

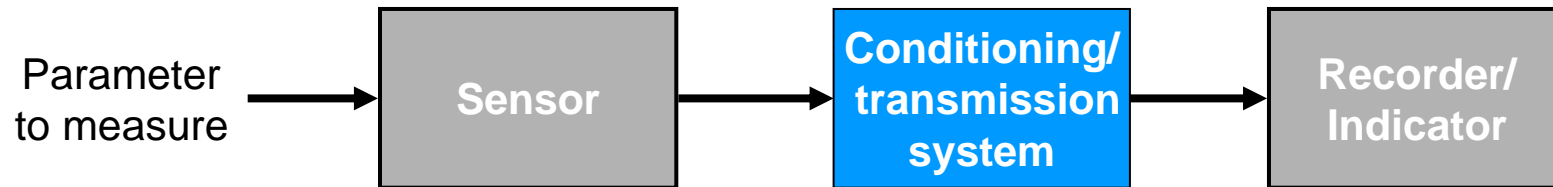
# Design IV

## E232 Fall 07

Class 4

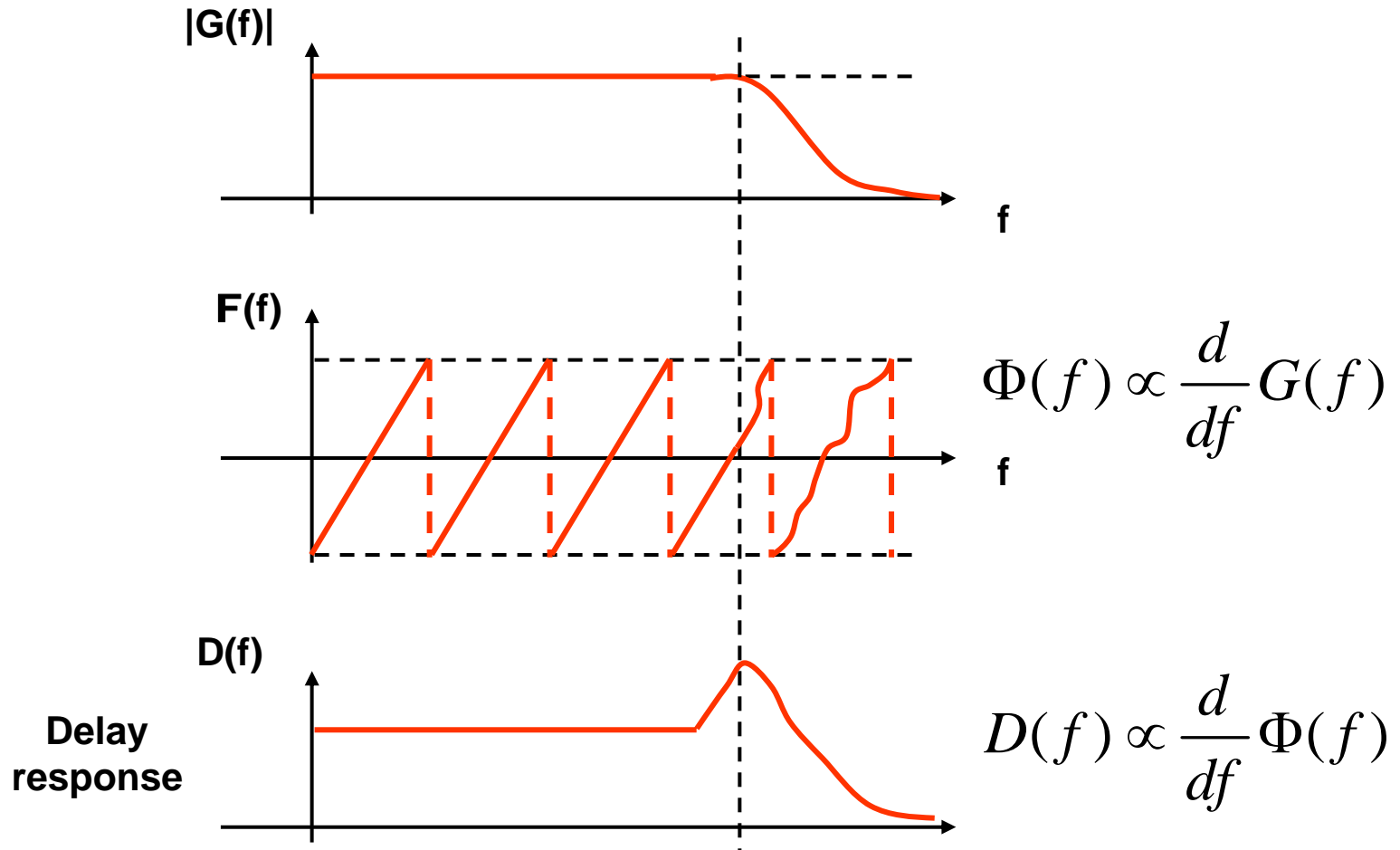
Bruce McNair  
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# Signal Conditioning And Transformation



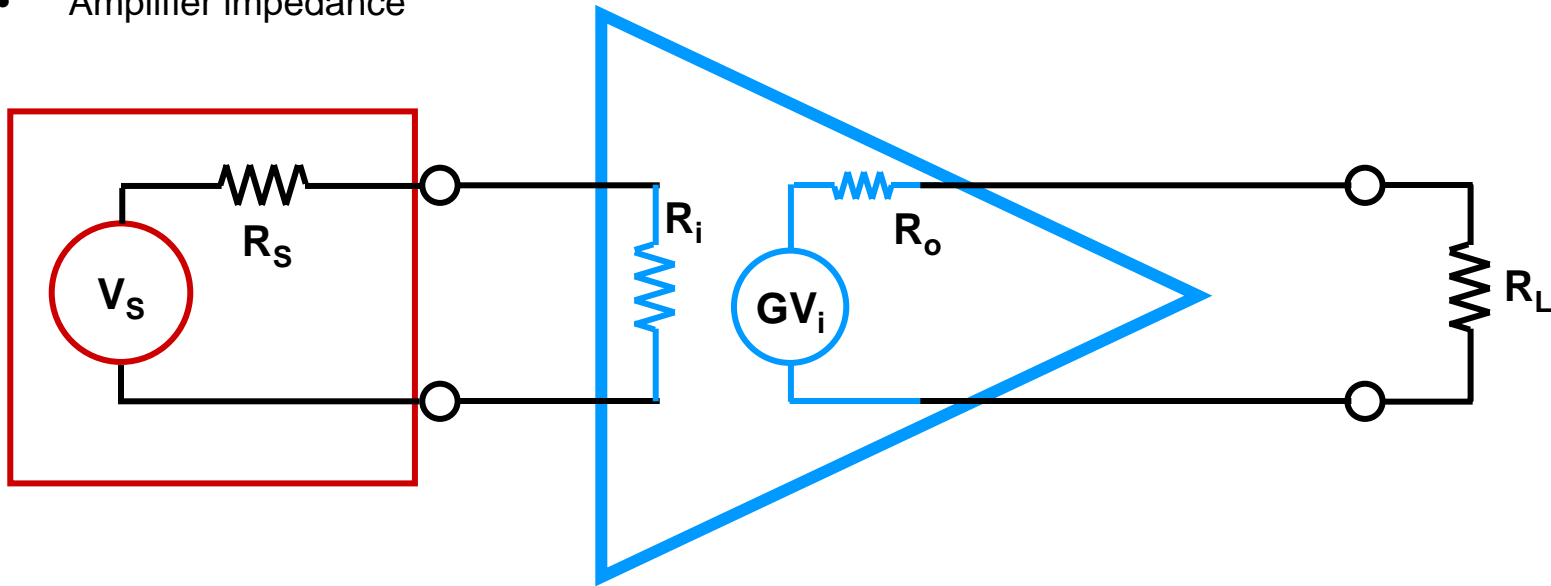
# Signal Conditioning And Transformation

- Amplifier characteristics



# Signal Conditioning And Transformation

- Amplifier impedance



**For greatest voltage gain, best frequency response:**

$$R_i \rightarrow \infty$$

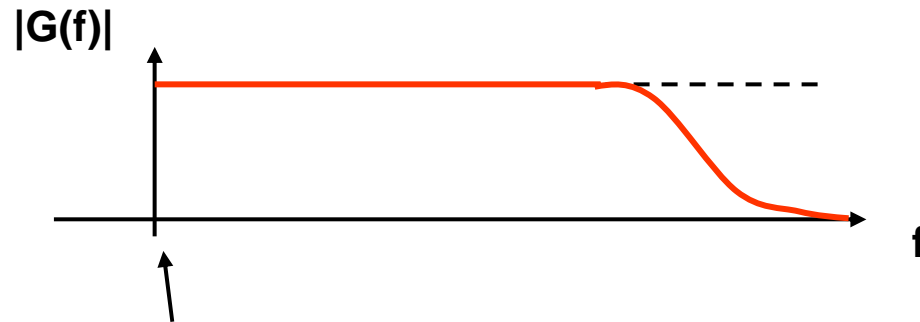
$$R_o \rightarrow 0$$

# Today's topics

- Signal conditioning, transformation
  - Amplifiers
    - DC drift/stabilization
    - Operational Amplifiers
  - Filtering
    - Filter families
  - Integration, differentiation

# Signal Conditioning And Transformation

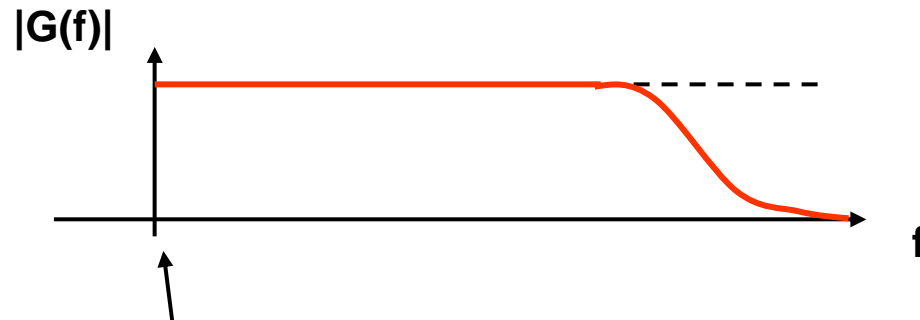
- Amplifier characteristics – DC drift and stabilization



