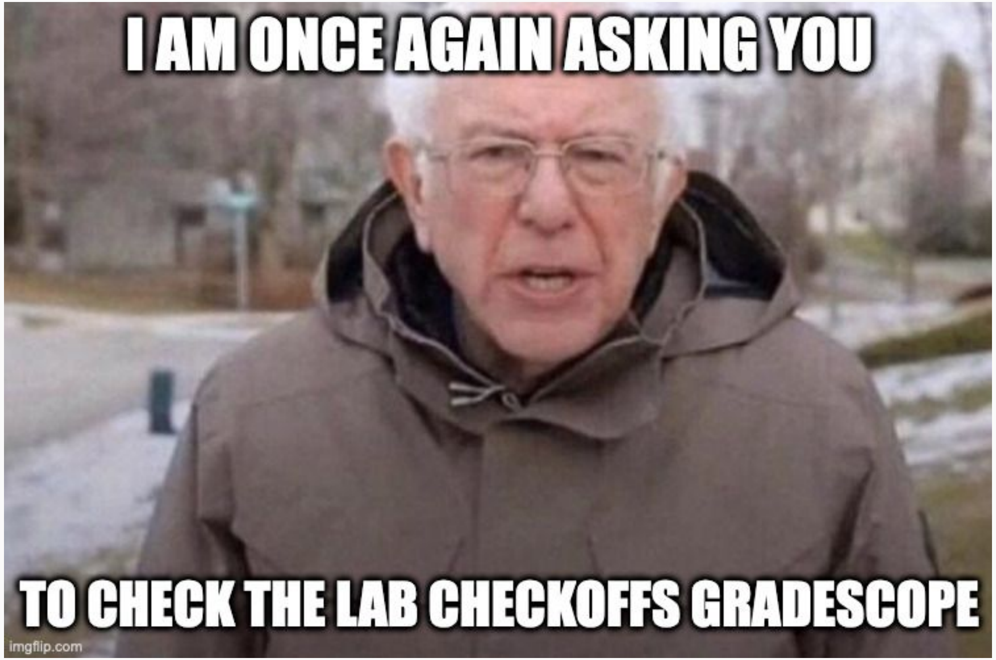
Lab 4: Sensing Part 1

EECS 16B Fall 2023

Slides: http://links.eecs16b.org/lab4-slides

Administrivia

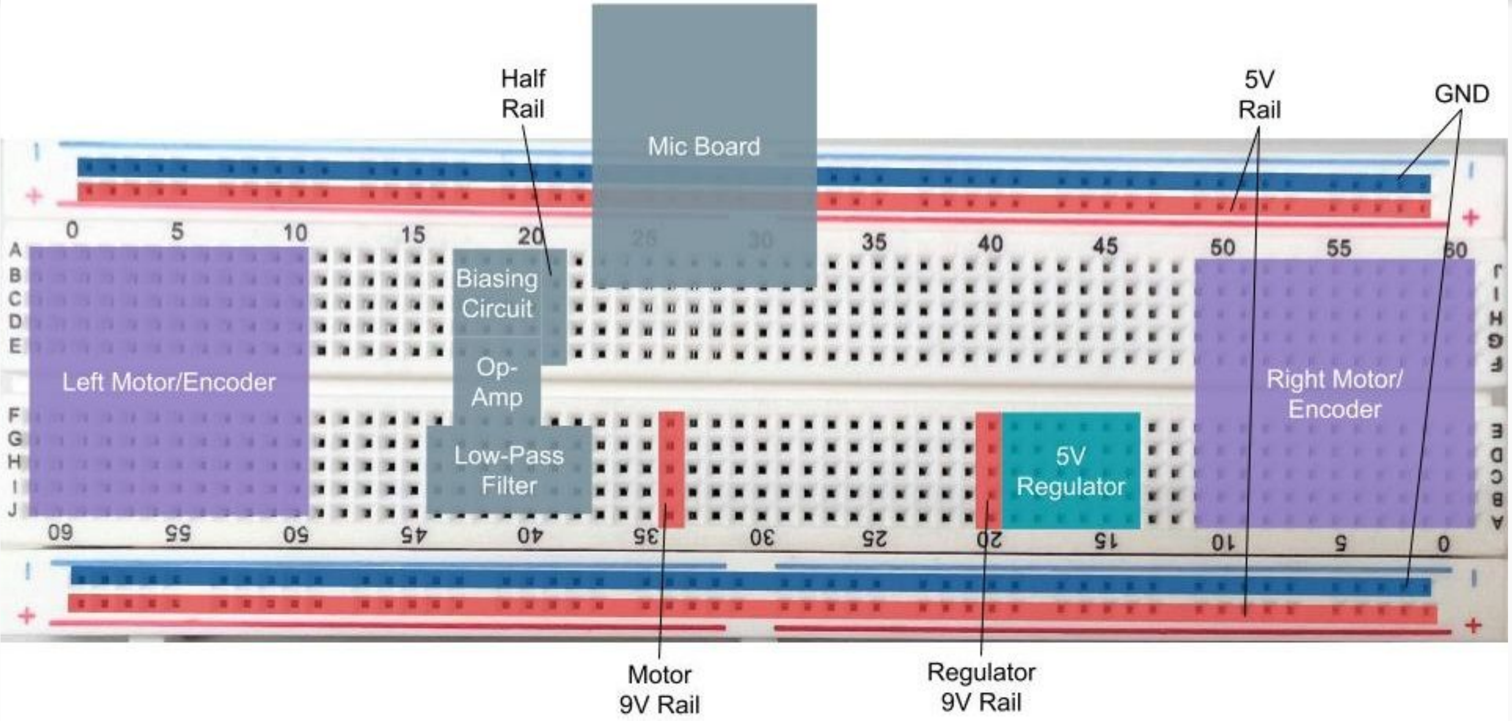
- What’s that



Lab 4 Overview

- Build and test mic board circuitry
  - Build biasing circuit
  - Tune mic board
  - Measure the frequency response of the speaker-microphone system
  - Build Low Pass Filter

BREADBOARD LAYOUT



A Powerful Note

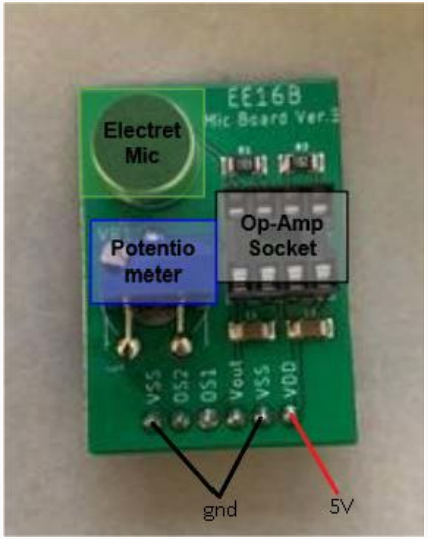
- Do NOT power the 5V rail from the 5V output from the power supply
- Instead, use the 9V input rail to power the 9V → 5V regulator which will power everything related to 5V off the rails
- Ensure your power rails are still 5V before starting

