Problem 6.24 For the op-amp circuit of Fig. P6.24 provide the following:

(a) An expression for $\mathbf{H}(\omega) = \mathbf{V}_o/\mathbf{V}_s$ in standard form.

(b) Spectral plots for the magnitude and phase of $\mathbf{H}(\omega)$, given that $R_1 = 1$ kΩ, $R_2 = 20$ Ω, $C_1 = 5$ μF, and $C_2 = 25$ nF.

(c) What type of filter is it? What is its maximum gain?

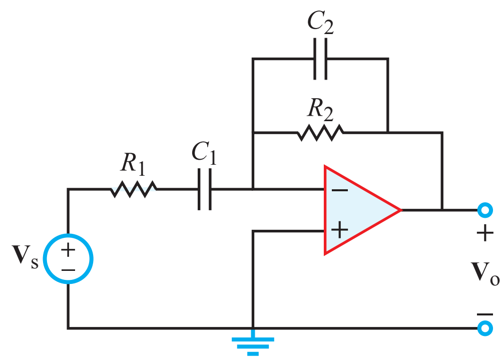


Figure P6.24: Circuit for Problem 6.24.

Solution: This is basically an inverting amplifier with a transfer function given by

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_s} = -\frac{\mathbf{Z}_f}{\mathbf{Z}_s} = \frac{-(R_2 \parallel 1/j\omega C_2)}{R_1 + 1/j\omega C_1}$$

$$= \frac{-j\omega R_2 C_1}{(1 + j\omega R_1 C_1)(1 + j\omega R_2 C_2)}$$

$$= \frac{-j(\omega/\omega_{c_1})}{(1 + j\omega/\omega_{c_2})(1 + j\omega/\omega_{c_3})},$$

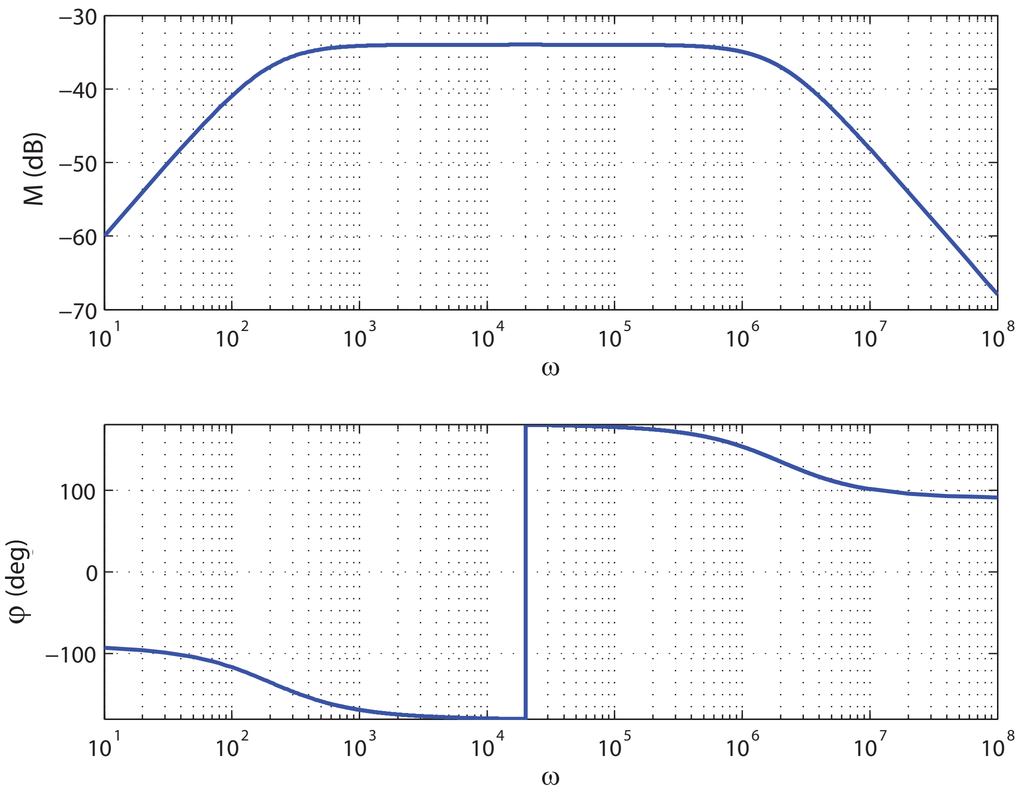
with

$$\omega_{c_1} = \frac{1}{R_2 C_1} = \frac{1}{20 \times 5 \times 10^{-6}} = 10^4 \text{ rad/s},$$

$$\omega_{c_2} = \frac{1}{R_1 C_1} = \frac{1}{10^3 \times 5 \times 10^{-6}} = 200 \text{ rad/s},$$

$$\omega_{c_3} = \frac{1}{R_2 C_2} = \frac{1}{20 \times 25 \times 10^{-9}} = 2 \times 10^6 \text{ rad/s}.$$

(b) Spectral plots are shown in Figs. P6.24(a) and (b).



Figures P6.24(a) and (b)

(c) This is a bandpass filter with corner frequencies of 200 rad/s and 10^6 rad/s. In the intermediate range, its maximum gain is approximately

$$G \approx 20\log\left(\frac{R_2}{R_1}\right) = 20\log 0.02 = -34 \text{ dB}.$$