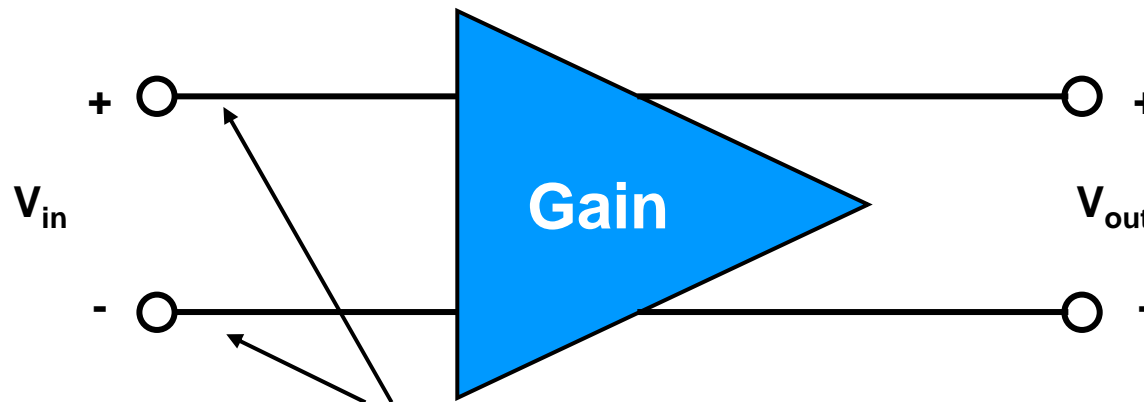
**(1) Amplifier has gain at DC**

# Signal Conditioning And Transformation

- Amplifier characteristics – DC drift and stabilization



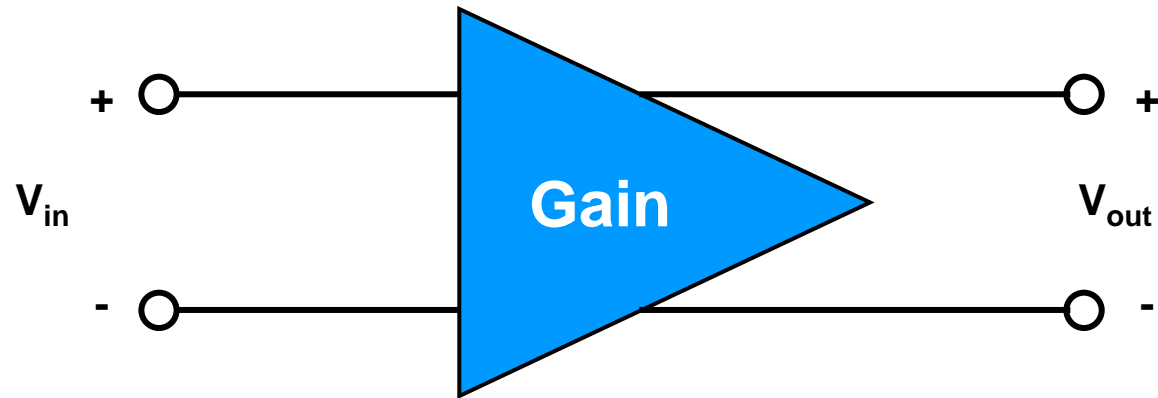
**(1) Amplifier has gain at DC**



**(2) Assume differential operation due to low signal levels**

# Signal Conditioning And Transformation

- Amplifier characteristics – DC drift and stabilization



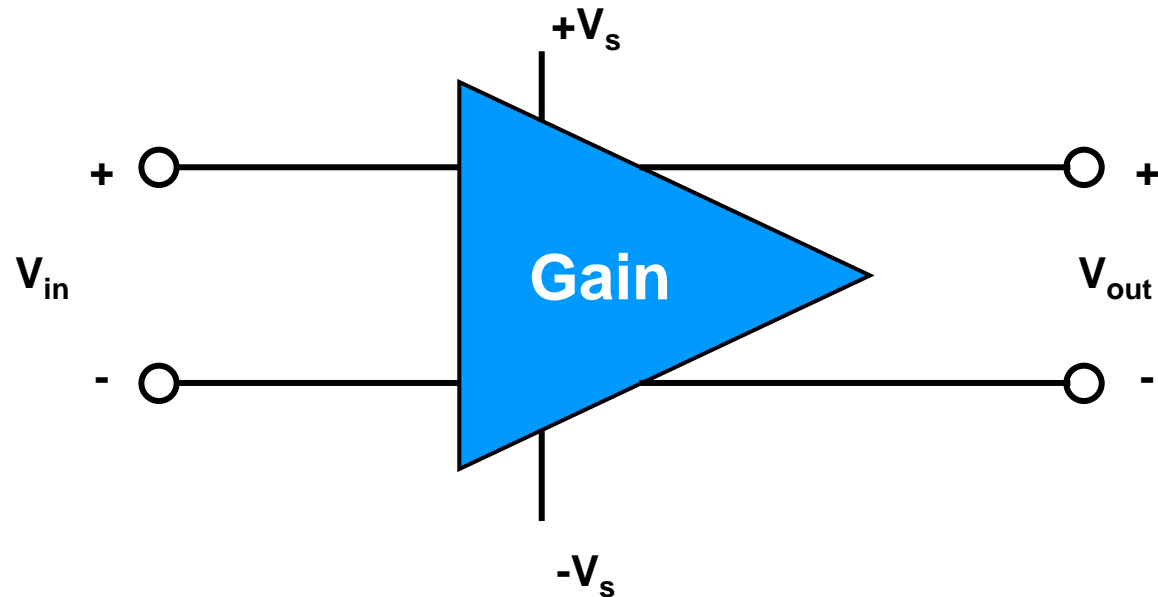
**(3) Assume high gain to boost low signal levels**

$$\mathbf{G = 1,000,000}$$

$$V_{out} = 1000000 \cdot (V_{in}^{+} - V_{in}^{-})$$

# Signal Conditioning And Transformation

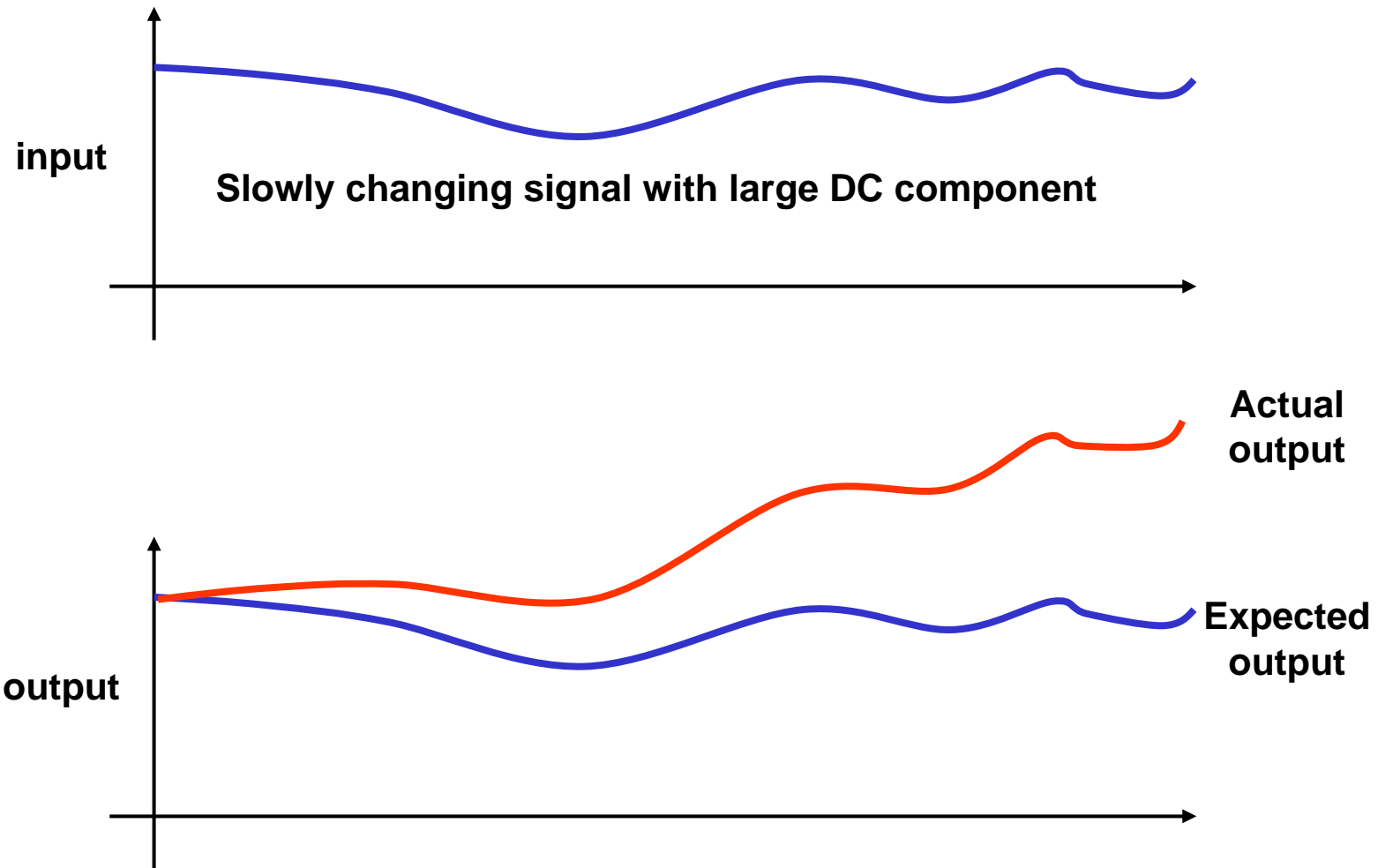
- Amplifier characteristics – DC drift and stabilization



**(4) Amplifier performance depends on power supply!  
If  $|+V_s|$  and  $|-V_s|$  differ, DC output of amplifier may change**

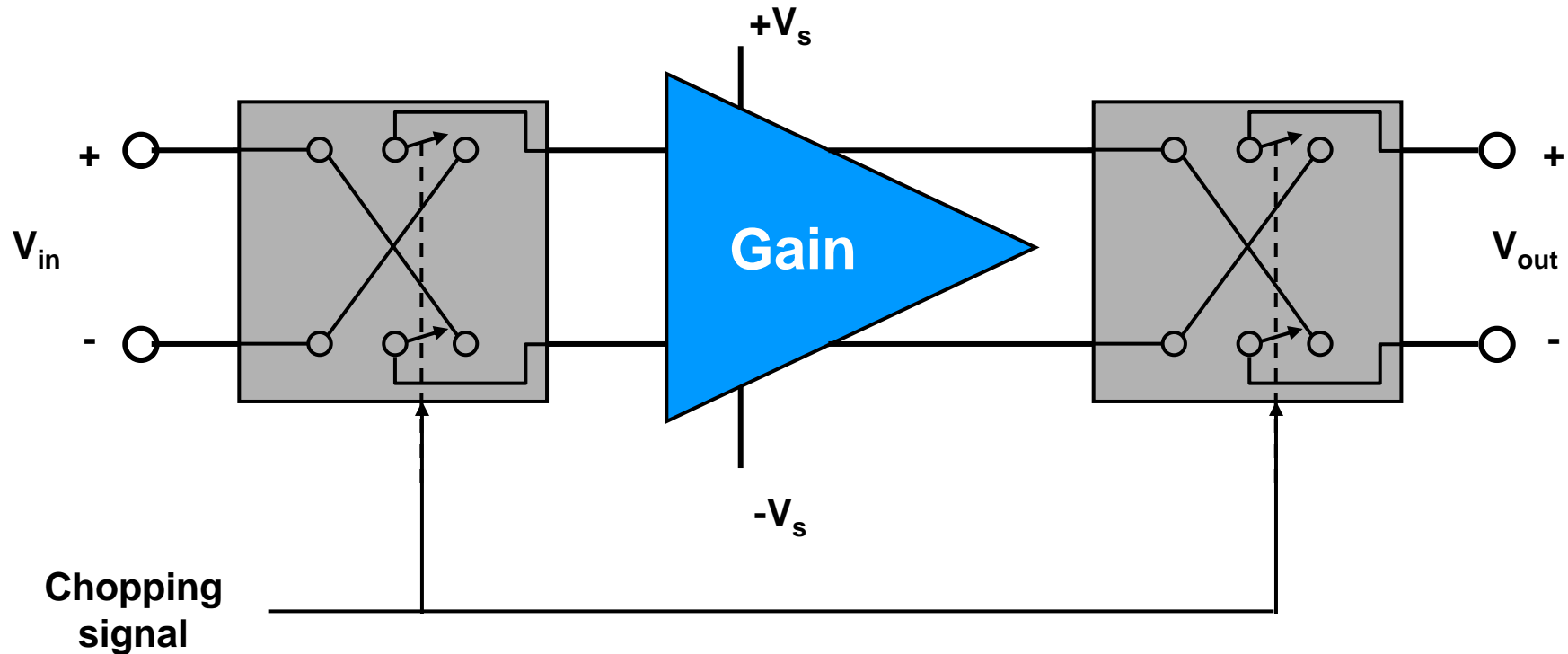
# Signal Conditioning And Transformation

