Administrivia

- Op-amps handout is the same as the theory handout for lab
- Note about lab #4:
  - Bring a check made out to UC Regents. $240/group. Post date to August 15th 2003. DO NOT FORGET THE CHECK!
  - To receive your calbot kit, please bring the check!
- How is HW #2 going?

Last Time...

- Thevenin's Theorem
- **Do you have questions on Thevenin's theorem?**

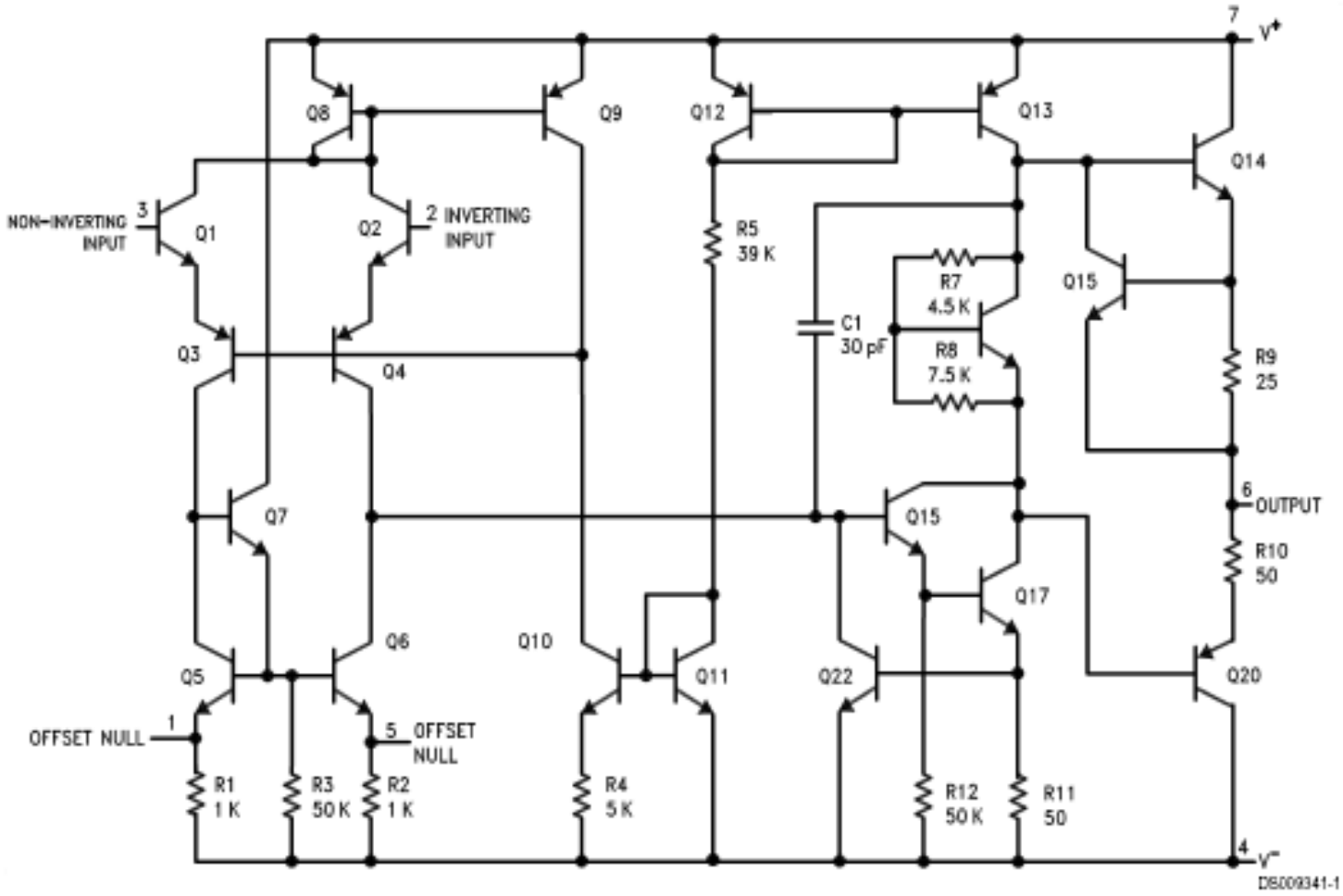
This Time...

