REPORT

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Title: Electronics Lab Final Project: Speaker System

Abstract

The report will be about the process of me completing my speaker system electronics lab final project. It includes details and complete circuits of how the wired and wireless modes are implemented. Major problems encountered are also explained and addressed in this report.

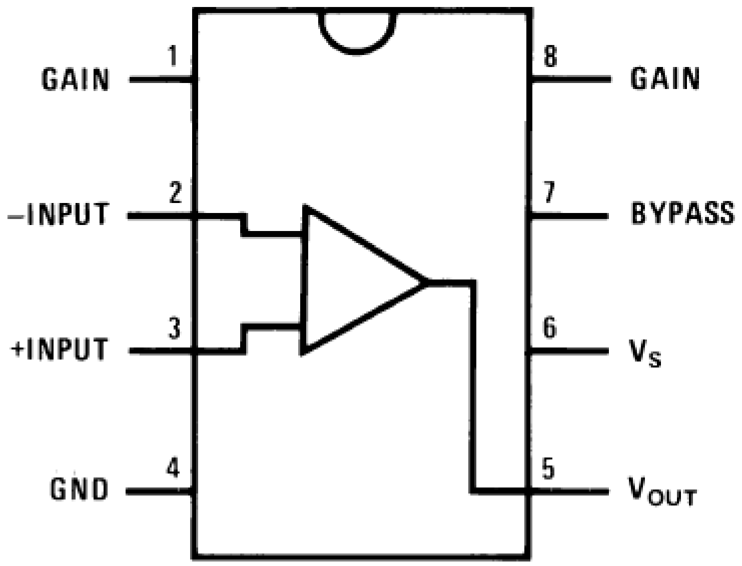
Introduction

In this project, we learned to construct our very own speaker utilizing two kinds of ICs, the LM741 and LM386. Expanding upon what we did in Lab09, wireless transmission method through light, this project also supports a crude wireless functionality via laser modulation.