- Amplifier characteristics – DC drift



# Signal Conditioning And Transformation

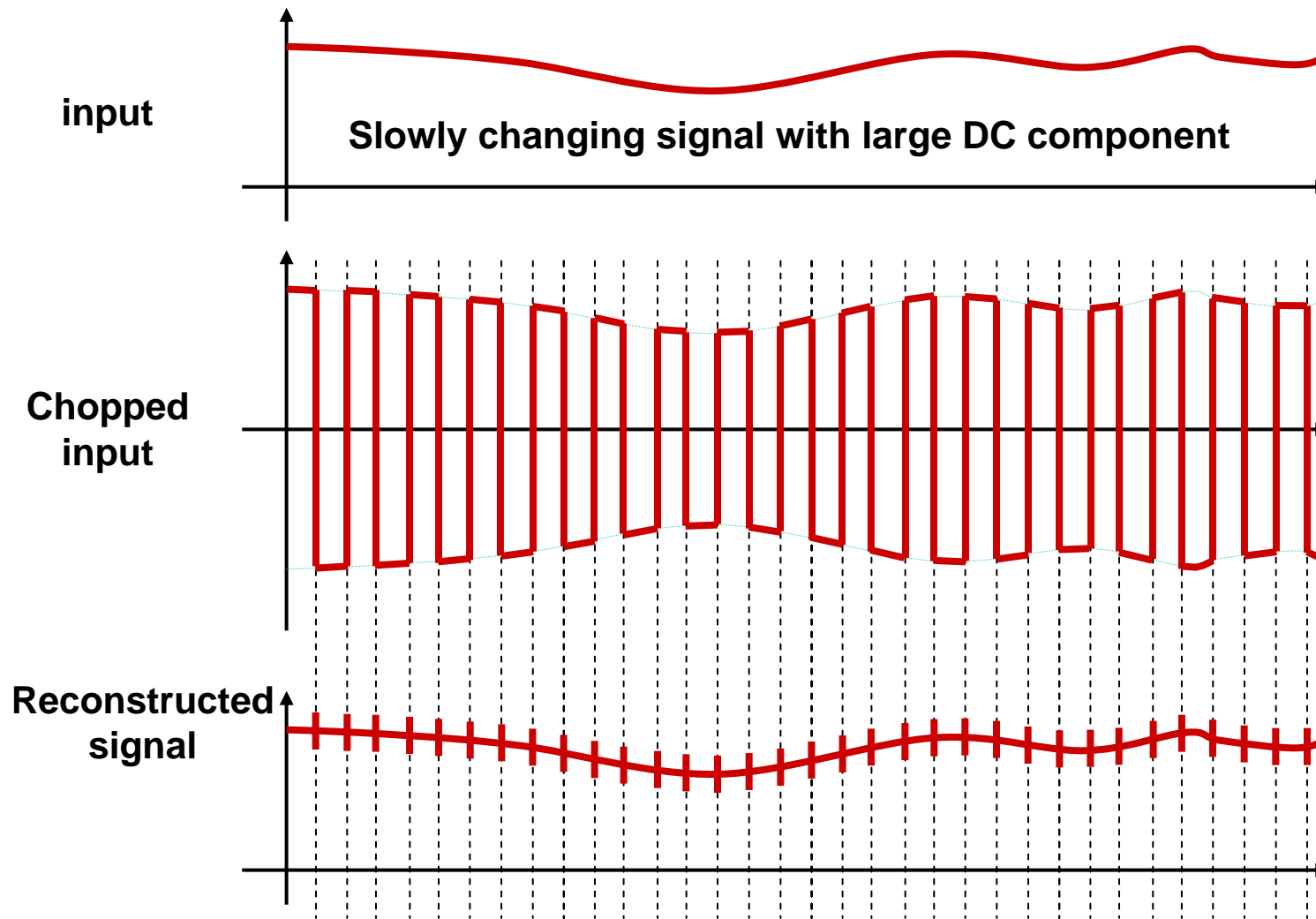
- Chopper stabilization of instrumentation amplifiers



**Change the input signal so the system is immune to DC shift**

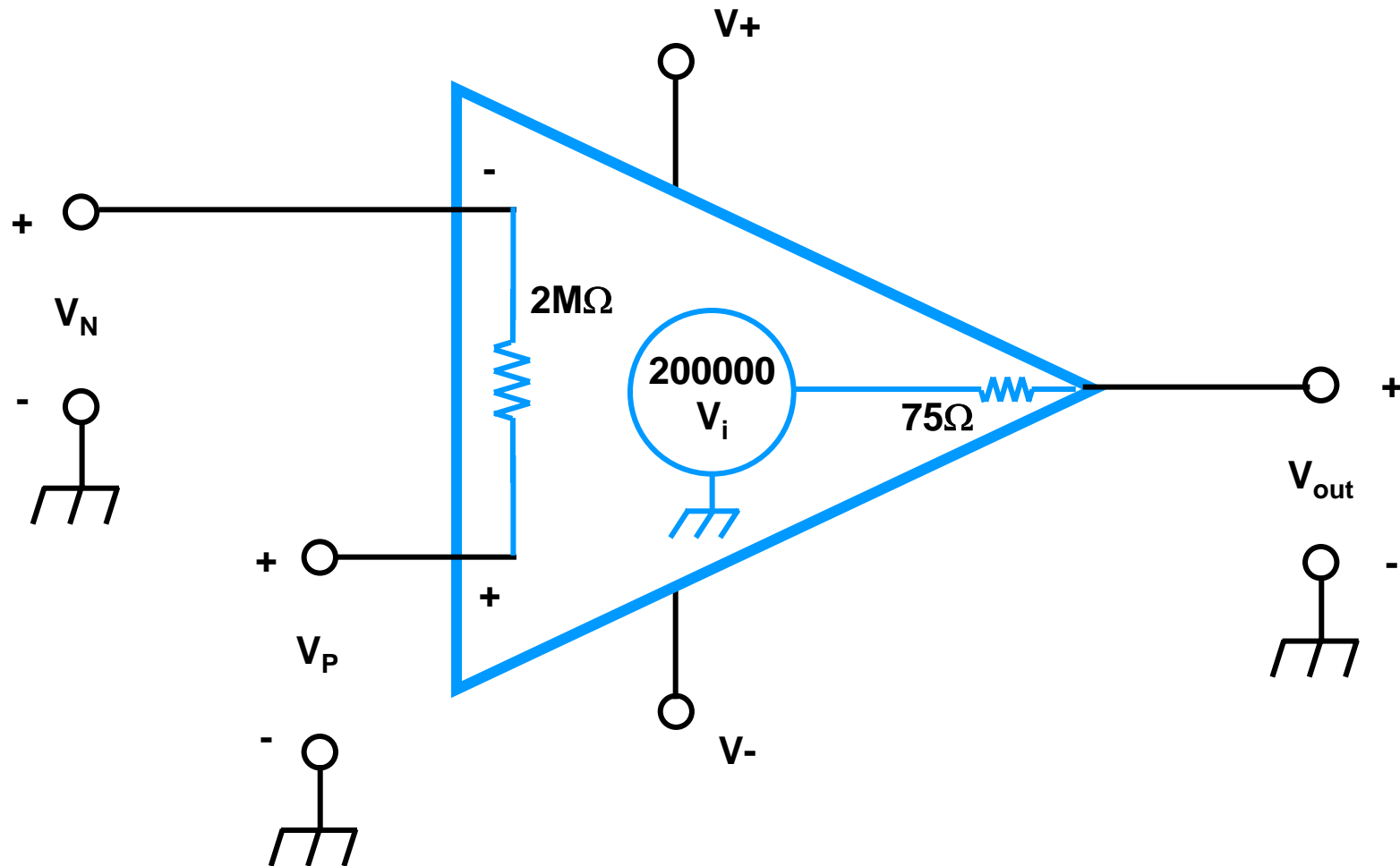
# Signal Conditioning and Transmission

- Chopper stabilization of instrumentation amplifiers



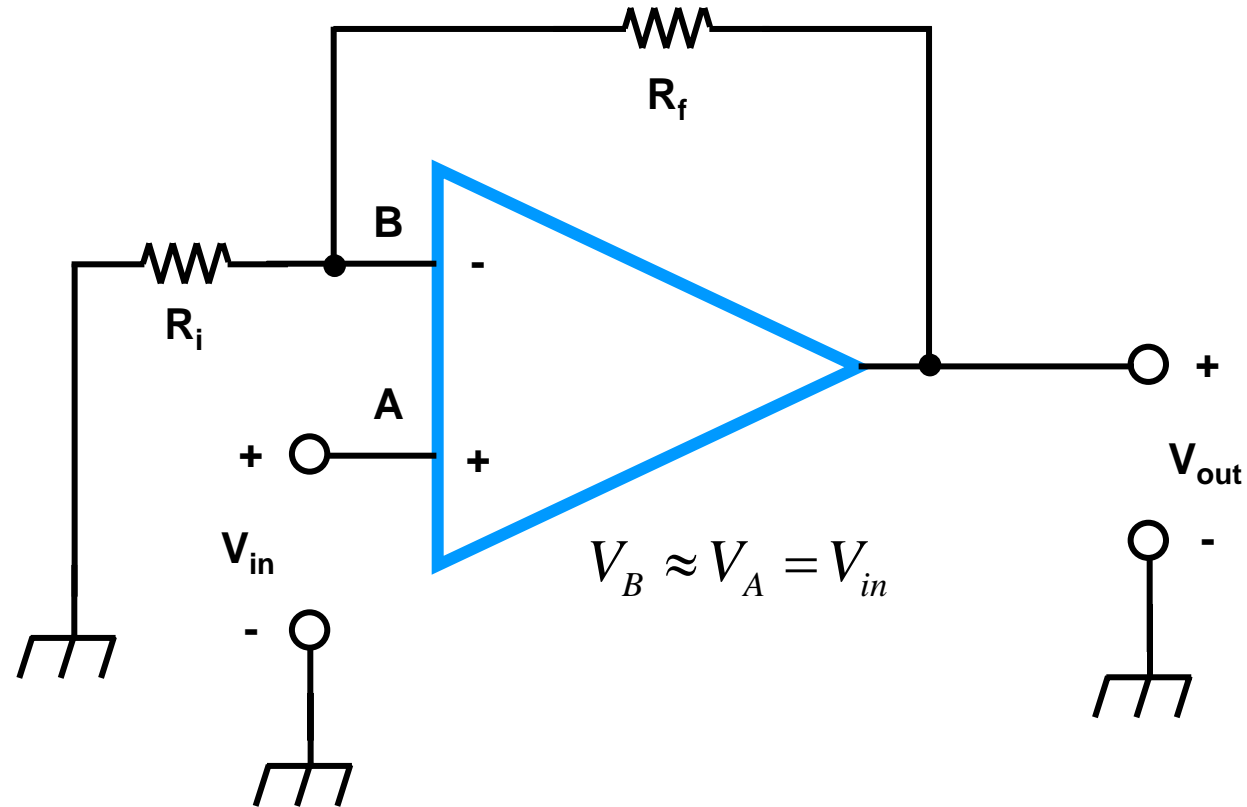
# Signal Conditioning and Transmission

- Operational Amplifiers ( $\mu\text{A}741$ )



