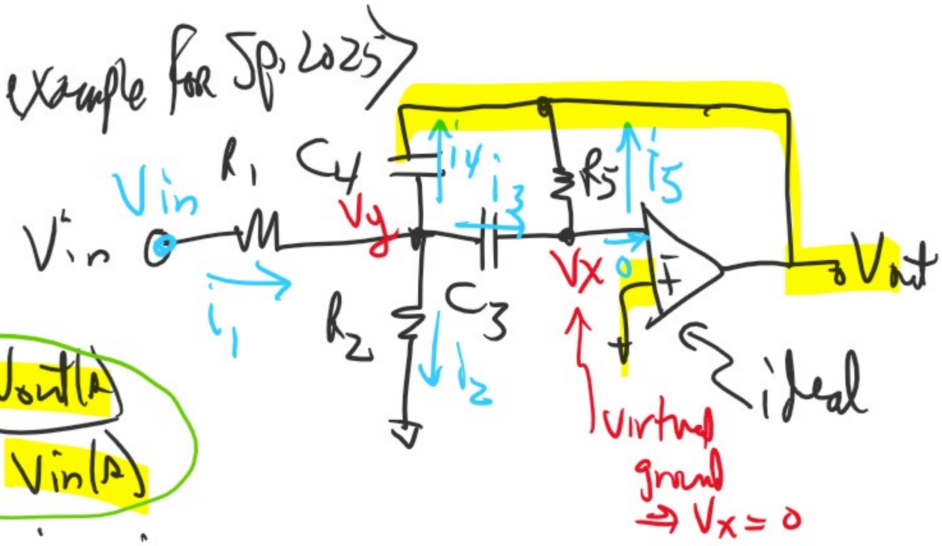
Friday, October 26, 2018 9:59 AM

Bode example <New example for Sp, 2025>



Derive TF: $H(s) = \dfrac{V_{out}(s)}{V_{in}(s)}$

KCL @ V_y: $i_1 = i_4 + i_2 + i_3$

$$Y_{R_1}(V_{in} - V_y) = Y_{C_1}(V_y - V_{out}) + Y_{R_2}V_y + Y_{C_3}(V_y - \cancel{V_x}^{\,0})$$

$$\Rightarrow V_y = \frac{Y_{R_1}V_{in} + Y_{C_4}V_{out}}{Y_{R_1} + Y_{R_2} + Y_{C_4} + Y_{C_3}} \quad (1)$$

KCL @ V_x: $i_3 = i_5 \Rightarrow Y_{C_3}(V_y - \cancel{V_x}^{\,0}) = Y_{R_5}(\cancel{V_x}^{\,0} - V_{out})$

$$\Rightarrow V_y = -\frac{Y_{R_5}}{Y_{C_3}}V_{out} \quad (2)$$

$\Rightarrow$ Set RHSs of (1) & (2) equal, eliminate V_y.

$$\Rightarrow Y_{R_1}V_{in} + Y_{C_4}V_{out} = -\left(\frac{Y_{R_5}}{Y_{C_3}}\right)\left[Y_{R_1} + Y_{R_2} + Y_{C_4} + Y_{C_3}\right)V_{out}$$

admittances $= 1/Z$

$$Y_{R_1} = 1/R_1 = G_1,\quad Y_{R_2} = 1/R_2 = G_2,\quad Y_{C_3} = sC_3,\quad Y_{C_4} = sC_4,\quad Y_{R_5} = 1/R_5 = G_5$$

$$\Rightarrow sG_1C_3V_{in} = -\left[s^2C_3C_4 + sG_5(C_3 + C_4) + (G_1 + G_2)G_5\right]V_{out}$$

$$H(s) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{-s G_1 C_3}{s^2 \boxed{C_3 C_4} + s G_5 (C_3 + C_4) + G_5 (G_1 + G_2)}$$

(factor C_3C_4 out of den)

$$= \frac{\dfrac{-s G_1 \cancel{C_3}}{\cancel{C_3} C_4}}{s^2 + s \dfrac{G_5 (C_3 + C_4)}{C_3 C_4} + \dfrac{G_5 (G_1 + G_2)}{C_3 C_4}}$$

$$= \frac{-s \left(\dfrac{1}{R_1 C_4}\right)}{s^2 + s \left(\dfrac{C_3 + C_4}{R_5 C_3 C_4}\right) + \dfrac{\left(1/R_1 + 1/R_2\right)}{R_5 C_3 C_4}}$$

$$H(s) = \frac{-\omega_x s}{s^2 + 2 \zeta \omega_0 s + \omega_0^2}$$

$\omega_x = \alpha \omega_0$

$\omega_0 =$ natural freq. (resonant)

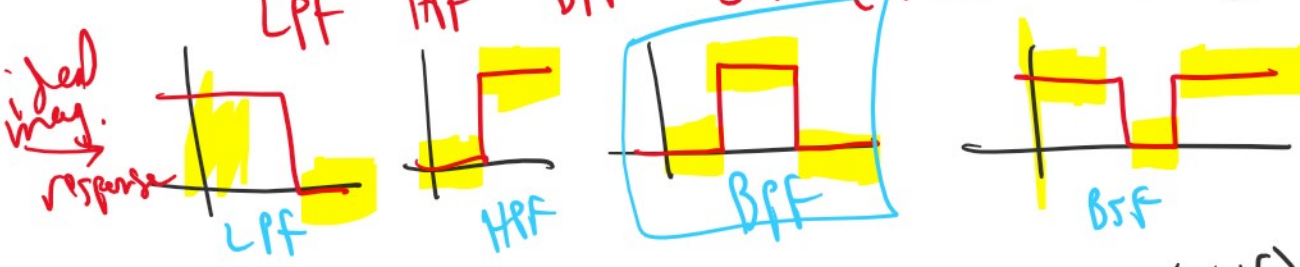
$$= \frac{-\alpha \omega_0 s}{s^2 + \dfrac{\omega_0}{Q} s + \omega_0^2}$$

$\zeta =$ damping coefficient factor

$Q = \dfrac{1}{2\zeta} =$ quality factor

What kind of filter will this be?

LPF HPF BPF BSF (& there are others)

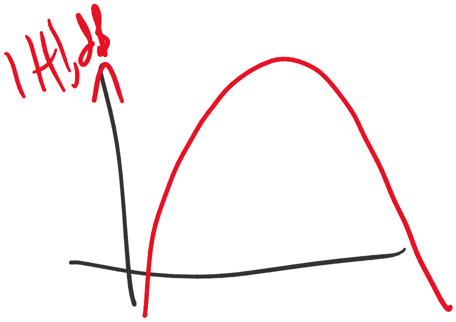


Consider the 2 extremes: $s \to 0$ (DC) & $s \to \infty$ (VHF)

$$\lim_{s \to 0} H(s) = \frac{0}{\omega_0^2} = 0 \quad // \quad \lim_{s \to \infty} \frac{-\alpha \omega_0 s}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2}$$

$$\lim_{s\to 0} H(s) = \frac{\quad}{w_0^2} = 0$$

$$\lim_{s\to\infty} \frac{\quad}{s^2+\frac{w_0}{Q}s+w_0^2} = \lim_{s\to\infty} -\frac{\alpha w_0 \cancel{s}}{s^{\cancel{2}}} = 0$$



BPF!