Unity – Gain KRC Design as given in Sergio Franco

Unity-Gain *KRC* Circuit

Imposing $K = 1$ minimizes the number of components and also maximizes the bandwidth of the op amp, an issue that will be studied in Chapter 6. To simplify the math, we relabel the components as $R_2 = R$, $C_2 = C$, $R_1 = mR$, and $C_1 = nC$. Then, Eq. (3.60) reduces to

$$H_{0LP} = 1\ \text{V/V} \qquad \omega_0 = \frac{1}{\sqrt{mn}RC} \qquad Q = \frac{\sqrt{mn}}{m+1} \tag{3.64}$$

You can verify that for a given n, Q is maximized when $m = 1$, that is, when the resistances are equal. With $m = 1$, Eq. (3.64) gives $n = 4Q^2$. In practice, one starts out with two easily available capacitances in a ratio $n \geq 4Q^2$; then m is found as $m = k + \sqrt{k^2 - 1}$, where $k = n/2Q^2 - 1$.

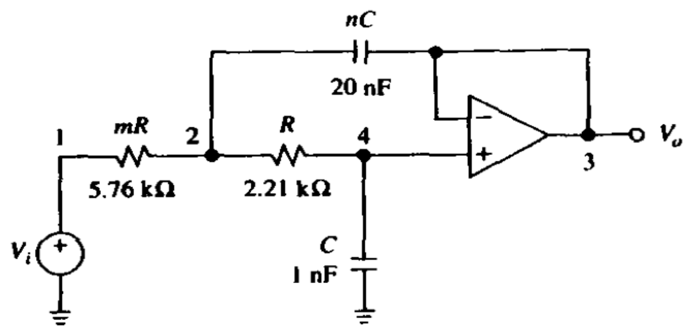

FIGURE 3.25
Filter of Example 3.10.

EXAMPLE 3.10. (*a*) Using the unity-gain option, design a low-pass filter with $f_0 =$ 10 kHz and $Q = 2$. (*b*) Use PSpice to visualize its frequency response.

Solution.

(*a*) Arbitrarily pick $C = 1$ nF. Since $4Q^2 = 4 \times 2^2 = 16$, let $n = 20$. Then, $nC = 20$ nF, $k = 20/(2 \times 2^2) - 1 = 1.5$, $m = 1.5 + \sqrt{1.5^2 - 1} = 2.618$, $R = 1/(\sqrt{mn}\omega_0 C) = 1/(\sqrt{2.618 \times 20} \times 2\pi 10^4 \times 10^{-9}) = 2.199$ kΩ (use 2.21 kΩ, 1%), and $mR =$ 5.758 kΩ (use 5.76 kΩ, 1%). The filter is shown in Fig. 3.25.

The advantages of the unity-gain design are offset by a quadratic increase of the capacitance spread n with Q. Moreover, the circuit does not enjoy the tuning advantages of the equal-component design because the adjustments of ω_0 and Q interfere with each other, as revealed by Eq. (3.64). On the other hand, at high Qs the equal-component design becomes too sensitive to the tolerances of R_B and R_A,