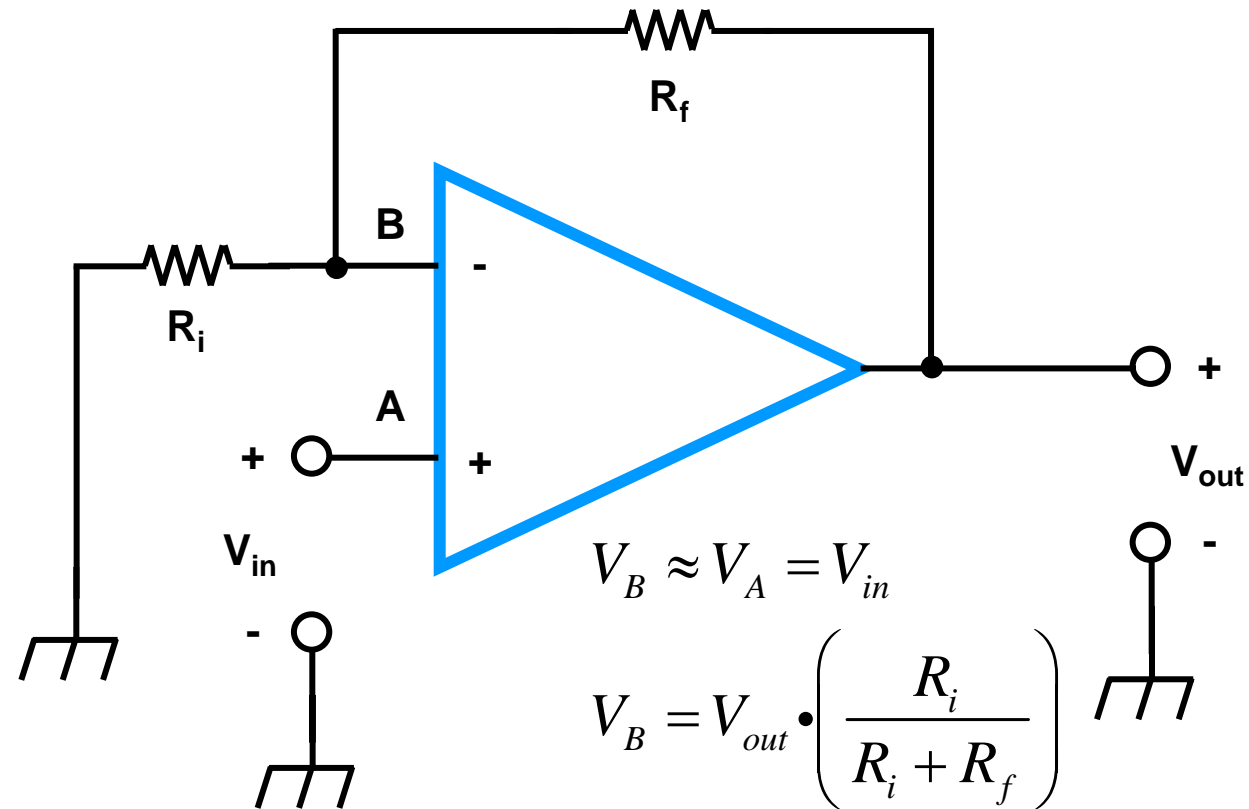
# Signal Conditioning and Transmission

- Operational Amplifier – noninverting amplifier



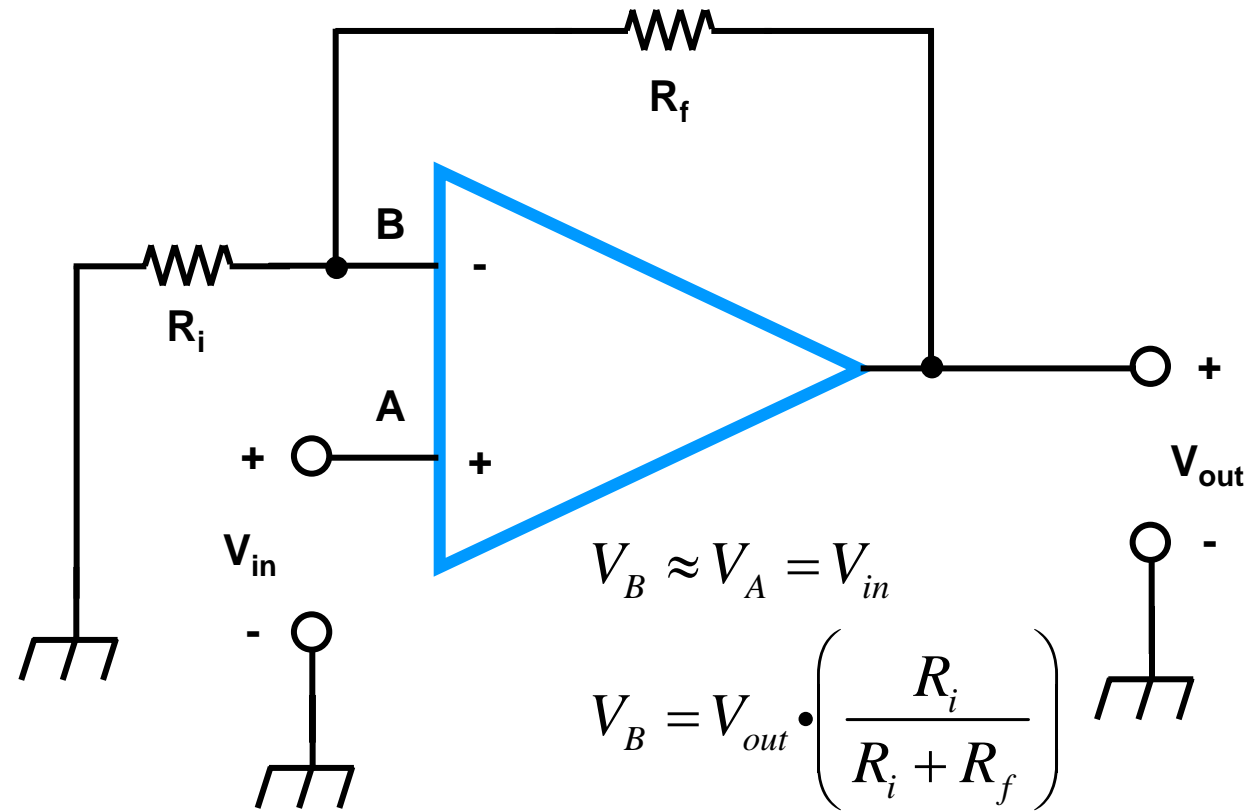
# Signal Conditioning and Transmission

- Operational Amplifier – noninverting amplifier



# Signal Conditioning and Transmission

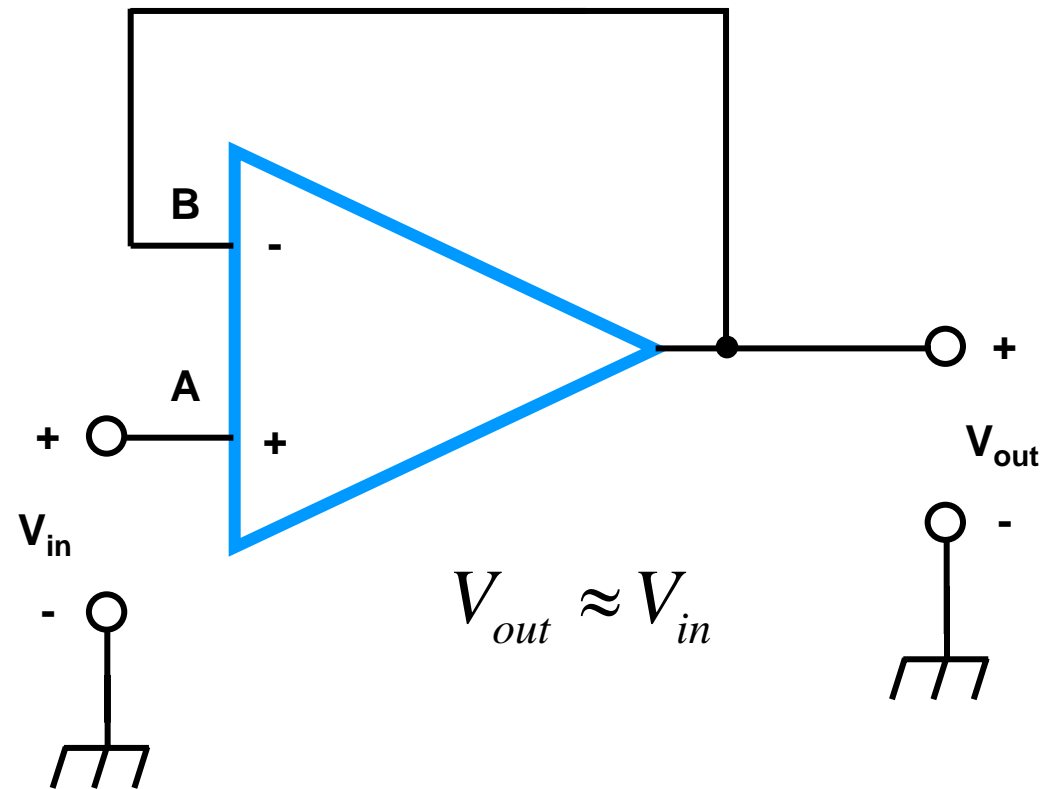
- Operational Amplifier – noninverting amplifier



