(s+3)}{s^2+10s+41} \times \frac{s^2+11s+30}{3(s+3)} = \frac{2(s^2+11s+30)}{(s^2+10s+41)}$

II) Using superposition,

$$I_{out} = \frac{V_a}{j\omega L + R_1 + R_2 + \frac{1}{j\omega C}} + \frac{I_b (R_1 + \frac{1}{j\omega C})}{j\omega L + R_2 + R_1 + \frac{1}{j\omega C}}$$

$$= \frac{j\omega C V_a + (j\omega C R_1 + 1) I_b}{(j\omega)^2 LC + j\omega C (R_1 + R_2) + 1}$$

0 rad/s:  $V_a = 10 \angle 0^\circ$   $I_b = 8 \cdot 10^{-3} \angle 0^\circ$

$$\frac{j(0)(2 \cdot 10^{-6}) 10 \angle 0^\circ + (j(0)(2 \cdot 10^{-6})(3000) + 1) 8 \cdot 10^{-3} \angle 0^\circ}{(j0)^2 (5 \cdot 10^{-3})(2 \cdot 10^{-6}) + j0(2 \cdot 10^3)(7000) + 1}$$

$$= 8 \cdot 10^{-3} \angle 0^\circ$$

$$i_{out, 0 \text{ rad/s}} = 8 \text{ mA}$$

1000 rad/s  $V_a = 6 \angle 15^\circ$   $I_b = 0$  (no component at 1krad/s)

$$\frac{(j1000)(2 \cdot 10^{-6}) 6 \angle 15^\circ + (j1000)(2 \cdot 10^{-6})(3000) + 1) 0}{(j1000)^2 (5 \cdot 10^{-3})(2 \cdot 10^{-6}) + j1000(2 \cdot 10^3)(7000) + 1}$$

$$= 8.5 \cdot 10^{-4} \angle 19^\circ$$

$$i_{out, 1000 \text{ rad/s}} = 0.85 \cos(1000t + 19^\circ) \text{ mA}$$

2000 rad/s  $V_a = 0$   $I_b = 7 \angle -127^\circ \text{ mA}$

$$\frac{(j2000)(2 \cdot 10^{-6}) 0 + (j2000)(2 \cdot 10^{-6})(3000) + 1) 7 \cdot 10^{-3} \angle -127^\circ}{(j2000)^2 (5 \cdot 10^{-3})(2 \cdot 10^{-6}) + j2000(2 \cdot 10^3)(7000) + 1}$$

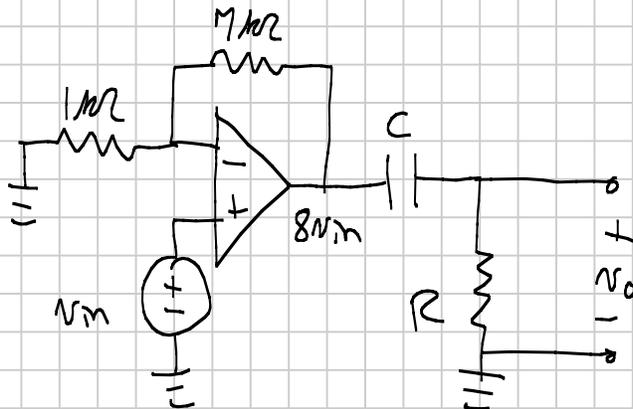
$$= 3 \cdot 10^{-3} \angle -129.8^\circ$$

$$i_{out, 2000 \text{ rad/s}} = 3 \cos(2000t - 129.8^\circ) \text{ mA}$$

$$i_{out} = 8 + 0.85 \cos(1000t + 19^\circ) + 3 \cos(2000t - 129.8^\circ) \text{ mA}$$

