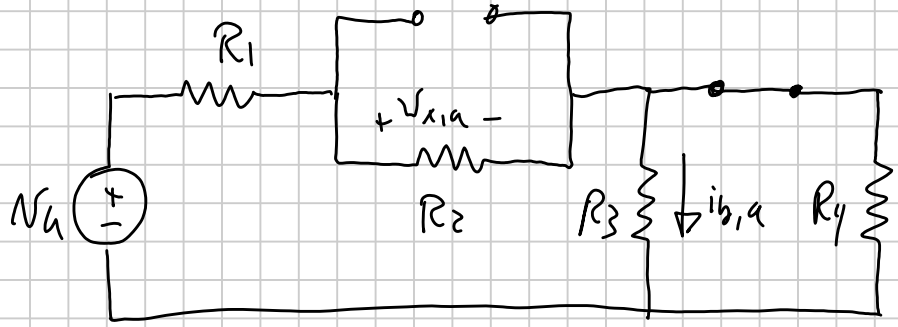
ECE 110 Spring 14 Test II

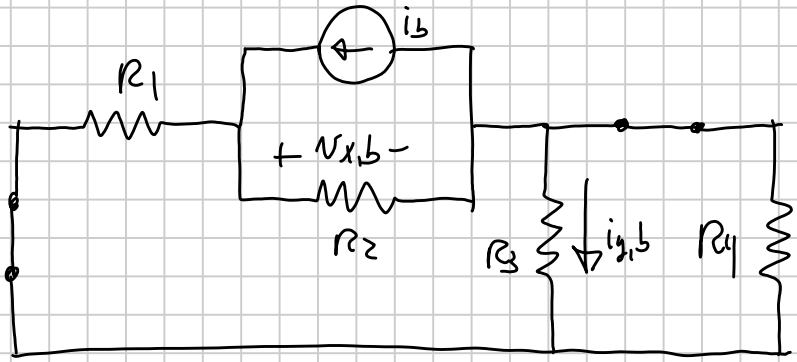
Note Title

I)



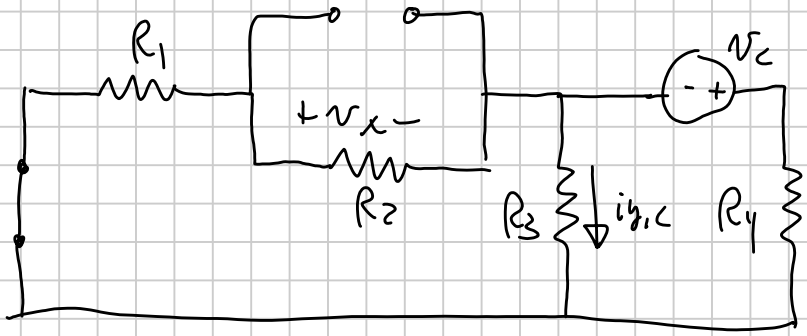
$$v_{x,a} = v_a \frac{R_2}{R_1 + R_2 + (R_3 \| R_4)} \quad \text{or} \quad \frac{v_a}{R_1 + R_2 + (R_3 \| R_4)} R_2$$

$$i_{y,a} = v_a \frac{1}{R_1 + R_2 + (R_3 \| R_4)} \frac{R_4}{R_3 + R_4} \quad \text{or} \quad v_a \frac{R_3 \| R_4}{R_1 + R_2 + (R_3 \| R_4)} \frac{1}{R_3}$$



$$v_{x,b} = i_b \left(R_2 \| \left(R_1 + (R_3 \| R_4) \right) \right) \quad \text{or} \quad \frac{i_b (R_1 + (R_3 \| R_4))}{R_2 + R_1 + (R_3 \| R_4)} R_2$$

$$i_{y,b} = -i_b \frac{R_2}{R_2 + (R_1 + (R_3 \| R_4))} \frac{R_4}{R_3 + R_4}$$



$$v_{x,c} = v_c \frac{R_3 \| (R_1 + R_2)}{R_4 + (R_3 \| (R_1 + R_2))} \frac{R_2}{R_1 + R_2}$$

$$i_{y,c} = -v_c \frac{R_3 \| (R_1 + R_2)}{R_4 + (R_3 \| (R_1 + R_2))} \frac{1}{R_3} \quad \text{or} \quad \frac{-v_c}{R_4 + (R_3 \| (R_1 + R_2))} \frac{R_1 + R_2}{R_1 + R_2 + R_3}$$

