ACTIVE FILTERS

Topic Outcomes

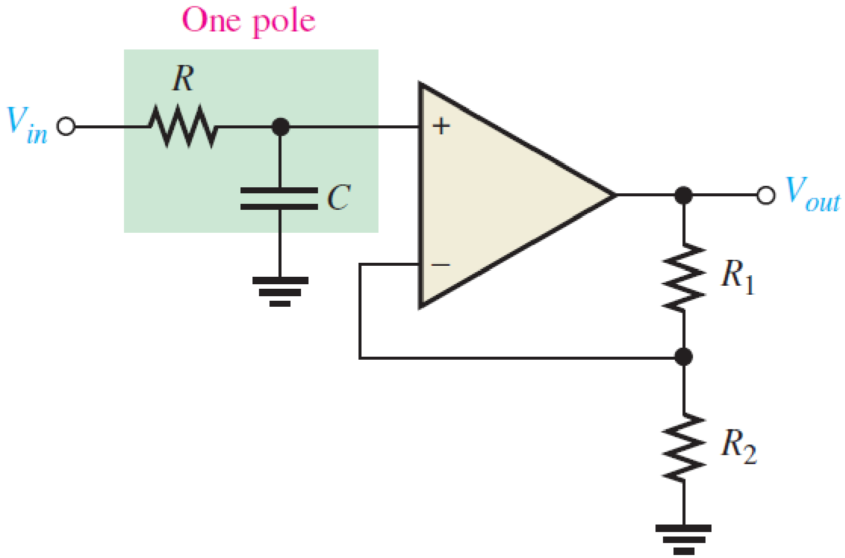
- Describe different types and components of active filters
- Differentiate active filters from passive filters
- Analyze the frequency response of active filters
- Measure frequency response, critical frequency, and bandwidth of active filters through computations

Active Filters

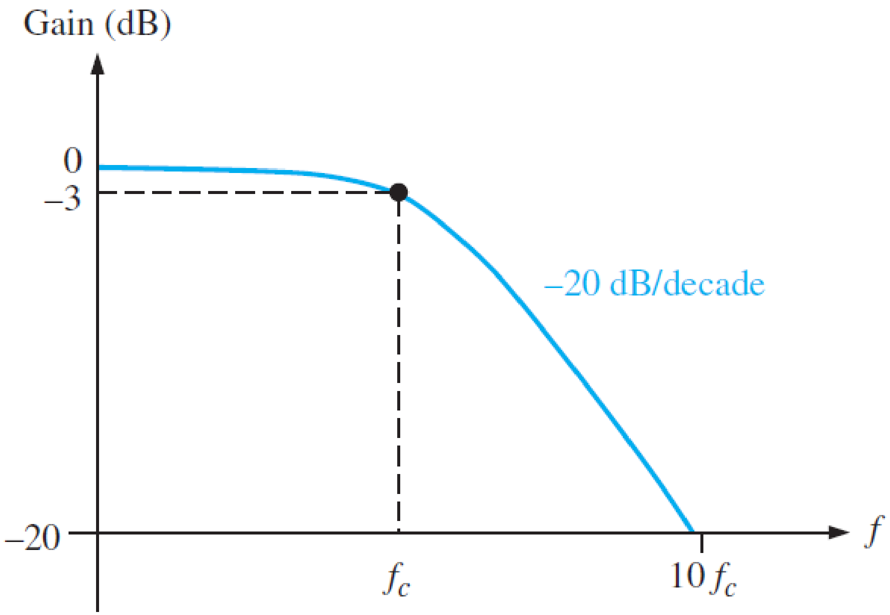
Active filters

- An active filter is a circuit composed of passive elements and one or more active elements.
- Its main function is to simulate the action of the passive filters and also providing amplification (the signal is not attenuated as it passes through the filter).
- Active filter applications:
  - Tone signaling
  - Data Acquisition Systems
  - Audio
  - Lab Signal Sources

