Basic Elec. Engr. Lab

ECS 204/210

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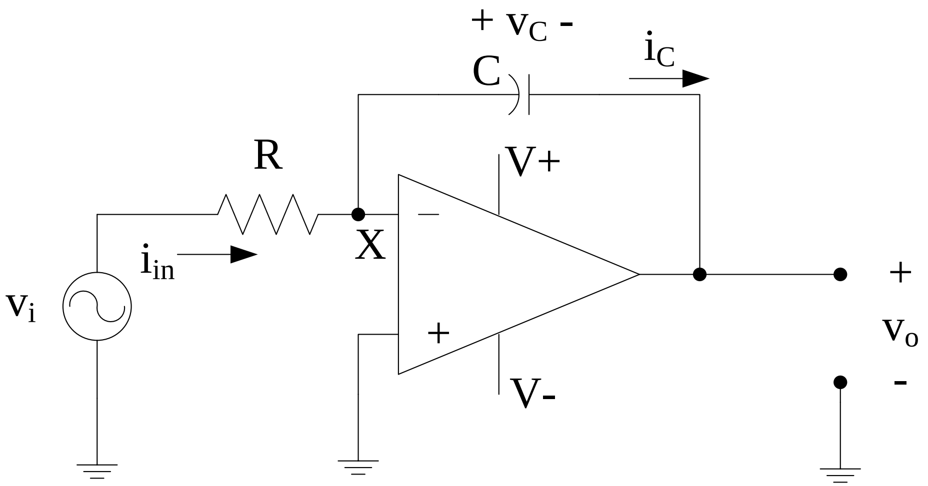
Office Hours:
BKD 3601-7
Tuesday 9:30-10:30
Friday 14:00-16:00

Lab 8

- Filter
  - Passive LPF
  - Active LPF
  - Passive HPF
- Circuit Design

Lab 7.B: Inverting Integrator:



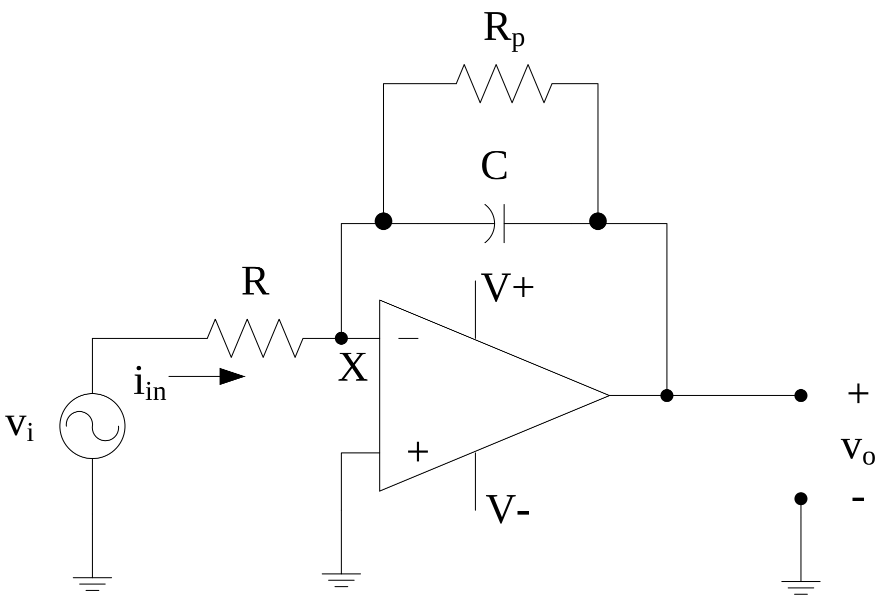
$$V_o = -\left(\frac{Z_C}{R}\right)V_i$$

$$= -\left(\frac{V_i}{R}\right) \times \frac{1}{j\omega C}$$

- The gain at $f = 0$ is unbounded.

