Design IV

E232 Spring 07

Class 4

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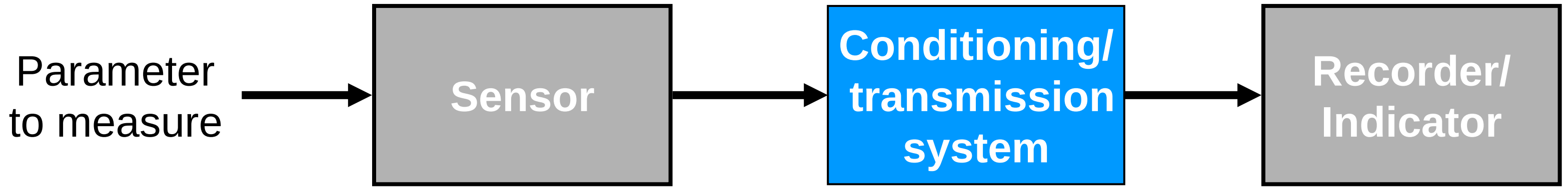
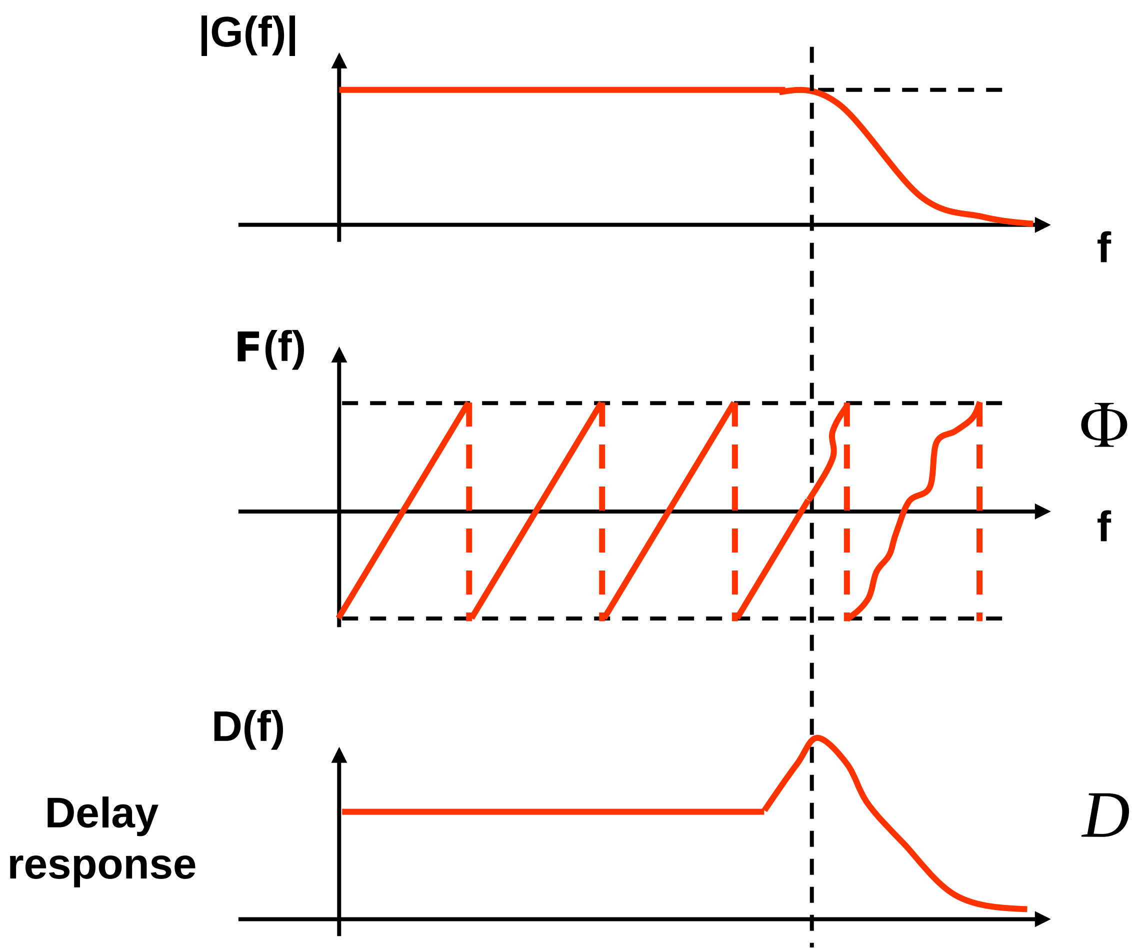
Signal Conditioning And Transformation



Signal Conditioning And Transformation

- Amplifier characteristics



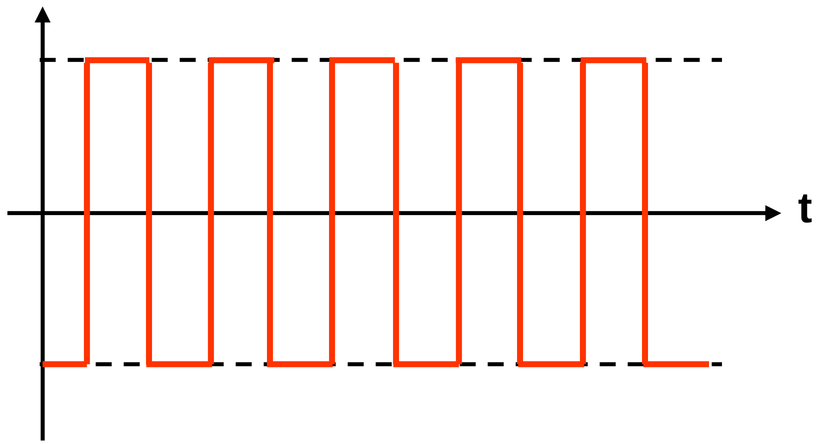
$$\Phi(f) \propto \frac{d}{df} G(f)$$

$$D(f) \propto \frac{d}{df} \Phi(f)$$

Effect Of Phase-Shift Variation

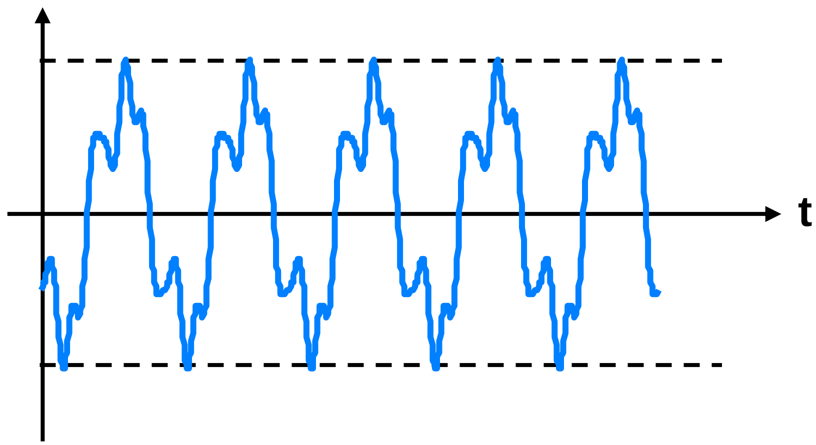
- Non-sinusoidal signals:

input



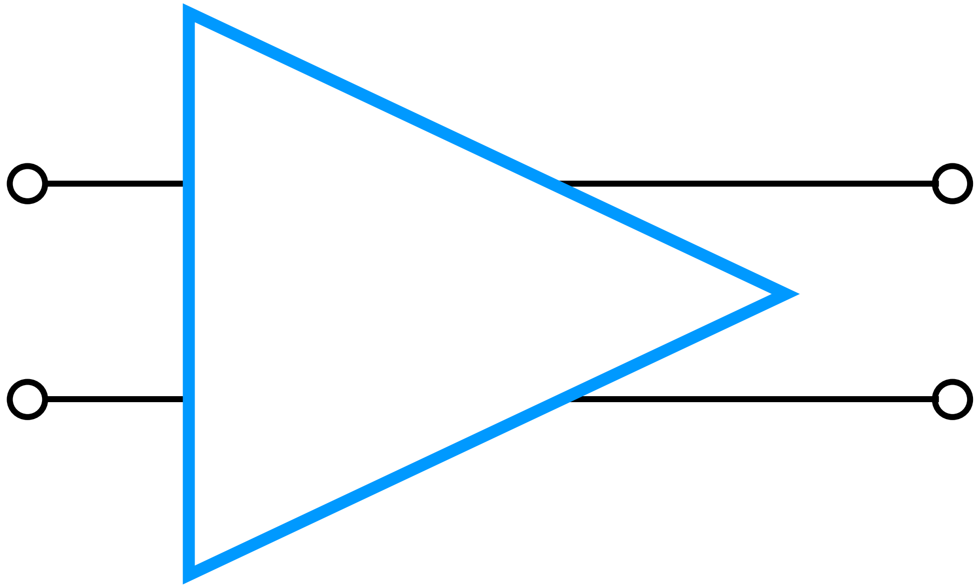
$$\sum_{i=1}^{\infty} \frac{\sin((2\bullet i+1)\bullet 2\pi f)}{2\bullet i+1}$$