$$v_x = v_{x,a} + v_{x,b} + v_{x,c}$$

$$i_y = i_{y,a} + i_{y,b} + i_{y,c}$$

(2) $P_{del,\,v_a} = v_a \left(\frac{v_1}{R_2} - i_b \right)$ (use KCL left of i_b)

or

$$v_a \left(\frac{v_a - (R_3 i_y + v_x)}{R_1} \right)$$

or

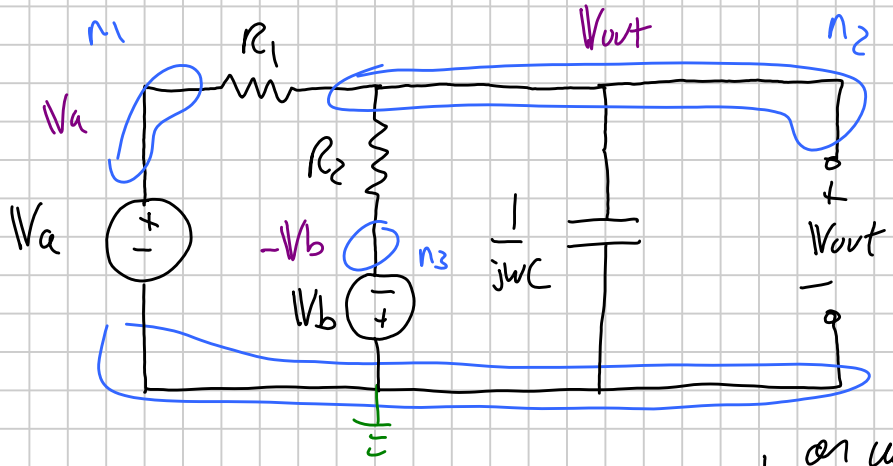
$$v_a \left(i_y + \frac{R_3 i_y + v_c}{R_4} \right)$$ (KCL, GND)

$$P_{del,\,i_b} = v_x i_b$$

$$P_{del,\,v_c} = v_c \left(\frac{v_x}{R_2} - i_b - i_y \right)$$ or

$$v_c \left(\frac{(R_3 i_y + v_c)}{R_4} \right)$$

(1)



KCL, n2: $\dfrac{V_{out}-V_a}{R_1} + \dfrac{V_{out}+V_b}{R_2} + \dfrac{V_{out}}{\frac{1}{j\omega C}} = 0$

$$V_{out}\left(\frac{1}{R_1}+\frac{1}{R_2}+j\omega C\right) = \frac{V_a}{R_1} - \frac{V_b}{R_2}$$

$$V_{out}\left(\frac{j\omega C R_1 R_2 + R_1 + R_2}{R_1 R_2}\right) = \frac{V_a R_2 - V_b R_1}{R_1 R_2}$$

$$V_{out} = \frac{V_a R_2 - V_b R_1}{j\omega C R_1 R_2 + R_1 + R_2}$$

$$= \frac{6000\,V_a - 3000\,V_b}{j\omega(7200) + 9000}$$

or use superposition

$$V_{out,a} = \frac{\frac{1}{j\omega C}\|R_2}{\frac{1}{j\omega C}\|R_2 + R_1} V_a$$

$$= \frac{\frac{R_2}{1+j\omega C R_2}}{\frac{R_2}{1+j\omega C R_2} + R_1} V_a$$

$$= \frac{R_2}{R_1+R_2+j\omega C R_1 R_2} V_a$$

$$V_{out,b} = \frac{-\frac{1}{j\omega C}\|R_1}{\frac{1}{j\omega C}\|R_1 + R_2} V_b$$

$$V_{out,b} = \frac{-R_1 V_b}{R_1+R_2+j\omega C R_1 R_2}$$

ω	V_a	V_b	V_{out}
0	9	0	6
1	$4\angle -108°$	$7\angle 124°$	$3.51\angle -122.5°$
3	0	$5\angle 160°$	$0.641\angle -87.4°$

