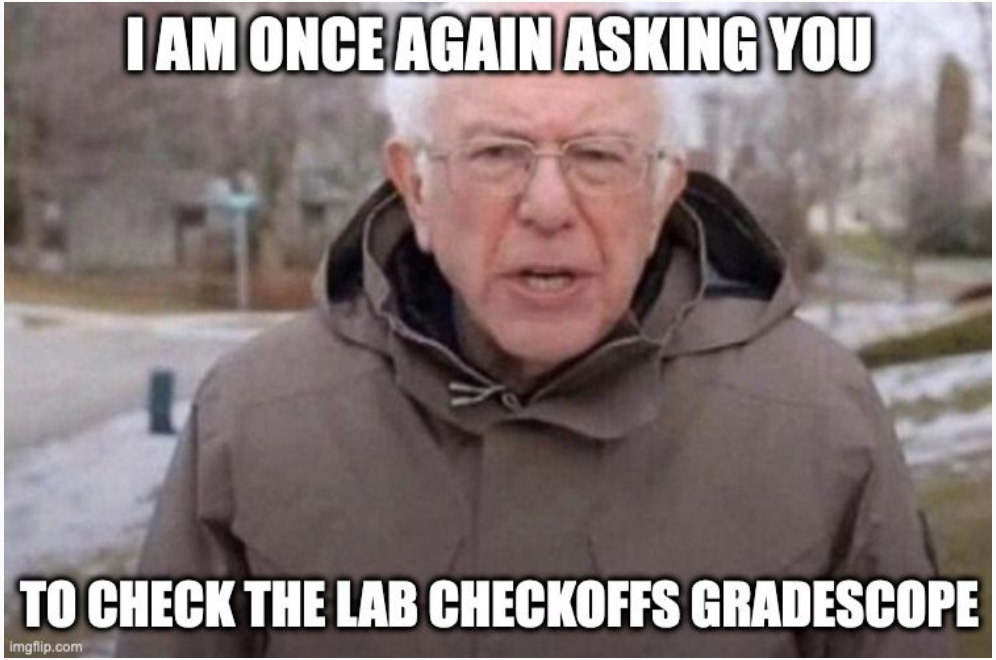
Lab 4: Sensing Part 1

EECS 16B Spring 2023

Slides: http://links.eecs16b.org/lab4-slides-sp23

Administrivia

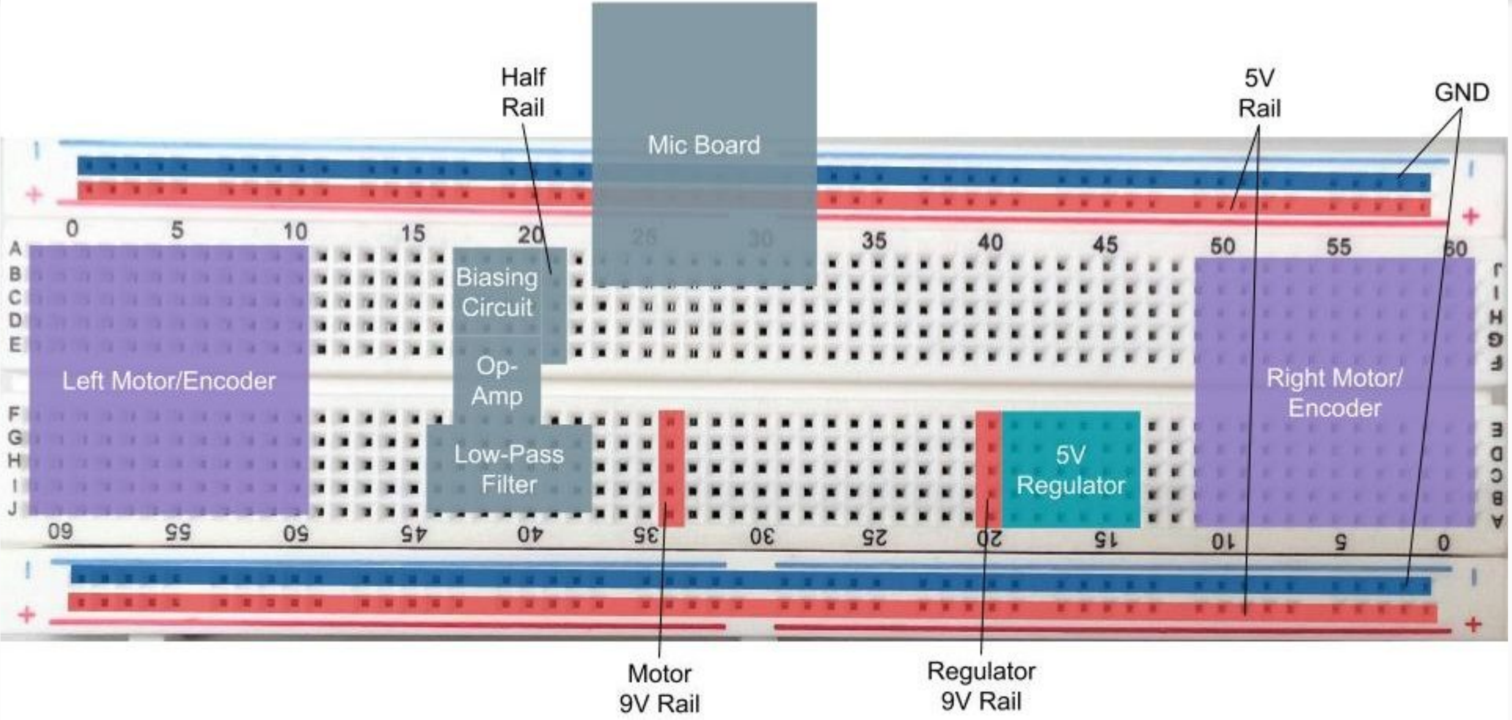
- What's that



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

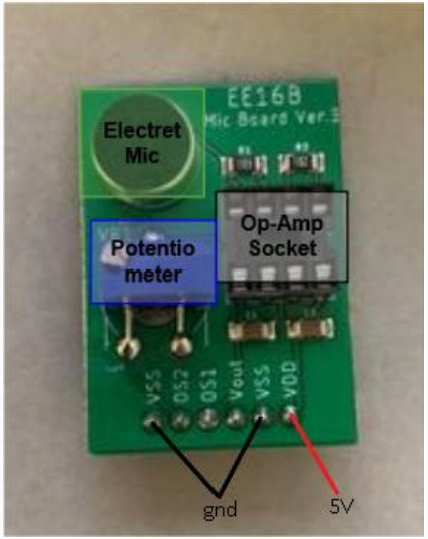
- Do NOT power the 5V rail from the 5V output from the power supply
- Instead, use the 9V input rail to power the 9V → 5V regulator which will power everything related to 5V off the rails
- Ensure your power rails are still 5V before starting