output



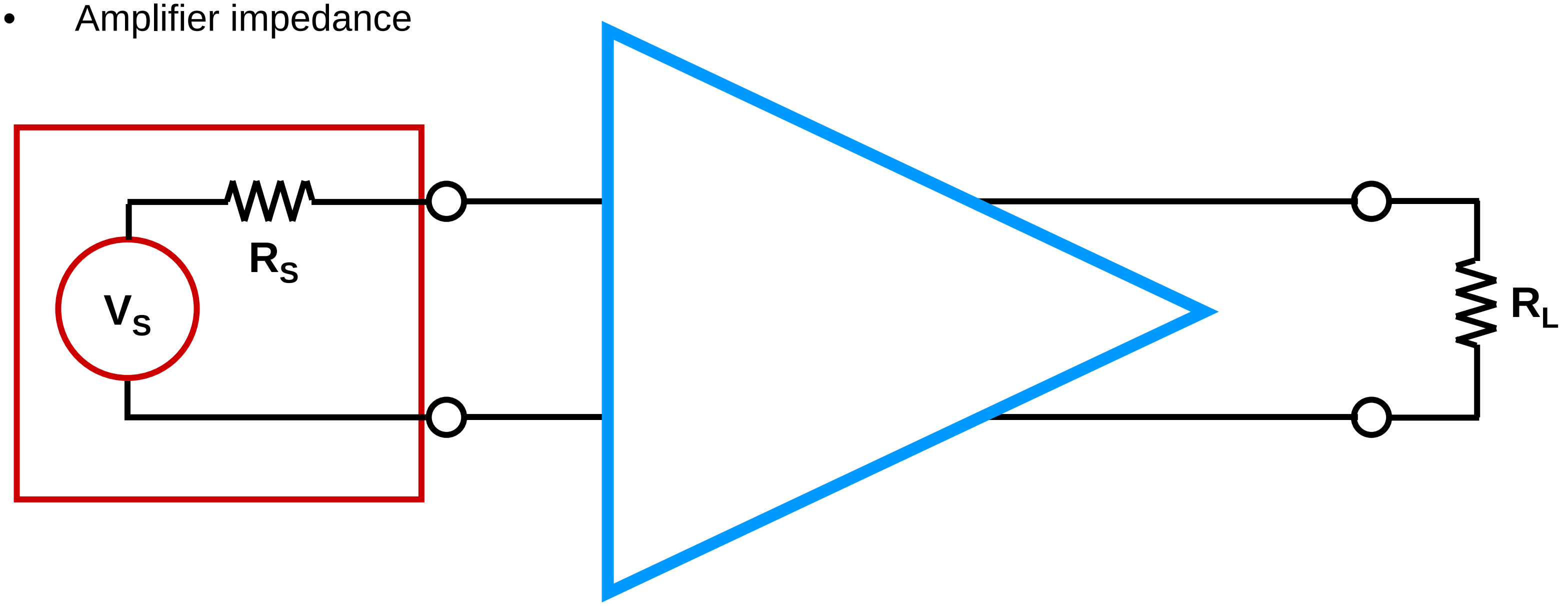
Signal Conditioning And Transformation

- Amplifier impedance



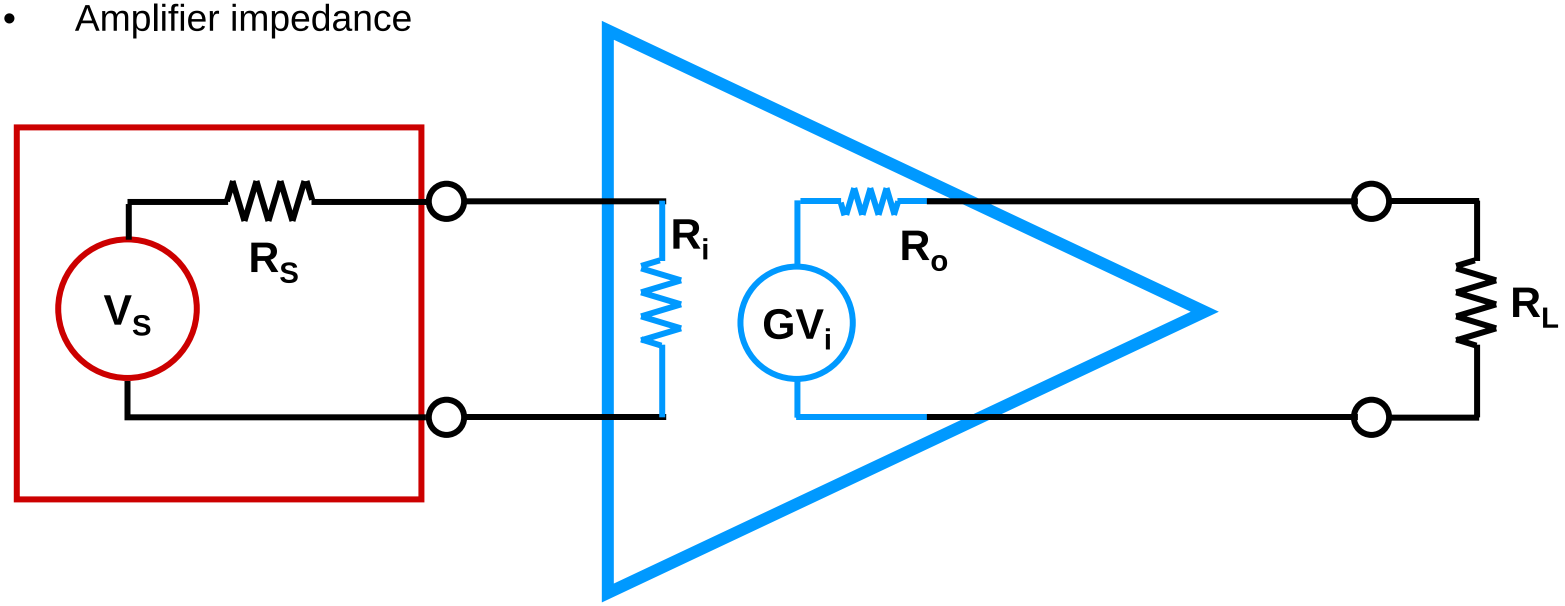
Signal Conditioning And Transformation

- Amplifier impedance



Signal Conditioning And Transformation

- Amplifier impedance



For greatest voltage gain, best frequency response:

$$R_i \to \infty$$

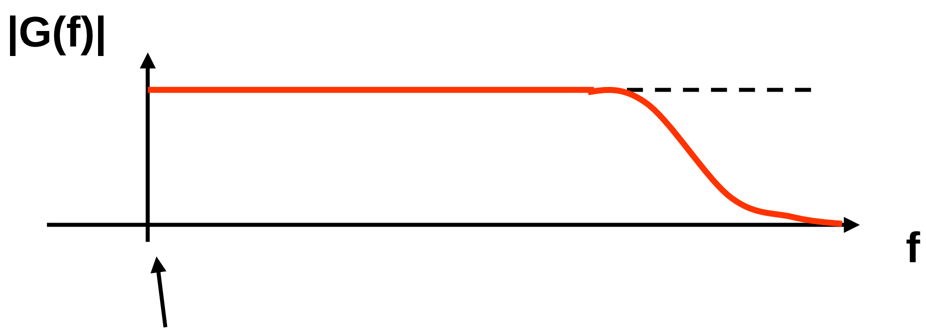
$$R_o \to 0$$

Today's topics

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

Signal Conditioning And Transformation

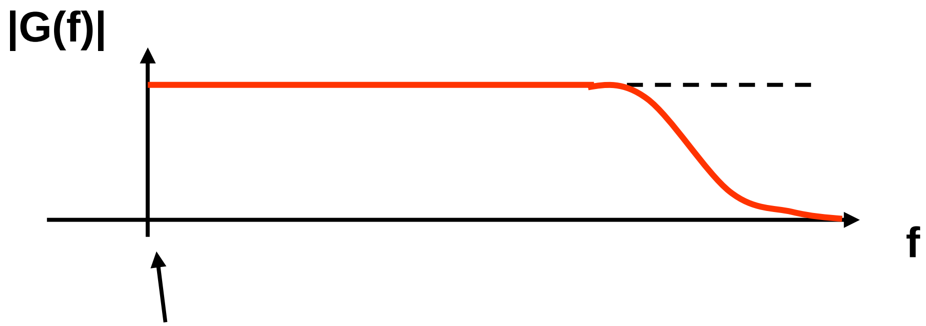
- Amplifier characteristics – DC drift and stabilization



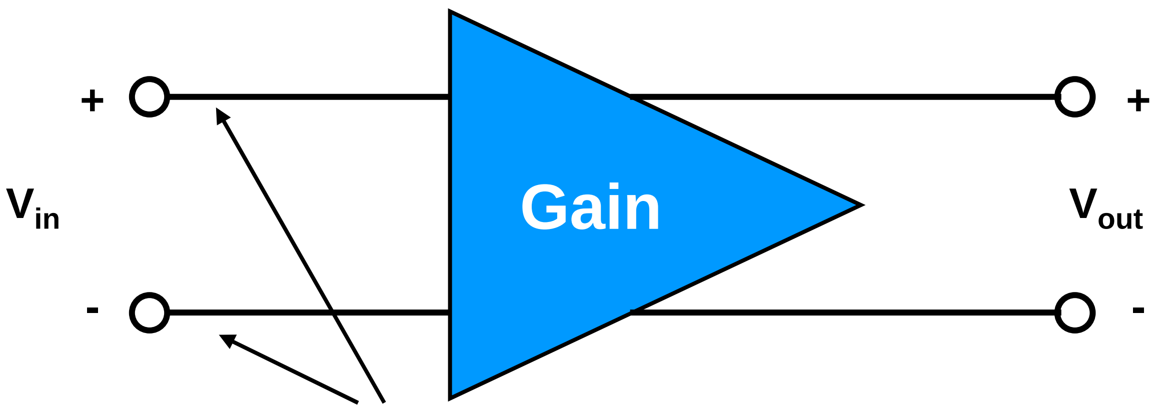
(1) Amplifier has gain at DC

Signal Conditioning And Transformation

- Amplifier characteristics – DC drift and stabilization



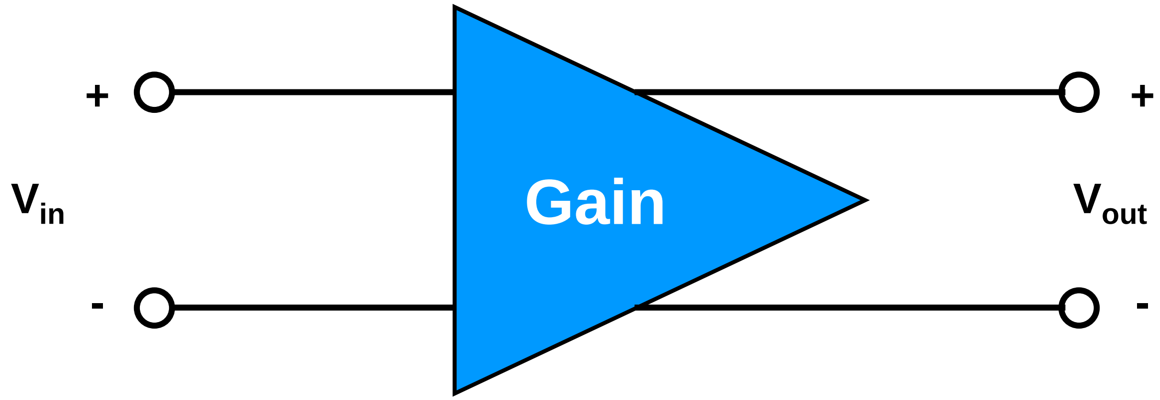
(1) Amplifier has gain at DC



(2) Assume differential operation due to low signal levels

Signal Conditioning And Transformation

- Amplifier characteristics – DC drift and stabilization



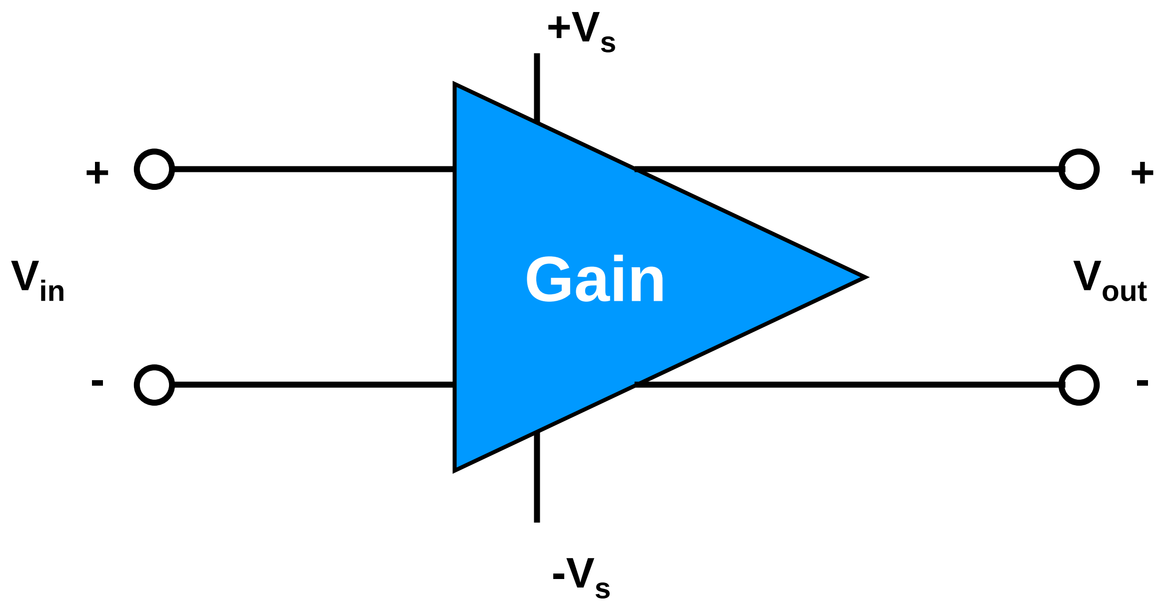
(3) Assume high gain to boost low signal levels