Results

Wired Configuration

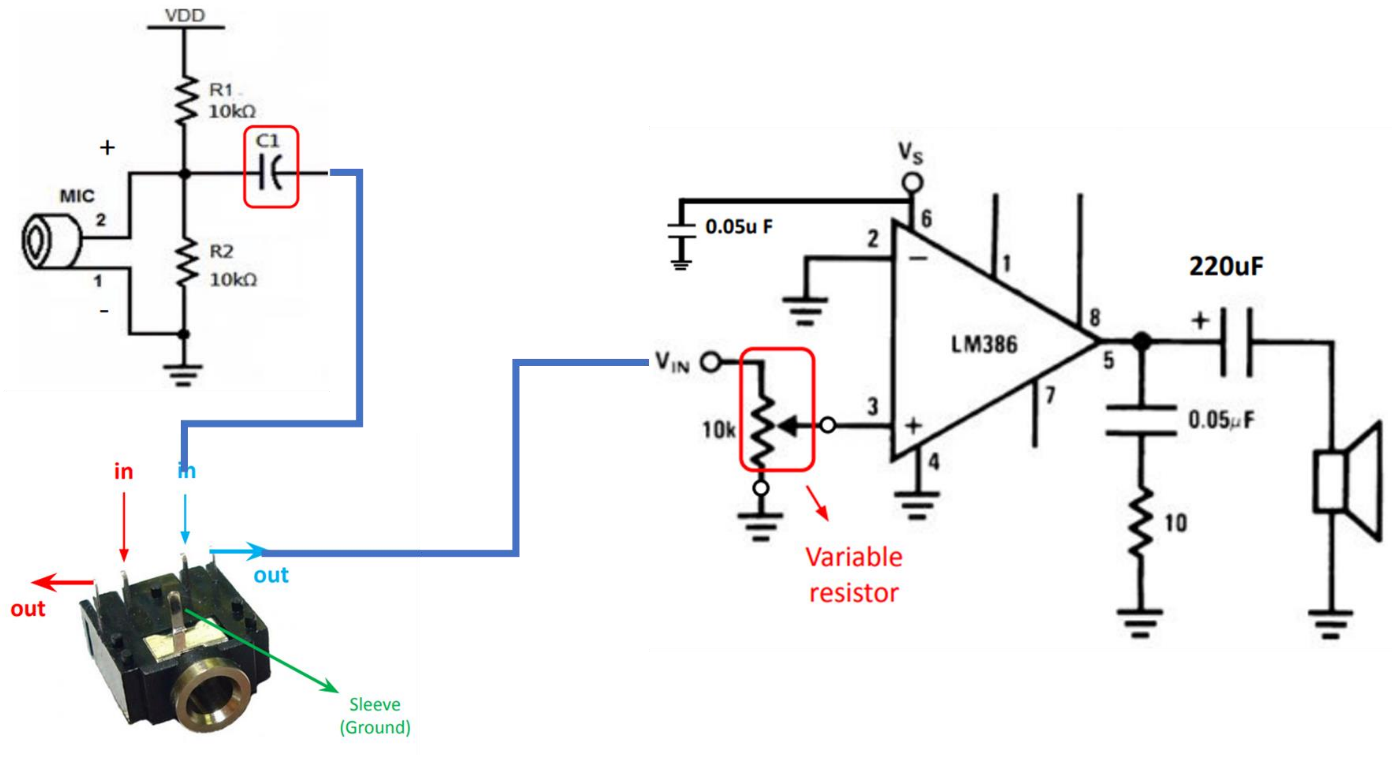
LM386 Pinout Diagram



- ✧ Pin 1 (Gain Control 1): This is **one of the two gain control pins**. When **used with Pin 8**, it allows for the adjustment of the amplifier's gain. If these pins are left open, the LM386 will have a gain of 20. If a **varactor(varicap)** is connected between these pins, the gain can be adjusted to a **maximum value of 200**.
- ✧ Pin 2 (Inverting Input): This is the inverting input to the internal operational amplifier. Your audio signal is fed into this pin for amplification.
- ✧ Pin 3 (Non-inverting Input): This is the non-inverting input. In most basic applications, this pin is grounded.
- ✧ Pin 4 (Ground): This is the ground pin. It is the reference point for the power supply and input signals.
- ✧ Pin 5 (Output): This is the output pin from where you get the amplified audio signal. This signal is typically fed to a speaker or another stage of audio processing.
- ✧ Pin 6 (V+): This is the positive voltage supply pin. The LM386 can be powered with a DC voltage typically ranging from **4 V to 12 V**.
- ✧ Pin 7 (Bypass): This pin is used for **noise reduction**. It can be connected to ground through a capacitor to filter power supply noise. This is not always used in basic applications.

✧ Pin 8 (Gain Control 2): This is the second **gain control pin**. As mentioned in Pin 1, connecting a capacitor between Pins 1 and 8 increases the gain.

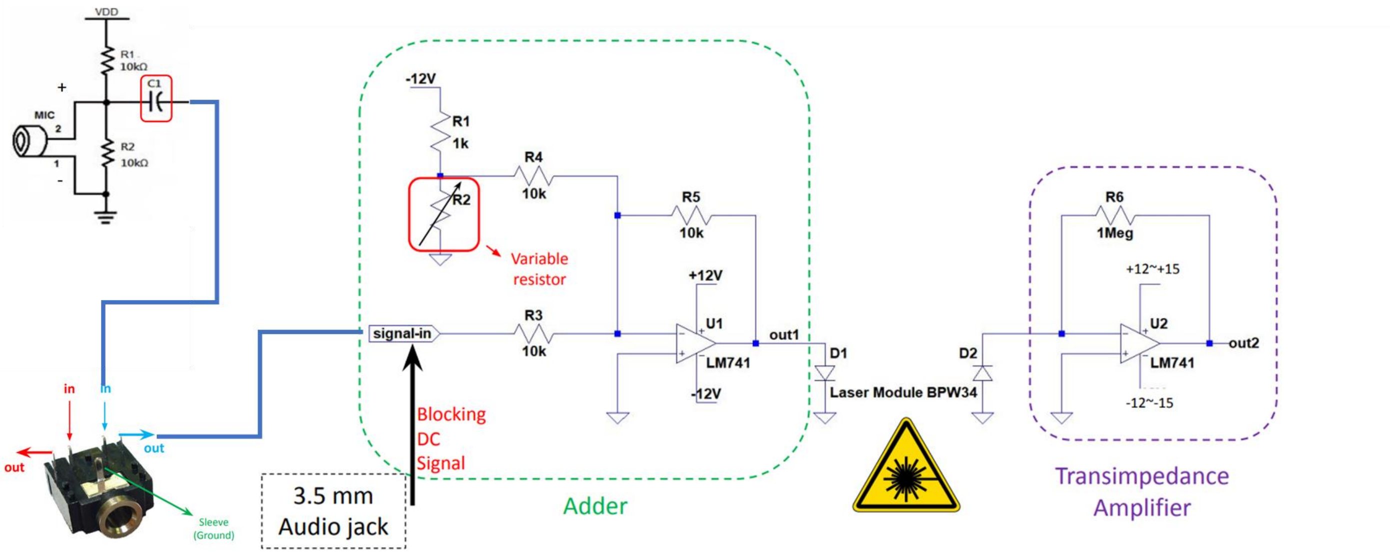
Complete Circuit (Wired):