$$V_{out} \approx V_{in} \cdot \left( 1 + \frac{R_f}{R_i} \right)$$

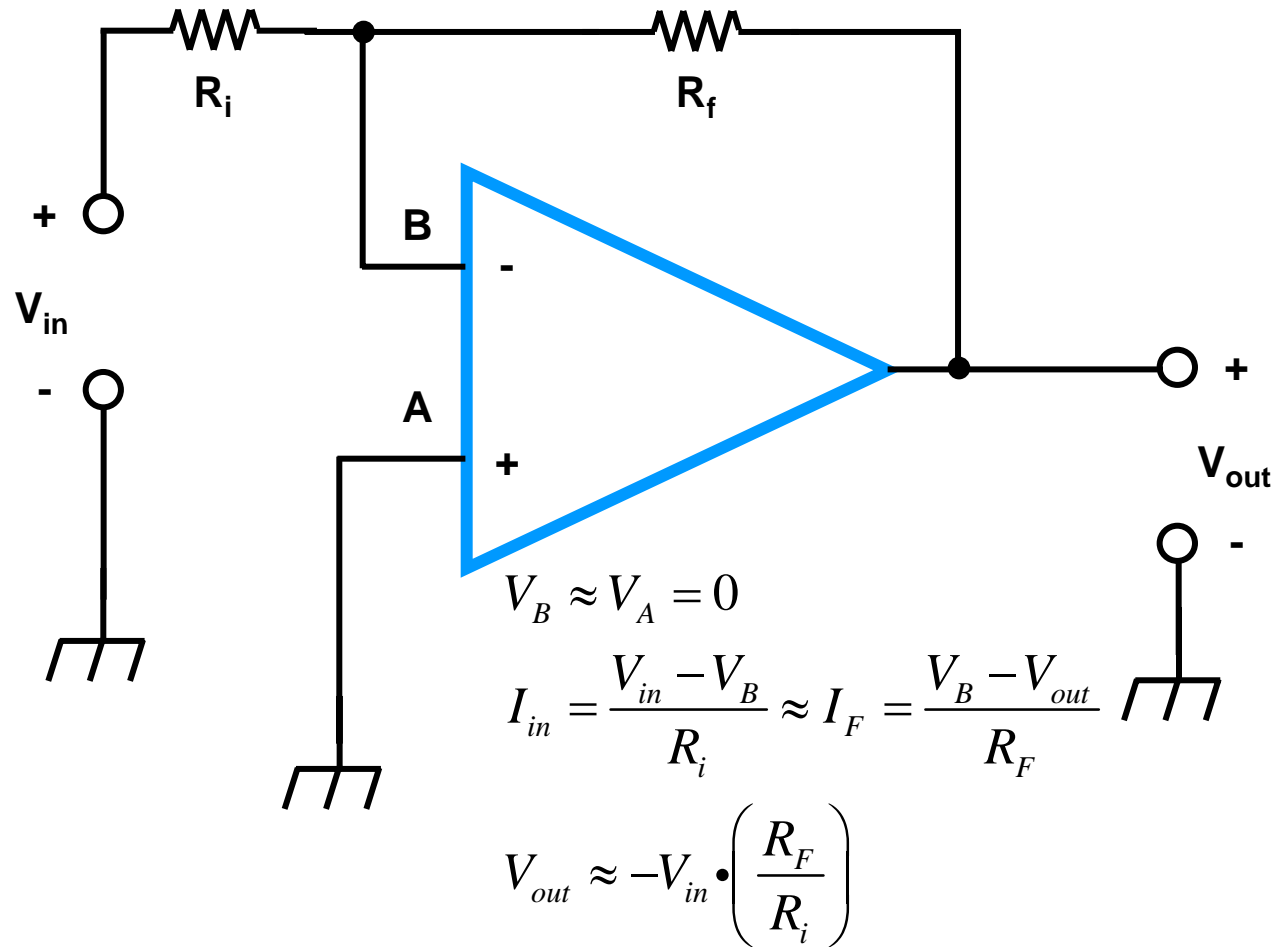
# Signal Conditioning and Transmission

- Operational Amplifier – noninverting amplifier: voltage follower



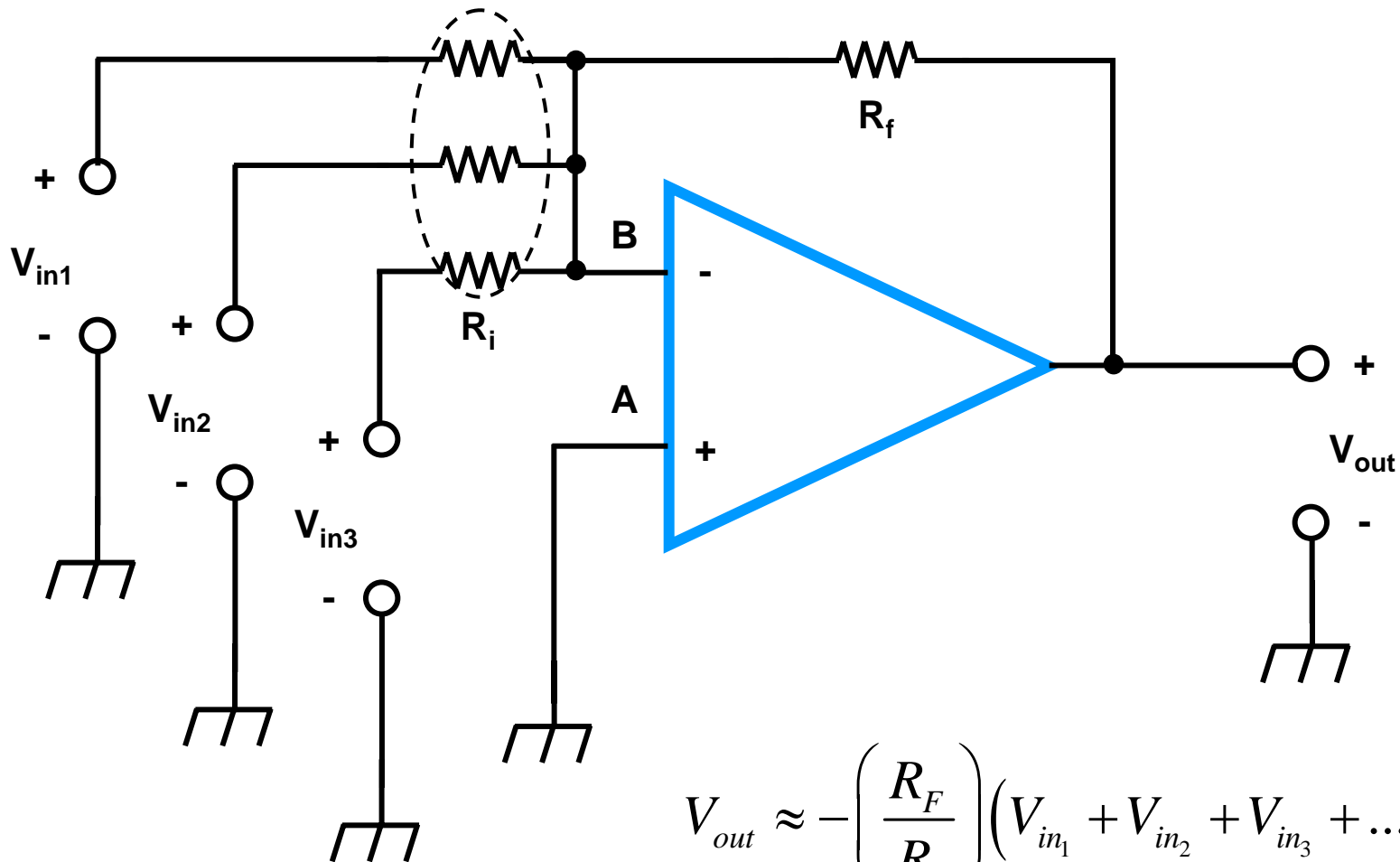
# Signal Conditioning and Transmission

- Operational Amplifier – inverting amplifier



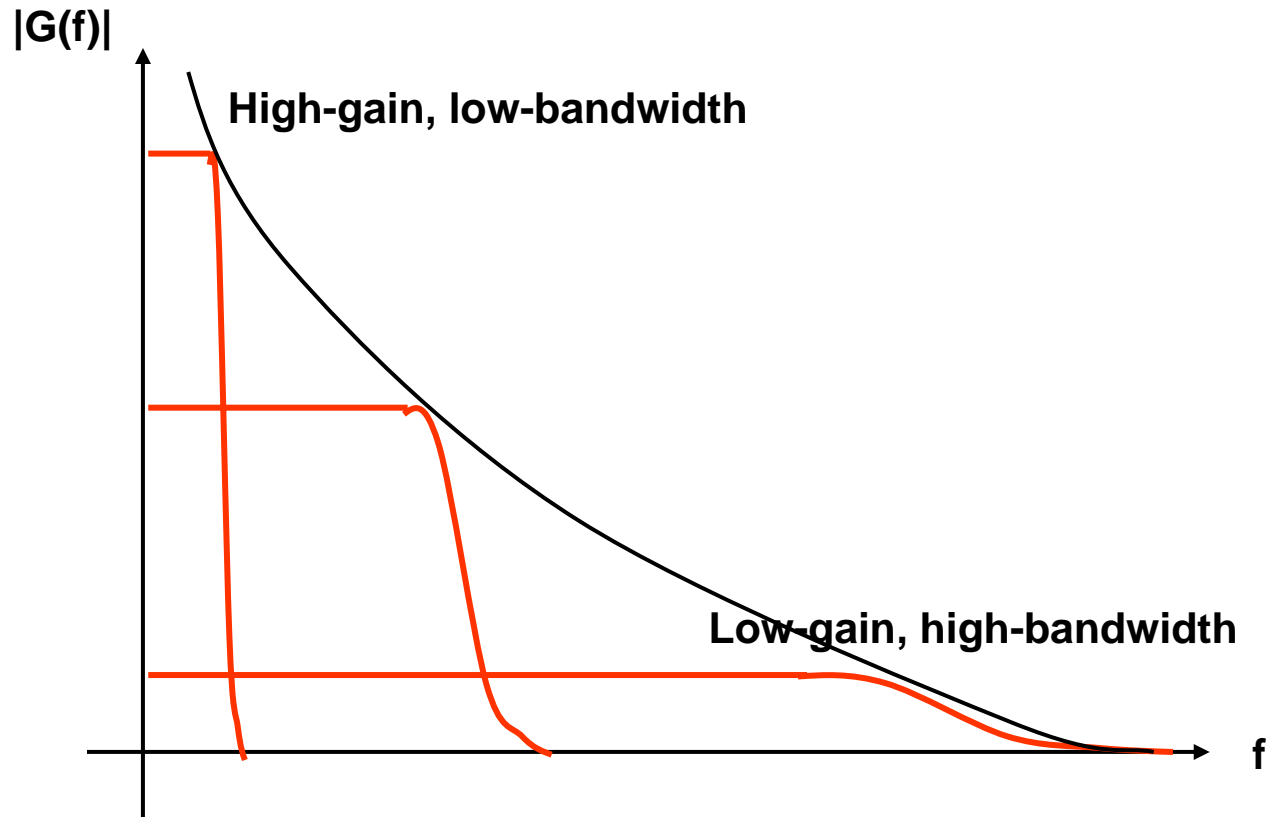
# Signal Conditioning and Transmission

- Operational Amplifier – summing amplifier



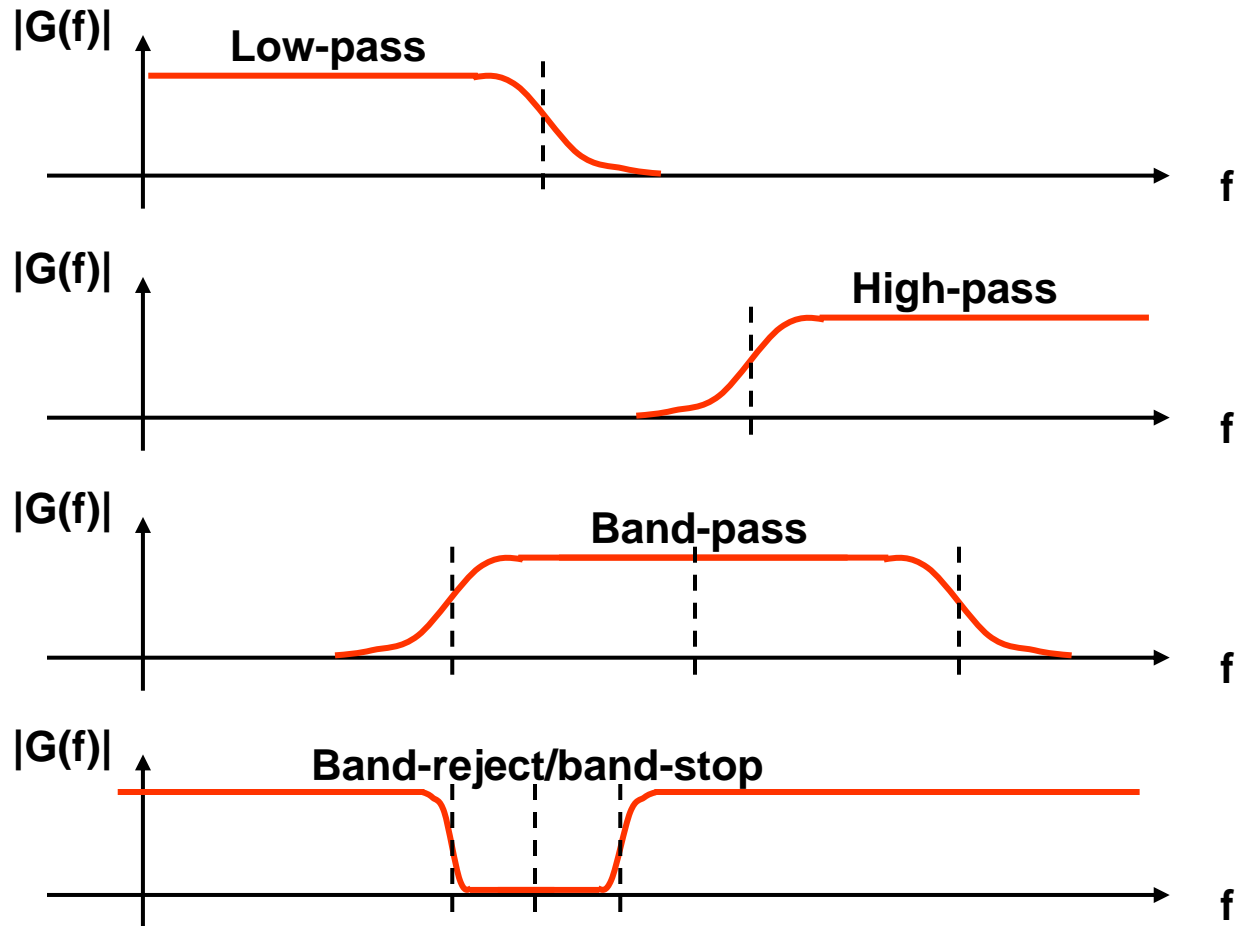
# Signal Conditioning and Transmission

- Operational Amplifiers – Gain Bandwidth Product



