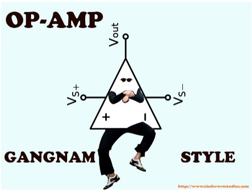
ECE 210 (AL2) - ECE 211 (E)

Chapter 3

Circuits for Signal Processing



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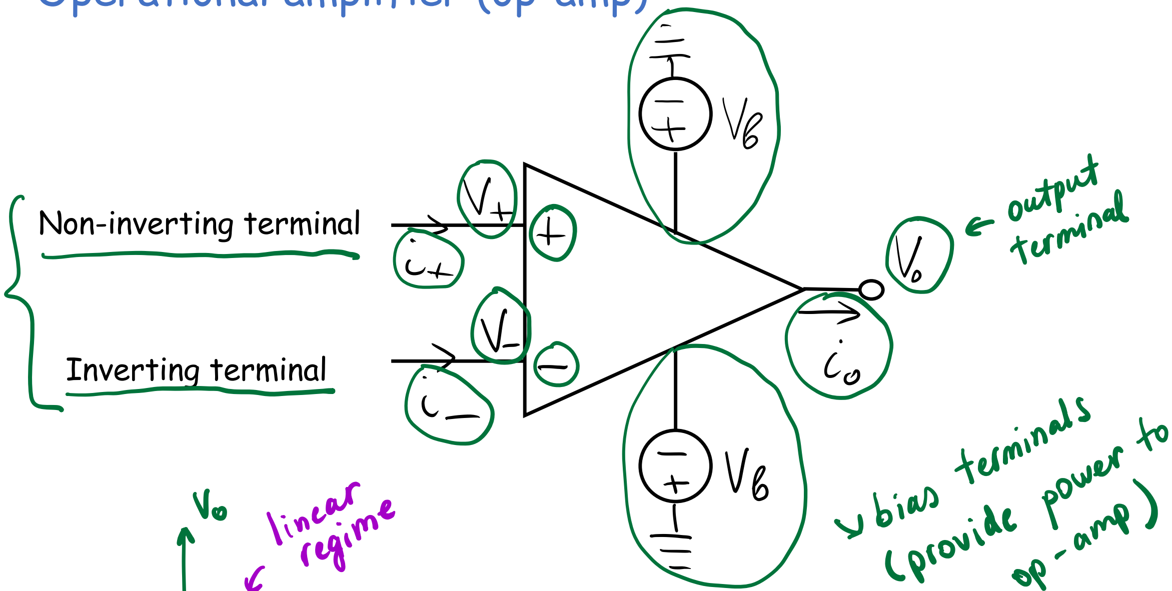
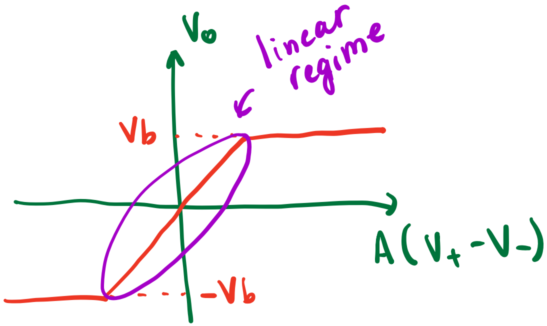
Chapter objectives

- Apply ideal op-amp approximation to do signal processing
- Understand zero-input and zero-state responses
- Understand what is linearity and how to test if a system is linear
- Understand what is time-invariance and how to test if system is TI
- Analyze first order RC and RL circuits with constant inputs:
    - How to obtain particular and homogeneous solutions
    - How to obtain zero-state and zero-input solutions
    - How to obtain transient and steady-state solutions
    - Understand the effect of the time-constant in the solution
- Analyze first order RC, RL circuits with time-varying inputs
    - How to obtain particular and homogeneous solutions
    - How to obtain zero-state and zero-input solutions
    - How to obtain transient and steady-state solutions
- Be familiar with n-th order LTI systems