Mic Board Circuitry

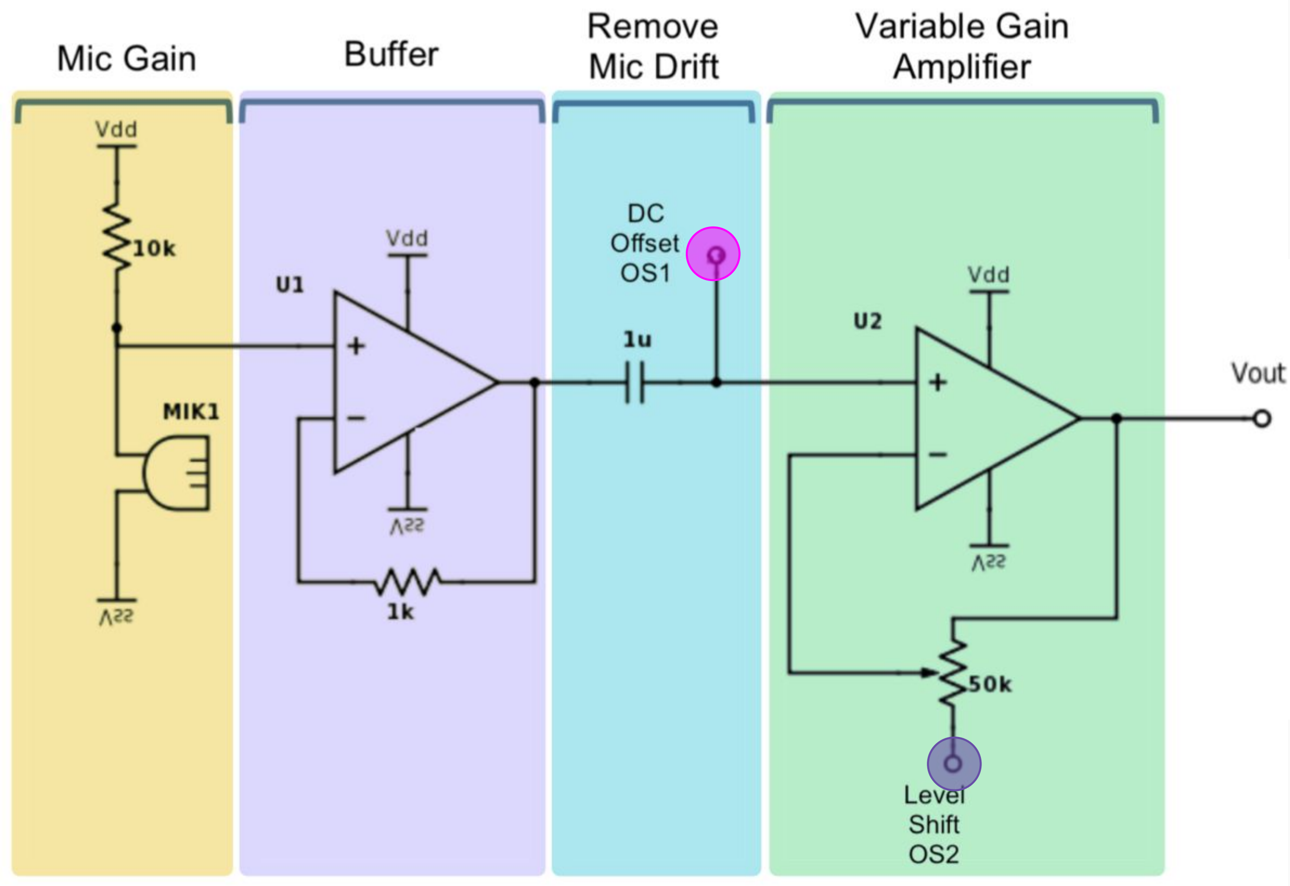
An annoyingly loud journey

What's a Mic Board?

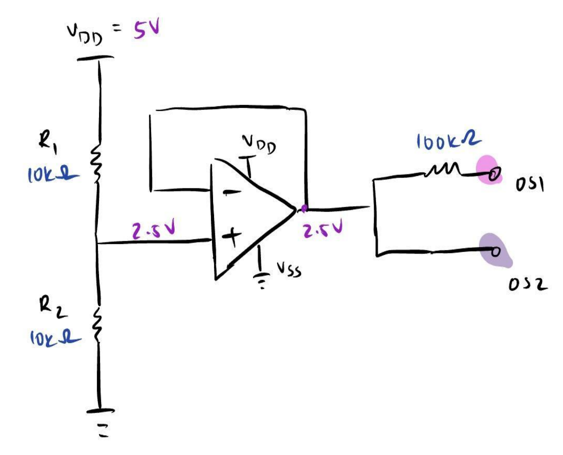
Mic board circuits pick up voice and sound signals and then convert them into electrical signals, which are amplified.



Mic Board Schematic



We're building this!