G = 1,000,000

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

Signal Conditioning And Transformation

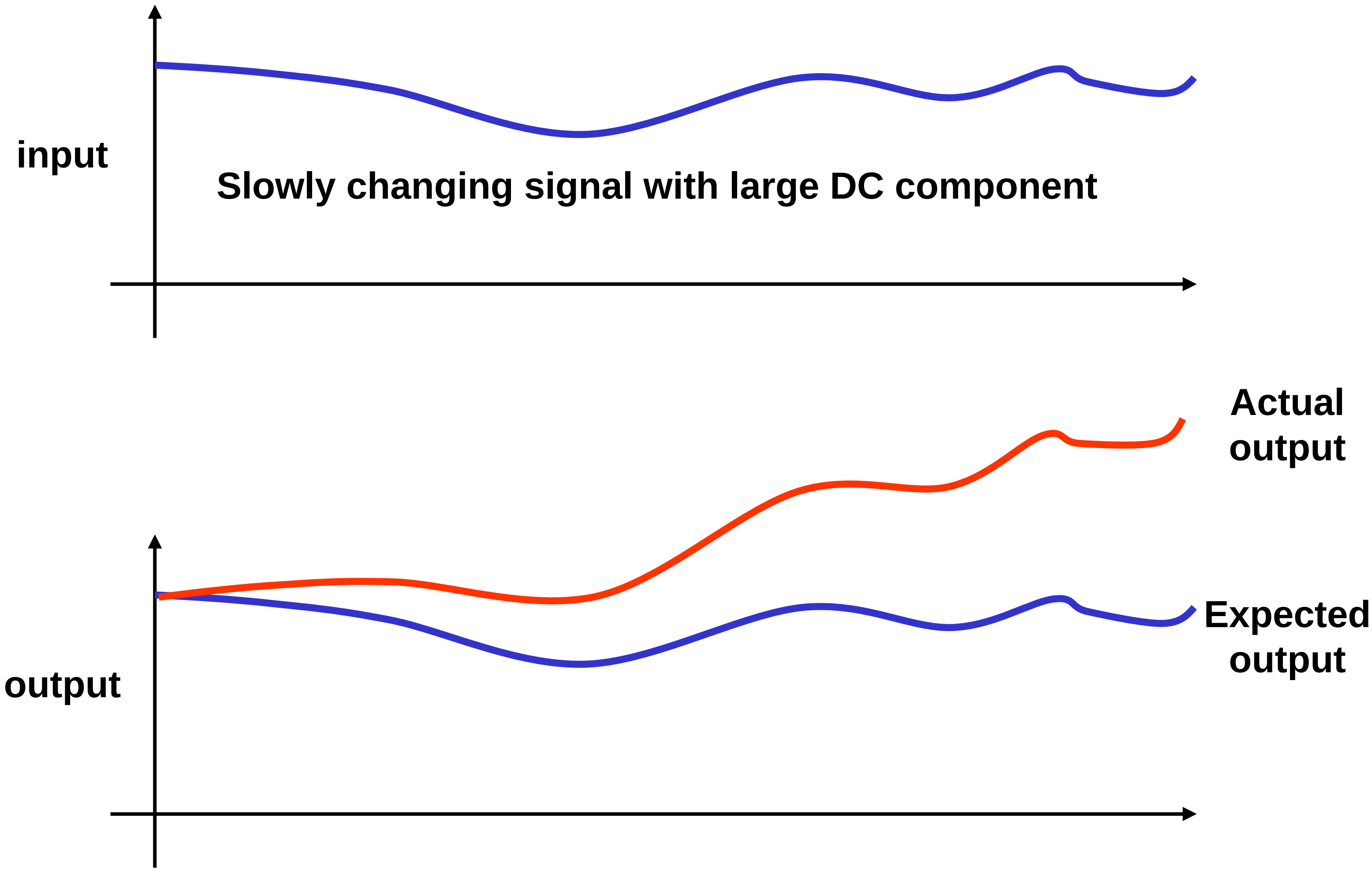
- Amplifier characteristics – DC drift and stabilization



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

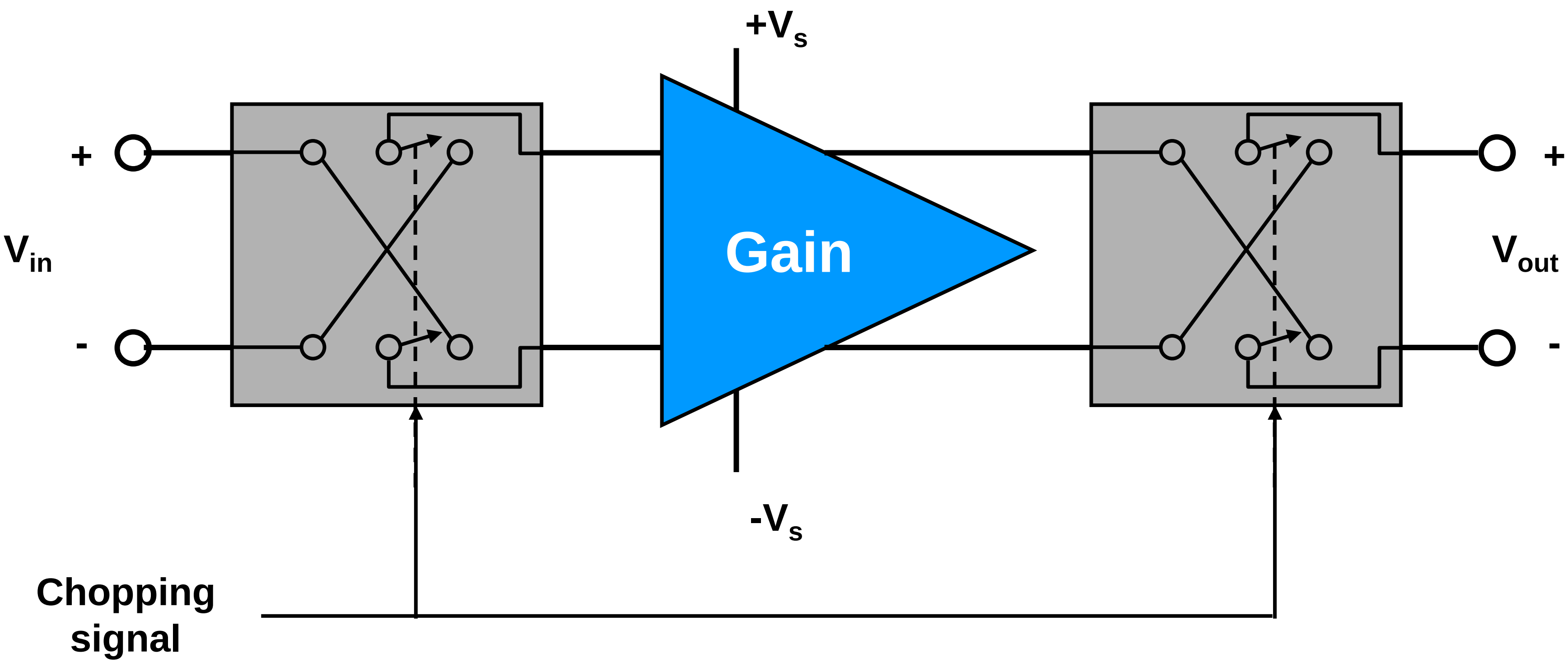
Signal Conditioning And Transformation

- Amplifier characteristics – DC drift



Signal Conditioning And Transformation

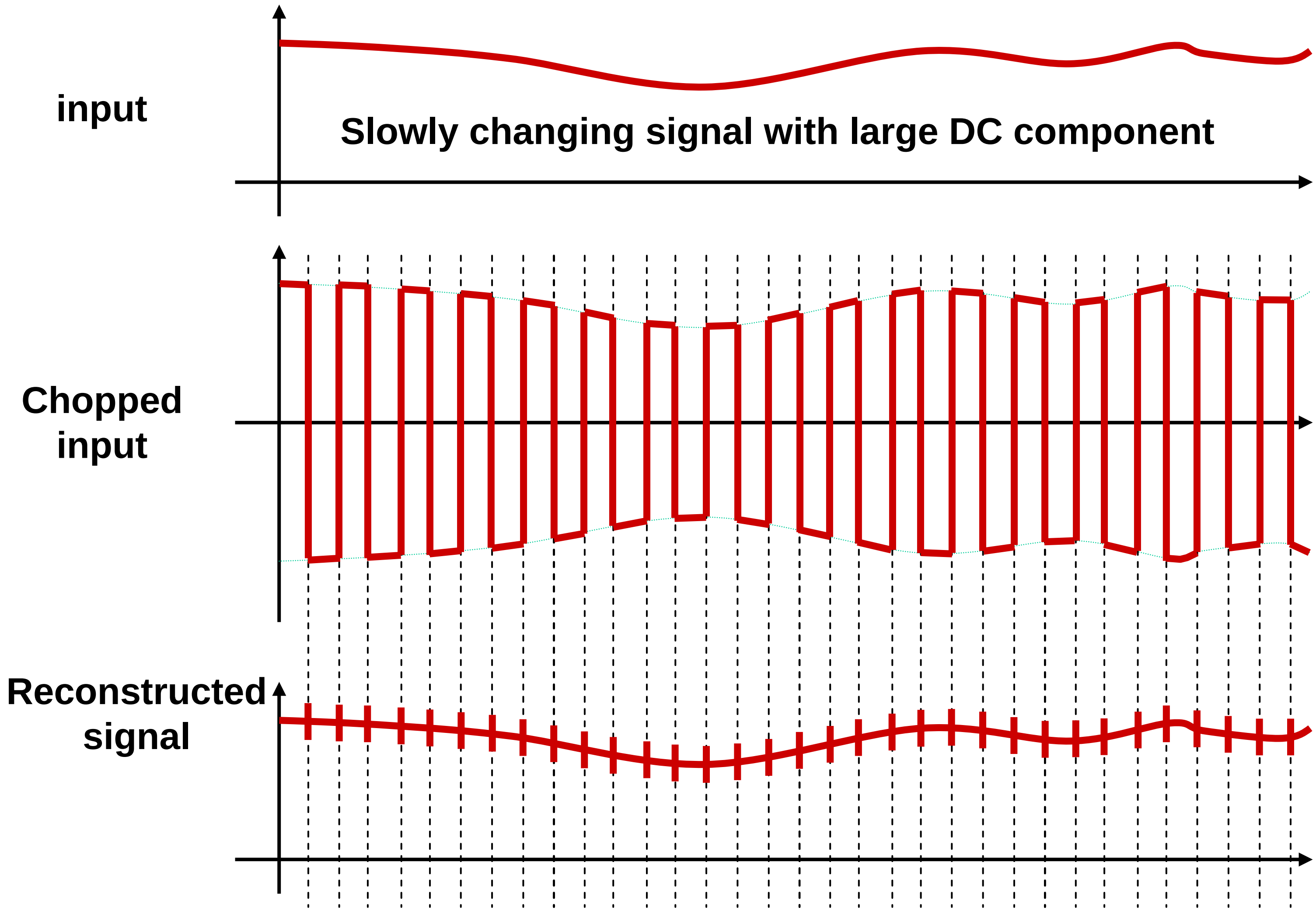
- Chopper stabilization of instrumentation amplifiers