Active Low-Pass Filter



First-order (One Pole) Low Pass Filter

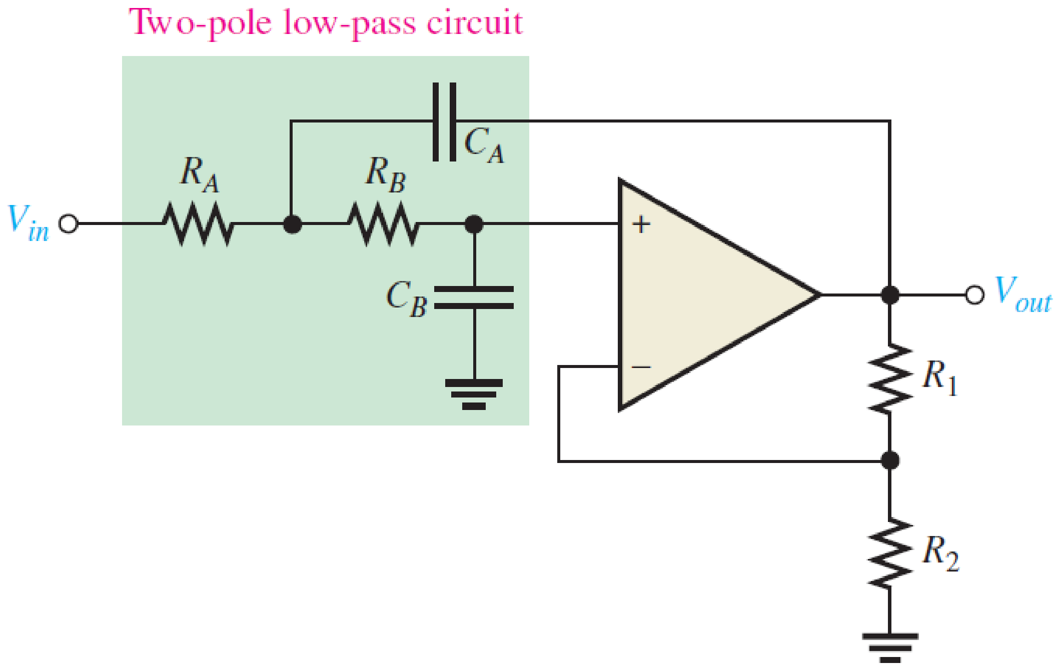


$$f_c = \frac{1}{2\pi RC}, A_V = 1 + \frac{R_1}{R_2}$$

Sallen-Key Low-Pass Filter

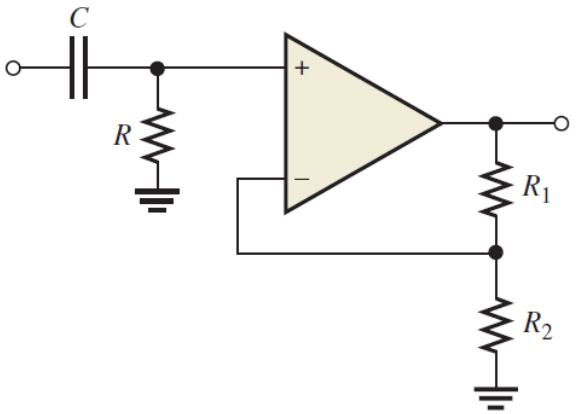
$$f_c = \frac{1}{2\pi\sqrt{R_A R_B C_A C_B}}$$