$$v_{out}(t) = 6 + 3.51\cos(t - 122.5°) + 0.641\cos(3t - 87.4°)\ \text{V}$$

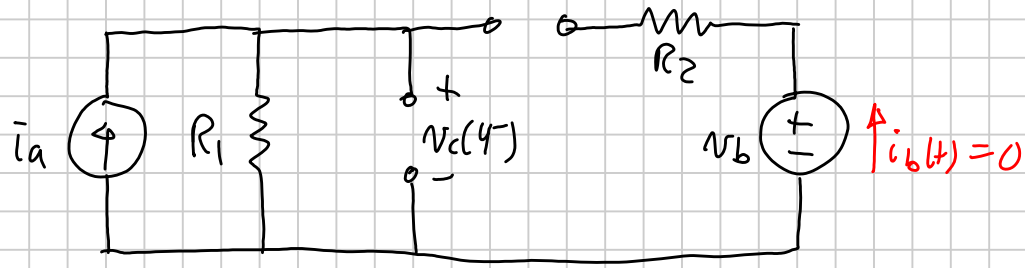
or do in two parts to get

$V_{out,a,\omega=1} = 2.08\angle -146.7°$

$V_{out,b,\omega=1} = 1.82\angle -94.7°$

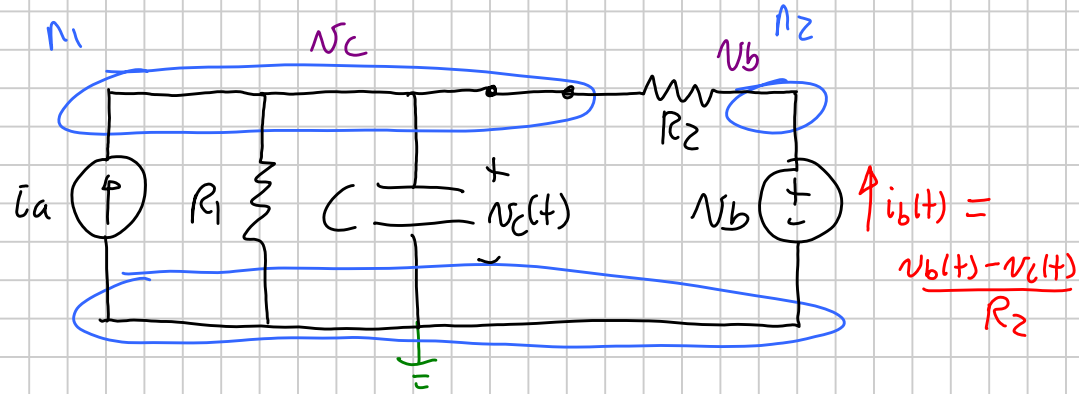
$V_{out,\omega=1} = 3.51\angle -122.5°$

III $t<4$



$$v_c(4^-) = R_1 i_a = 1.05\,V$$

$t>4$



KCL, n_1: $$-i_a + \frac{v_c}{R_1} + C\frac{dv_c}{dt} + \frac{(v_c - v_b)}{R_2} = 0$$

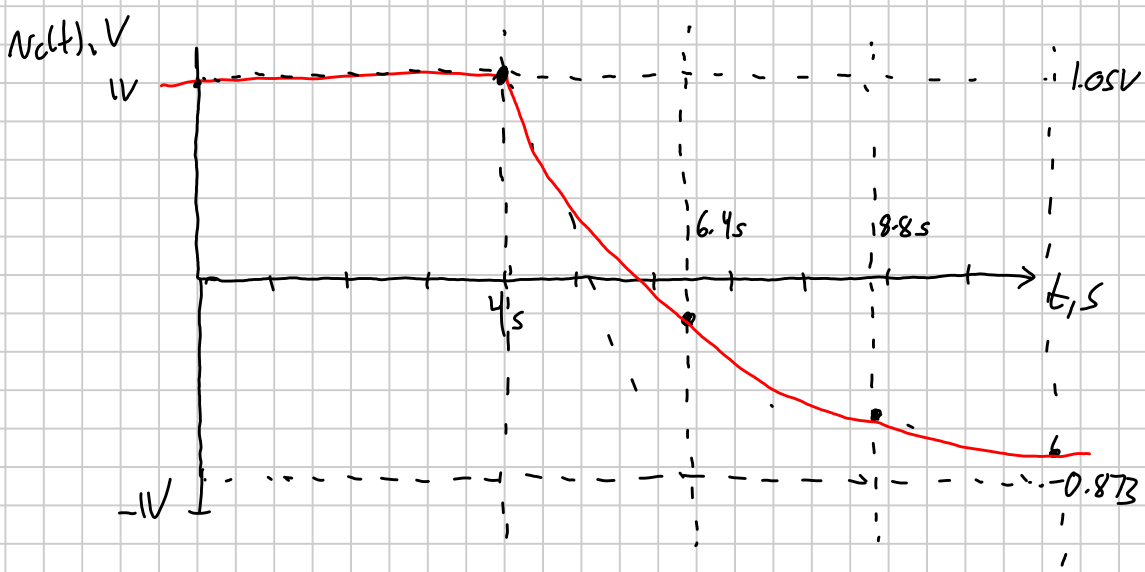
$$C\frac{dv_c}{dt} + \left(\frac{1}{R_1}+\frac{1}{R_2}\right)v_c = i_a + \frac{v_b}{R_2}$$