Lab 7.B: Inverting Integrator

- In practical circuit, a large resistor R_p is usually shunted across the capacitor



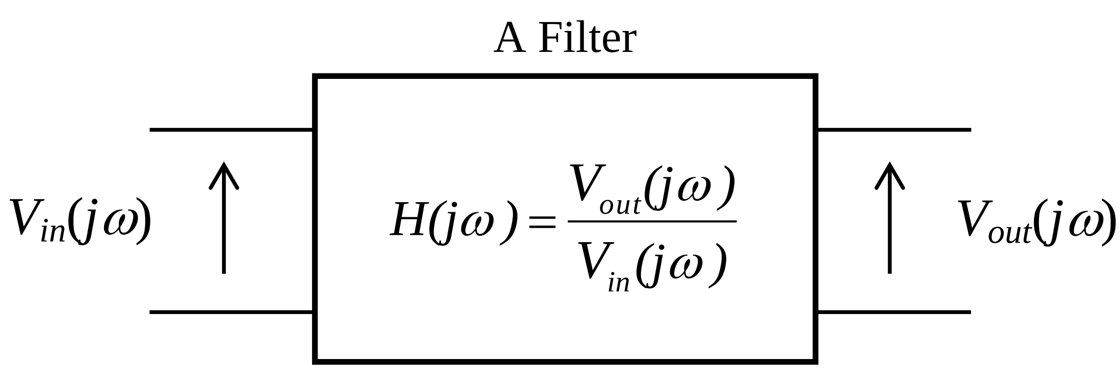
$$V_o = -\left(\frac{Z_C // R_p}{R}\right)V_i$$

$$= -\left(\frac{V_i}{R}\right) \times \frac{R_p}{j\omega R_p C + 1}$$

- Observe that at $f = 0$, the gain is finite.

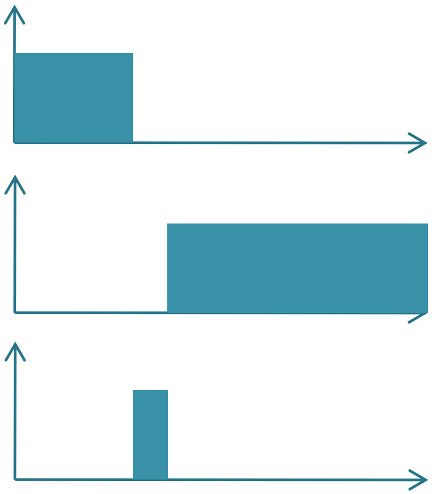
Filter

- Used in circuits to
  - remove unwanted frequency components, or
  - enhance wanted ones, or
  - both
- Transfer function
  - Magnitude response ("voltage gain" or "frequency response")
  - phase response ("phase shift")

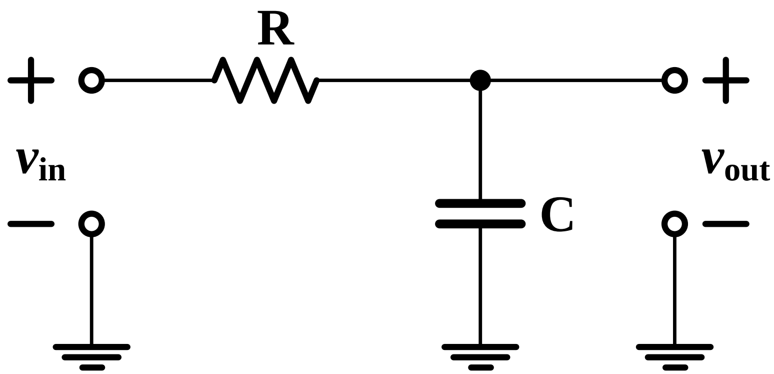


Filter

- By Function:
  - Low-pass filter (LPF)
  - High-pass filter (HPF)
  - Bandpass filter (BPF)
- By Electronic Realization:
  - Active
    - contain amplifying devices such as transistors and amplifiers
  - Passive



Low-pass filter (LPF)



