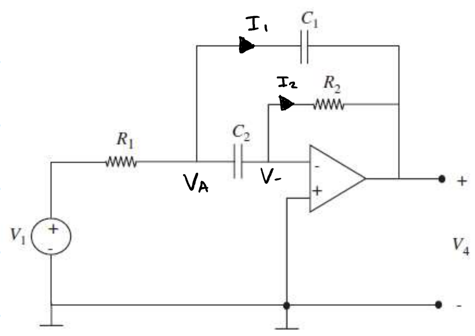
Homework 9

Thursday, June 1, 2017 2:58 PM

Pr 15.34)



a. $\frac{V_1 - V_A}{R_1} = I_1 + I_2 \qquad V_- = V_+ = 0$

$$I_1 = \frac{V_A - V_4}{\frac{1}{i\omega C_1}} = i\omega C_1 (V_A - V_4)$$

$$I_2 = \frac{V_- - V_4}{R_2} = -\frac{V_4}{R_2}$$

$$I_2 = \frac{V_A - V_-}{\frac{1}{i\omega C_2}} = i\omega C_2 V_A$$

$$V_A = \frac{-1}{i\omega R_2 C_2} V_4 = \frac{-1}{i\omega \tau_2} V_4$$

$$V_1 + \frac{1}{i\omega\tau_2} V_4 = i\omega\tau_1 \left(\frac{-1}{i\omega\tau_2} V_4 - V_4 \right) - \frac{R_1}{R_2} V_4$$

$$V_1 = -\left(\frac{1}{i\omega\tau_2} + \frac{\tau_1}{\tau_2} + i\omega\tau_1 + \frac{R_1}{R_2} \right) V_4$$

$$\frac{V_4}{V_1} = -\frac{1}{\frac{1}{i\omega\tau_2} + \frac{\tau_1}{\tau_2} + i\omega\tau_1 + \frac{R_1}{R_2}}$$

$$= -\frac{i\omega\tau_2}{1 + i\omega\tau_1 - \omega^2\tau_1\tau_2 + i\omega R_1 C_2}$$

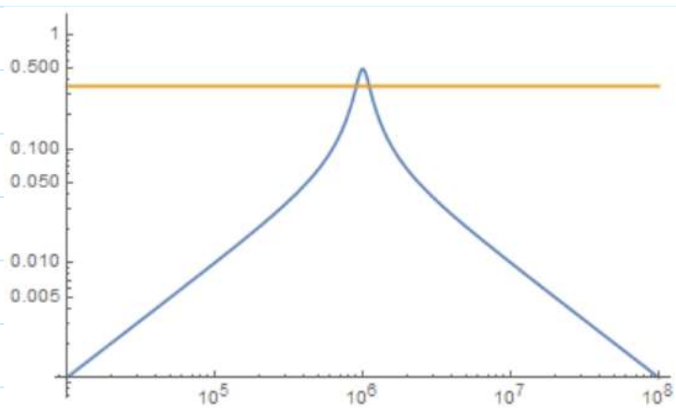
$$G(\omega) = \boxed{\frac{-i\omega\tau_2}{1 - \omega^2\tau_1\tau_2 + i\omega R_1(C_1 + C_2)}}$$

b. $\left| \frac{V_4}{V_1} \right| = \frac{\omega\tau_2}{\sqrt{(1-\omega^2\tau_1\tau_2)^2 + \omega^2 R_1^2 (C_1+C_2)^2}}$

$C_1 = C_2 = .01\,\mu F$

$R_1 = 10\,\Omega\ ,\ R_2 = 1k\Omega$

$\tau_1 = .1\,\mu s,\ \tau_2 = .01\,ms$



minimizing denominator of G maximizes G

$$\boxed{\omega_r = \frac{1}{\sqrt{\tau_1\tau_2}} = 10^6\ s \qquad G(\omega_r) = \frac{1}{2}}$$

