# ECE 214 – Electrical Circuits Lab
# Lecture 4

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# Announcements

- Finally, no snow.
- Be sure to get your pre-lab and labs checked off.

# Microcap

- I know it's a pain. We'll work through it.
- Building a circuit seems to be going OK.
- Setting up the signals is the problem.
- Mostly a problem with limits. It likes to reset them for reasons I don't really understand.

# Matlab/Octave

- Updated the Lab with the graphing instructions. Was missing a few quotes that were needed for Octave.

- The supercomputer directions probably don't work anymore, haven't had time to track that down.

# Notes from Previous Labs

- Explain Function Generator / Oscilloscope mismatch
- 50 Ohm input resistance, 50 Ohm output resistance. So Vout is twice as high to account for the voltage divider
- When measured with a 1M scope, the voltage divider is $V_{out} = \frac{1M}{1M+50\Omega}$ which is roughly 1.
- So the result you get for high impedance loads is twice what you'd get if you were driving a 50 Ohm load.

# Lab #4 – OpAmps

- OpAmps – What are the good for?
- Analog Computers

# PreLab

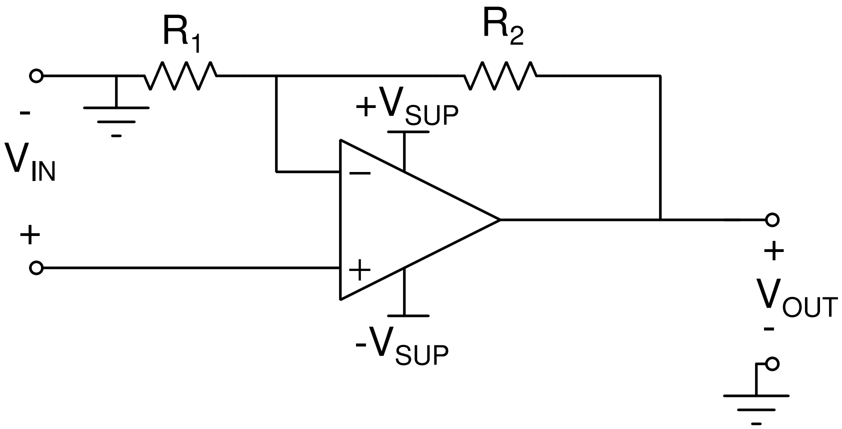
- You can watch the somewhat long Australian Oscilloscope video

- Talks briefly about triggering at 17:50 but otherwise you should know most of what's covered already.

# Operational Amplifiers (OpAmps)

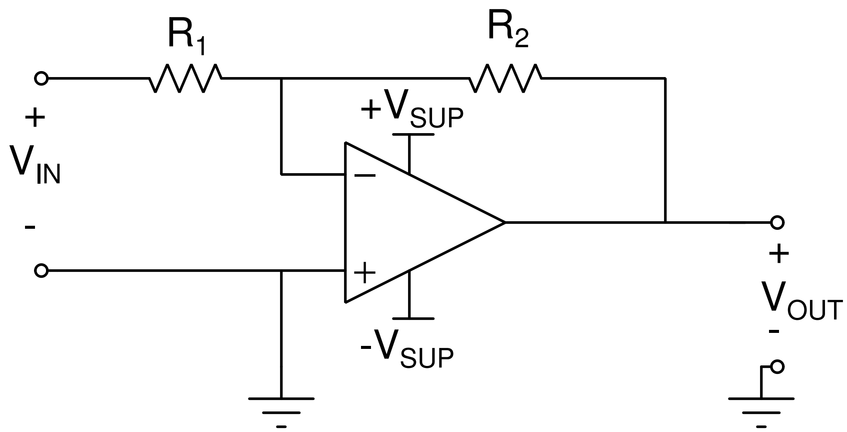
- Voltage-controlled voltage source
- Ideally infinite amplification, infinite input resistance, zero output resistance
- “Inverting” terminal marked with -
- “Non-inverting” terminal marked with $+$
- $v_o = A(v_2 - v_1)$