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

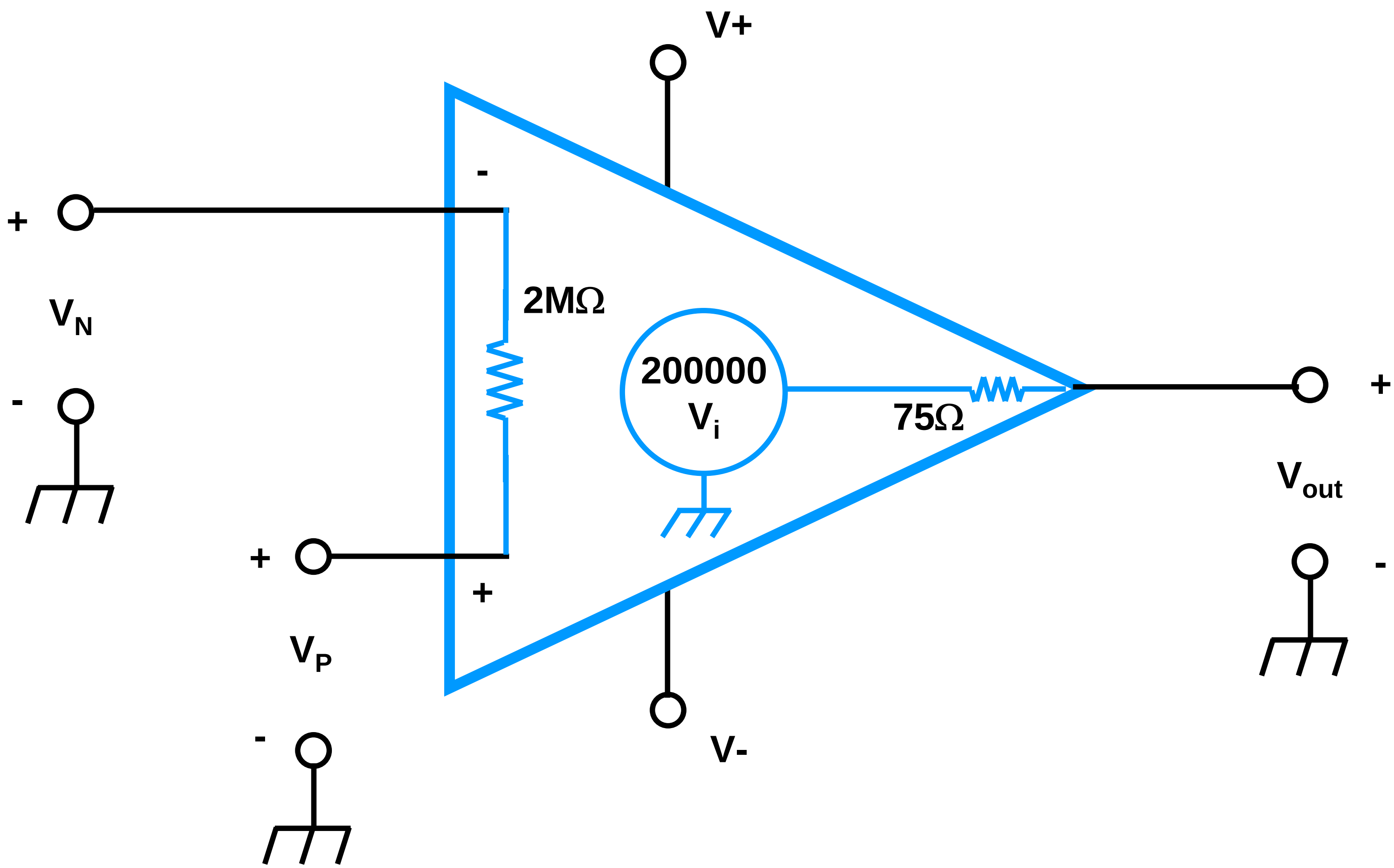
Signal Conditioning and Transmission

- Chopper stabilization of instrumentation amplifiers



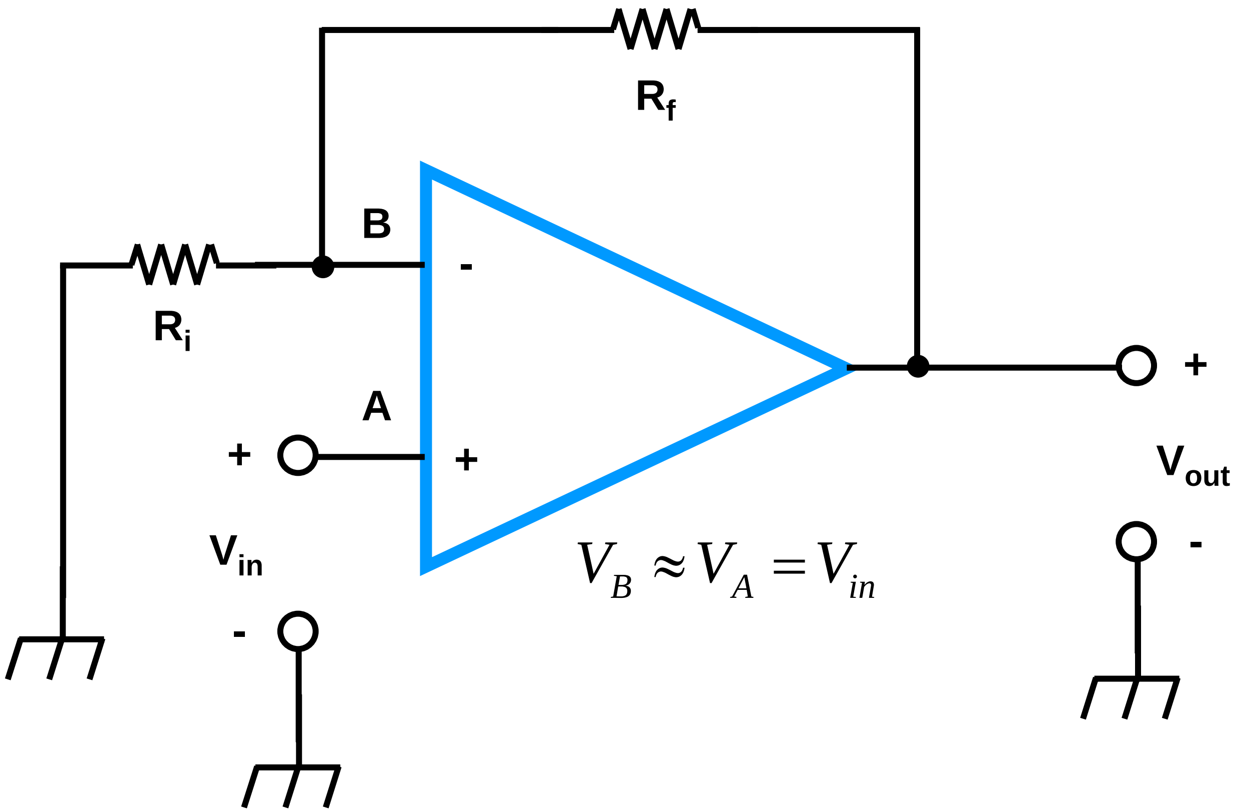
Signal Conditioning and Transmission

- Operational Amplifiers (μA741)



Signal Conditioning and Transmission

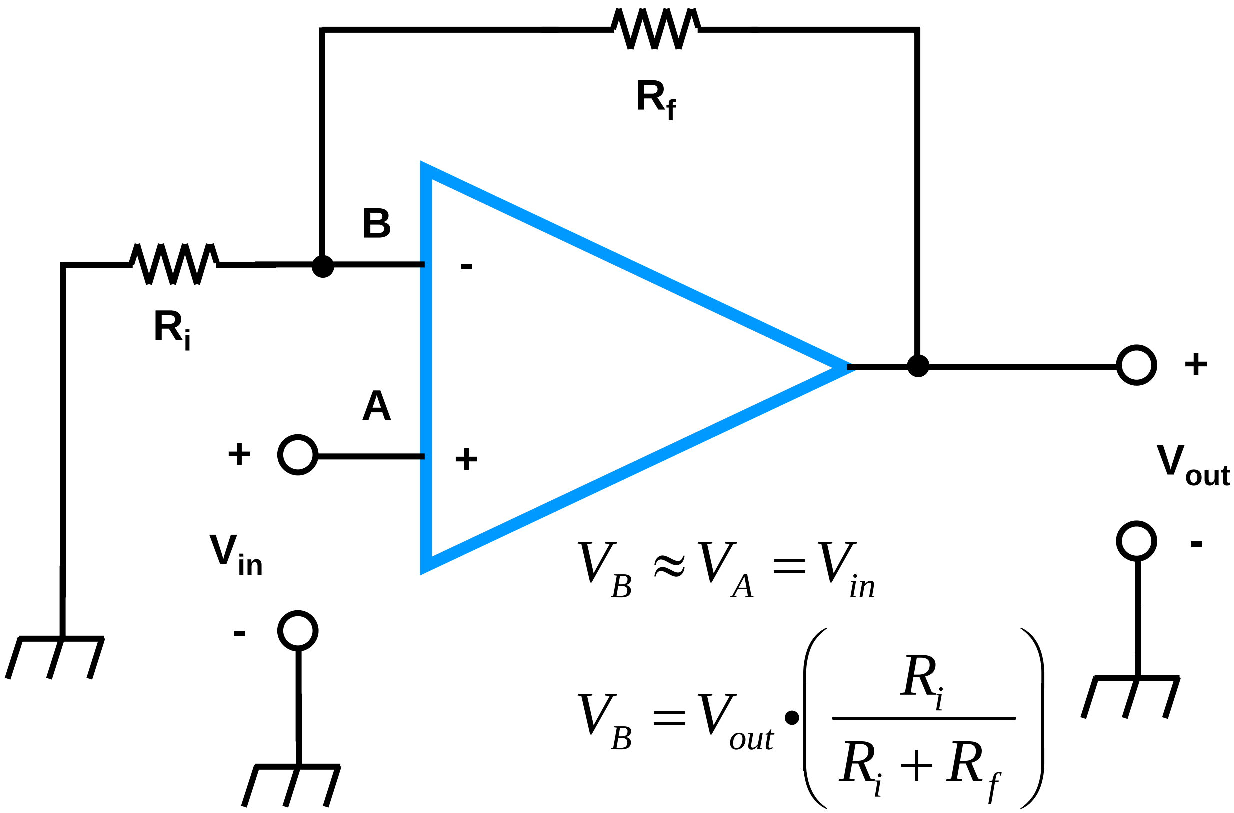
- Operational Amplifier – noninverting amplifier