- The Operational Amplifier
  - General Amplifier Model
  - The Op Amp model
  - Amplifier circuits
    - Voltage follower
    - Non inverting Amplifier
    - Inverting Amplifier
    - Integrator
  - Introduction to frequency response
  - Practical applications of op-amp

The Operational Amplifier

- Op-amp for short.
- A device that amplifies as well as perform other functions like integration, differentiation and evaluating the logarithm.
- We are going to be using the “ideal circuit model”. Op-amp is very complicated (take EECS 140 @ UC Berkeley):

Schematic Diagram



- Source: http://www.national.com/ds/LM/LM741.pdf

General Amplifier Model

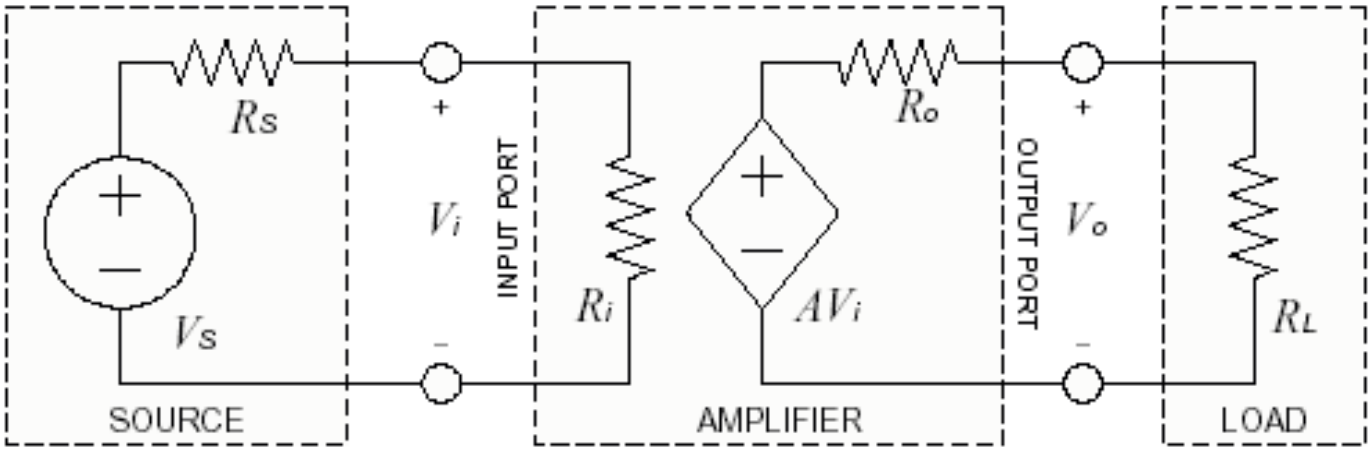


Figure 1: Circuit model of an amplifier circuit.

The Op Amp

- Symbol and notations (don't forget the power supply)
- Non-ideal vs ideal:

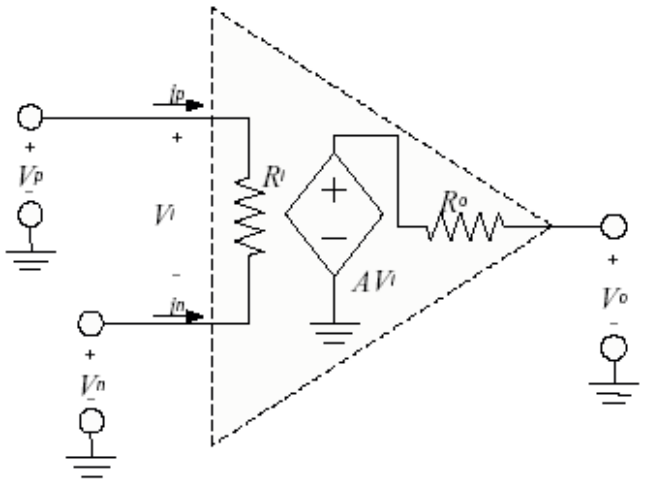


Figure 2: Standard op-amp

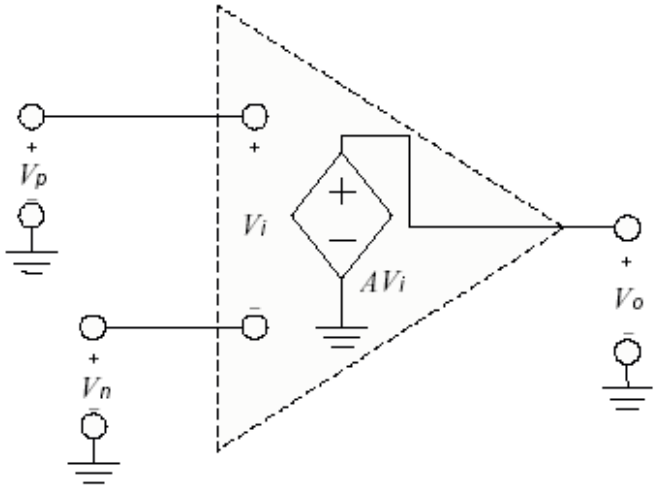


Figure 3: Ideal op-amp

Ideal Op Amp Assumptions

- Remember these ideal op-amp assumptions:

