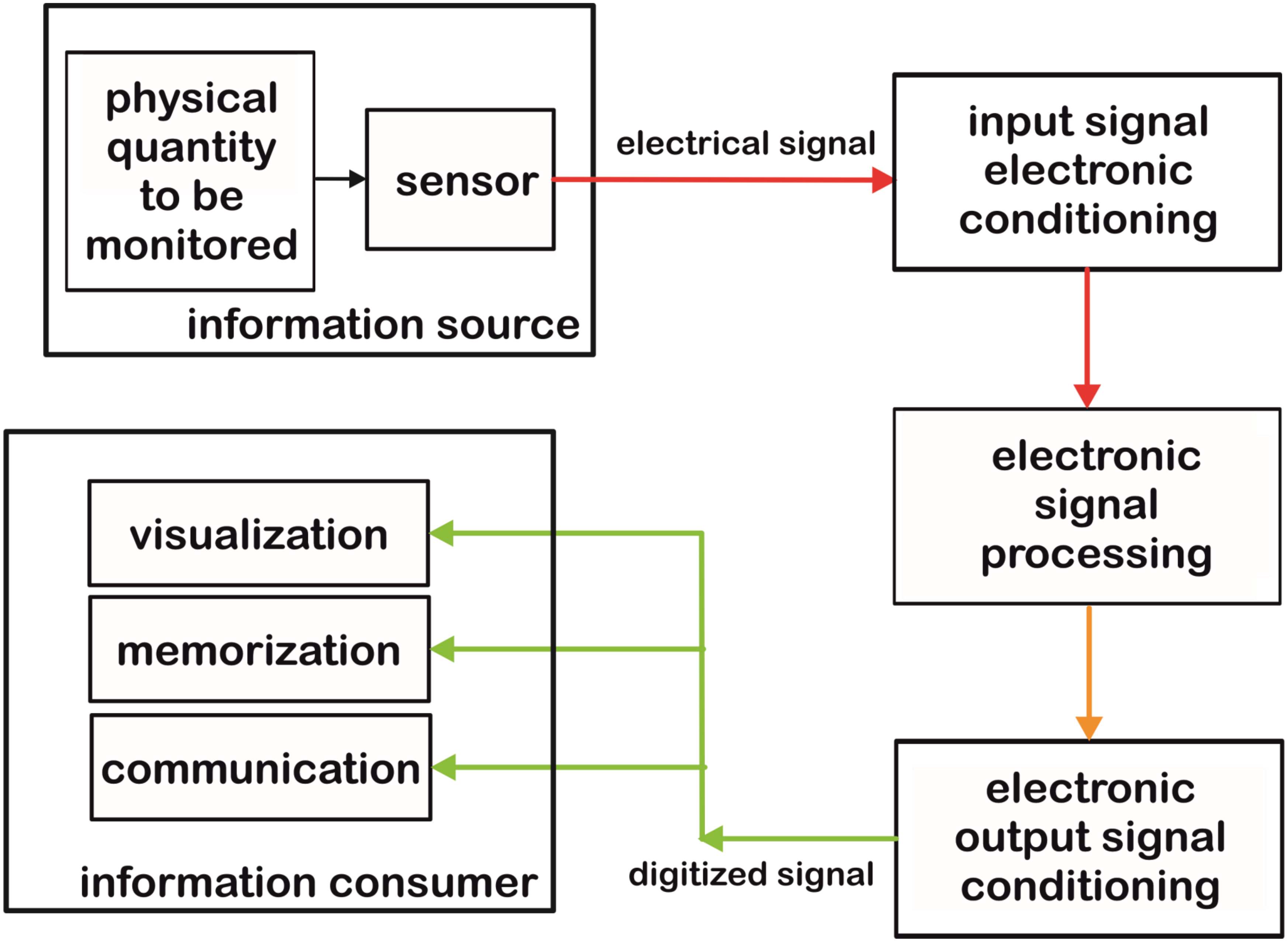
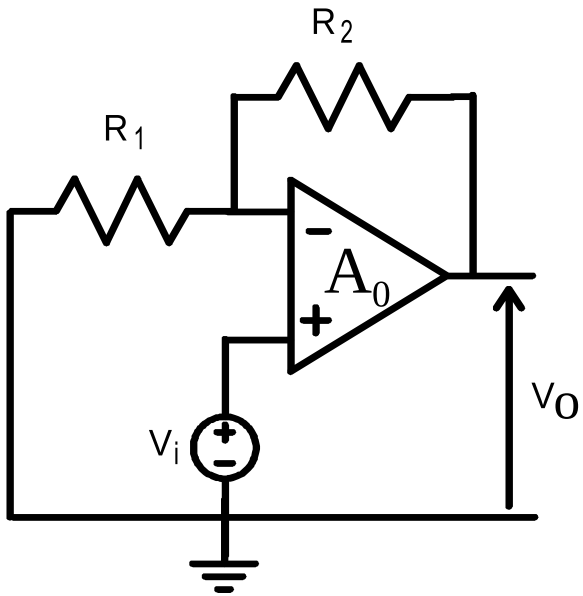
Measuring chain