$$V_B \approx V_A = V_{in}$$

Signal Conditioning and Transmission

- Operational Amplifier – noninverting amplifier

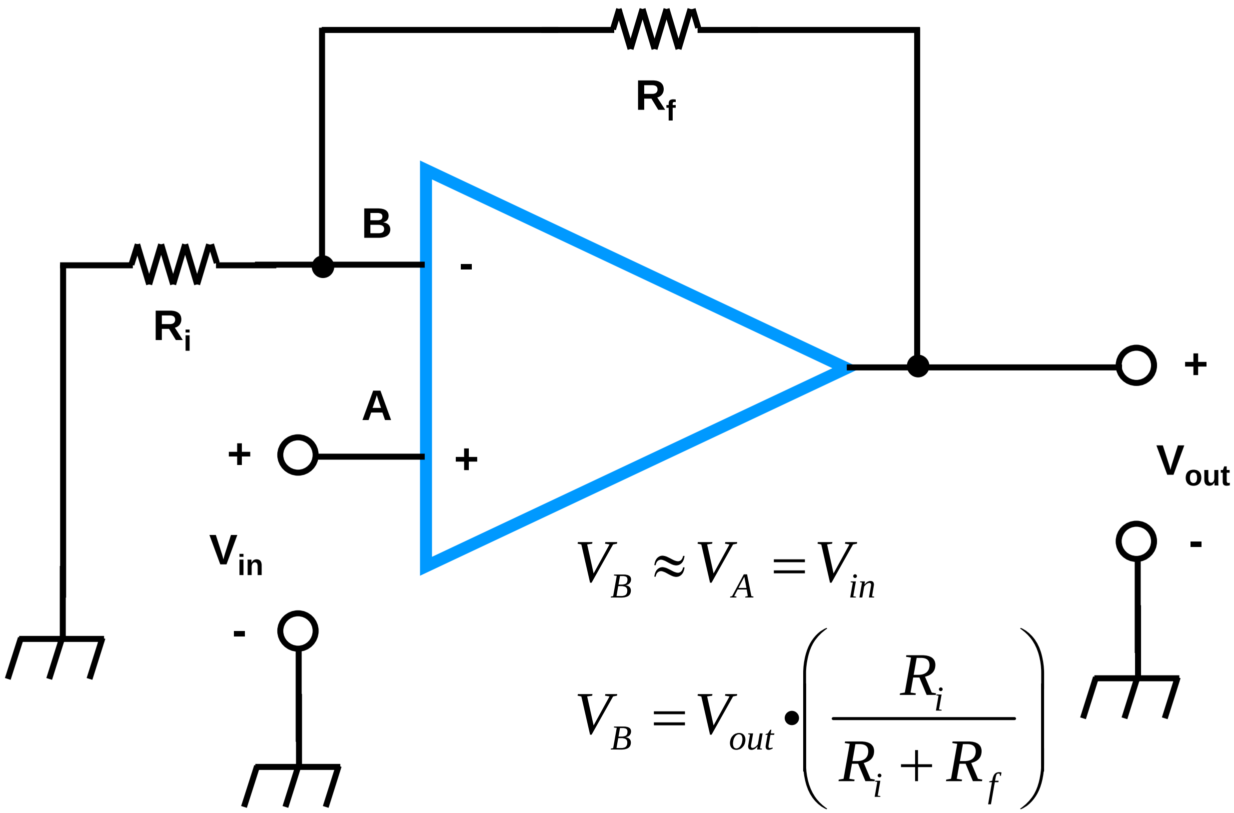


$$V_B \approx V_A = V_{in}$$

$$V_B = V_{out} \bullet \left(\frac{R_i}{R_i + R_f} \right)$$

Signal Conditioning and Transmission

- Operational Amplifier – noninverting amplifier



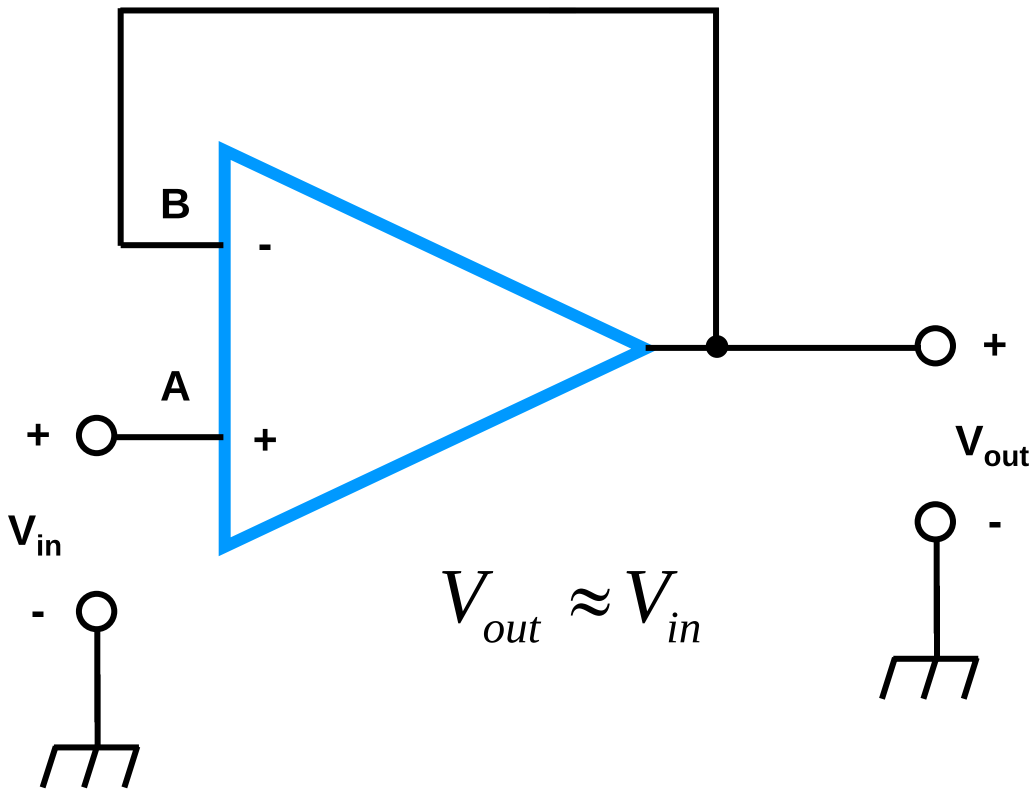
$$V_B \approx V_A = V_{in}$$

$$V_B = V_{out} \bullet \left(\frac{R_i}{R_i + R_f} \right)$$

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

Signal Conditioning and Transmission

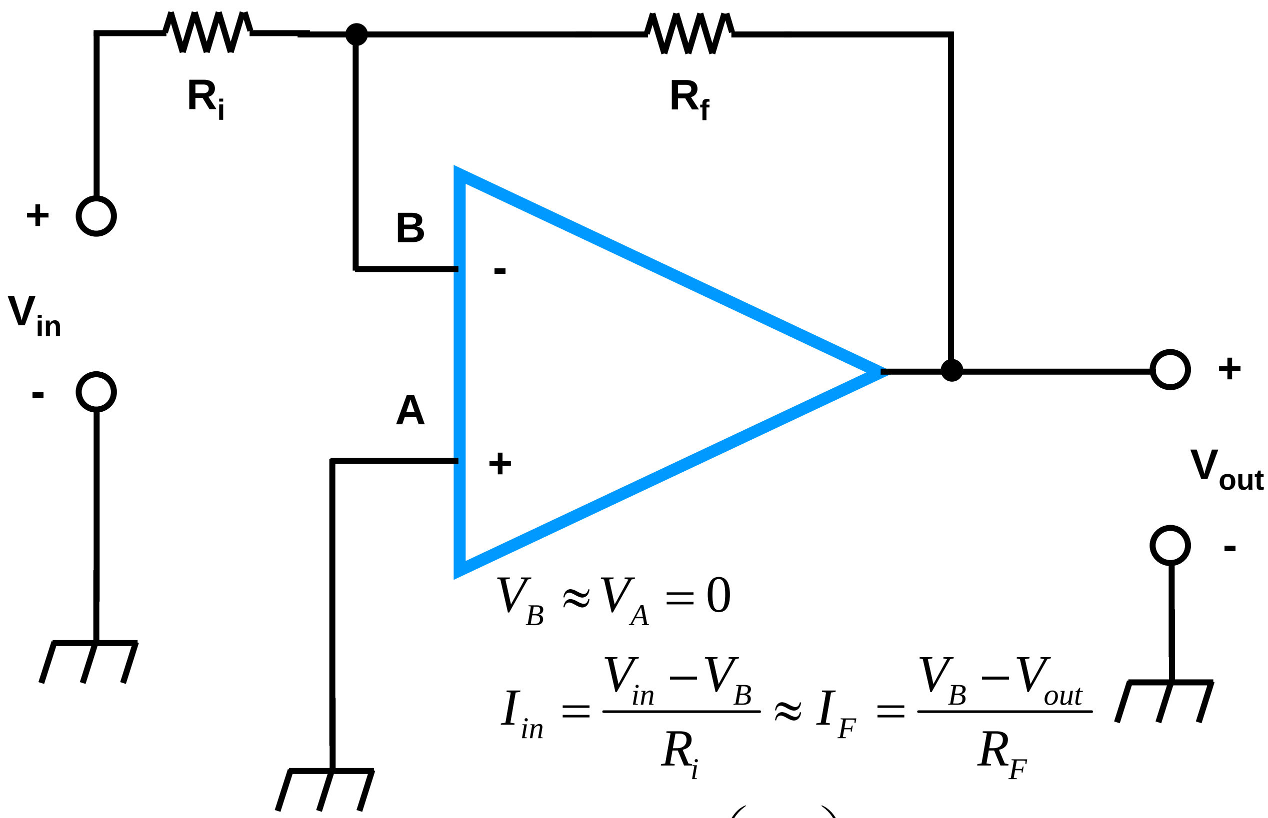
- Operational Amplifier – noninverting amplifier: voltage follower



$$V_{out} \approx V_{in}$$

Signal Conditioning and Transmission

- Operational Amplifier – inverting amplifier



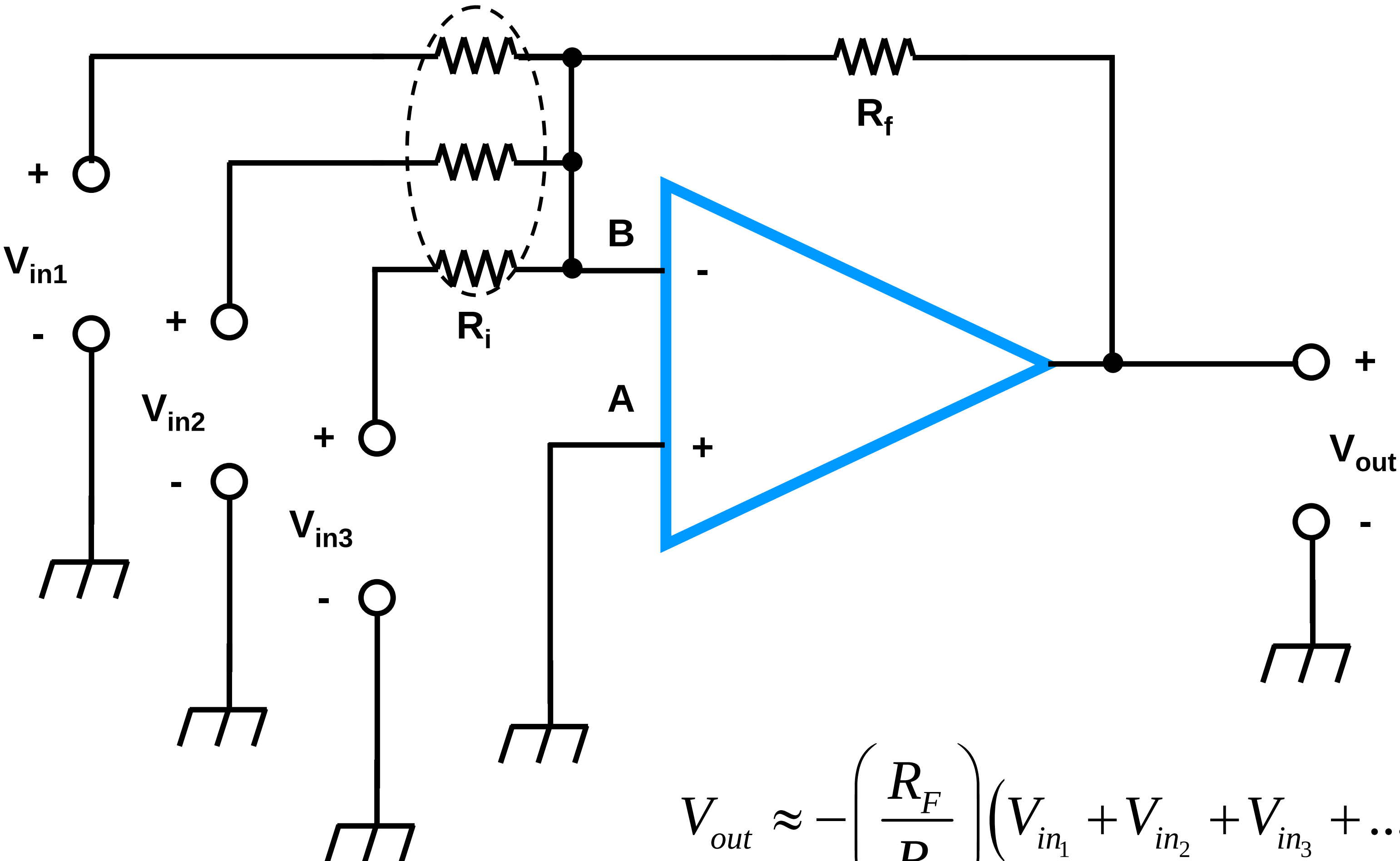
$$V_B \approx V_A = 0$$

$$I_{in} = \frac{V_{in} - V_B}{R_i} \approx I_F = \frac{V_B - V_{out}}{R_F}$$

$$V_{out} \approx -V_{in} \bullet \left(\frac{R_F}{R_i} \right)$$

Signal Conditioning and Transmission

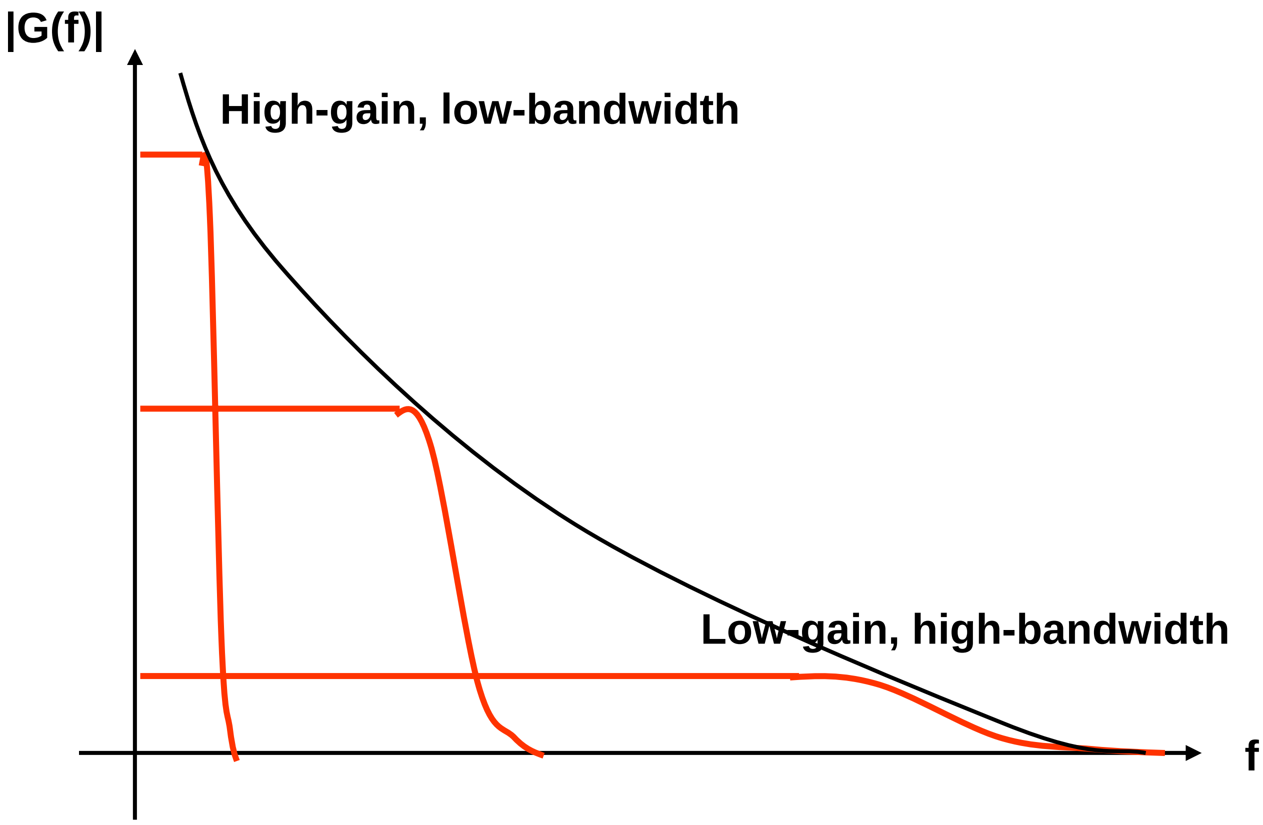
- Operational Amplifier – summing amplifier



$$V_{out} \approx -\left(\frac{R_F}{R_i}\right)\left(V_{in_1} + V_{in_2} + V_{in_3} + \ldots\right)$$