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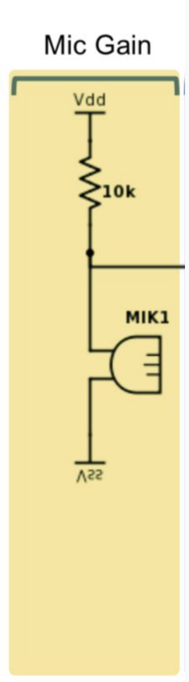
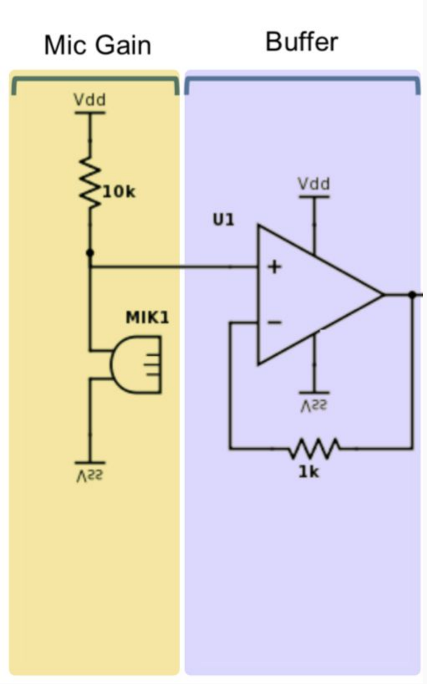


1. Mic Gain

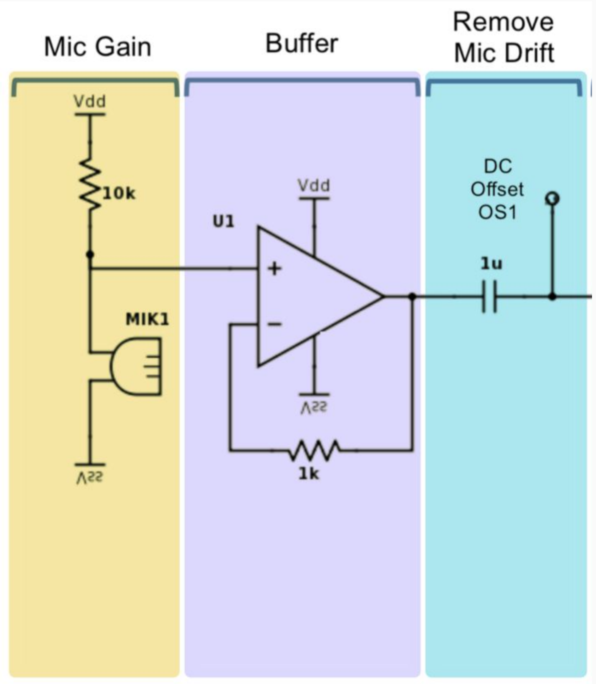
- Our mic is a variable current source, but we convert it to a voltage signal by placing it in series with a 10K resistor.