Mic Board Circuitry

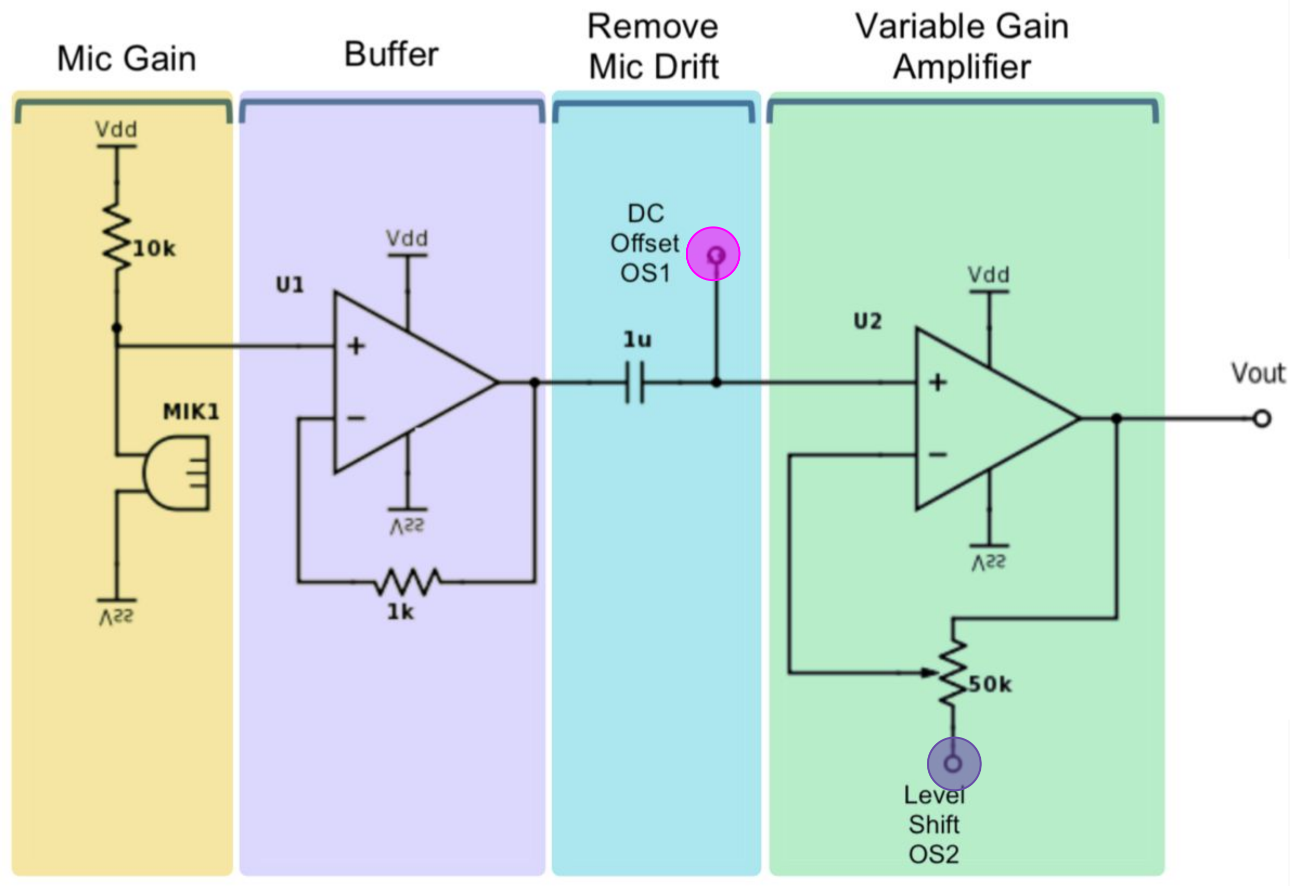
An annoyingly loud journey

What’s a Mic Board?

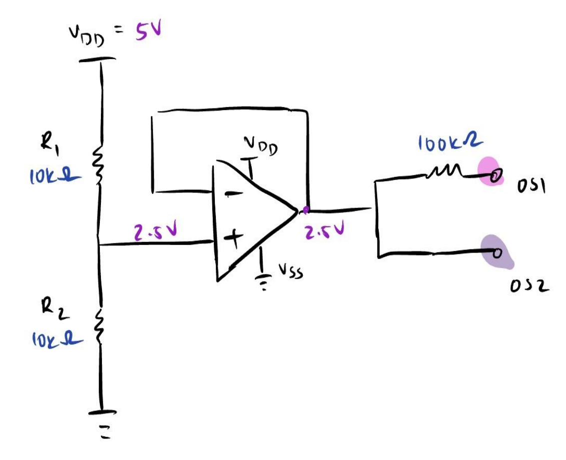
Mic board circuits pick up voice and sound signals and then convert them into electrical signals, which are amplified.



Mic Board Schematic

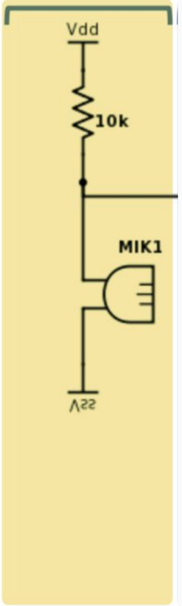


We're building this!