III) 1)  $K=8$   $\omega_{co} = 2\pi \cdot 5000 = 31415 \text{ rad/s}$

$$H(j\omega) = \frac{8j\omega}{j\omega + 31415}$$



$$\frac{R}{R + \frac{1}{j\omega C}} = \frac{j\omega CR}{j\omega CR + 1} = \frac{j\omega}{j\omega + \frac{1}{CR}}$$

$$\frac{1}{CR} = 31415$$

$$R = \frac{1}{31415 \cdot C} = \underline{677.3 \Omega}$$

(2)  $\omega_{lo} = 1000$   $\omega_{hi} = 10000$   $K = 20$

$$\omega_n = \sqrt{\omega_{lo} \omega_{hi}} = 3162.2 \text{ r/s}$$

$$\omega_{lim, \text{mean}} = \frac{\omega_{lo} + \omega_{hi}}{2} = 5500 \text{ r/s}$$

$$BW = \omega_{hi} - \omega_{lo} = 9000 \text{ r/s}$$

$$Q = \frac{\omega_n}{BW} = 0.351$$

$$\beta = \frac{1}{2Q} = 1.423$$

$$\omega_1 \omega_2 = \omega_n^2 = 1 \cdot 10^7$$

$$\omega_1 + \omega_2 = BW = 9000$$

$$\omega_1 (9000 - \omega_1) = 1 \cdot 10^7$$

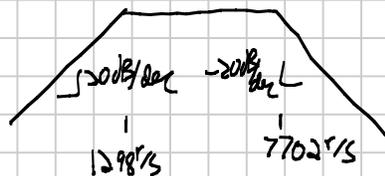
$$\omega_1^2 - 9000\omega_1 + 1 \cdot 10^7 = 0$$

$$\omega_1 = \frac{9000 \pm \sqrt{9000^2 - 4 \cdot 10^7}}{2}$$

$$= 4500 \pm 3201 = 1298.44 \text{ r/s}$$

$$\omega_2 = 7701.56 \text{ r/s}$$

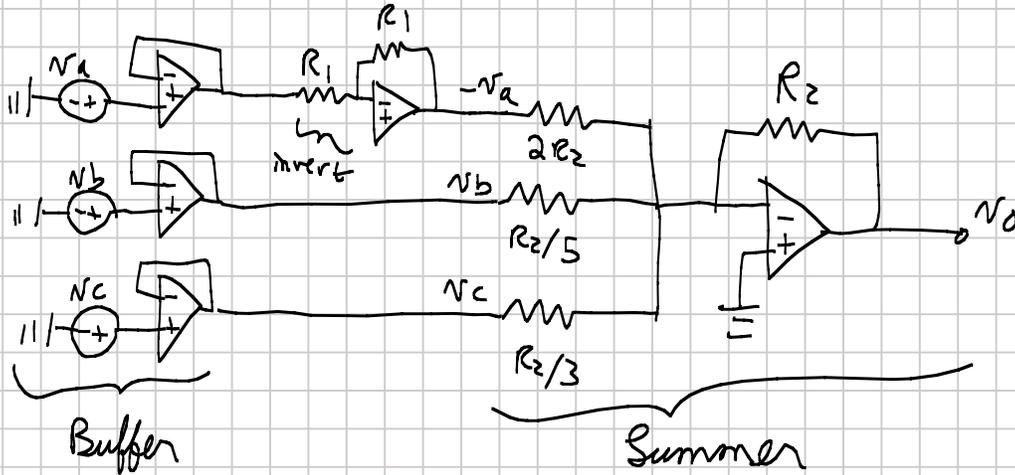
26 dB



IV) (1) will accept either  $A \rightarrow \infty$  alone or

$A \rightarrow \infty, r_i \rightarrow \infty, r_o \rightarrow 0$

(2) many possibilities; one straightforward one:



inverting amp  $V_1 = -\frac{1/j\omega C}{R_1} V_{in} = \frac{-1}{j\omega C R_1} V_{in}$

non-inverting  $V_2 = \left(1 + \frac{j\omega L}{R_4}\right) V_{in} = \left(\frac{R_4 + j\omega L}{R_4}\right) V_{in}$

$V_{out} = V_1 - V_2 = \left(\frac{-1}{j\omega C R_1} - 1 - \frac{j\omega L}{R_4}\right) V_{in}$

$\frac{V_{out}}{V_{in}} = \frac{-1}{j\omega C R_1} - 1 - \frac{j\omega L}{R_4}$

$= -\left(\frac{(j\omega)^2 L C R_1 + j\omega C R_1 R_4 + R_4}{j\omega C R_1 R_4}\right)$

$C R_1 R_4 \frac{d^2 v_{out}}{dt^2} = -\left(L C R_1 \frac{d^2 v_{in}}{dt^2} + C R_1 R_4 \frac{d v_{in}}{dt} + R_4 v_{in}\right)$