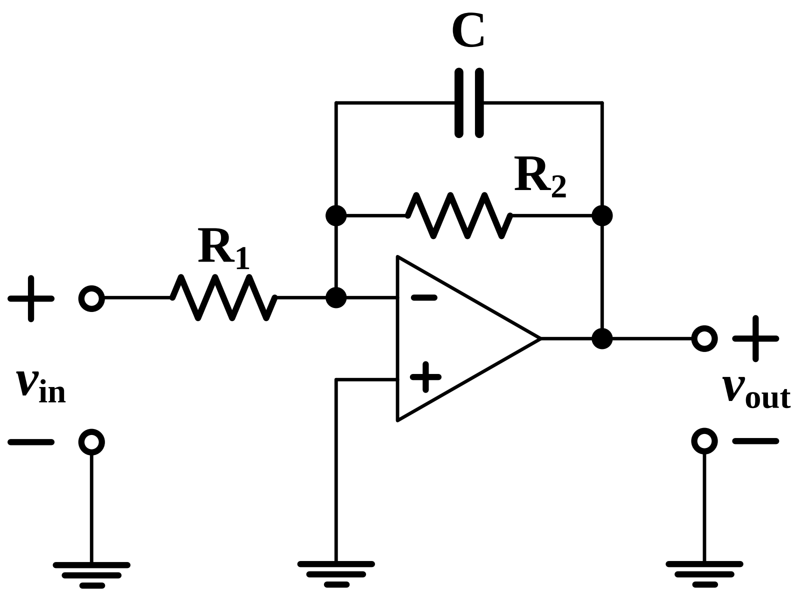
Transfer Function

$$H_{LP,passive}(j\omega) = \frac{1}{1 + j\omega RC}$$

Cut-off frequency

$$\omega_c = \frac{1}{\tau} = \frac{1}{RC} = 2\pi f_c$$

(a) A passive low-pass filter.



Transfer Function

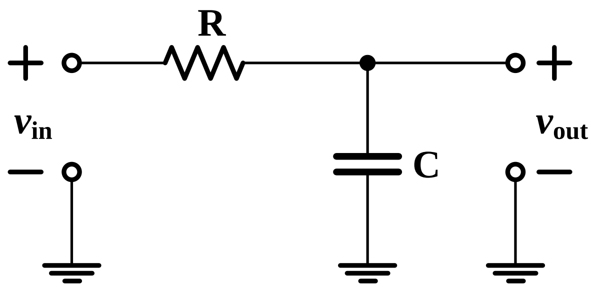
$$H_{LP,active}(j\omega) = -\frac{R_2}{R_1}\left(\frac{1}{1 + j\omega R_2 C}\right)$$

Cut-off frequency

$$\omega_c = \frac{1}{\tau} = \frac{1}{R_2 C} = 2\pi f_c$$

(b) An active low-pass filter

Part A: Passive LPF



Transfer Function

$$H_{LP,passive}(j\omega) = \frac{1}{1 + j\omega RC}$$

Cut-off frequency

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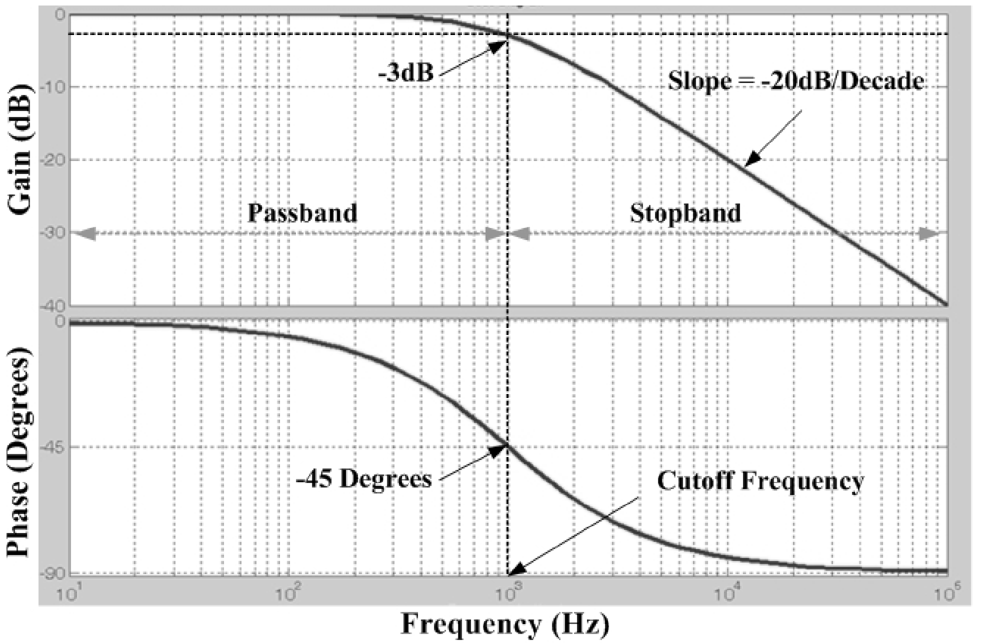
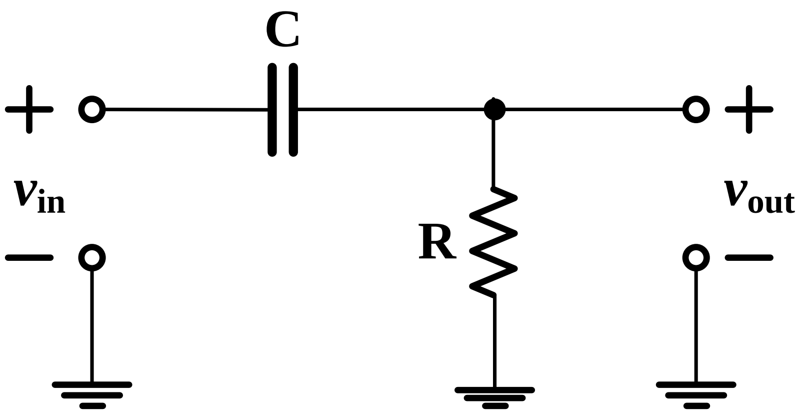
(a) A passive low-pass filter.