Mic Board Schematic



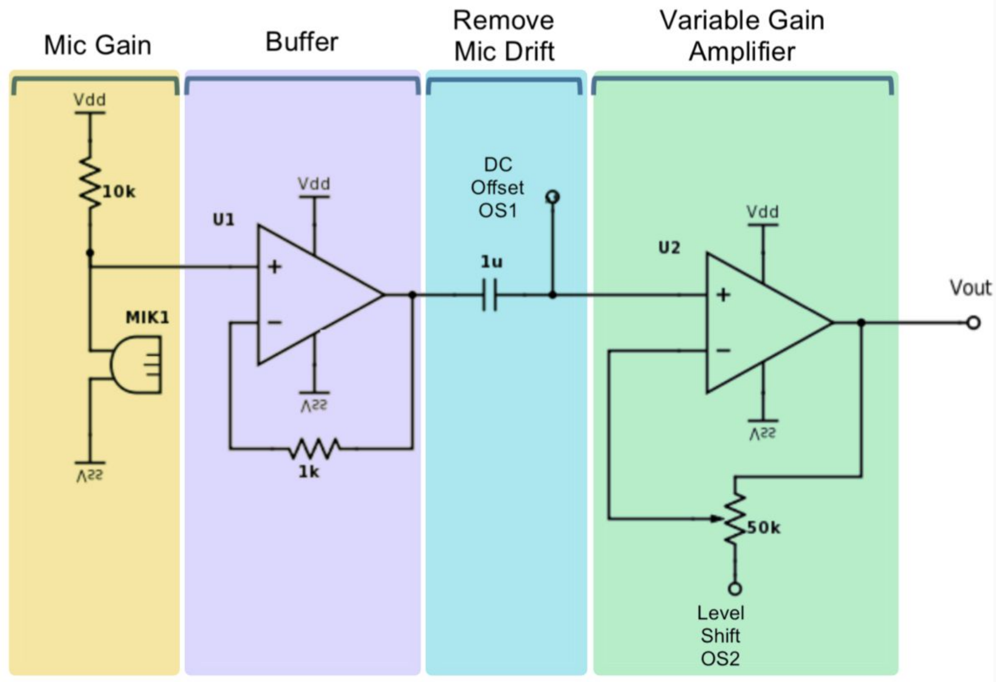
1. **Mic Gain**
   - Our mic is a variable current source, but we convert it to a voltage signal by placing it in series with a 10K resistor.
2. **Buffer**
   - This keeps the rest of the circuit from affecting our mic board signal

Mic Board Schematic



1. **Mic Gain**
    - Our mic is a variable current source, but we convert it to a voltage signal by placing it in series with a 10K resistor.
2. **Buffer**
    - This keeps the rest of the circuit from affecting our mic board signal
3. **Removing Mic Drift**
    - The 1μF capacitor is a *coupling capacitor*, meaning it serves as a short to AC voltage but blocks DC voltage. Used to remove unpredictable mic offset so we can add our own via OS1
    - **OS1** - centers signal at 2.5V. Connected through a 100kΩ resistor, since OS1's voltage isn't equal to our signal.

Mic Board Schematic



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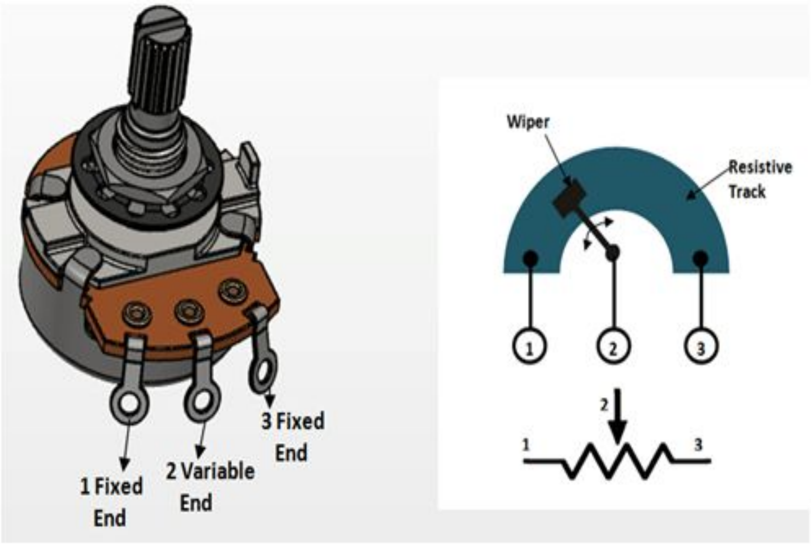
4. **Non-inverting amplifier**
   - Uses a potentiometer for variable gain
   - **OS2** - serves as a virtual ground so we don't amplify the 2.5V offset

Review: Potentiometers

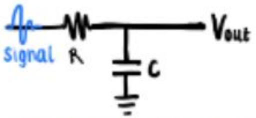
- Wiper divides resistive material, creating two resistors with variable length
- Resistance is proportional to length, so wiper changes the **resistance ratio**!
- Resistors form a **voltage divider**



Low Pass Filter Derivation

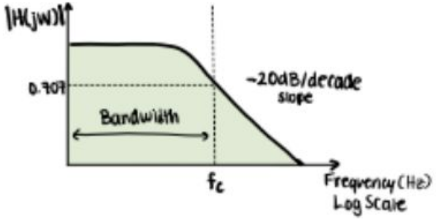
Lowpass Filter

Circuit Schematic



Think: the "gate" C is lower.