Measuring chain: signal processing

- analog processing
  - linear amplification, addition, difference
  - integration, derivation, linear filtering
  - non-linear amplification, multiplication, division
  - scansion
- analog to digital conversion
  - sampling
  - conversion
- digital processing
  - hardware
  - software

Non-inverting amplifier



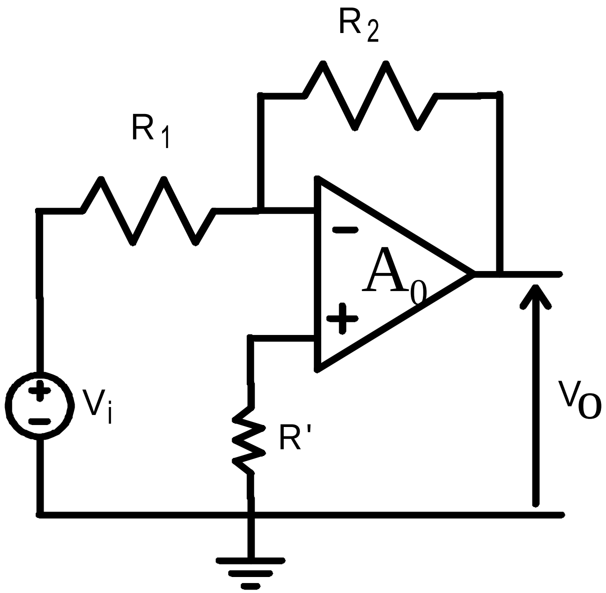
$$v^{-} = \beta V_u = \frac{R_1}{R_1 + R_2} V_u$$

$$G_{loop} = -\beta A_0 = -\frac{R_1 \cdot A_0}{R_1 + R_2}$$

$$A = \frac{V_u}{V_i} = \frac{A_0}{1 - G_{loop}} = \frac{1}{\beta + 1/A_0} \cong \frac{1}{\beta} = \left(1 + \frac{R_2}{R_1}\right)$$

- ❑ **accurate gain: low tolerance resistors, small values of gain A**
- ❑ **input impedance: very high**
- ❑ **typical values:**
  - **gain less than 10^2 -10^3 (min gain is one)**
  - **R_2 between 2 and 100 KΩ**