$$\frac{C R_1 R_2}{R_1+R_2}\frac{dv_c}{dt} + v_c = \frac{i_a R_1 R_2}{R_1+R_2} + \frac{v_b R_1}{R_1+R_2}$$

$$2.4\frac{dv_c}{dt} + v_c = -0.873$$

$$v_c(t) = -0.873 + (1.05-(-0.873))e^{-(t-4)/2.4}$$

$$v_c(t) = -0.873 + 1.923\,e^{-(t-4)/2.4}\ V \quad t>4$$



(2) $p_{del,i_a}(t) = v_c(t)\, i_a = \begin{cases} 73.5 \ \mu W & t<4 \\ -61.1 + 134.6\, e^{-(t-4)/2.4} \ \mu W & t>4 \end{cases}$

(3) $p_{del,v_b}(t) = v_b\, i_b(t)$

where $v_b = -6$ and $i_b(t) = \begin{cases} 0 & t<4 \\ \dfrac{v_b - v_c(t)}{R_2} = \dfrac{-5.127 - 1.923\, e^{-(t-4)/2.4}}{40\,000} & t>4 \end{cases}$

switch open!

so, $p_{del,v_b}(t) = \begin{cases} 0 \ W & t<4 \\ 0.769 + 0.288\, e^{-(t-4)/2.4} \ mW & t>4 \end{cases}$

IV (1) $\omega_0 = 200$ rad/s $\quad T = \frac{2\pi}{\omega_0} = .01\pi = .0314$ s.

$v_{0,in} = 3$

$V_{4,in} = 1\angle 9^\circ$

$V_{9,in} = 7\angle -156^\circ$

$V_{11,in} = 15\angle -79^\circ$

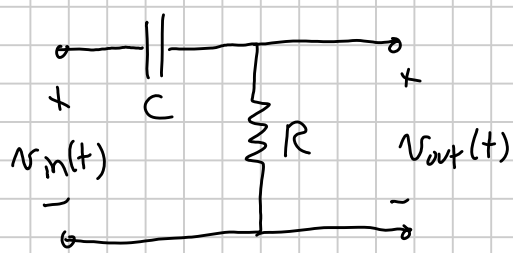
(2) (a) HPF ; $\lim_{\omega\to 0} |H(j\omega)| = 0 \quad \lim_{\omega\to\infty} |H(j\omega)| = 1$

max gain $= 1 \quad \omega_{HP} = 1100$

(b)

n	$n\omega_0$	$V_{n,in}$	$H(jn\omega_0)$	$V_{n,out}$
0	0	3	0	0 $\leftarrow v_{0,out}$
4	800	$1\angle 9^\circ$	$0.588\angle 53.97^\circ$	$0.588\angle 62.97^\circ$
9	1800	$7\angle -156^\circ$	$0.853\angle 31.43^\circ$	$5.97\angle -124.6^\circ$
11	2200	$15\angle -79^\circ$	$0.894\angle 26.57^\circ$	$13.4\angle -52.43^\circ$

(c) HPF



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

$\frac{1}{CR} = 1100$

$C = \frac{1}{1100R} = 6.06\times 10^{-8}$

$= 60.6$ nF

(d) $v_{out}(t) = 0.588\cos(800t + 62.97^\circ) + 5.97\cos(1800t - 124.6^\circ) + 13.4\cos(2200t - 52.43^\circ)$ V

(3) only keep terms $\omega > \omega_{co}$ or 1100, so

$v_x(t) = 7\cos(1800t - 156^\circ) + 15\cos(2200t - 79^\circ)$ V

(ok if written as original)