Mic Board Schematic

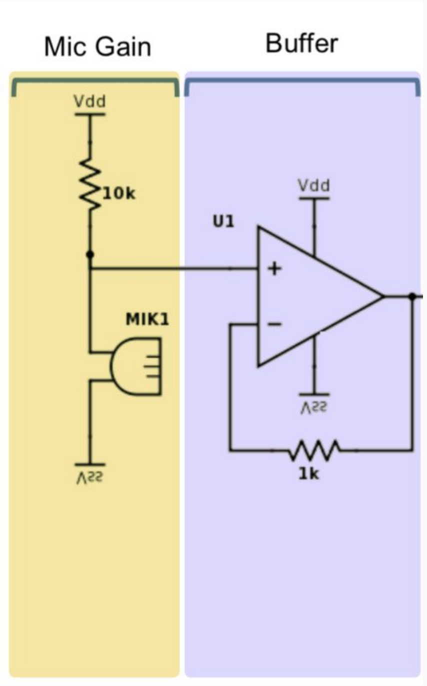
Mic Gain



1. Mic Gain

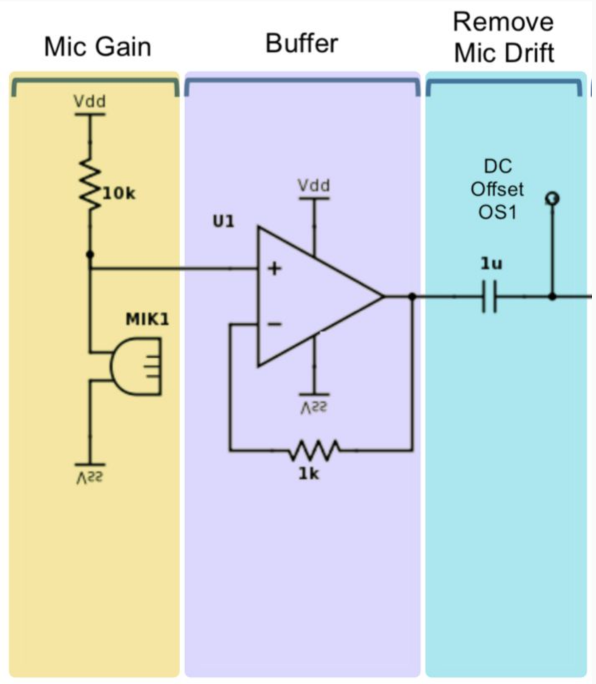
- Our mic is a variable current source, but we convert it to a voltage signal by placing it in series with a 10K resistor.

Mic Board Schematic



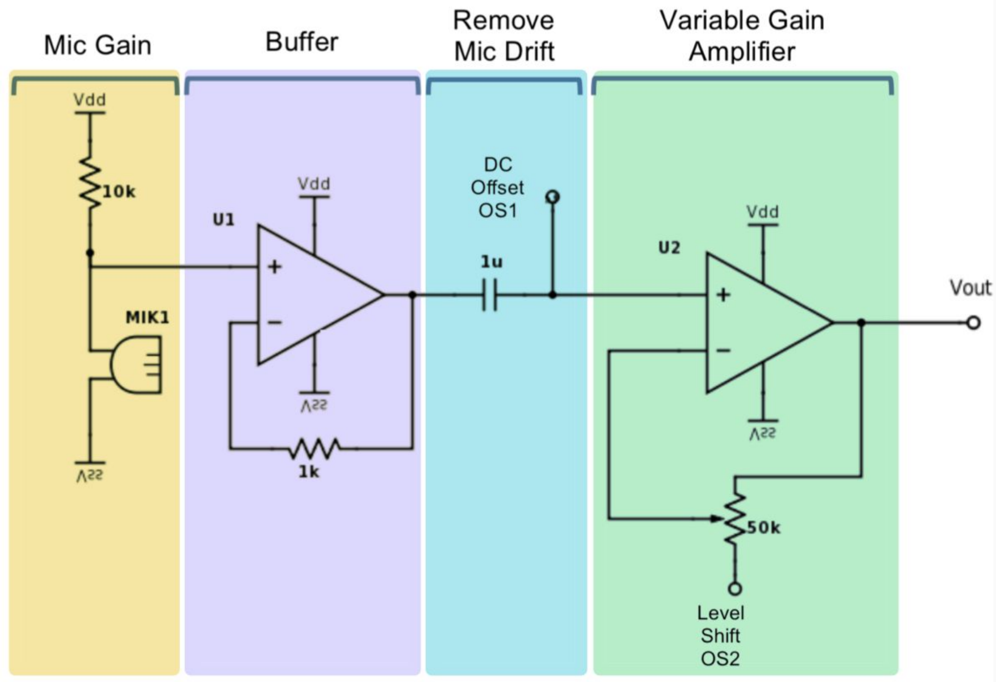
1. **Mic Gain**
   - Our mic is a variable current source, but we convert it to a voltage signal by placing it in series with a 10K resistor.
2. **Buffer**
   - This keeps the rest of the circuit from affecting our mic board signal