Inverting amplifier



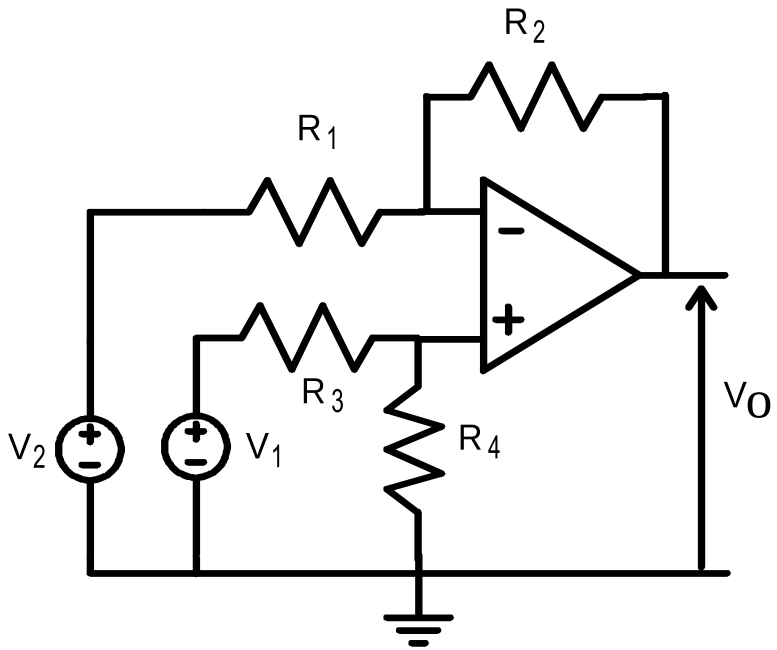
$$v^- = \beta V_u = \frac{R_1}{R_1 + R_2} V_u$$

$$G_{loop} = -\beta A_0 = -\frac{R_1 \cdot A_0}{R_1 + R_2}$$

$$A = \frac{V_u}{V_i} = \frac{-A_0 \cdot \frac{R_2}{R_1 + R_2}}{1 - G_{loop}} = \frac{-A_0 \cdot \frac{R_2}{R_1 + R_2}}{1 + A_0 \cdot \frac{R_1}{R_1 + R_2}} \cong -\frac{R_2}{R_1}$$

- accurate gain: low tolerance resistors, small values of gain A
- the input impedance is relatively low
- typical gain between 0,1 and 10^3
- $R' = \frac{R_1 \cdot R_2}{R_1 + R_2}$

Difference amplifier

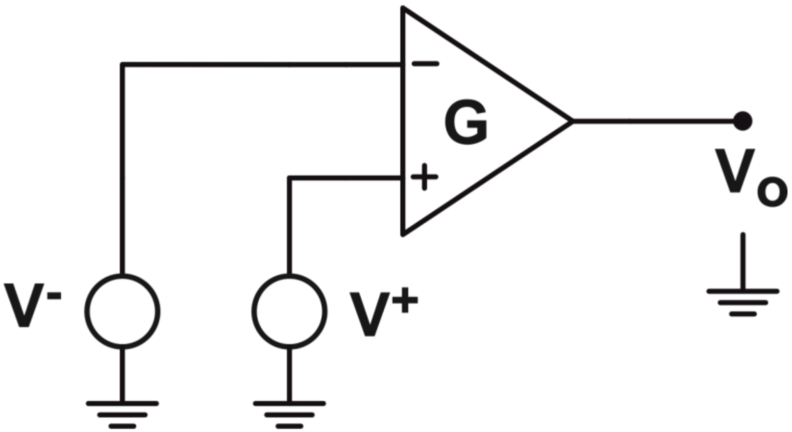


$$V_o = V_1 \cdot \frac{R_4}{R_3 + R_4} \cdot \frac{R_1 + R_2}{R_1} - V_2 \cdot \frac{R_2}{R_1}$$

$$R_1 = R_3 \text{ e } R_2 = R_4$$

$$V_o = \frac{R_2}{R_1} \cdot (V_1 - V_2)$$

Common Mode Rejection Ratio (CMRR)



$$V_o = G^+ \cdot V^+ - G^- \cdot V^-$$

$$G_d = \frac{G^+ + G^-}{2}$$

$$G_c = G^+ - G^-$$

$$\Rightarrow \quad G^- = G_d - \frac{G_c}{2} \qquad G^+ = G_d + \frac{G_c}{2}$$

$$\boxed{CMRR \overset{DEF}{=} G_d / G_c}$$

$$V_o = \left(G_d + \frac{G_c}{2}\right) \cdot V^+ - \left(G_d - \frac{G_c}{2}\right) \cdot V^-$$

$$\Rightarrow \quad V_o = G_d \cdot (V^+ - V^-) + G_c \cdot \left(\frac{V^+ + V^-}{2}\right)$$