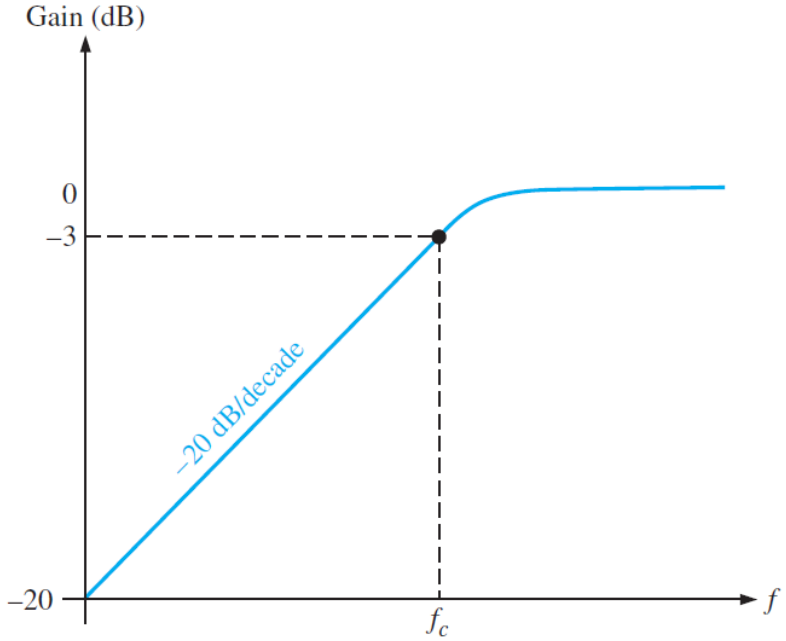
$$A_V = 1 + \frac{R_1}{R_2}$$



Second-order (Two Pole) Low Pass Filter

Active High-Pass Filter

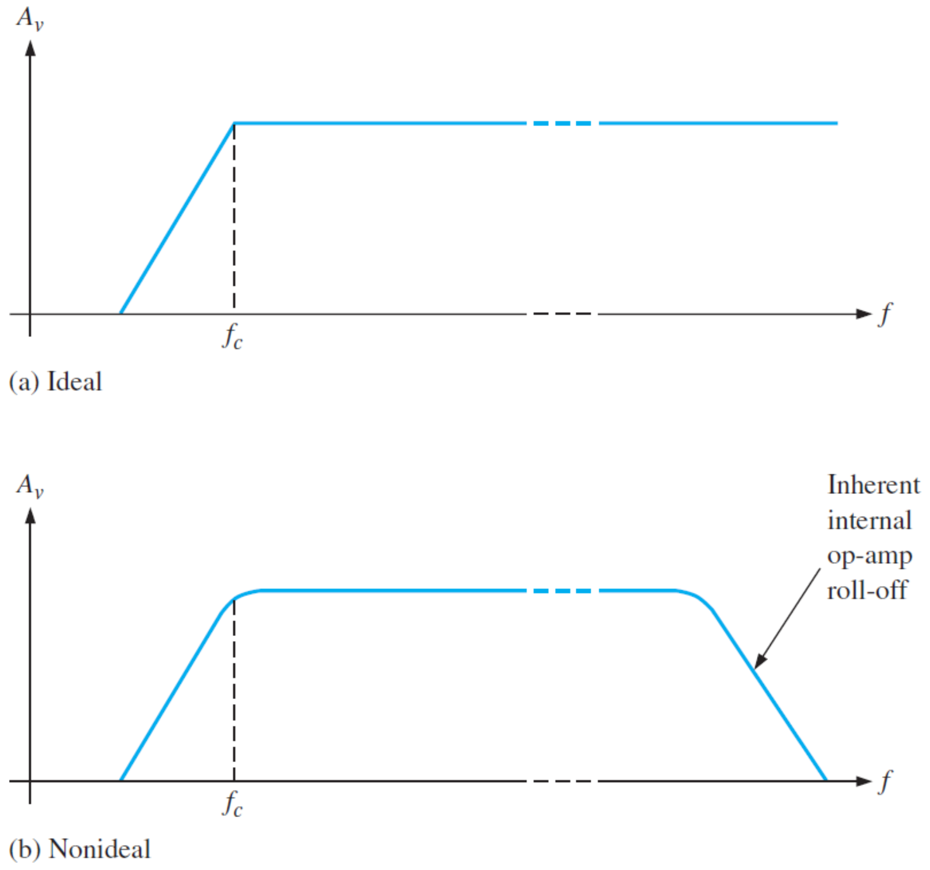




First-order (One Pole) High-Pass Filter

$$f_c = \frac{1}{2\pi RC}, A_V = 1 + \frac{R_1}{R_2}$$

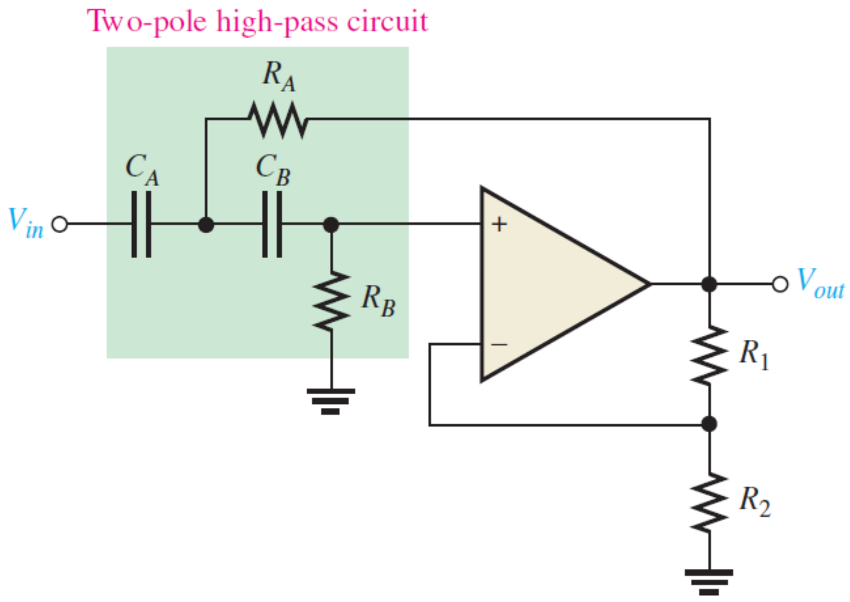
Active High-Pass Filter



Sallen-Key High-Pass Filter