Low Pass Frequency Response



$$\hat{V}_{out} = \hat{V}_{in}\cdot\frac{Z_C}{Z_R+Z_C} = \hat{V}_{in}\frac{\frac{1}{jwC}}{R+\frac{1}{jwC}} = \hat{V}_{in}\frac{1}{jwRC+1}$$

$\frac{V_{out}}{V_{in}} = H(jw)$ and cutoff frequency is at half power, where $\frac{|\hat{V}_{out}|}{|\hat{V}_{in}|} = \frac{1}{\sqrt{2}} = 0.707$.

$$|H(jw)| = \frac{1}{\sqrt{2}} = \frac{\sqrt{1}}{\sqrt{(wRC)^2+(1)^2}} = \frac{1}{\sqrt{1+(wRC)^2}}$$

$$2 = 1+(wRC)^2$$

$$1 = wRC$$

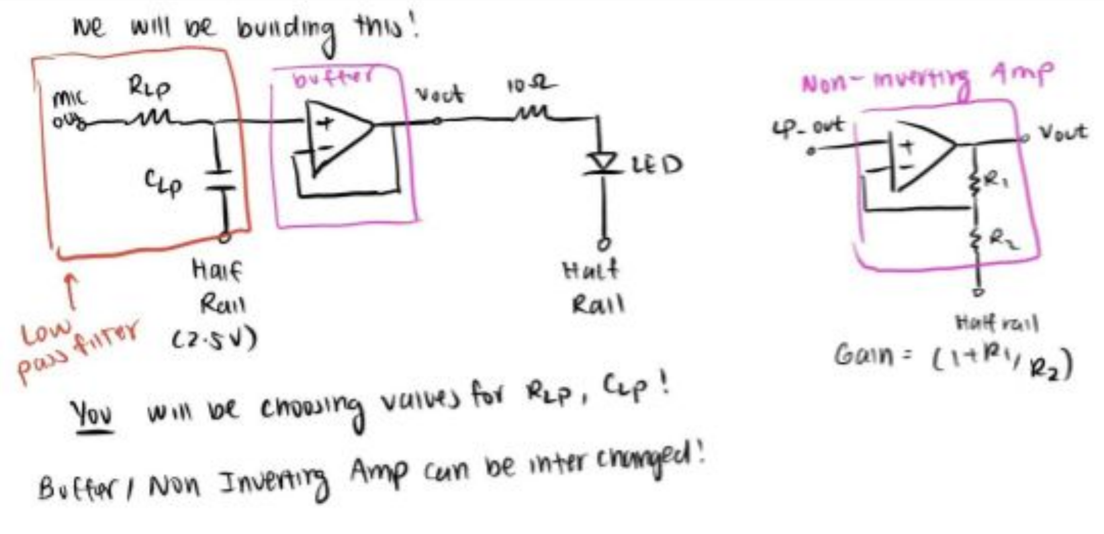
$w = \frac{1}{RC}$ angular cutoff frequency

