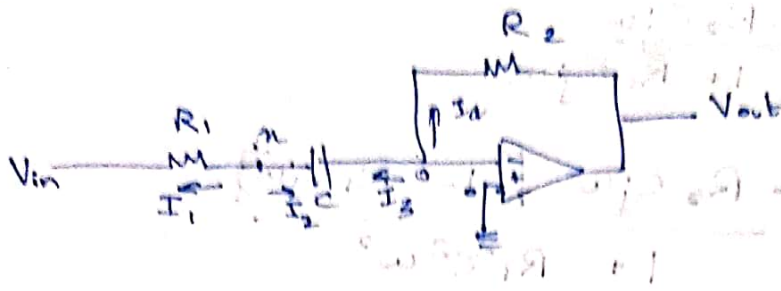


differentiator



a) ~~Current~~ Current law in n.

$$I_1 + I_2 = 0$$

$$\frac{n - V_{in}}{R_1} + C \frac{d(n - 0)}{dt} = 0$$

$$\text{or } \frac{n - V_{in}}{R_1} + C \frac{dn}{dt} = 0$$

$$\text{or } \frac{n(j\omega) - V_{in}(j\omega)}{R_1} + C j\omega n(j\omega) = 0$$

$$\text{or } n(j\omega) \left[\frac{1}{R_1} + C j\omega \right] = \frac{V_{in}(j\omega)}{R_1}$$

$$\text{or } n(j\omega) = \frac{V_{in}(j\omega)}{1 + R_1 C j\omega} = (w)^{-1/2} \angle -45^\circ$$

b) $I_4 + I_3 = 0$

$$= \frac{0 - V_{out}}{R_2} + \left[C \frac{d(0 - n)}{dt} \right] = 0$$

$$\text{or } -\frac{V_{out}}{R_2} - C \frac{dn}{dt} = 0$$

$$\text{or } -\frac{V_{out}(j\omega)}{R_2} - C j\omega n(j\omega) = 0$$

$$\text{or } -\frac{V_{out}(j\omega)}{R_2} - \frac{C j\omega V_{in}(j\omega)}{1 + R_1 C j\omega} = 0$$

$$\text{or } V_{out}(j\omega) = \frac{-R_2 C j\omega}{1 + R_1 C j\omega} V_{in}(j\omega)$$

$$H(j\omega) = \frac{-R_2 C j\omega}{1 + R_1 C j\omega}$$

$$= \frac{-R_2 C j\omega [1 - R_1 C j\omega]}{1 + R_1^2 C^2 \omega^2}$$

$$= \frac{-R_2 C j\omega + R_1 R_2 C^2 \omega^2}{1 + R_1^2 C^2 \omega^2}$$

$$= \left[\frac{R_1 R_2 C^2 \omega^2 + R_2 C j\omega}{1 + R_1^2 C^2 \omega^2} \right]$$

$$|H(j\omega)| = \sqrt{\frac{R_1^2 R_2^2 C^4 \omega^4 + R_2^2 C^2 \omega^2}{1 + R_1^2 C^2 \omega^2}}$$

$$\angle H(j\omega) = -\tan^{-1} \left[\frac{R_2 C \omega}{R_1 R_2 C^2 \omega^2} \right]$$

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$$= -\tan^{-1} \left[\frac{1}{R_1 C \omega} \right]$$

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$$0 = \frac{\omega_i \omega_o}{\omega_i \omega_o} - \frac{\omega_i \omega_o}{\omega_i \omega_o}$$

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$$\frac{\omega_i \omega_o}{\omega_i \omega_o} = \frac{\omega_i \omega_o}{\omega_i \omega_o}$$