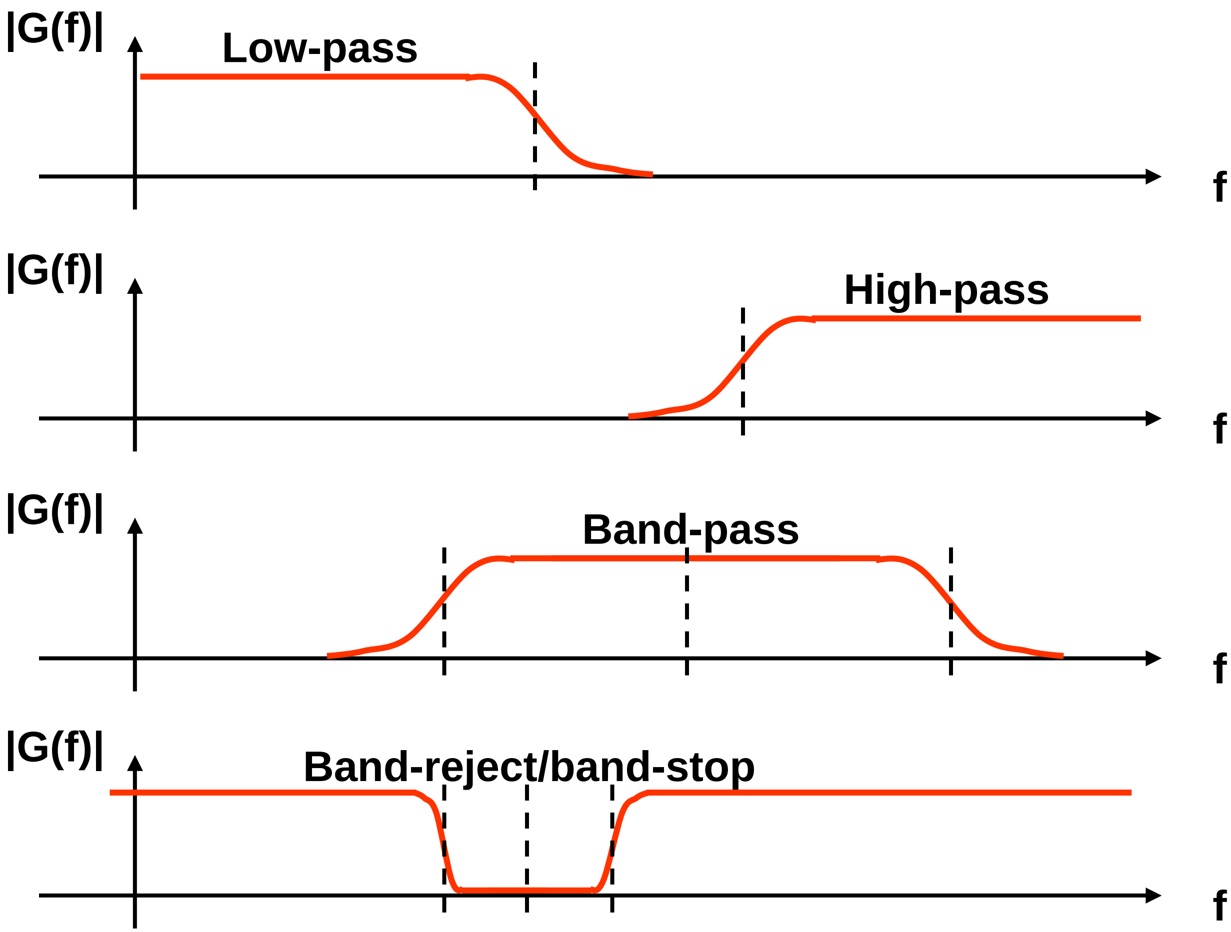
Signal Conditioning and Transmission

- Operational Amplifiers – Gain Bandwidth Product



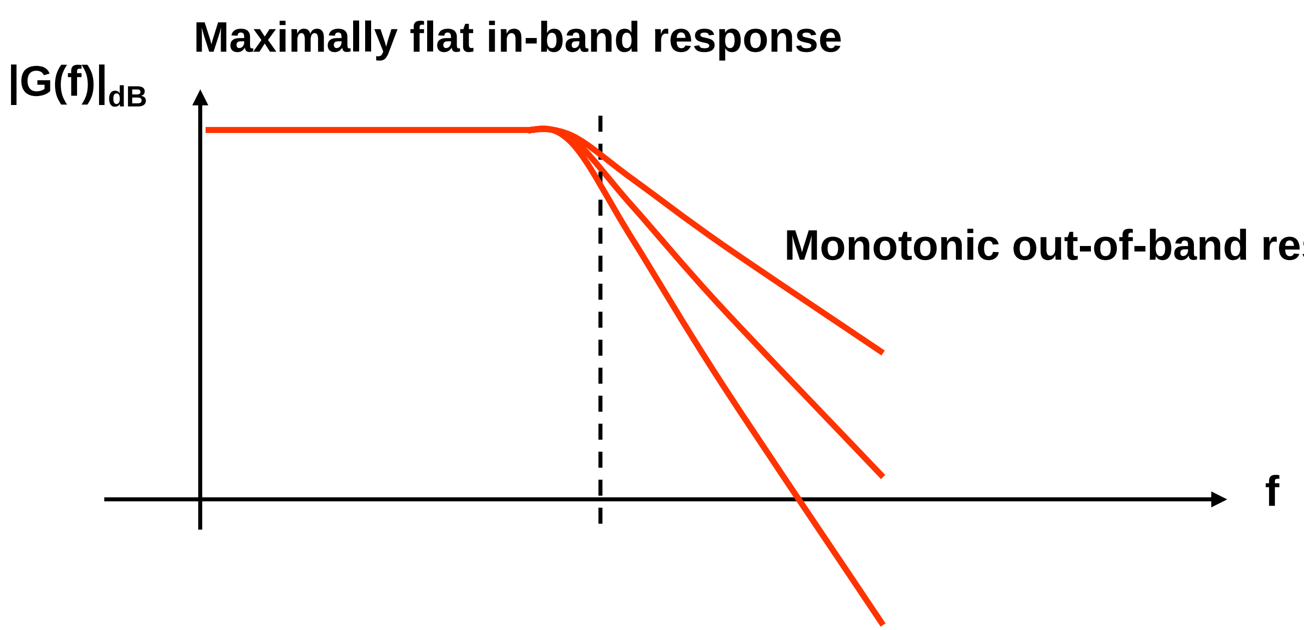
Signal Conditioning and Transmission

- Filtering



Signal Conditioning and Transmission

- Filter families

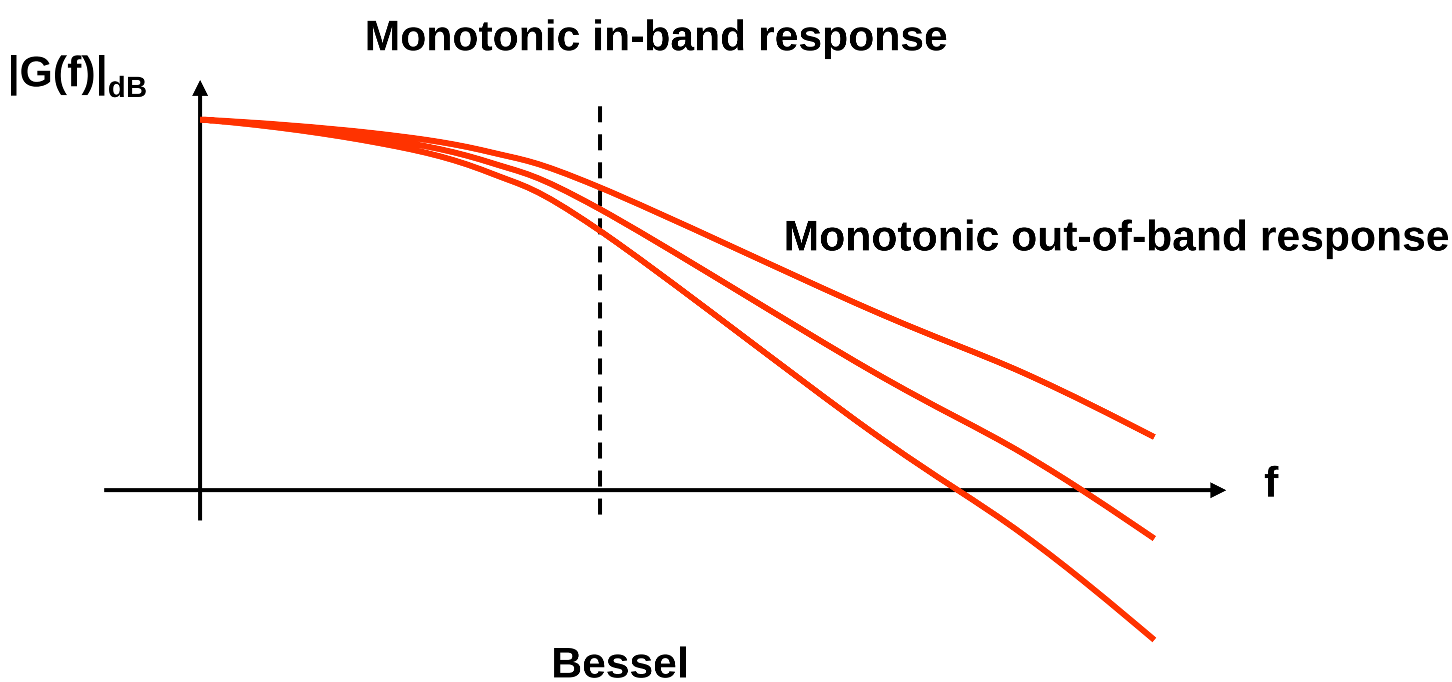


Butterworth

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

Signal Conditioning and Transmission

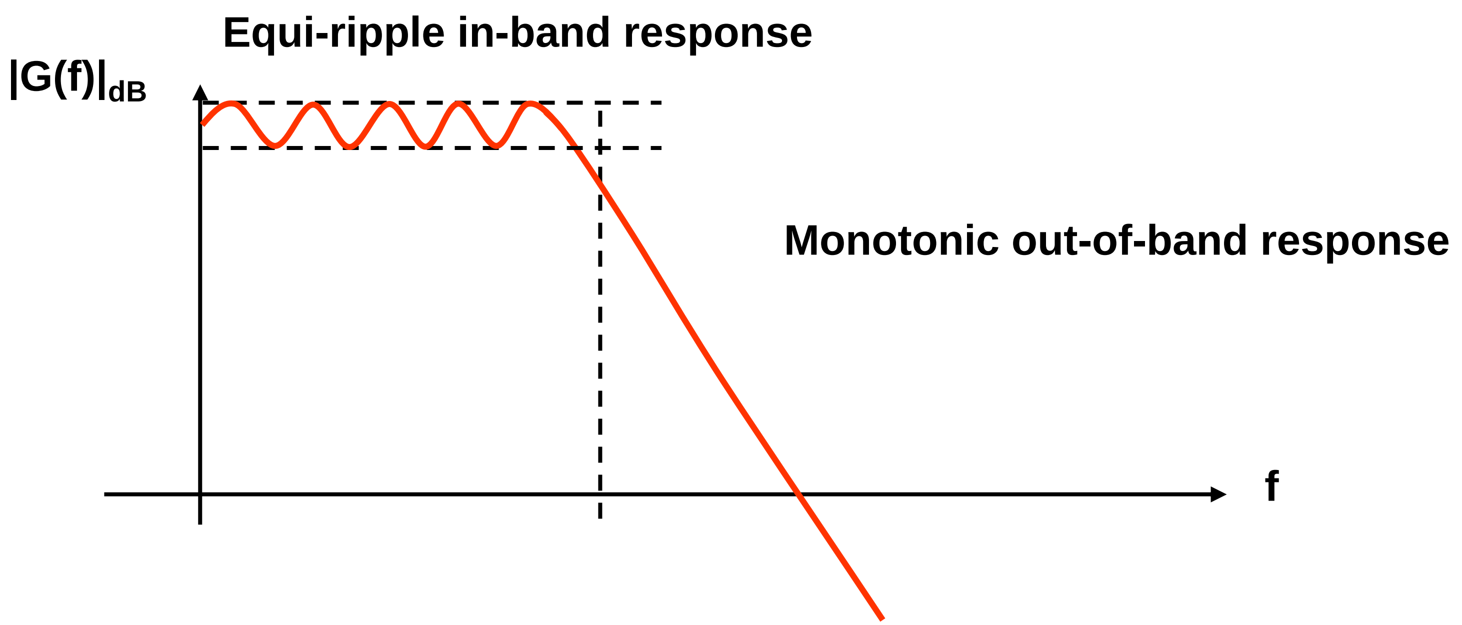
- Filter families



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

Signal Conditioning and Transmission

- Filter families

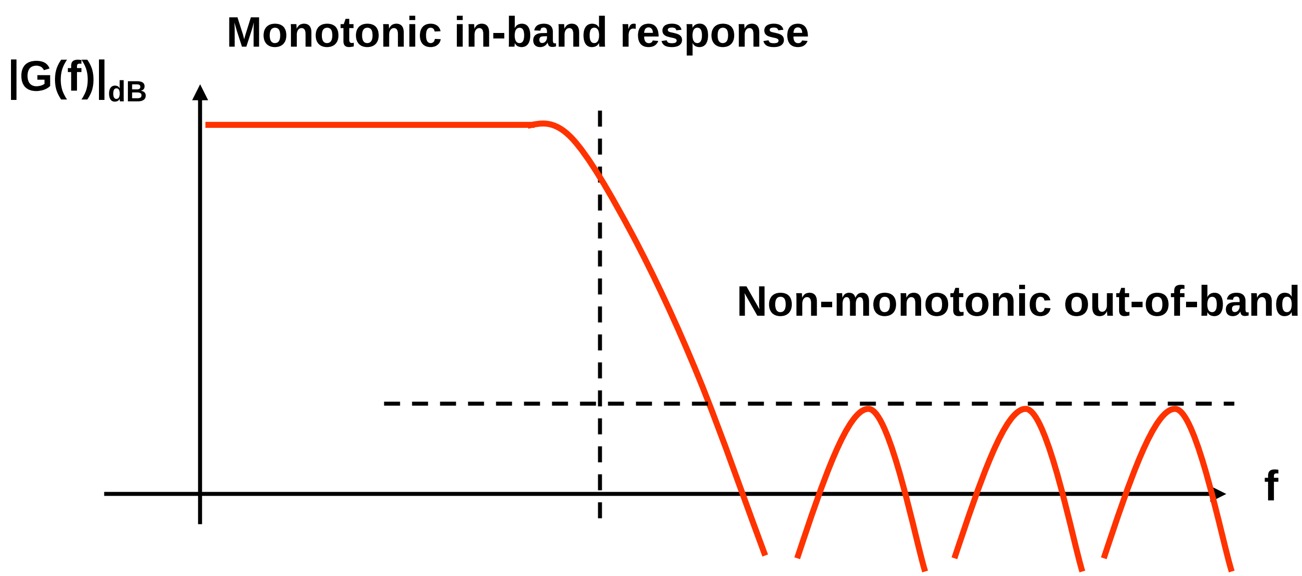