$f_c = \frac{1}{2\pi RC}$ cutoff frequency

Conceptually: as $w \to \infty$, $|H(jw)| \to 0$
as $w \to 0$, $|H(jw)| \to 1$

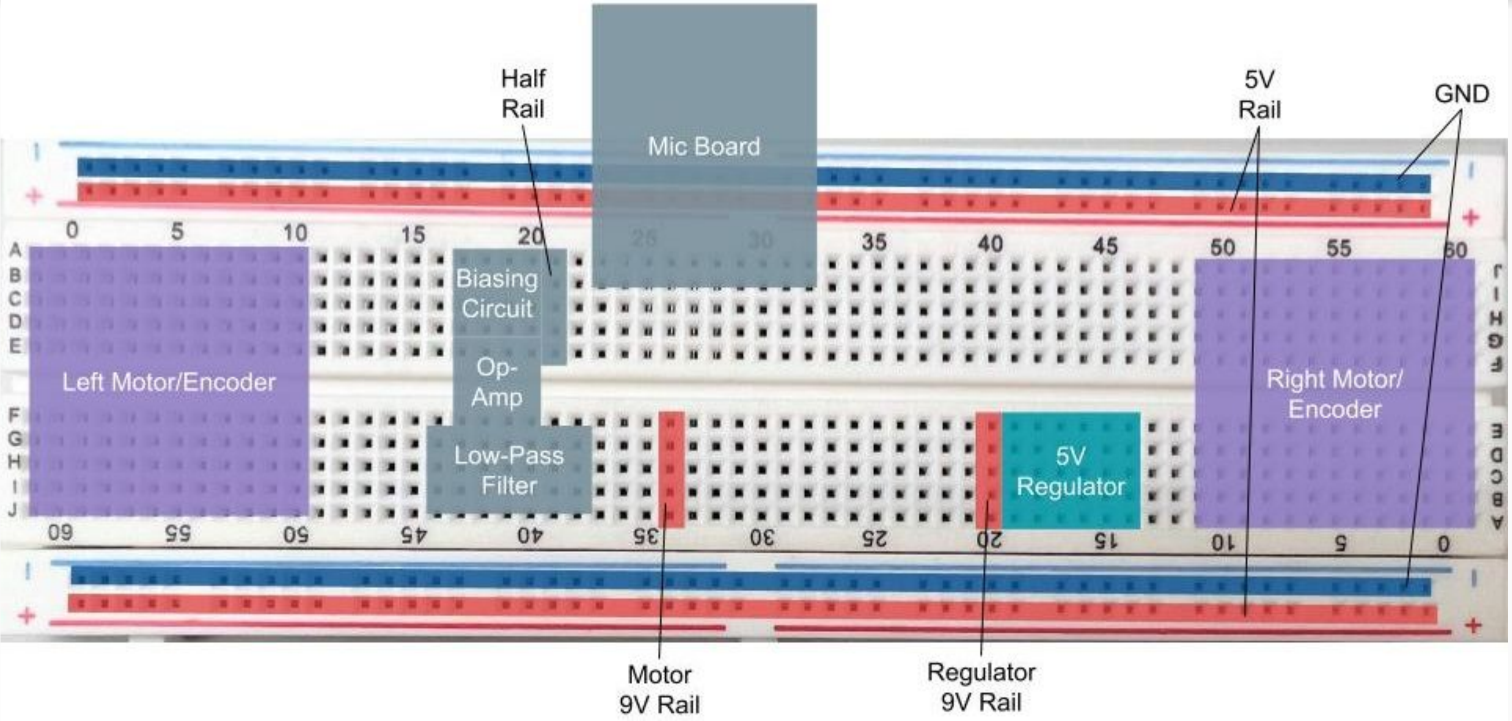
Everything that is less than f_c gets through. Note that our cutoff isn't clean & perfect because the attenuation is gradual.

Circuit Schematic



- We use a unity gain buffer in between the LPF and LED to prevent loading.
- If your LED is not lighting up, but based on the waveform generator your frequencies are attenuating properly, change the unity gain buffer into a **non-inverting amplifier.** You may use any reasonable gain of choice.

REMINDER: BREADBOARD LAYOUT



Important Forms/Links

- Help request form: https://eecs16b.org/lab-help
- Checkoff request form: https://eecs16b.org/lab-checkoff
- Extension Requests: https://eecs16b.org/extensions
- Makeup Lab: https://makeup.eecs16b.org
- Slides: http://links.eecs16b.org/lab4-slides-sp23
- Anon Feedback: https://eecs16b.org/lab-anon-feedback
- Checkoff Error: https://eecs16b.org/lab-checkoff-error