$$f_c = \frac{1}{2\pi\sqrt{R_A R_B C_A C_B}}$$

$$A_V = 1 + \frac{R_1}{R_2}$$



Provides a roll-off rate of -40dB/decade

Second-order (Two Pole) Low Pass Filter

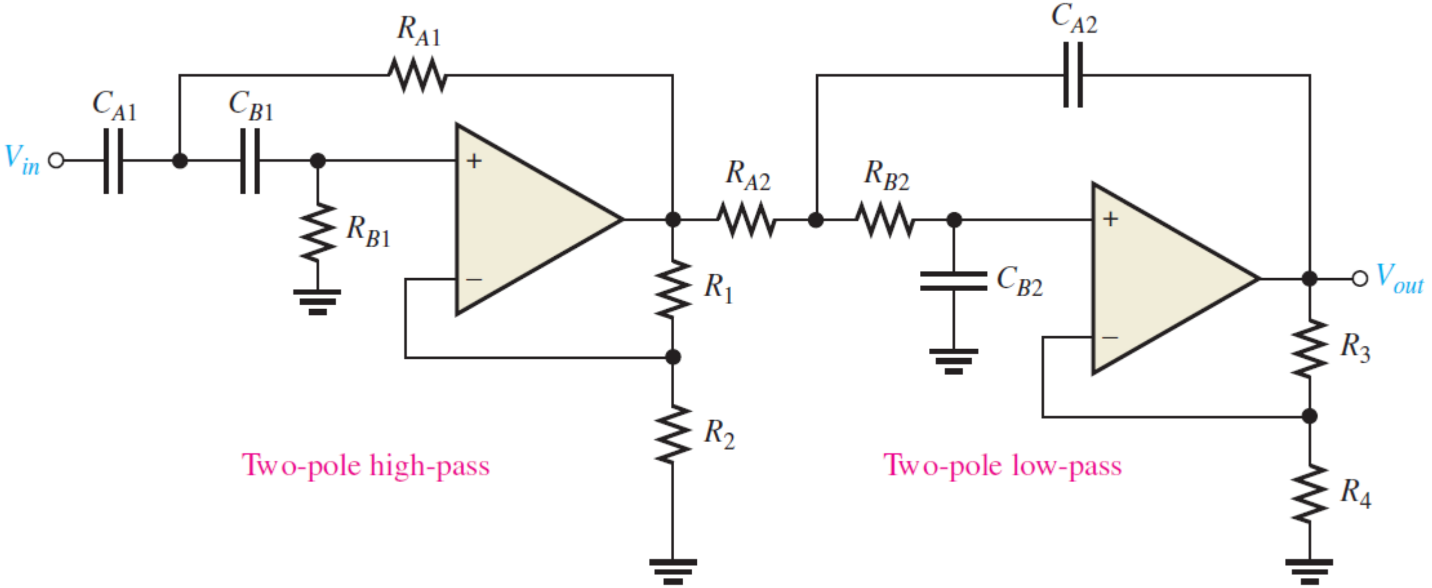
Active Band-Pass Filter

$$f_{c_2} = \frac{1}{2\pi\sqrt{R_{A_1}R_{B_1}C_{A_1}C_{B_1}}}$$

$$f_{c_1} = \frac{1}{2\pi\sqrt{R_{A_2}R_{B_2}C_{A_2}C_{B_2}}}$$

$$A_{V_1} = 1 + \frac{R_1}{R_2}$$