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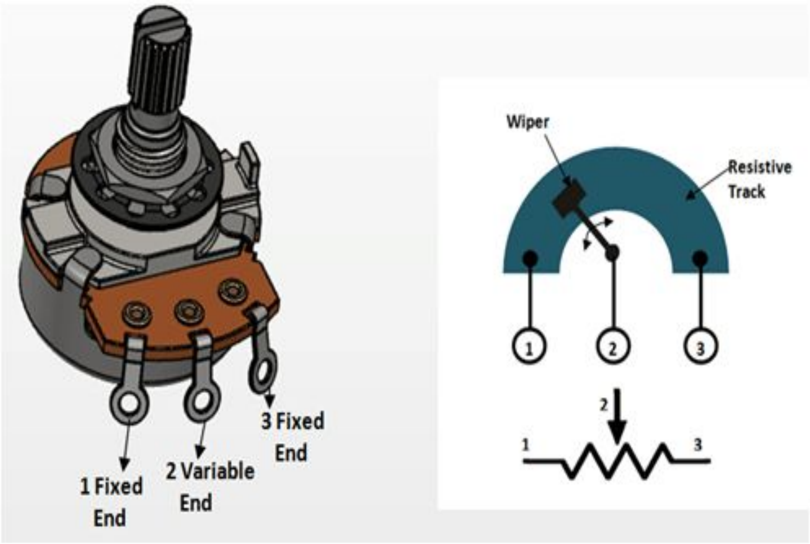
4. **Non-inverting amplifier**
   - Uses a potentiometer for variable gain
   - **OS2** - serves as a virtual ground so we don’t amplify the 2.5V offset

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**

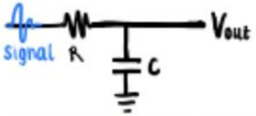


Low Pass Filter Derivation

Lowpass Filter

$$\hat{V}_{out} = \hat{V}_{in}\cdot\frac{Z_C}{Z_R+Z_C} = \hat{V}_{in}\frac{\frac{1}{j\omega C}}{R+\frac{1}{j\omega C}} = \hat{V}_{in}\frac{1}{j\omega RC+1}$$

Circuit Schematic



Think: the "gate" C is lower.

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

$$|H(j\omega)| = \frac{1}{\sqrt{2}} = \frac{\sqrt{1}}{\sqrt{(\omega RC)^2+(1)^2}} = \frac{1}{\sqrt{1+(\omega RC)^2}}$$

$$2 = 1+(\omega RC)^2$$

$$1 = \omega RC$$

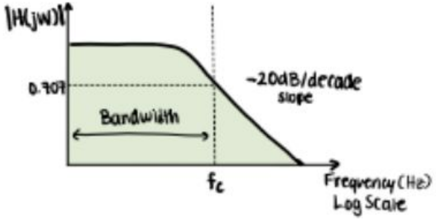
$\omega = \frac{1}{RC}$ angular cutoff frequency

