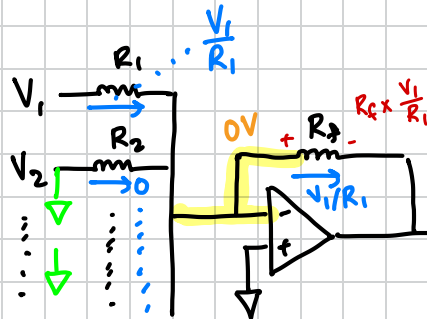


IDEAL OP-AMP LIMITATIONS

① Limited output swing $\Rightarrow V_o$ cannot go above V_{DD} or below $-V_{DD}$

② Limited input voltage

- Absolute voltage rating
- $V_+ \approx V_-$ **Input Common Mode Voltage** $\frac{V_+ + V_-}{2}$
- RRI \Rightarrow Rail to Rail Input

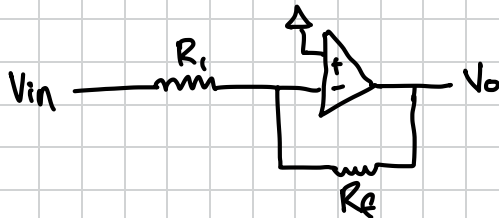


V_o due to V_1 alone

True output

$$= -\frac{R_f}{R_1} V_1 - \frac{R_f}{R_2} V_2 - \frac{R_f}{R_3} V_3 + \dots$$

$$= -R_f \sum_{i=1}^n \frac{1}{R_i} V_i$$



Node Analysis

$$\frac{V_{in} - V_-}{R_i} = \frac{V_- - V_o}{R_f}$$

~~$V_- = 0$~~

$$\frac{V_-}{R_f} + \frac{V_-}{R_i} = \frac{V_{in}}{R_i} + \frac{V_o}{R_f}$$

$$V_o = A(V_+ - V_-) \quad (R_f + R_i) V_- = R_f V_{in} + R_i V_o$$

$$V_+ = 0$$

$$V_o = A \left(0 - \frac{R_f}{R_f + R_i} V_{in} - \frac{R_i}{R_f + R_i} V_o \right)$$

Feedback

$$V_o \left(1 + A \frac{R_i}{R_f + R_i} \right) = -A \frac{R_f}{R_f + R_i} V_{in}$$

$$V_o = \frac{-A \frac{R_f}{R_f + R_i}}{1 + A \frac{R_i}{R_f + R_i}} V_{in}$$

CONTROL SYSTEMS