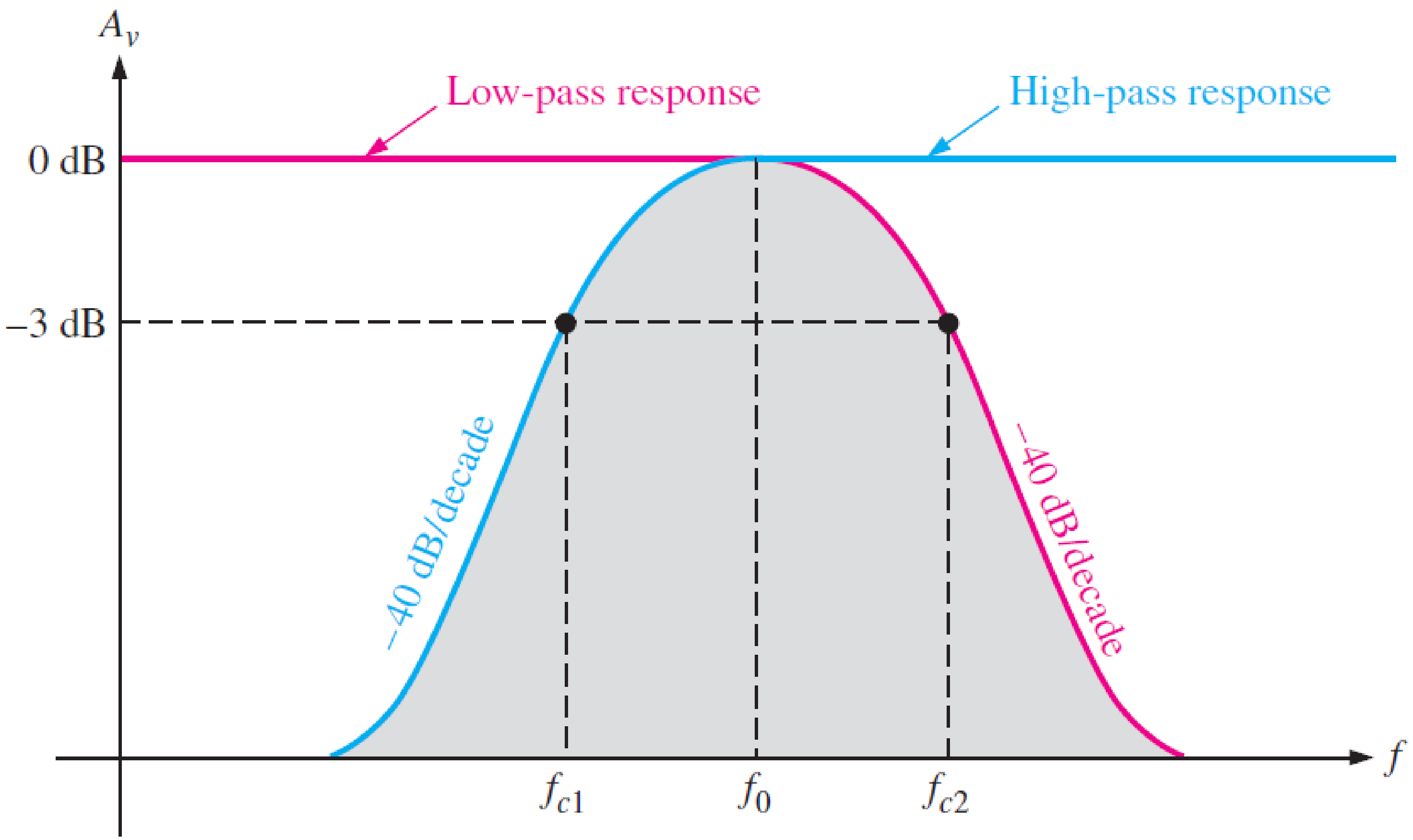
$$A_{V_2} = 1 + \frac{R_3}{R_4}$$



Provides a roll-off rate of -40dB/decade

Second-order (Two Pole) Low Pass Filter

Active Band-Pass Filter

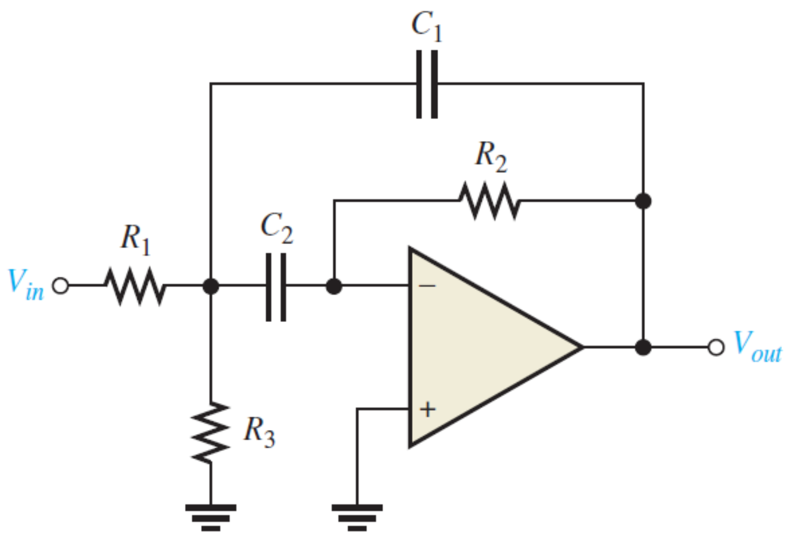


Multiple-Feedback Band-Pass Filter

$$f_o = \frac{1}{2\pi\sqrt{(R_1 \parallel R_3)R_2C_1C_2}}$$

If $C_1 = C_2 = C$

$$f_o = \frac{1}{2\pi C}\sqrt{\frac{R_1 + R_3}{R_1R_2R_3}}$$