High-pass filter (HPF)



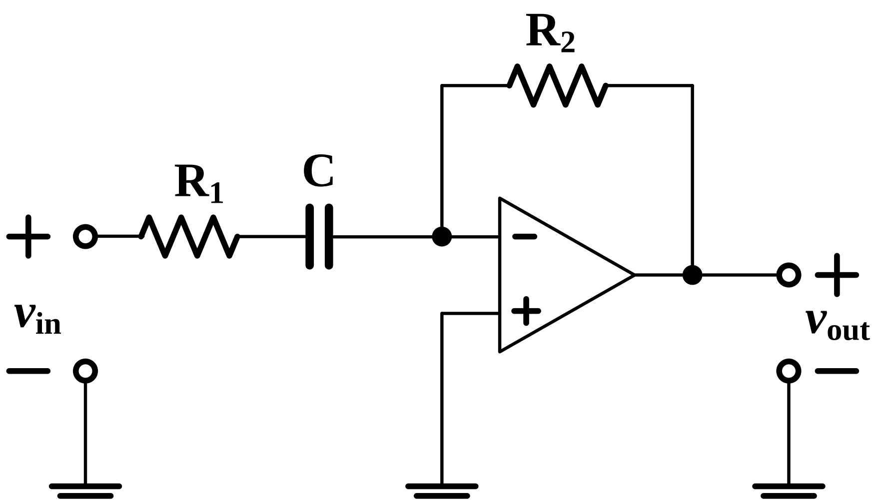
Transfer Function

$$H_{HP,passive}(j\omega) = \frac{j\omega RC}{1 + j\omega RC}$$

Cut-off frequency

$$\omega_c = \frac{1}{\tau} = \frac{1}{RC} = 2\pi f_c$$

(a) A passive high-pass filter.



Transfer Function

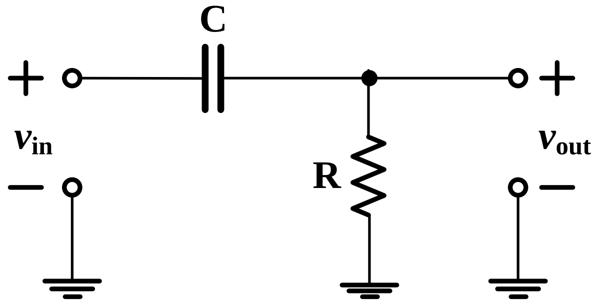
$$H_{HP,active}(j\omega) = -\frac{j\omega R_2 C}{1 + j\omega R_1 C}$$