Chebychev

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

Signal Conditioning and Transmission

- Filter families

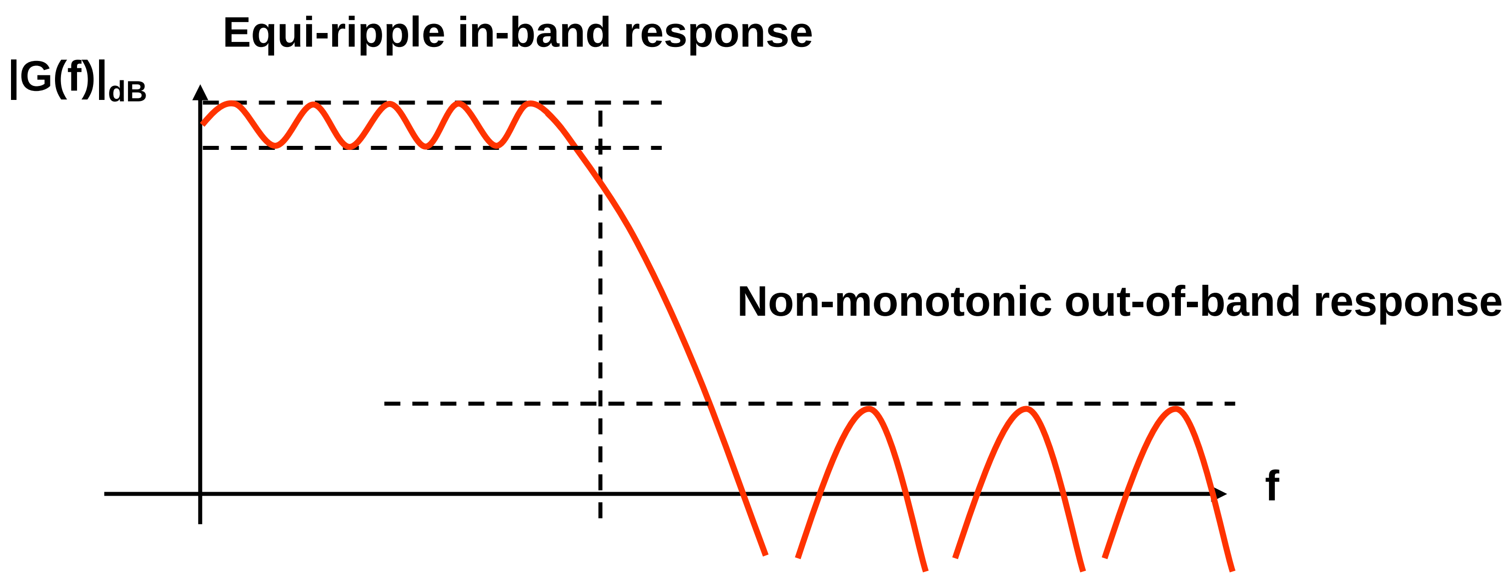


Inverse-Chebychev

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

Signal Conditioning and Transmission

- Filter families



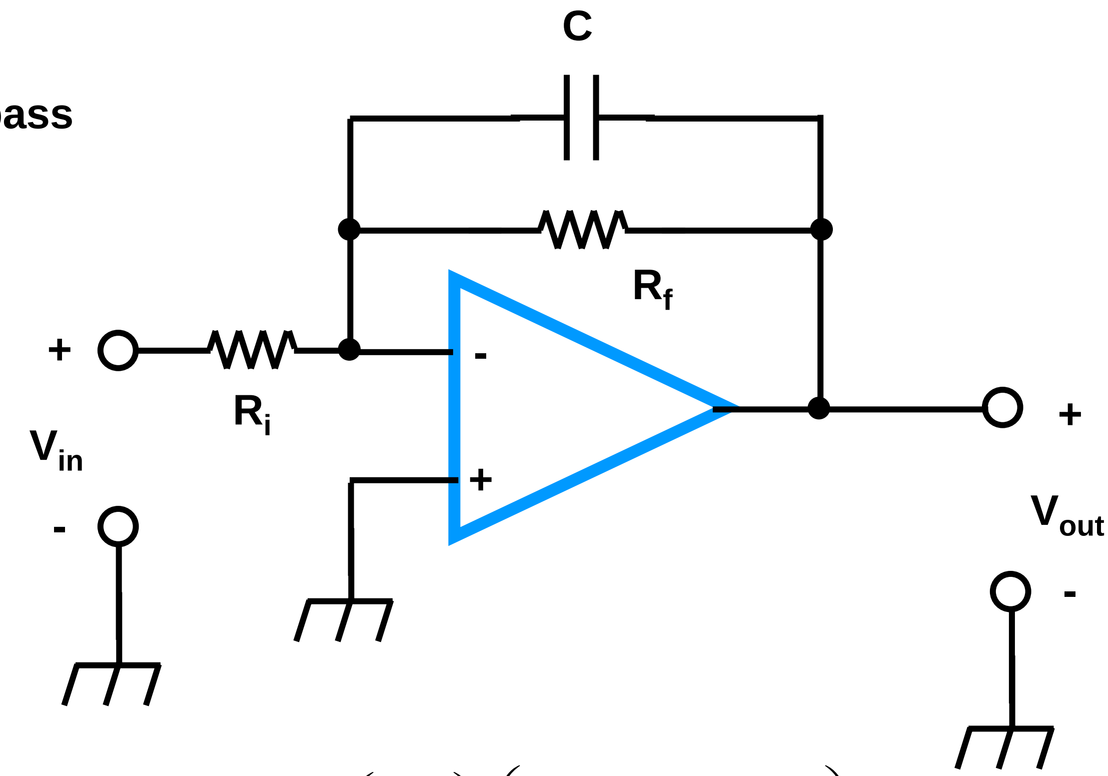
Elliptical

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

Signal Conditioning and Transmission

- Building filters with op-amps

Low-pass

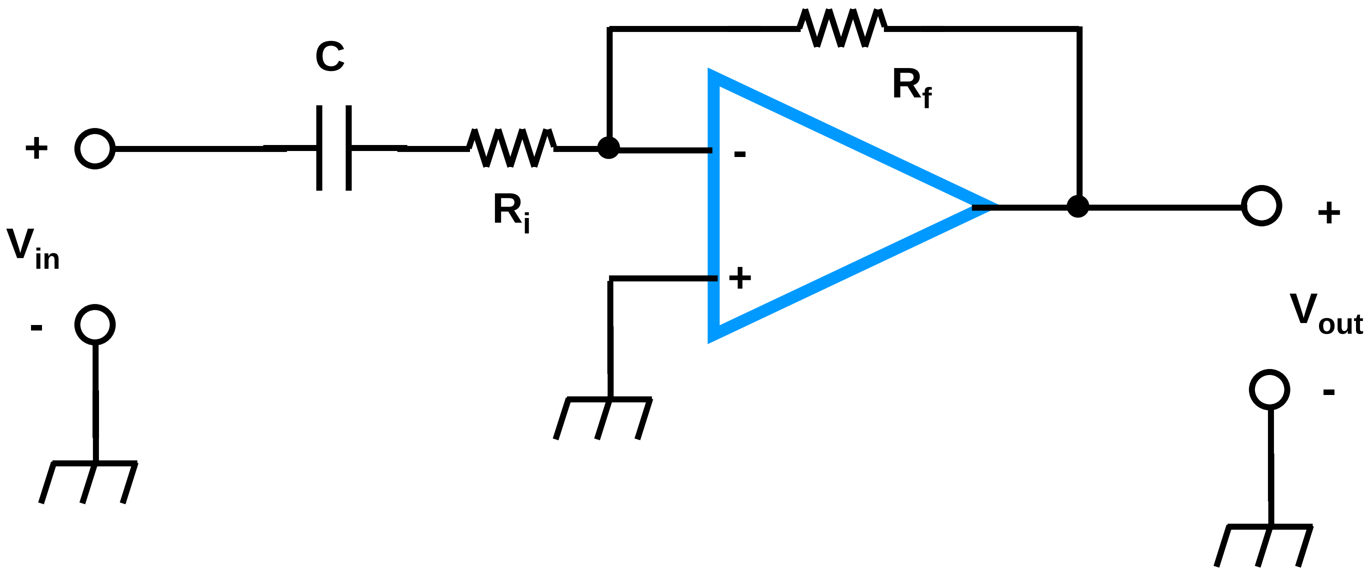


$$G(f) = -\left(\frac{R_f}{R_i}\right) \bullet \left(\frac{1}{1 + j2\pi fCR_f}\right)$$