A value for the capacitors are chosen and the three resistor values are calculated to achieve the desired values for f_0, BW and A_0

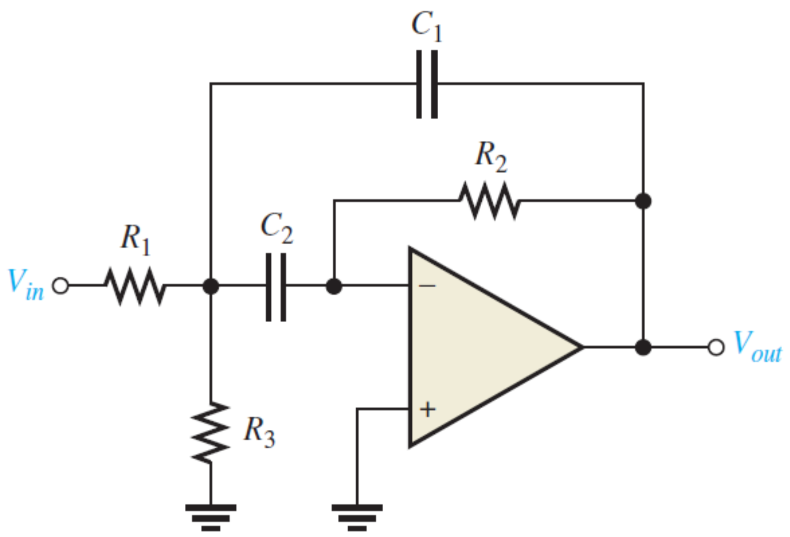
Multiple-Feedback Band-Pass Filter

$$R_1 = \frac{Q}{2\pi f_0 C A_0}$$

$$R_2 = \frac{Q}{\pi f_0 C}$$

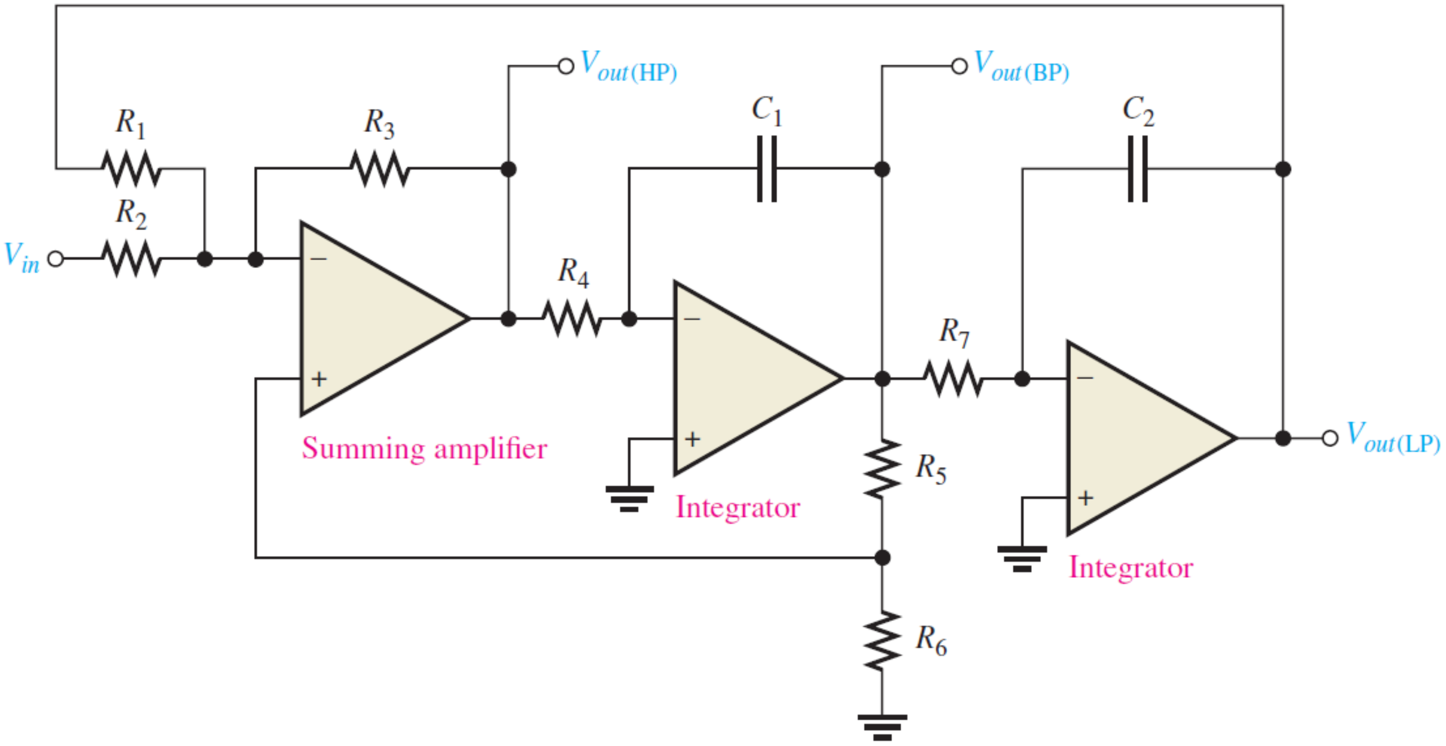
$$R_3 = \frac{Q}{2\pi f_0 C(2Q^2 - A_0)}$$

