Problem 9.38 For the op-amp circuit of Fig. P9.38:

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

(b) Generate spectral plots for the magnitude and phase of $\mathbf{H}(\omega)$, given that $R_1 = 99$ kΩ, $R_2 = 1$ kΩ, and $C = 0.1$ μF.

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

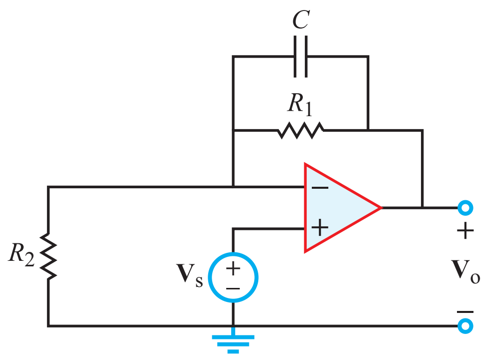
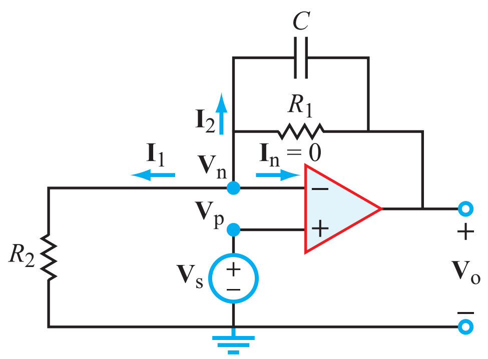


Figure P9.38: Circuit for Problem 9.38.

Solution:



(a) $\mathbf{V}_n = \mathbf{V}_p = \mathbf{V}_s$

At node $\mathbf{V}_n$:

$$\mathbf{I}_1 + \mathbf{I}_2 = 0,$$

or equivalently

$$\frac{\mathbf{V}_s}{R_2} + \frac{\mathbf{V}_s - \mathbf{V}_o}{\left(R_1 \parallel \frac{1}{j\omega C}\right)} = 0,$$

which leads to

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_s} = \frac{(R_1 + R_2)\left[1 + j\omega\left(\frac{R_1 R_2}{R_1 + R_2}\right)C\right]}{R_2(1 + j\omega R_1 C)}$$

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

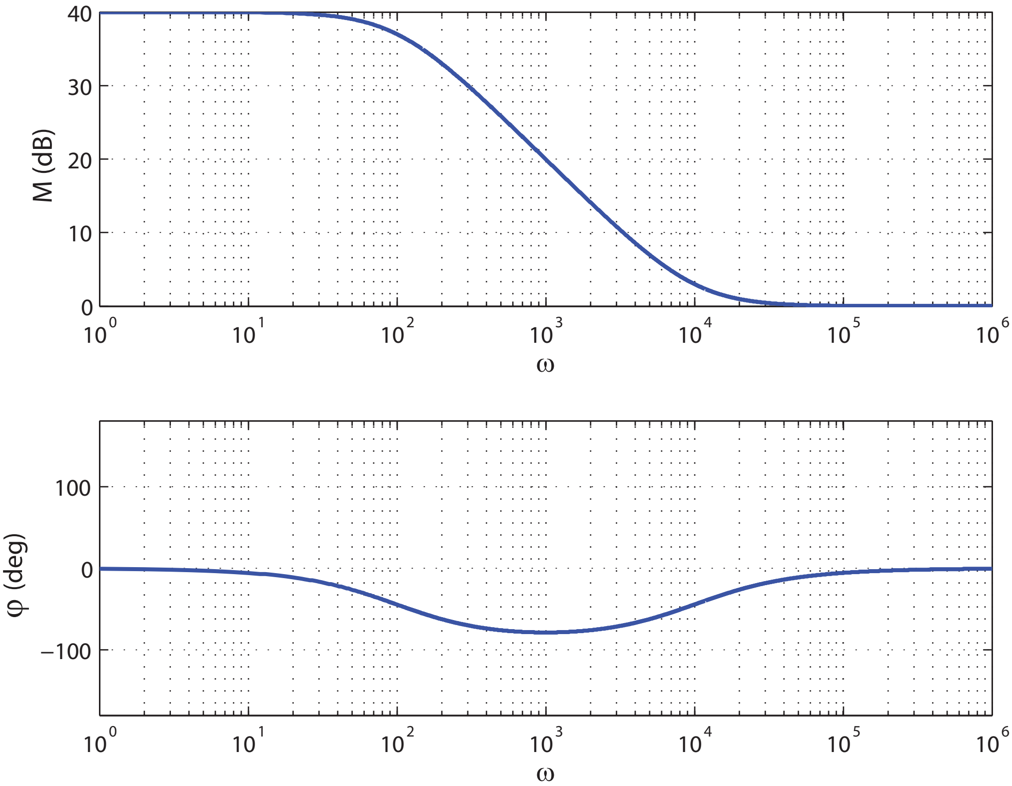
with

$$K = \frac{R_1 + R_2}{R_2} = 100,$$

$$\omega_{c_1} = \frac{R_1 + R_2}{R_1 R_2 C} = \frac{100 \times 10^3}{99 \times 10^6 \times 10^{-7}} \simeq 10^4 \text{ rad/s},$$

$$\omega_{c_2} = \frac{1}{R_1 C} = \frac{1}{99 \times 10^3 \times 10^{-7}} \simeq 100 \text{ rad/s}.$$

(b) Spectral plots are shown in Figs. P9.38(b) and (c).



Figures P9.38(b) and (c)

(c) It is a 40-dB gain amplifier at low frequencies (below 100 rad/s) and a 0 dB amplifier at frequencies much higher than 10^4 rad/s.