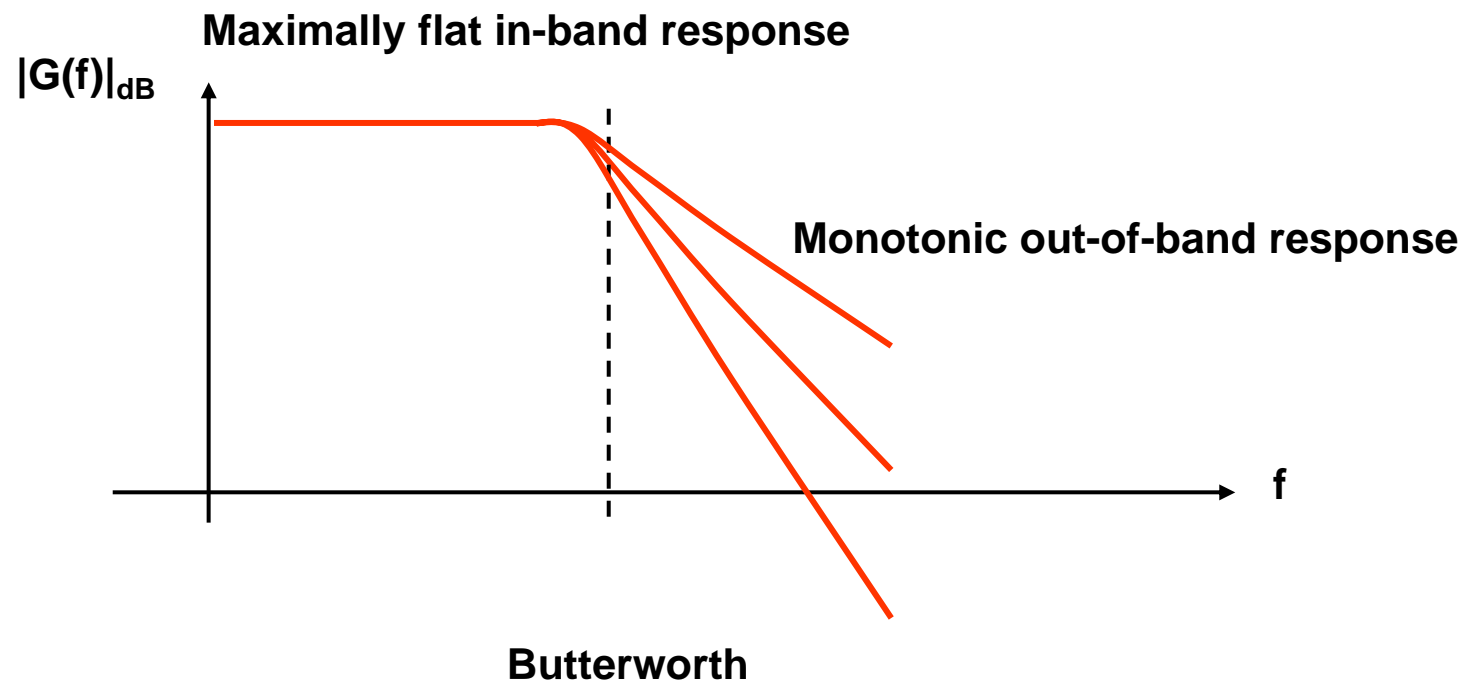
# Signal Conditioning and Transmission

- Filtering



# Signal Conditioning and Transmission

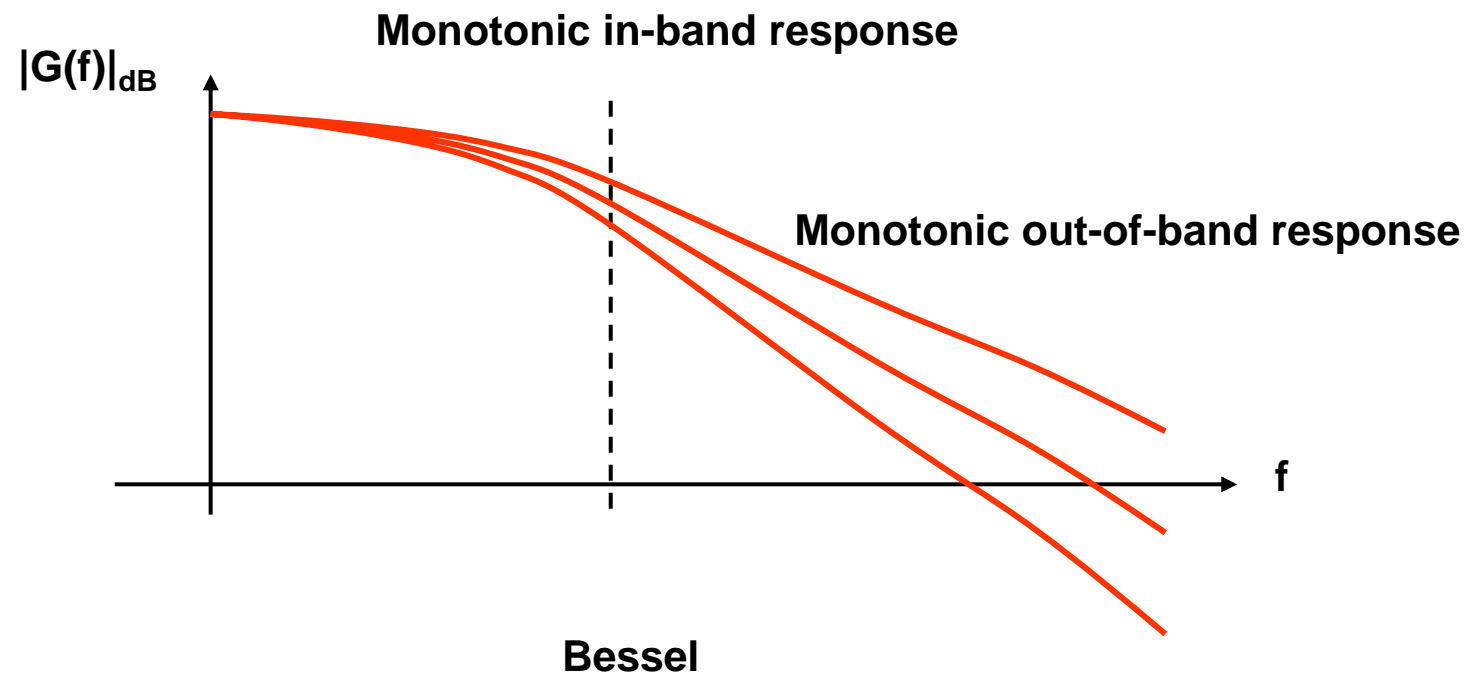
- Filter families



**Good phase response**  
**High filter order needed for high out-of-band attenuation**

# Signal Conditioning and Transmission

- Filter families

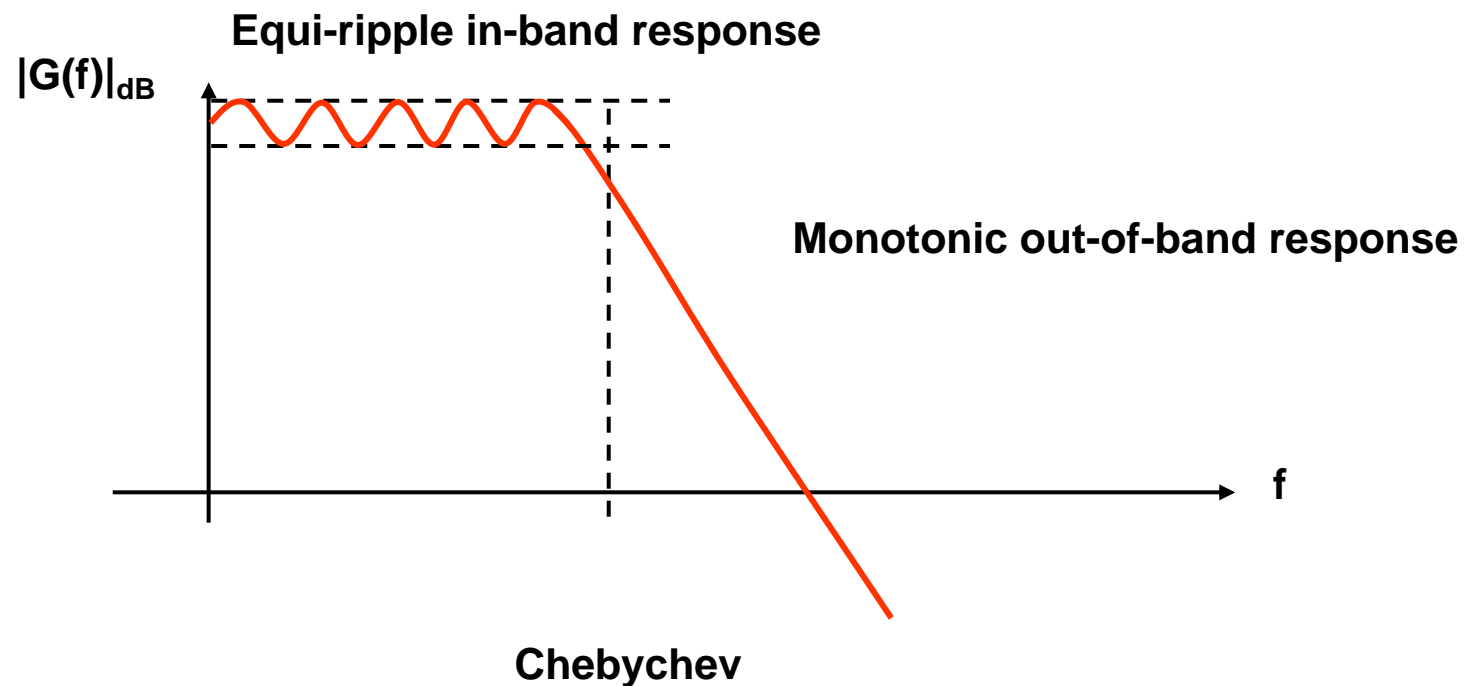


**Bessel**

**Uniform phase response**  
**Very high filter order needed for high out-of-band attenuation**

# Signal Conditioning and Transmission

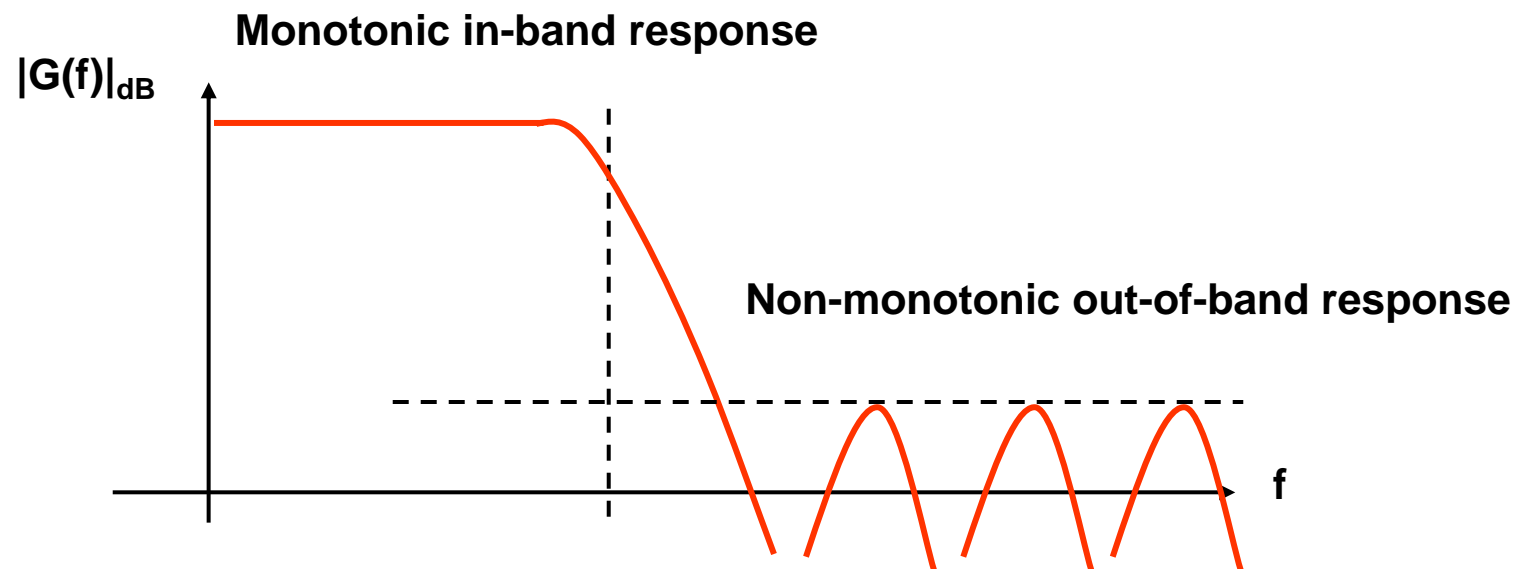
- Filter families