$$A_0 = \frac{R_2}{2R_1}$$



State-Variable Filter

- Also known as universal active filter
- Widely used for band-pass applications and consists of a summing amplifier and 2 op-amp integrators in a cascaded arrangement
- Aside from the band-pass output, it can also provide low-pass (LP) and high-pass (HP) outputs

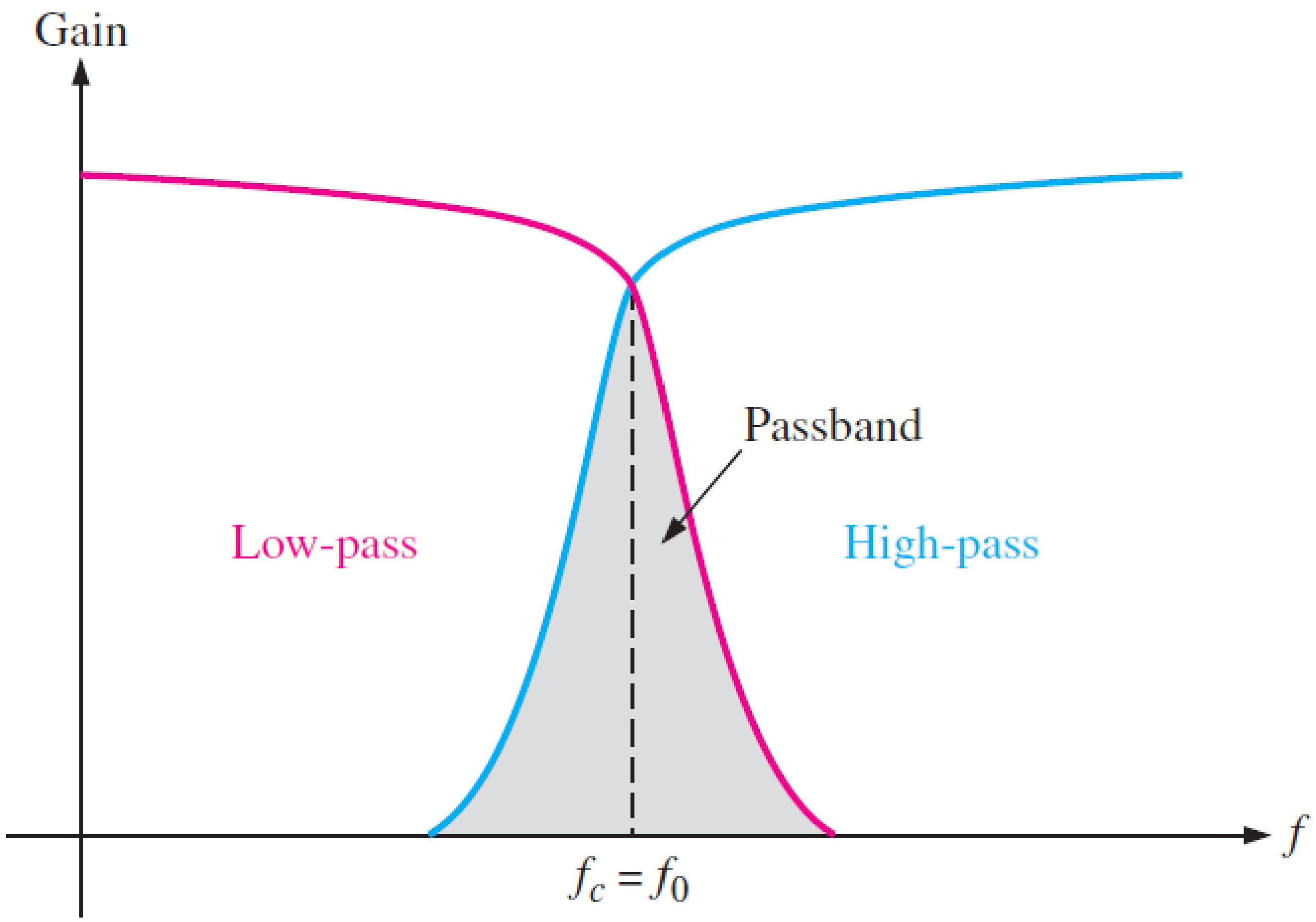


State-Variable Filter

$$f_{c_1} = \frac{1}{2\pi R_4 C_1}$$

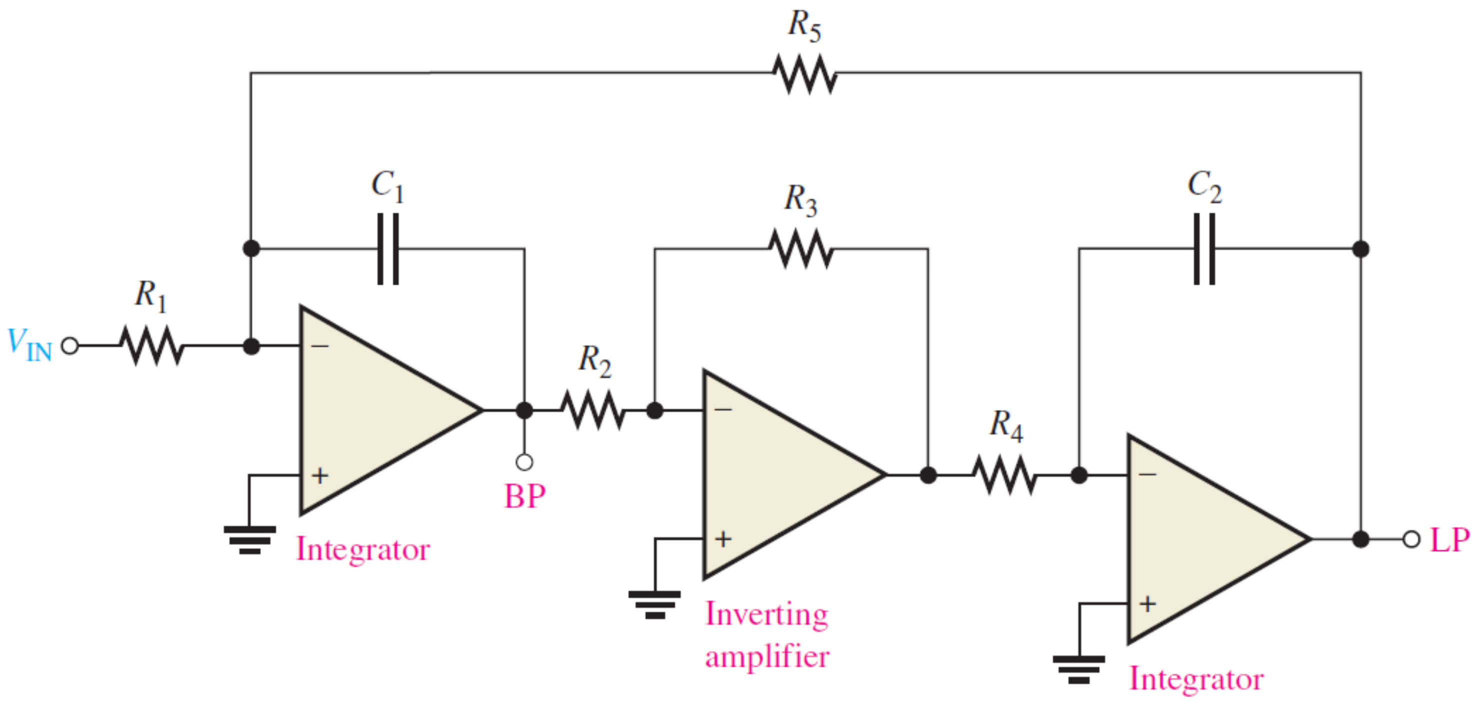
$$f_{c_2} = \frac{1}{2\pi R_7 C_2}$$

$$Q = \frac{1}{3}\left(\frac{R_5}{R_6} + 1\right)$$



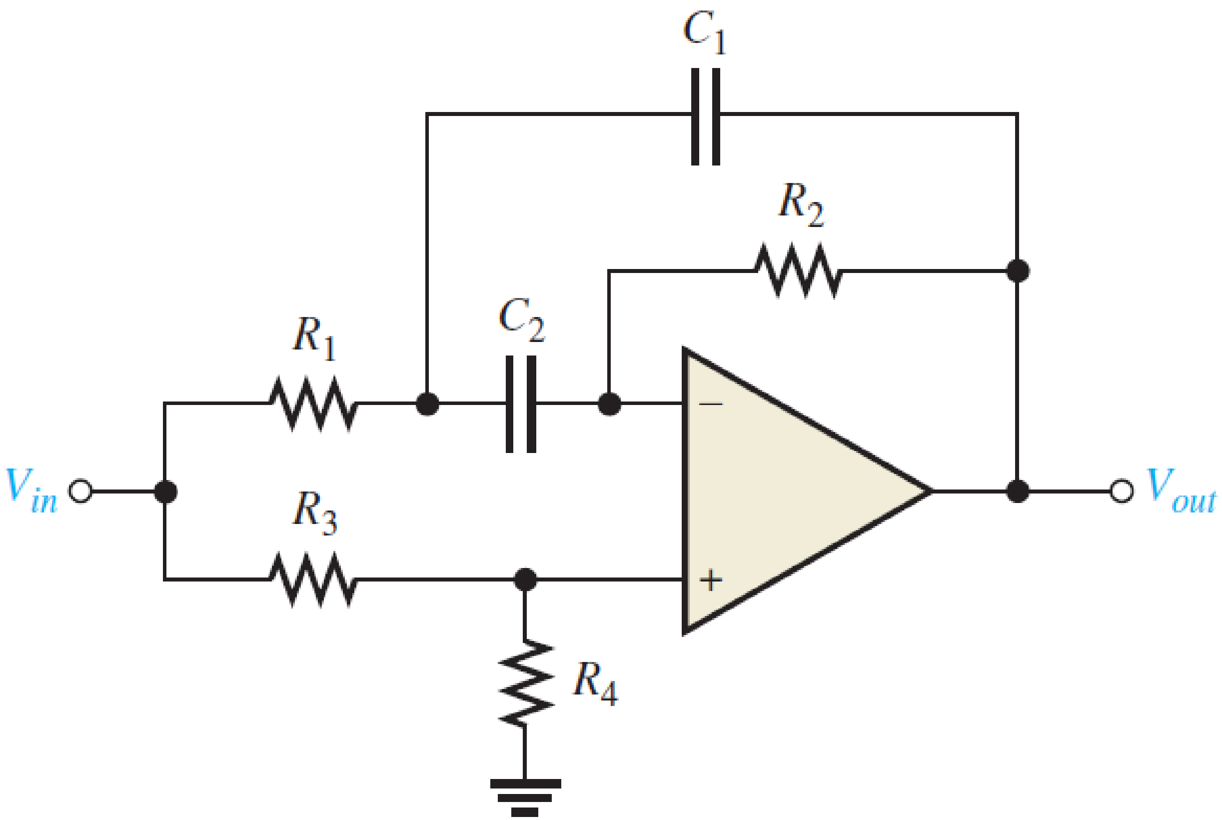
Bi-Quad Filter