Signal Conditioning and Transmission

- Building filters with op-amps

High-pass



Signal Conditioning and Transmission

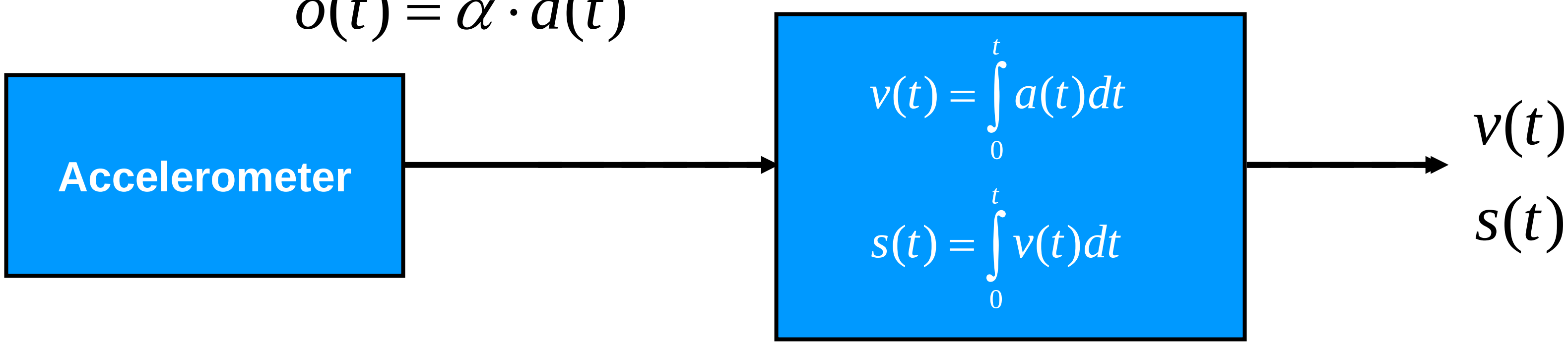
- Computing integral and derivative values

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

Signal Conditioning and Transmission

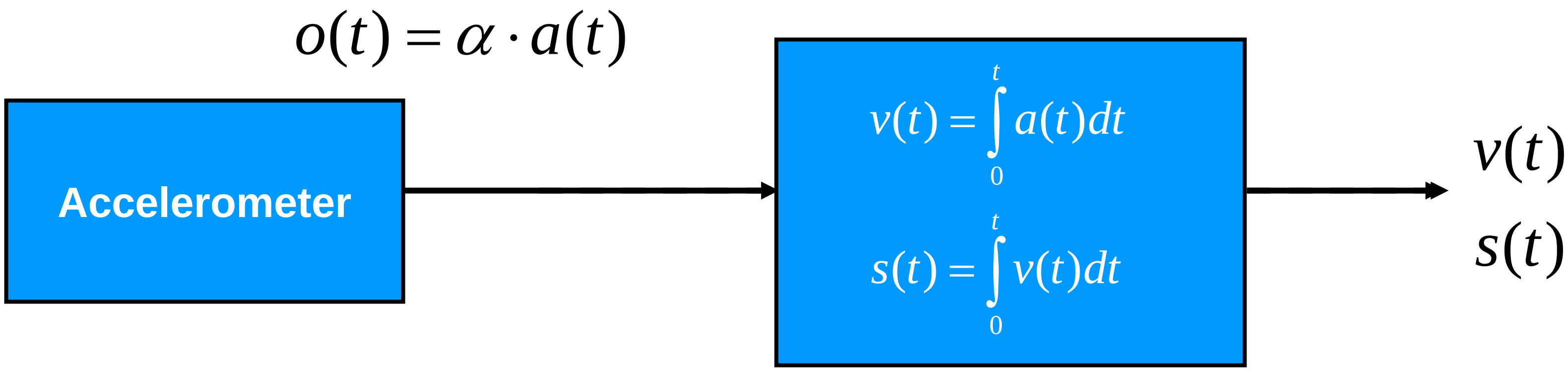
- Computing integral and derivative values

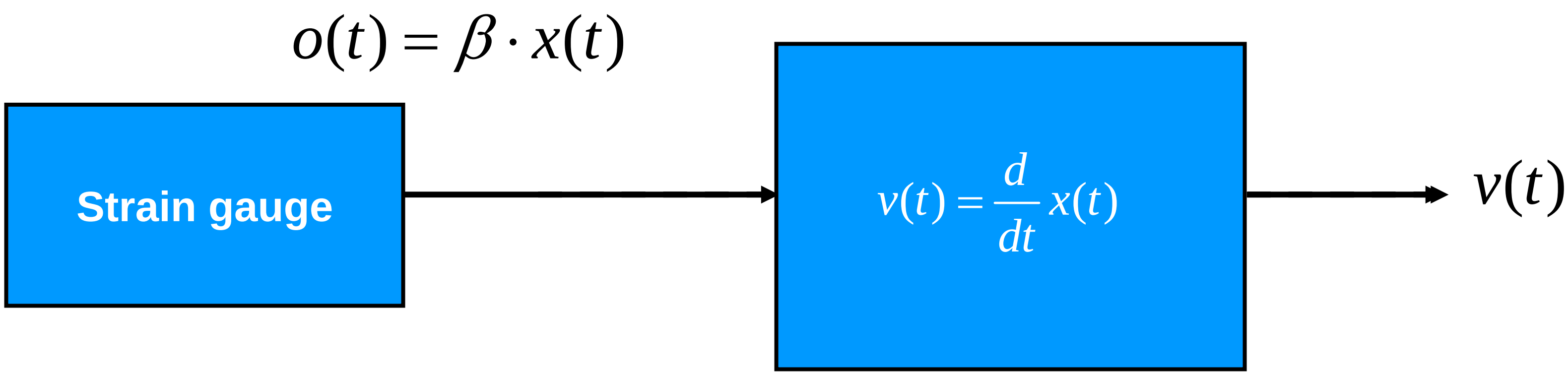
$$o(t) = \alpha \cdot a(t)$$



Signal Conditioning and Transmission

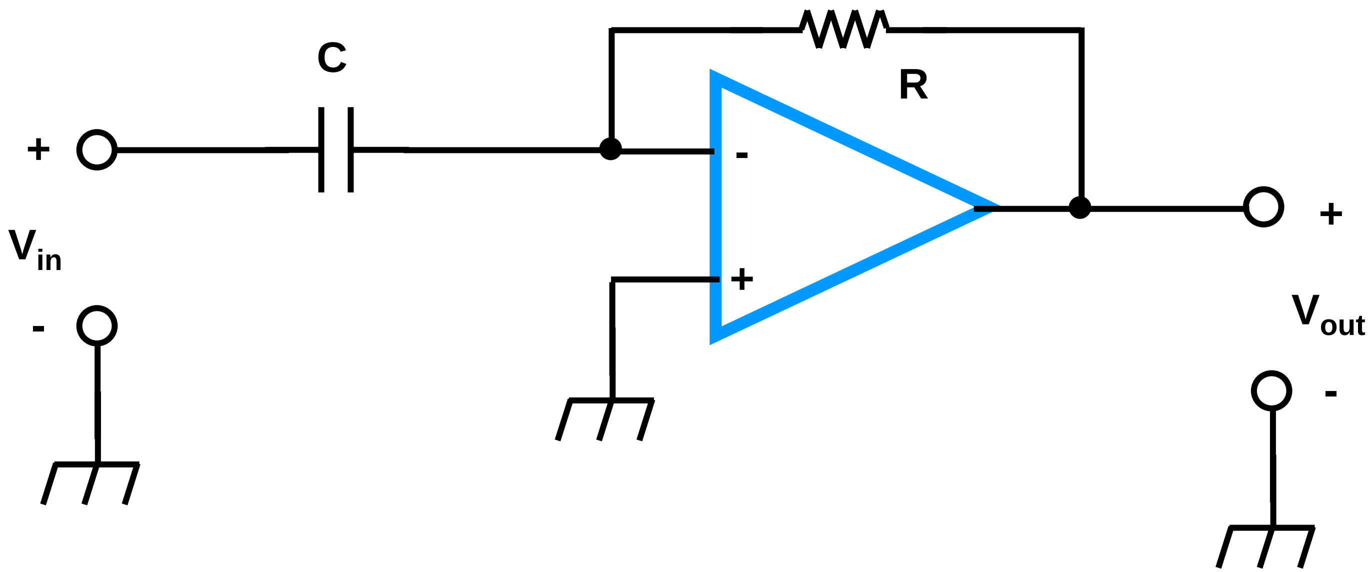
- Computing integral and derivative values





Signal Conditioning and Transmission

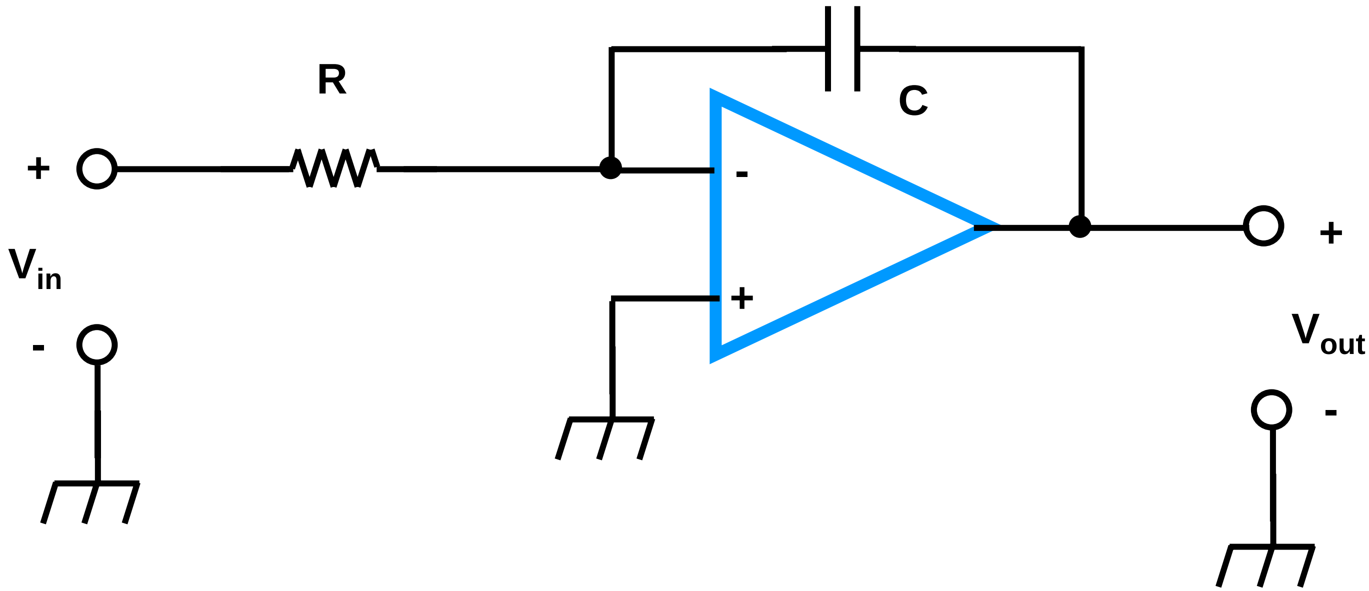
- Differentiator



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

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 3.2, 3.8, 3.16, 3.23