Cut-off frequency

$$\omega = \frac{1}{\tau} = \frac{1}{R_1 C} = 2\pi f$$

(b) An active high-pass filter

Part B: Passive HPF



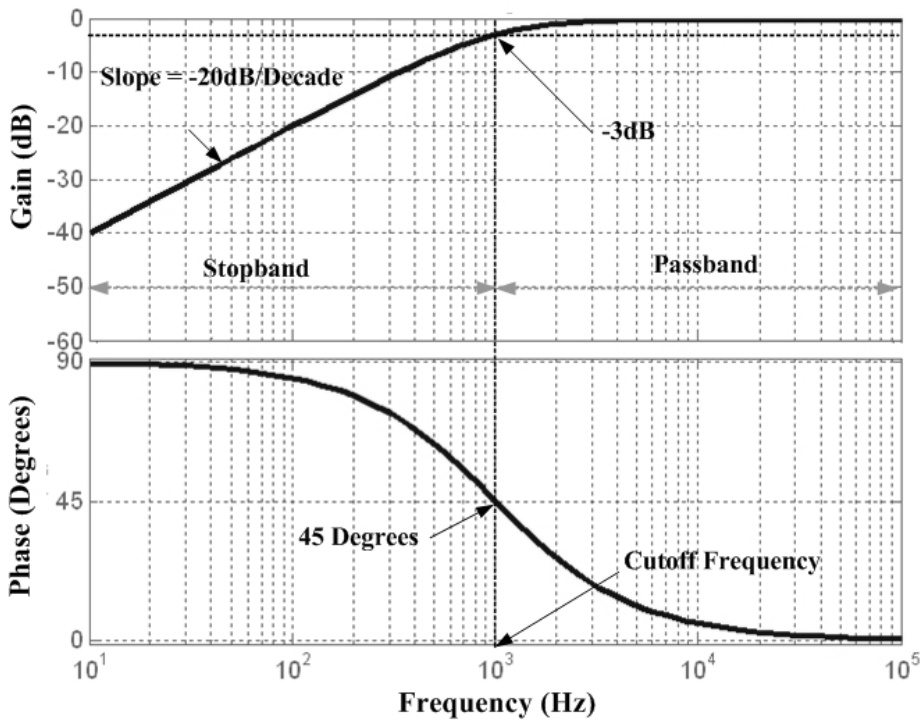
Transfer Function

$$H_{HP,passive}(j\omega) = \frac{j\omega RC}{1 + j\omega RC}$$

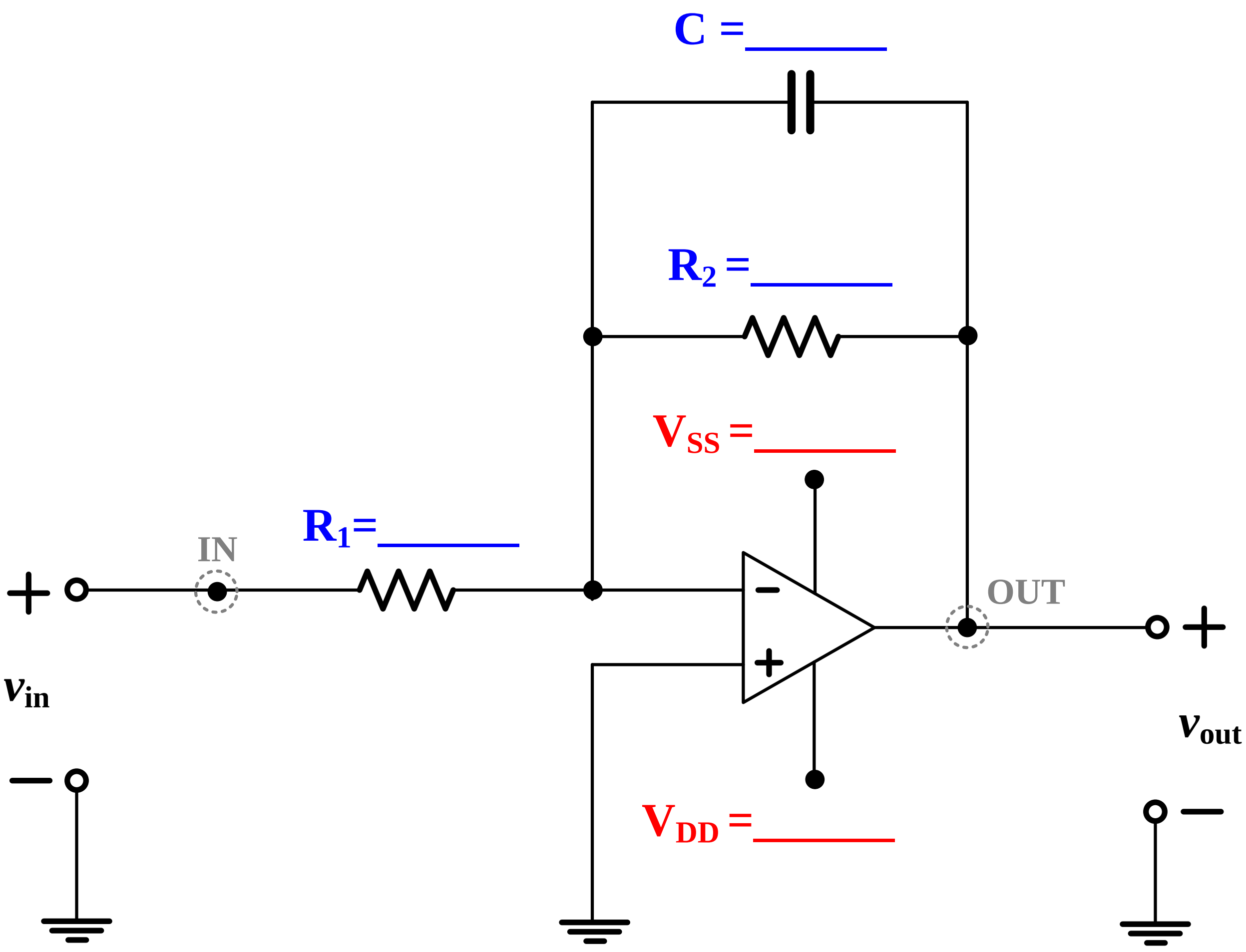
Cut-off frequency

$$\omega_c = \frac{1}{\tau} = \frac{1}{RC} = 2\pi f_c$$