Gain is infinite: $A \rightarrow \infty$

Input resistance is infinite: $R_i \rightarrow \infty$

Output resistance is zero: $R_o = 0$

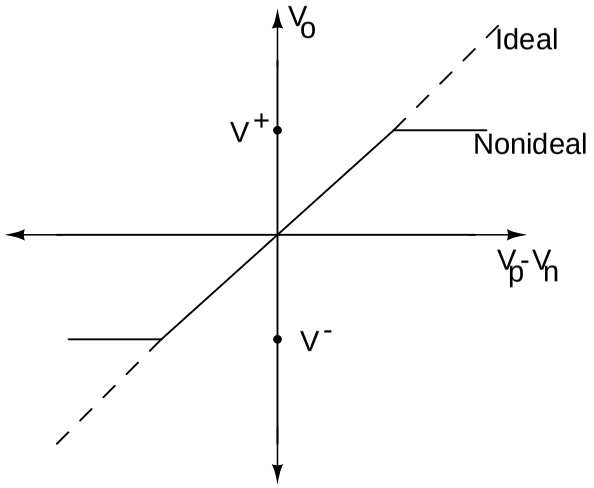
- Practically important:

$$i_n = i_p$$

$$V_p = V_n$$

Voltage Transfer Characteristic

- Voltage Transfer Characteristic (VTC) is a plot of V_{out} vs. V_{in}
- Ideal versus non-ideal op-amp VTC:



Graph 1. Op-amp voltage transfer characteristic

- Now we look at op-amp circuits.

