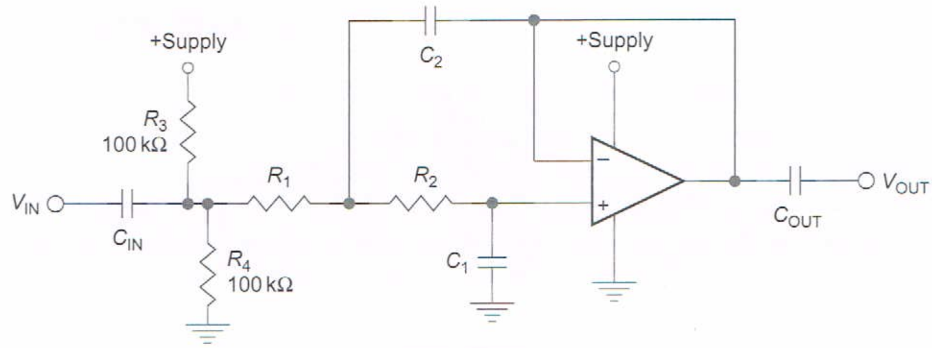

Figure 6.8
Low-Pass Filter

6.3.2 *Low-Pass Filter*

A low-pass filter is shown in Figure 6.8.

Design Procedure

- Pick C_1.
- Calculate $C_2 = C_1{*}2$.
- Calculate R_1 and R_2: $\dfrac{1}{2\sqrt{2}{*}\pi{*}\mathrm{C}_1{*}\mathrm{Frequency}}$.
- Calculate $C_{IN} = C_{OUT} = 100$ to 1000 times C_1 (not critical).
- DONE!

Digging Deeper

The filter selected is a unity-gain Sallen–Key Filter, with a Butterworth response characteristic. Note that with the addition of C_{IN} and C_{OUT}, the filter is no longer purely a low-pass filter. It is a wide bandpass filter, but the high-pass response characteristic can be placed well below the frequencies of interest. If a DC response is required, the circuit should be modified to operate off split supplies.

6.3.3 *High-Pass Filter*

A high-pass filter is shown in Figure 6.9.

Design Procedure

- Pick $C_1 = C_2$.
- Calculate R_1: $\dfrac{1}{\sqrt{2}{*}\pi{*}\mathrm{C}_1{*}\mathrm{Frequency}}$.

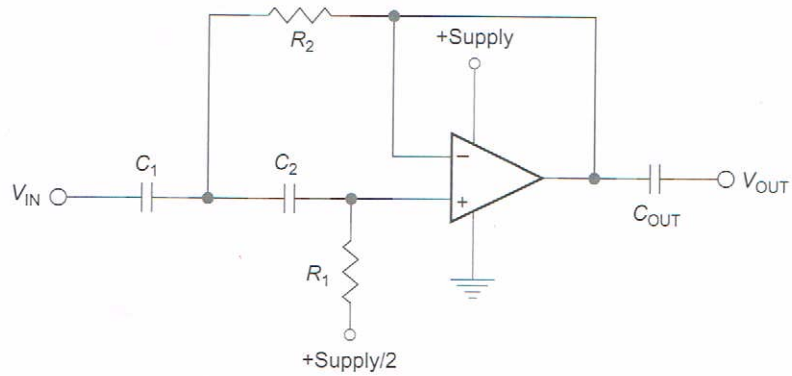

Figure 6.9
High-Pass Filter

- Calculate R_2: $\dfrac{1}{2\sqrt{2}*\pi*C_1*\text{Frequency}}$.
- Calculate C_{OUT} = 100 to 1000 times C_1 (not critical).
- DONE!

Digging Deeper

The filter selected is a unity-gain Sallen–Key filter, with a Butterworth response characteristic. Just as was the case with the low-pass filter, there is no such thing as an active high-pass filter, but for a different reason. The gain/bandwidth product of the op amp used will ultimately produce a low-pass response characteristic, making this a wide bandpass filter. It is your responsibility to choose an op amp with a frequency limit well above the bandwidth of interest.

6.3.4 Narrow (Single-Frequency) Bandpass Filter

A narrow bandpass filter is shown in Figure 6.10.

Design Procedure

- Pick $C_1 = C_2$.
- Calculate $R_1 = R_4$: $\dfrac{1}{2*\pi*C_1*\text{Frequency}}$.
- Calculate $R_3 = 19*R_1$.
- Calculate $R_2 = \dfrac{R_1}{19}$.
- Calculate $C_{IN} = C_{OUT}$ = 100 to 1000 times C_1 (not critical).
- DONE!

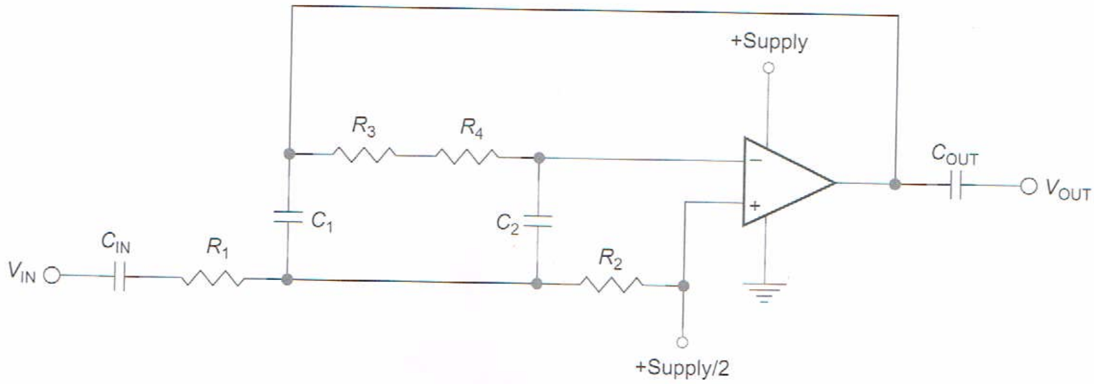

Figure 6.10
Narrow Bandpass Filter

Digging Deeper

The filter selected is a modified Deliyannis filter. A Deliyannis filter is a special case of the multiple-feedback (MFB) bandpass configuration, one that is very stable and relatively insensitive to component variation. The Q is set at 10, which also locks the gain at 10, as the two are related by the expression:

$$\frac{R_3 + R_4}{2 \cdot R_1} = Q = \text{Gain} \tag{6.10}$$

A higher Q was not selected, because the op amp gain bandwidth product can be easily reached, even with a gain of 20 dB. At least 40 dB of headroom should be allowed above the center frequency peak. The op amp slew rate should also be sufficient to allow the waveform at the center frequency to swing to the amplitude required.

6.3.5 Wide Bandpass Filter

A wide bandpass filter is shown in Figure 6.11.

Design Procedure

- Go to Section 6.3.3, and design a high-pass filter for the low end of the band.
- Go to Section 6.3.2, and design a low-pass filter for the high end of the band.
- Calculate $C_{IN} = C_{OUT} =$ 100 to 1000 times C_1 in the low-pass filter section (not critical).
- DONE!