$Q = \frac{\omega_r}{\Delta\omega} \qquad G(\omega_{1,2}) = \frac{1}{\sqrt{2}}\frac{1}{2} \longrightarrow \omega_1 = .905 \times 10^6\ s,\ \omega_2 = 1.105 \times 10^6\ s$

$$\boxed{Q = \frac{1}{1.105 - .905} = \frac{1}{.2} = 5}$$

Pr 15.34) c. filter is band pass

transfer functions w/ denominator $-\omega^2 A + i\omega B + C$ have

$$\omega_2 - \omega_1 = \frac{B}{A}$$

$$\omega_2 - \omega_1 = \frac{R_1(C_1 + C_2)}{R_1 C_1 R_2 C_2}$$

$$= \boxed{\frac{C_1 + C_2}{R_2 C_1 C_2}}$$

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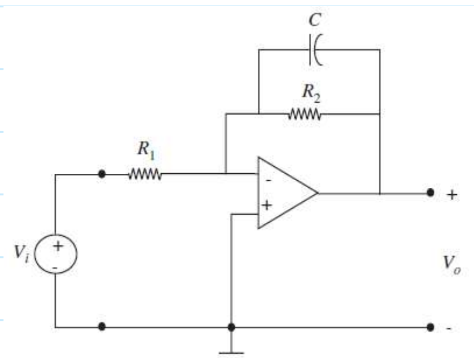


a. $\frac{V_{in} - V_-}{R_1} = \frac{V_- - V_o}{Z}$ $\qquad \frac{1}{Z} = i\omega C + \frac{1}{R_2} \longrightarrow Z = \frac{R_2}{1 + i\omega R_2 C}$

$$V_- = V_+ = 0$$

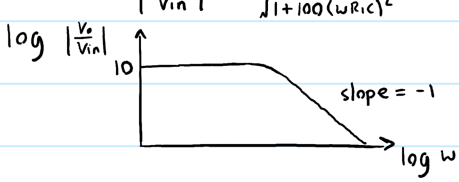
$$V_o = -\frac{Z}{R_2} V_{in} = -\frac{R_2}{R_1(1 + i\omega R_2 C)} V_{in}$$

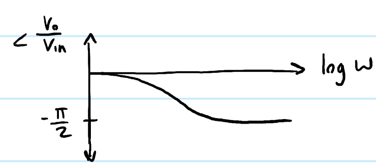
$$\boxed{\frac{V_o}{V_{in}} = \frac{-R_2}{R_1(1 + i\omega R_2 C)}}$$

$$R_2 = 10 R_1$$

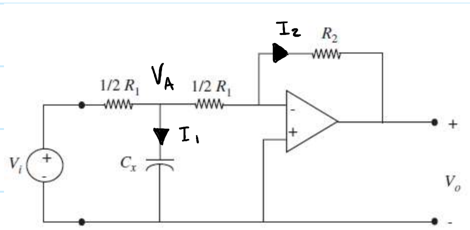
$$\frac{V_o}{V_{in}} = \frac{-10}{1 + 10 i\omega R_1 C} \qquad \angle \frac{V_o}{V_{in}} = -\arctan(10\omega R_1 C)$$

$$\left|\frac{V_o}{V_{in}}\right| = \frac{10}{\sqrt{1 + 100(\omega R_1 C)^2}}$$





b.



$$V_- = V_+ = 0$$

$$\frac{V_{in} - V_A}{\frac{1}{2} R_1} = I_1 + I_2 \qquad I_2 = \frac{V_- - V_o}{R_2} = -\frac{V_o}{R_2}$$

$$I_1 = i\omega C_x V_A \qquad I_2 = \frac{V_A - V_-}{\frac{1}{2} R_1} = \frac{2 V_A}{R_1} \longrightarrow V_A = \frac{1}{2} I_2 R_1 = -\frac{1}{2}\frac{R_1}{R_2} V_o$$

Pr 15.35) b. $V_{in} + \frac{1}{2}\frac{R_1}{R_2}V_o = \frac{1}{2} i w C_x R_1 \left(-\frac{1}{2}\frac{R_1}{R_2}V_o\right) - \frac{1}{2}\frac{R_1}{R_2}V_o$

$$V_{in} = -\frac{1}{4} i w C_x R_1 \left(\frac{R_1}{R_2}V_o\right) - \frac{R_1}{R_2}V_o$$

$$= -\frac{R_1}{R_2}V_o \left(1 + \frac{1}{4} i w C_x R_1\right)$$

$$\frac{V_o}{V_{in}} = -\frac{R_2}{R_1\left(1 + i w \frac{C_x}{4} R_1\right)} \longrightarrow \boxed{C_x = 40\,C}$$