# Non-Inverting OpAmps



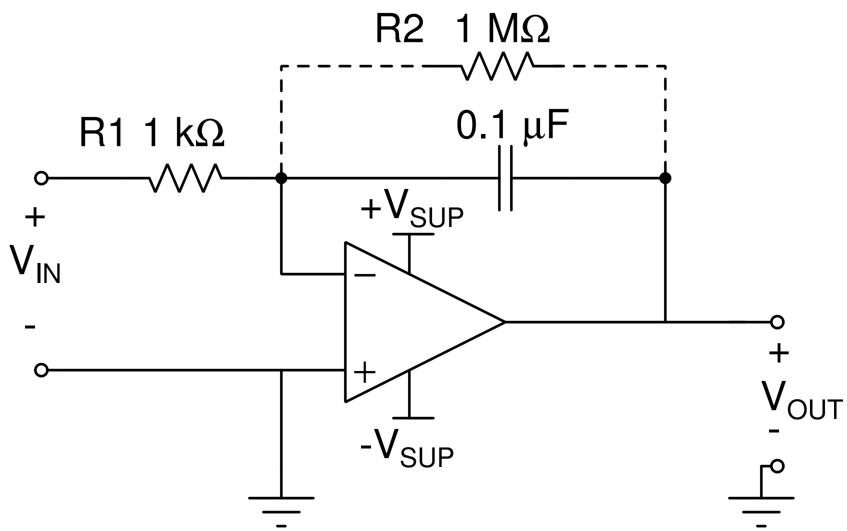

- Feedback. $i = \frac{v_o - v_1}{R_2}$
- Since $R_{in}$ is infinite, $i = \frac{v_1}{R_1}$, $v_2 = V_{IN}$
- Substitute; $v_o(t) = (1 + \frac{R_2}{R_1})V_{IN}$; $A = 1 + \frac{R_2}{R_1}$

# Inverting OpAmps




- Feedback. $i = \frac{v_1 - v_o}{R_2}$
- Since $R_{in}$ is infinite, $i = \frac{V_{IN} - v_1}{R_1}$, $v_2 = 0$
- Substitute; $v_o(t) = -\frac{R_2}{R_1})V_{IN}$; $A = -\frac{R_2}{R_1}$

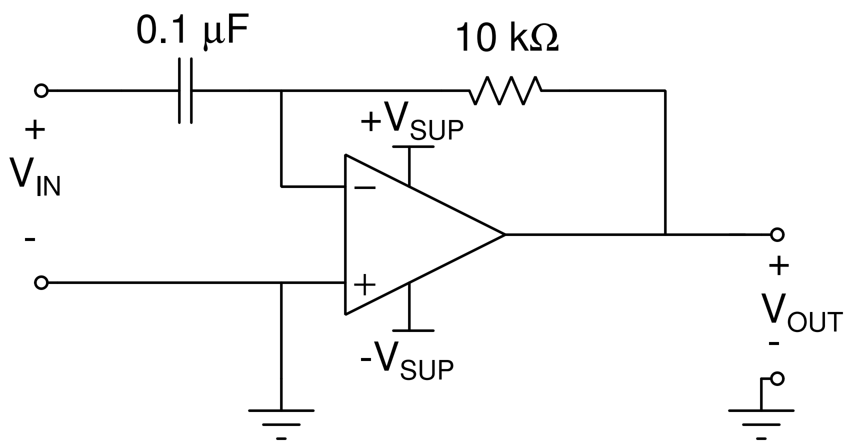
# Inverting Integrating OpAmps




- $v_o(t) = -\frac{1}{RC}\int_0^t v_s(\tau)d\tau + V_o$
- DC Gain $= -\frac{R_2}{R_1}$, AC Gain $= -\frac{R_2}{R_1} \times \frac{1}{1+2\pi f C R_2}$
- Actually operates a bit like a low pass filter, with the

low pole at $\frac{1}{2\pi R_2 C}$ and one at $\frac{1}{2\pi R_1 C}$.

# Inverting Differentiating OpAmps




- $V_{OUT}(t) = -CR\frac{dV_{IN}(t)}{dt}$
- Gain $=$ -$RX_C = -Rj2\pi fC$

# Integral/Differentiating

- Practical use of calculus!
- Input a Sine wave get a Cosine
- Square wave ?
- Sawtooth wave ?
- etc.

# Negative Feedback

- Why is positive feedback bad?

# Phase shift

- Calculate it as you did previous labs
- Will it always be ideal?

# Advanced Oscilloscope

- This may be necessary to find the Integrator results, as the constant added might push the signal off the screen.

# Oscilloscope – Coupling

- AC Coupling: Filters out the DC part of the signal (using a capacitor or similar)
- DC Coupling: Shows all of a signal
- You can select for an input by pressing the 1 or 2 button on the scope.