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

Conceptually: as $\omega \to \infty$, $|H(j\omega)| \to 0$

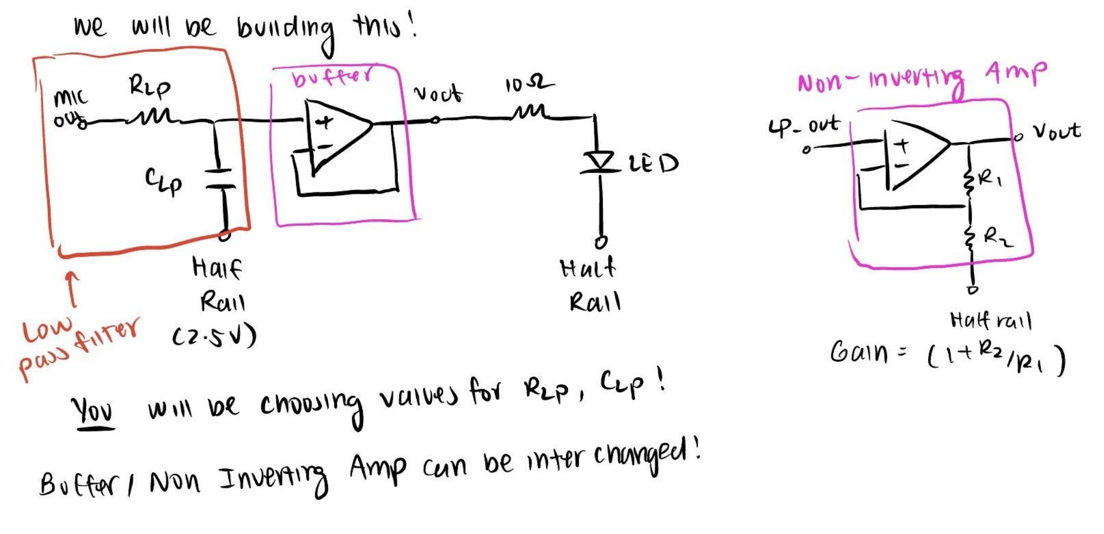
as $\omega \to 0$, $|H(j\omega)| \to 1$

Low Pass Frequency Response



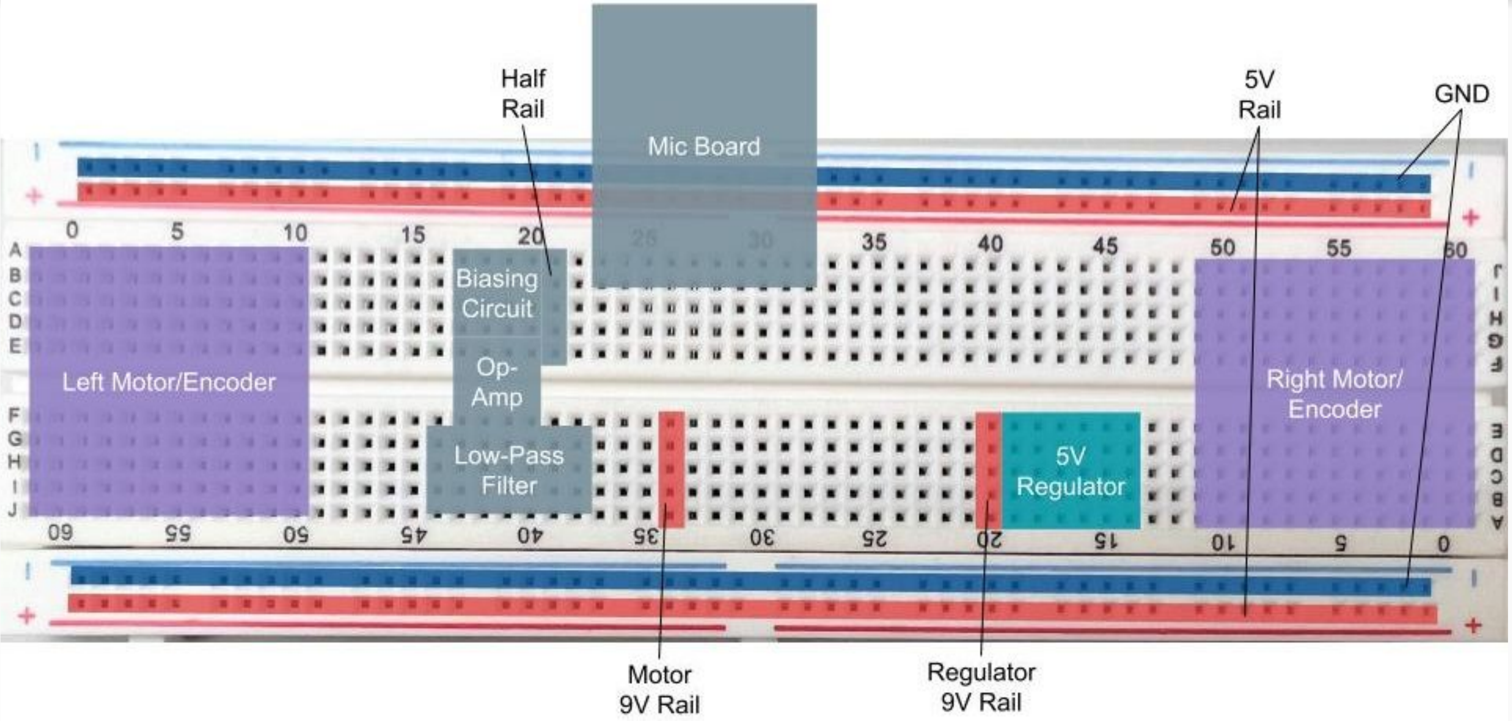
Everything that is less than f_c gets through. Note that our cutoff isn't clean & perfect because the attenuation is gradual.

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