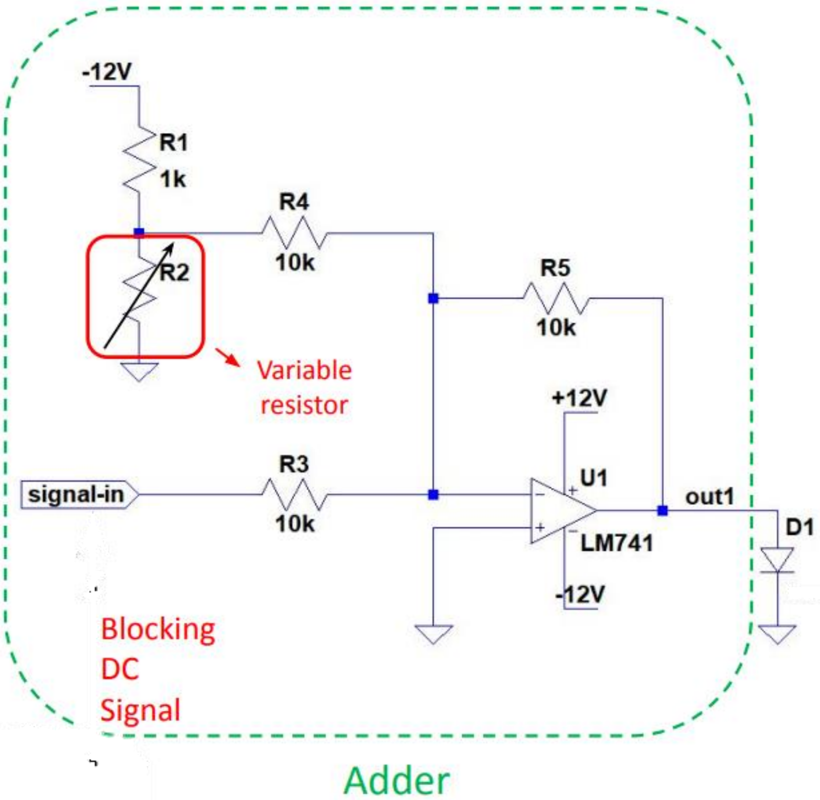


The wired configuration is fairly simple. We connect the audio signal we wish to play on the speaker to an LM386 with a **gain of 20** (since we left pins 1 and 8 empty), and connect the speaker to the amplifier's output pin. Voila! There's our speaker! A **1~10kΩ potentiometer is connected to pin 3 to allow the adjustment of volume.**

Wireless Configuration

Complete Circuit (Wireless):

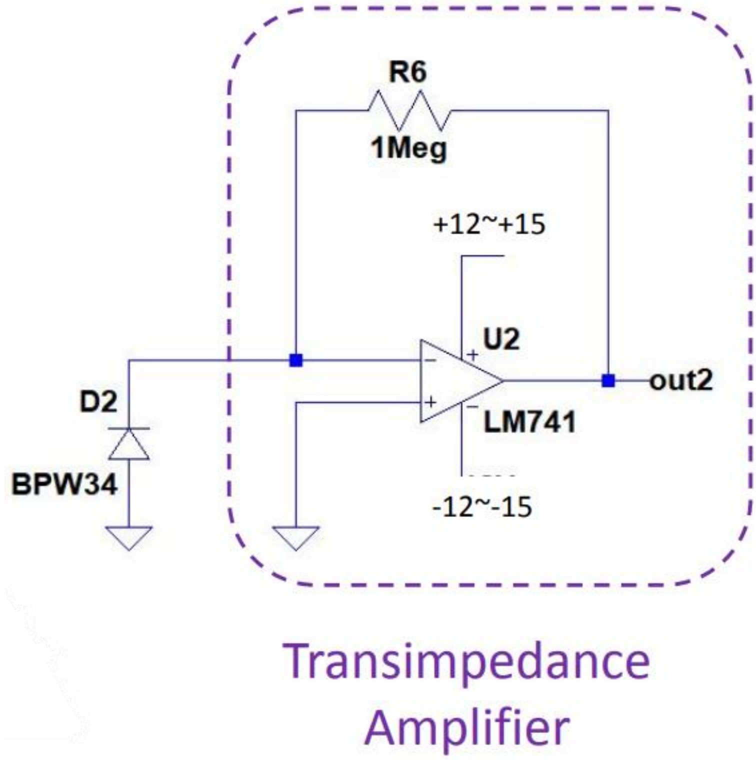




We can analyze this "Adder" circuit using superposition. The -12V supply is connected to a **voltage divider composed of a 1~10kΩ potentiometer**. This is what powers the laser diode. The potentiometer allows us to easily adjust the intensity of the laser. Using the formula for the inverting amplifier configuration of the 741,