# Oscilloscope – Triggering

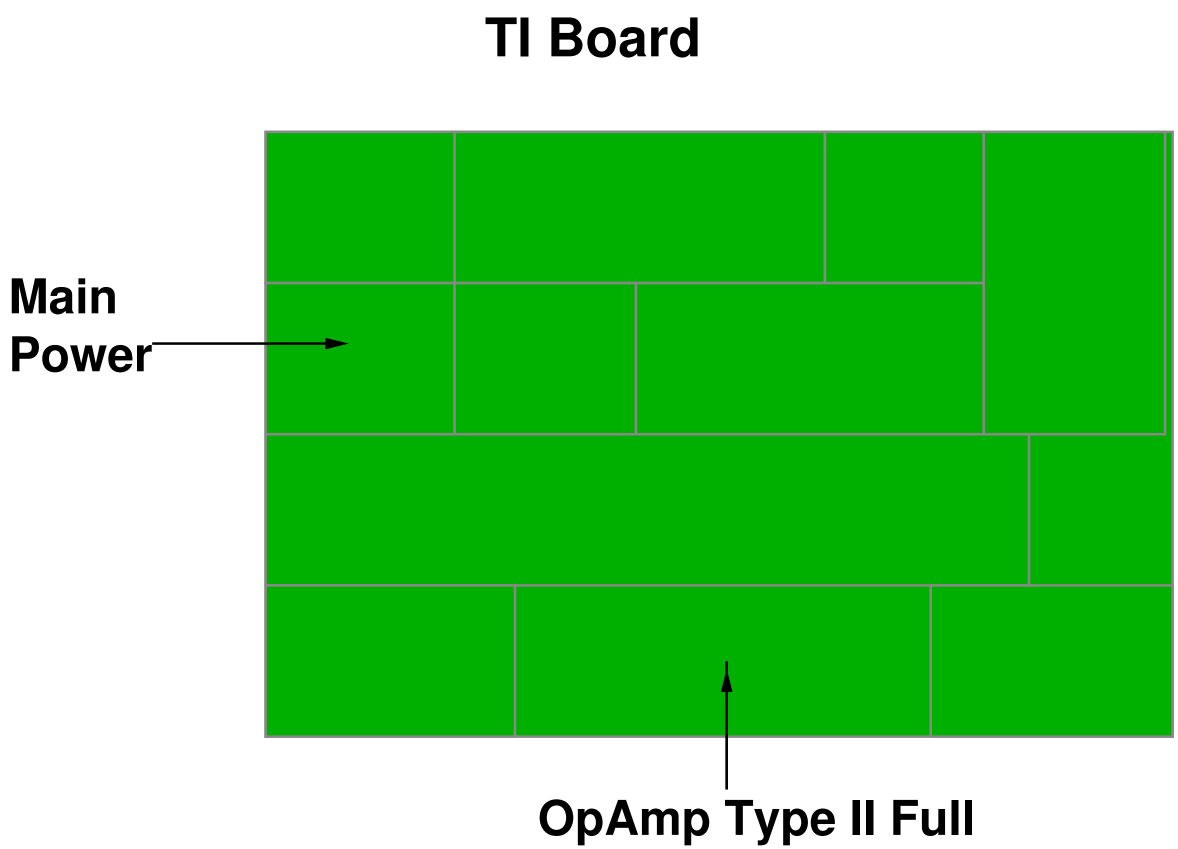
- Triggers on a certain setting of the trace, letting you you get a stable signal on the screen (rather than say a free-running sine wave) or grab a single-shot output
- Trigger Level – what value the voltage has to hit before it starts displaying the trace
- Trigger Slope – Trigger on positive or negative slope
- Internal – Trigger on the signal you are viewing

- External – Trigger on an external signal.

# Oscilloscope – Measuring Phase

- Lissajous
- Measuring $\Delta t$ of where signals cross x-axis, multiply by 360 and frequency.
- Some of the scopes can calculate for you (time button, then next menu, next menu, next menu)

# TI Boards




- Be careful! Follow directions! Easy to let out magic

## smoke

- Remember OpAmps have positive and negative supply. Negative supply is not the same as ground (unless you are building specific single-supply circuits, which we are not).

# Connecting Power

- Turn all power supply values to 0 first.
- Hook up +20 output to +10 on Main Power on TI board.
- Hook up ground to ground
- Hook up -20 output to -10 on Main Power
- Gradually turn dial to raise power to 10V on supply

- Be sure not smoking
- Verify expected power rails with DVM
- There are traces on the TI board connecting the Main power to all of the circuits

# Building the Circuits