Voltage Follower

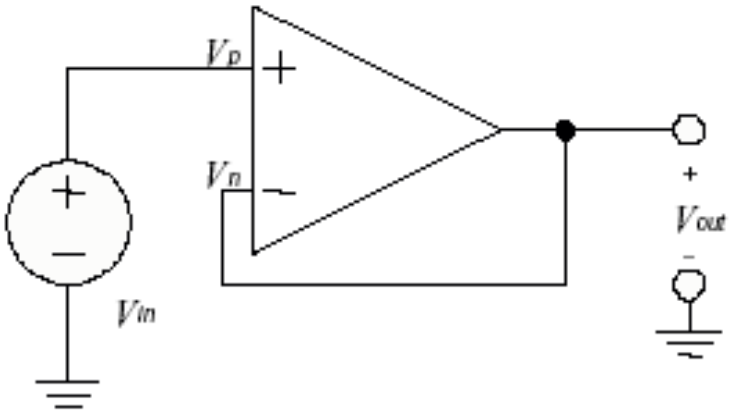


Figure 5a: Voltage follower

Non inverting Amplifier

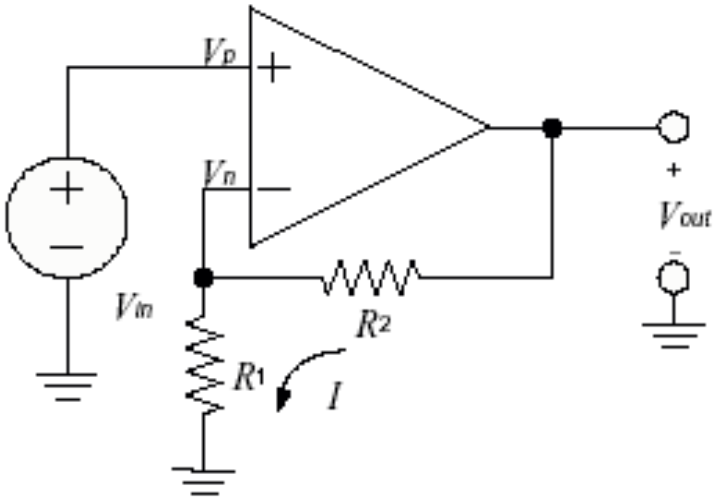


Figure 4a: Non-inverting amplifier

Inverting Amplifier

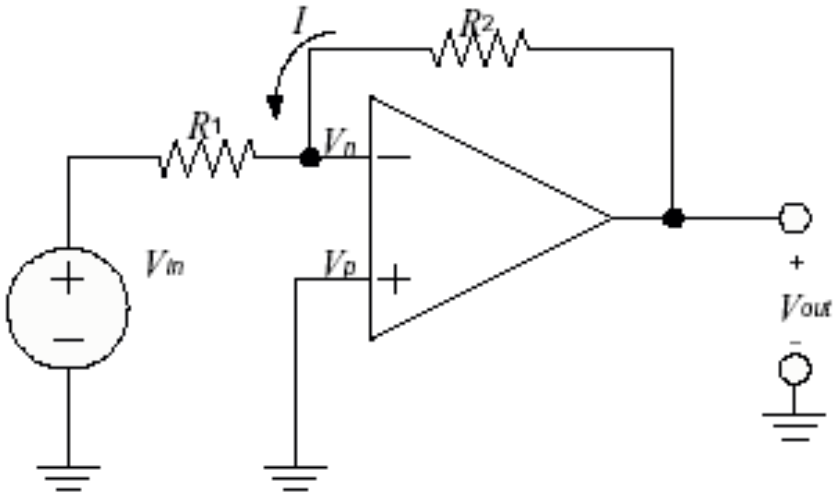


Figure 6a: Inverting amplifier

Integrator

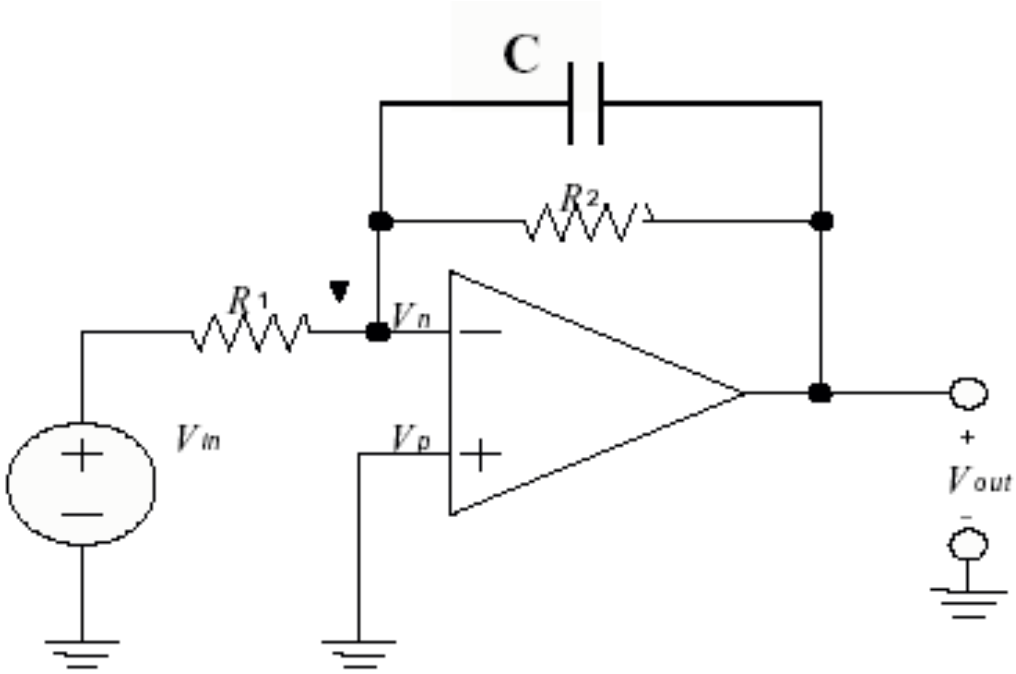
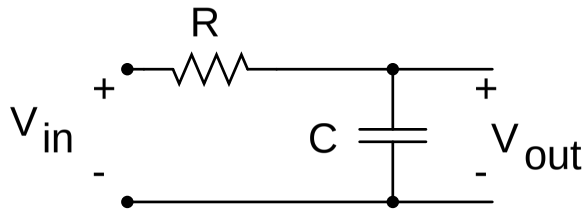


Figure 8: Integrator

Intro. to Frequency Response

- Out of the scope of this class. Just give a hand-wavy intro using a low pass filter:



Op-Amp Practical Applications

- My EECS 192 race car:
  - Op-amp used to amplify magnetic signals from track

Summary

- Another tool added to our toolbox: the op-amp
  - REMEMBER THE IDEAL OP-AMP ASSUMPTIONS!
  - Some typical op-amp configurations: voltage buffer, inverting amplifier, non-inverting amplifier and the integrator
  - Practice them circuits!

In Conclusion...

- Next time: Official end of circuit analysis - Source transformations
- Introduction to IC fabrication - prelude to guest lecture
- Reading: Finish chapter 4 of the reader - source transforms and maximum power transfer theorem.
- Lab 3 should help you understand op-amps better
- REMEMBER CHECK FOR CALBOT KIT!
- I will talk a little bit about the calbot project...
- Questions?