**Good out-of band response**  
**Significant phase variation in-band**

# Signal Conditioning and Transmission

- Filter families

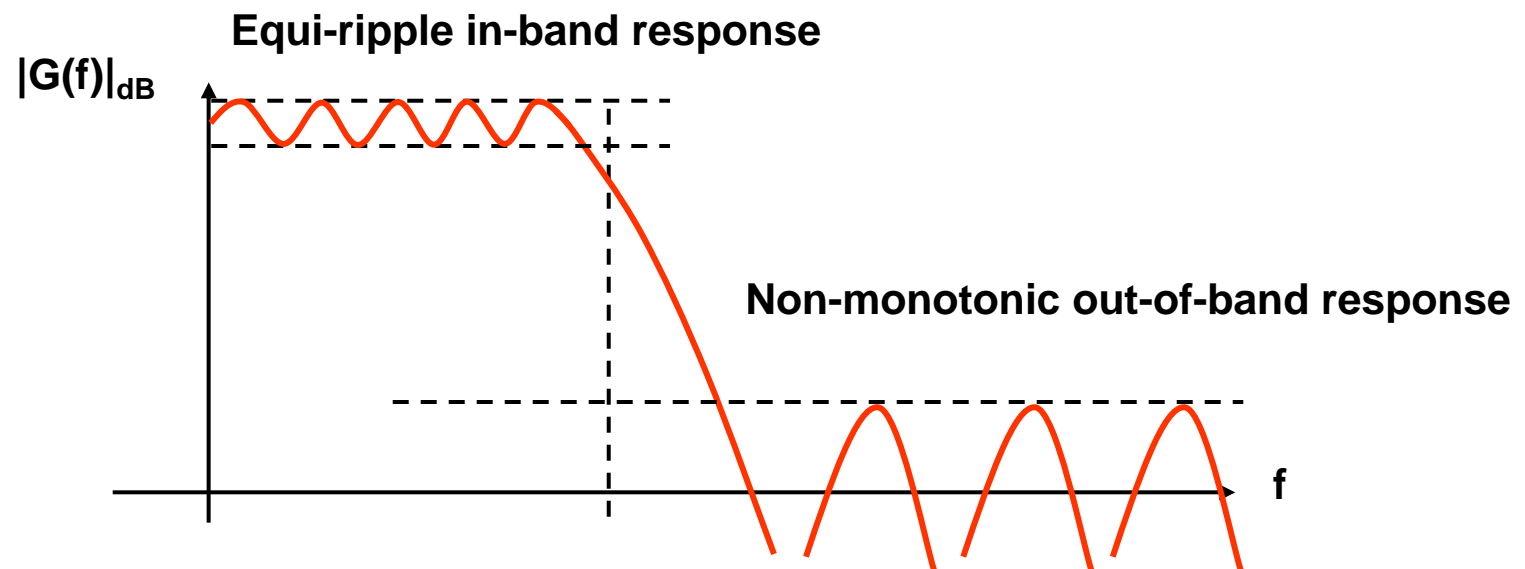


**Inverse-Chebyshev**

**Very good out-of band response**  
**Moderate phase variation in-band**

# Signal Conditioning and Transmission

- Filter families

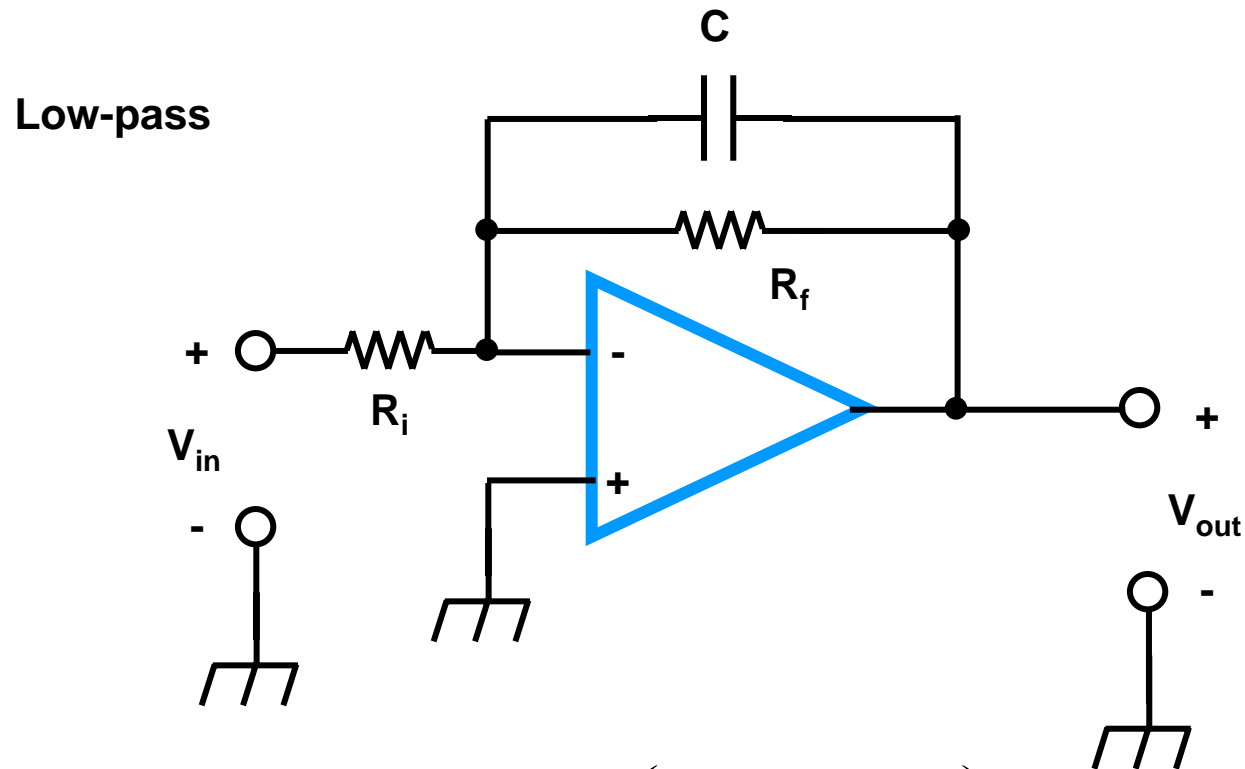


**Elliptical**

**Best out-of band response for given order  
Substantial phase variation in-band**

# Signal Conditioning and Transmission

- Building filters with op-amps

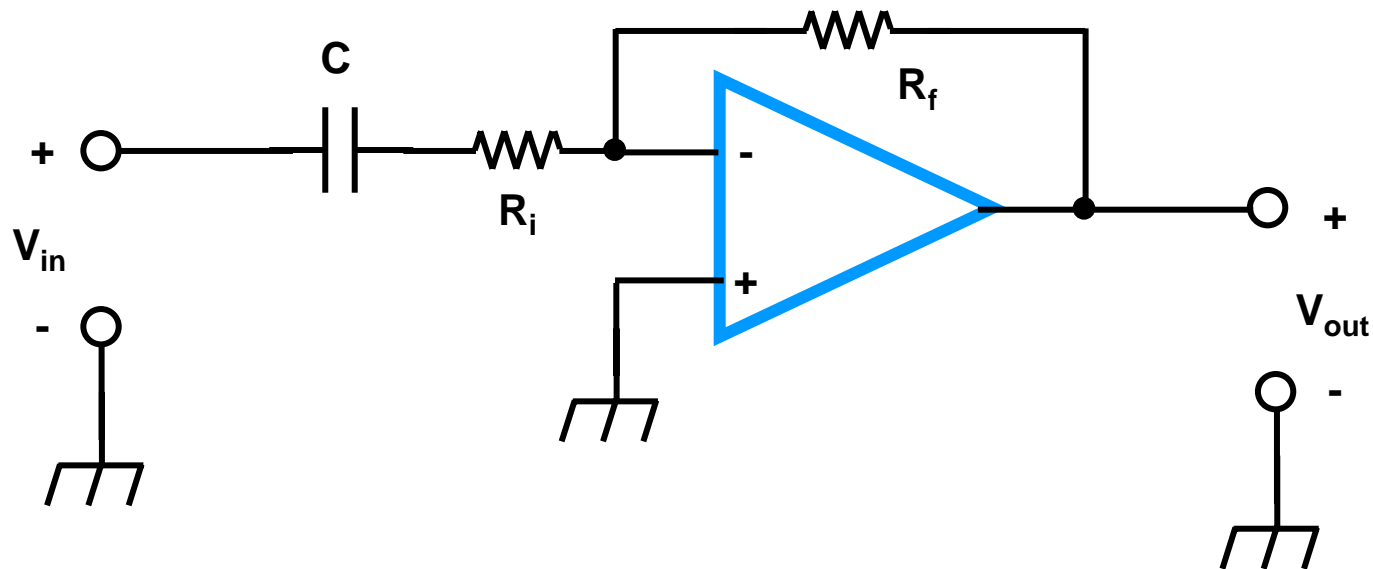


$$G(f) = -\left(\frac{R_f}{R_i}\right) \cdot \left(\frac{1}{1 + j2\pi fCR_f}\right)$$