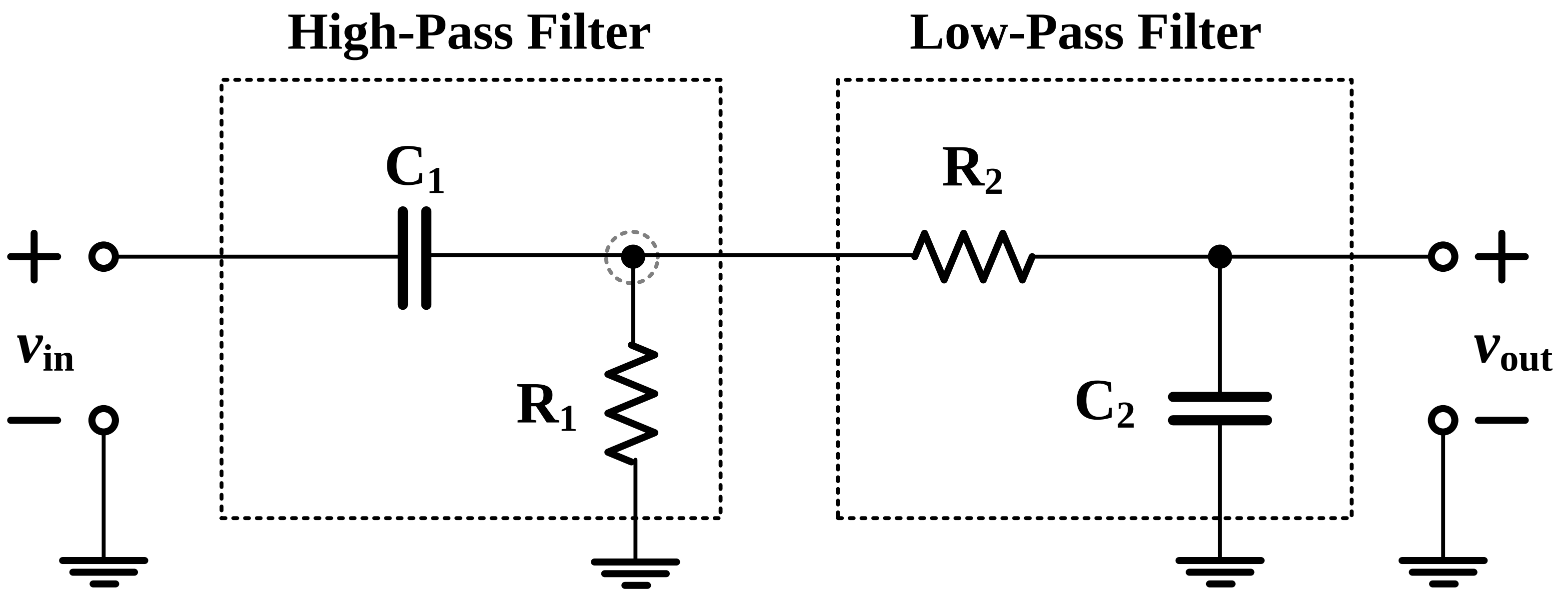
(a) A passive high -pass filter.



Part C: Active LPF Design



Part D: Bandpass filter (BPF) - Optional



Lower cutoff frequency

(Determined by HP filter)

$$\omega_1 = \frac{1}{\tau_1} = \frac{1}{R_1 C_1} = 2\pi f_1$$

Upper cutoff frequency

(Determined by LP filter)

$$\omega_2 = \frac{1}{\tau_2} = \frac{1}{R_2 C_2} = 2\pi f_2$$