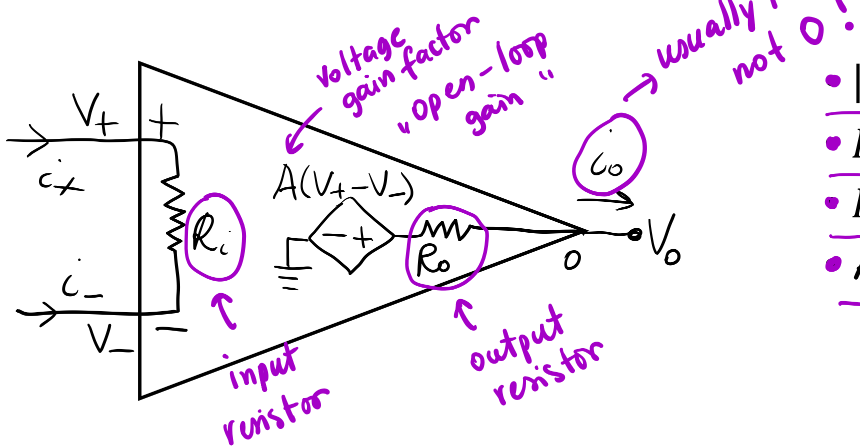
- Circuits for signal processing
    - Addition
    - Subtraction
    - Amplification
    - Differentiation
    - Integration
    - Etc.

- Operational amplifier (op-amp)





- Op-amp in the linear regime



- $|V_+ - V_-| \ll (< 10\mu V)$
- $R_i \gg (> 10^6 \Omega)$
- $R_o \ll (< 10\ \Omega)$
- $A \gg (> 10^6)$

ideal op-amp approximation:

$\boxed{\begin{array}{l} i_+ = i_- = 0 \\ V_+ = V_- \end{array}}$

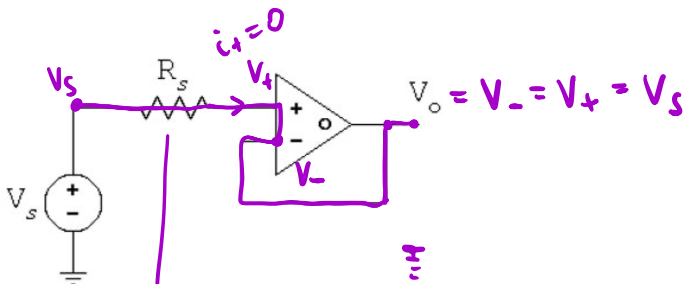
→ within pA 10^{-12}

→ within μV

- Example #1: voltage follower
  - Obtain Vo in the following circuit assuming the ideal op-amp approximation

$V_+ = V_-$

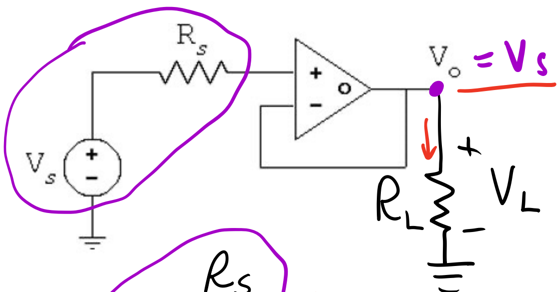
$i_+ = i_- = 0$



no voltage drop because $i_+ = 0$

- Example #1-cont: voltage follower
  - If Vo = Vs, why use the op-amp?

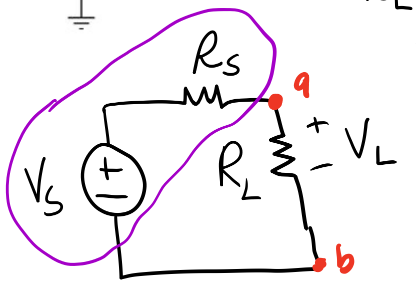
Consider attaching a load:



$$P_L = \frac{V_L^2}{R_L} = \frac{V_S^2}{R_L}$$

← full voltage from the source accross the load

↓ op-amp acts as a buffer between a source and a load



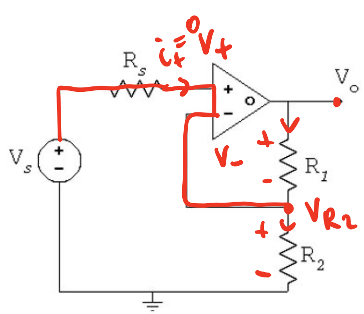
↑ less power :(

$$P_L = \frac{V_L^2}{R_L} = \frac{1}{R_L}\cdot\left(V_S\frac{R_L}{R_L+R_S}\right)^2 =$$

$$= \frac{V_S^2}{R_L}\underbrace{\left(\frac{R_L^2}{(R_L+R_S)^2}\right)}_{<1}$$

- Example #2: non-inverting amplifier
  - Obtain Vo in the following circuit assuming the ideal op-amp approximation

$$\boxed{\begin{gathered} V_+ = V_- \\ i_+ = i_- = 0 \end{gathered}}$$



$V_o = V_{R_1} + V_{R_2} = V_{R_1} + V_s$

$V_{R_2} = V_- = V_+ = V_s$