# Signal Conditioning and Transmission

- Building filters with op-amps

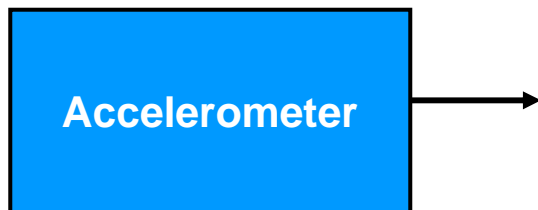
## High-pass



# Signal Conditioning and Transmission

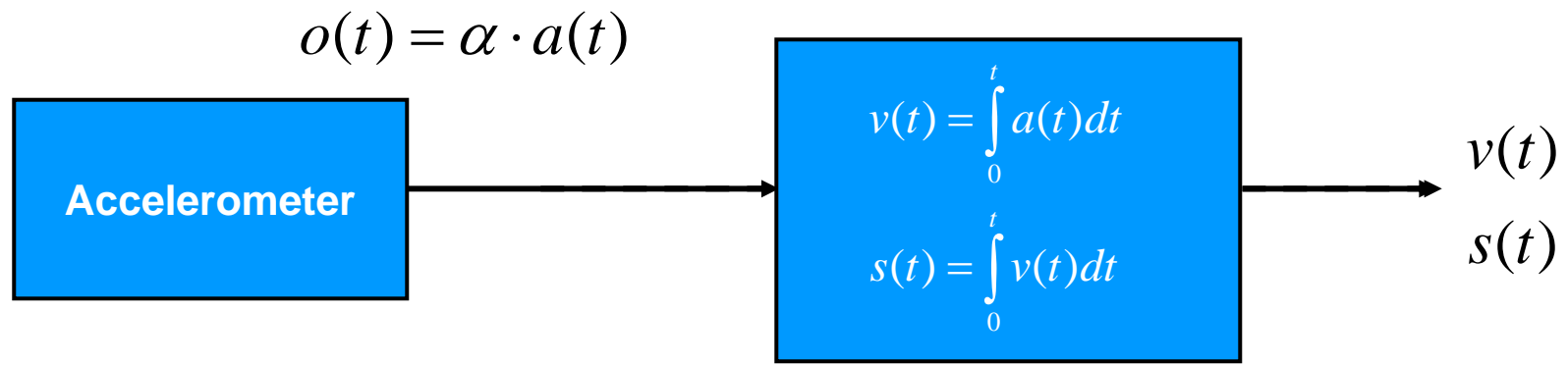
- Computing integral and derivative values

$$o(t) = \alpha \cdot a(t)$$



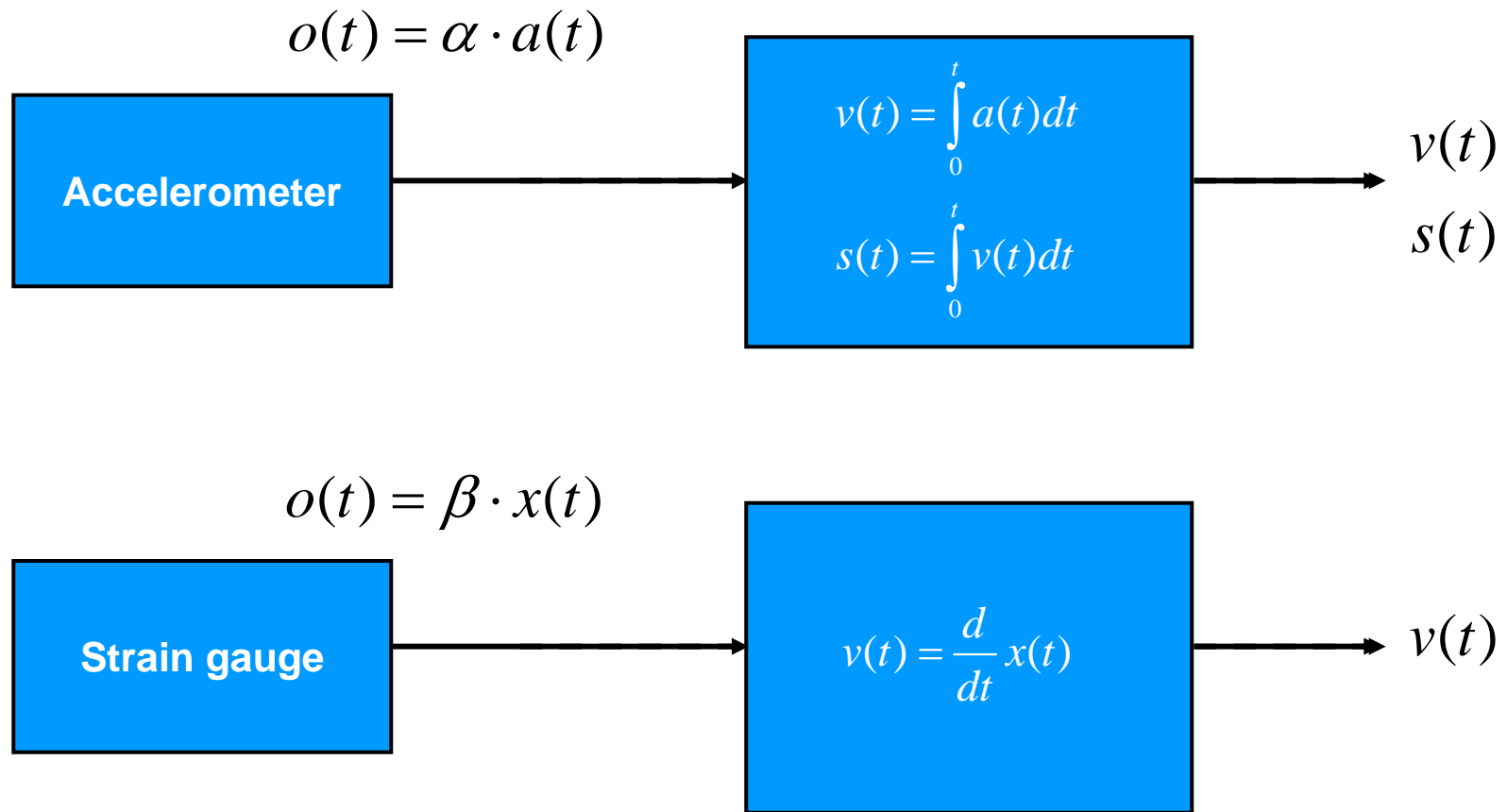
# Signal Conditioning and Transmission

- Computing integral and derivative values



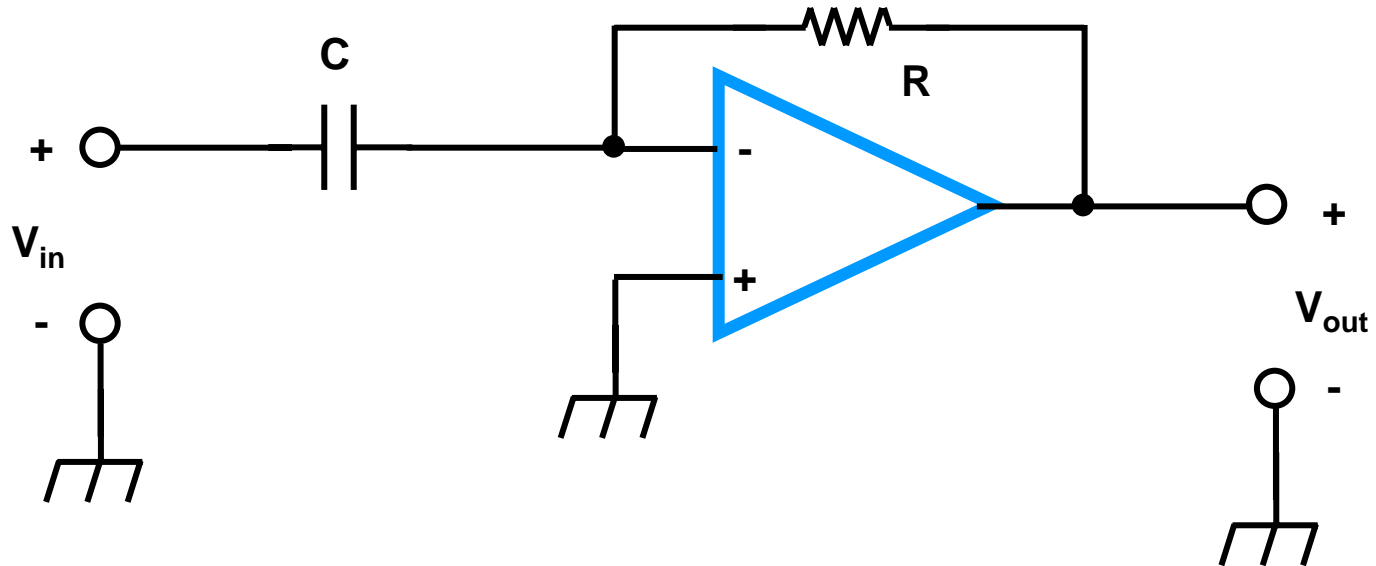
# Signal Conditioning and Transmission

- Computing integral and derivative values



# Signal Conditioning and Transmission

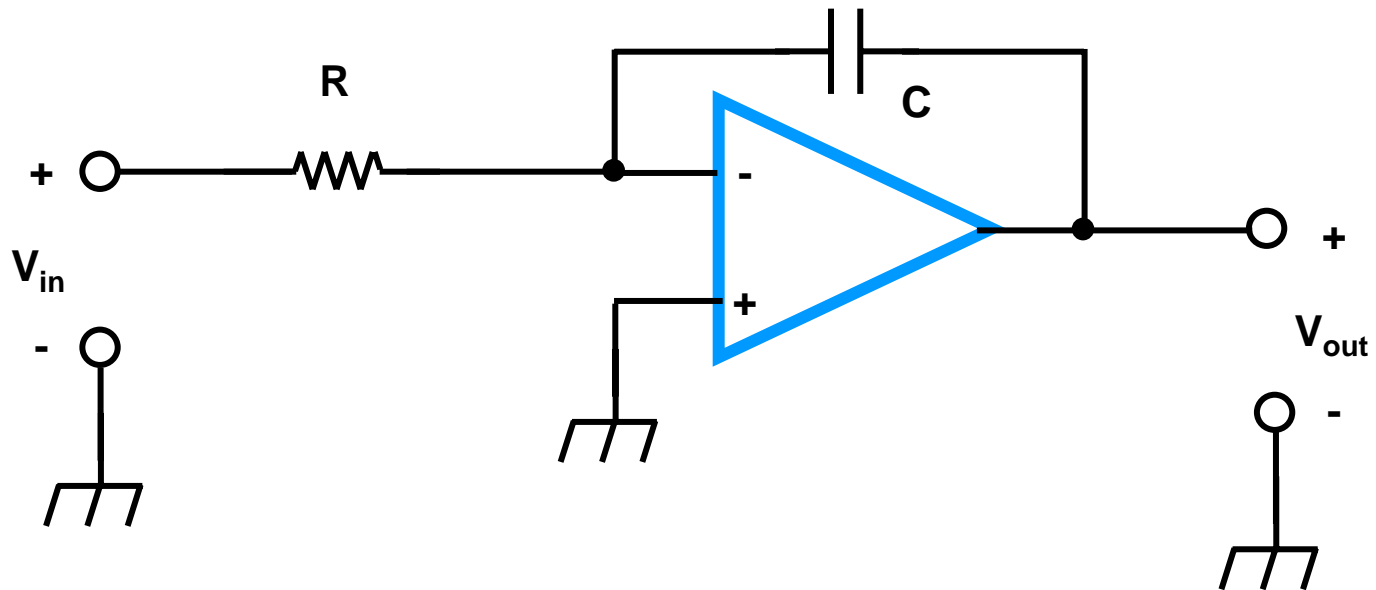
- Differentiator



$$V_{out}(t) = -RC \frac{d}{dt} V_{in}(t)$$

# Signal Conditioning and Transmission

- Integrator



$$V_{out}(t) = V_{out}(0) - \frac{1}{RC} \int_0^t V_{in}(t) dt$$

# Next topics

- Indicators and recording devices
  - Voltage
  - Waveforms
  - Frequency
  - Spectrum
- Transmission
  - Signal level considerations
  - Interference sources
  - Ground loops
  - Rationale for digital signal transmission

# Homework 2

- Show your work
- Problems 3.1, 3.6, 3.18
  
- Please include an estimate of the total time you spent on this assignment (hours: minutes)