- Consists of an integrator followed by and inverting amplifier and another integrator
- The bandwidth is independent and the Q is dependent on the critical frequency
- Can only provide band-pass and low-pass outputs

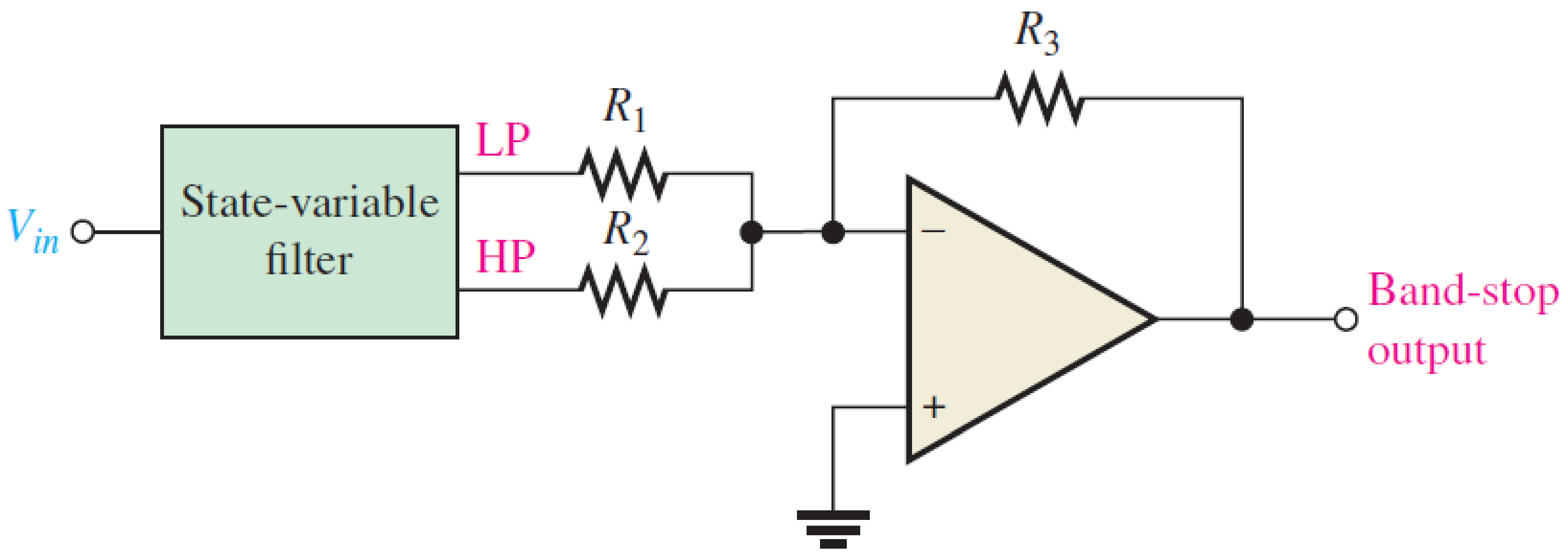


Multiple-Feedback Band-Stop Filter

The characteristic of band-stop filter is opposite to band-pass filter. One configuration of band-stop filter is the multiple-feedback. It has the same configuration of band-pass filter except there is a resistor that has been removed and added.



State-Variable Band-Stop Filter



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