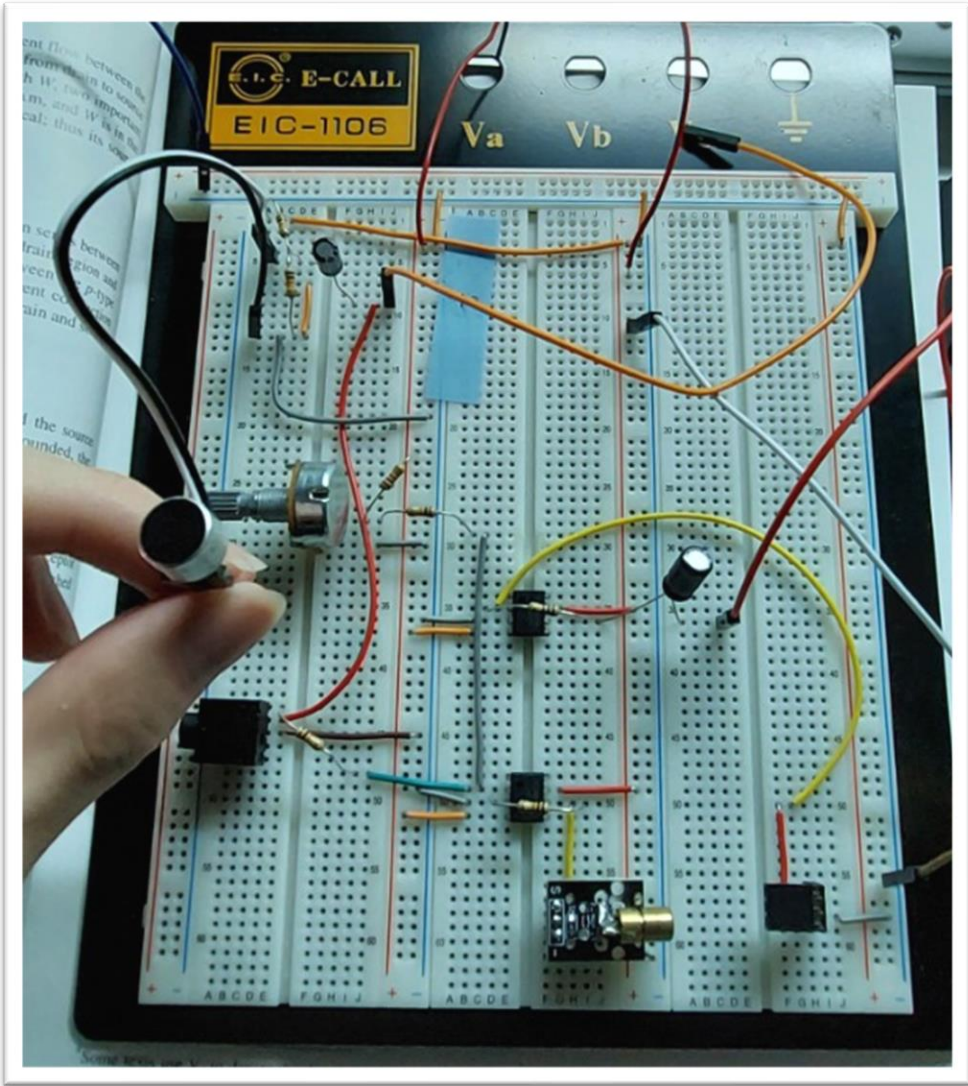
$$V_{out} = V_{in} \times (-\frac{R_f}{R_{in}})$$

We can see that the **gain is -1**. The circuit simply **inverts the signal, but doesn't amplify it**. This is also true for the small signal input from the audio jack. The adder allows for the combination of the two signals. **Both inputs are necessary because the smaller signal alone wouldn't be enough to power up the laser. This technique we use is called "modulation".** More specifically, we are utilizing amplitude modulation, the small signal is encoded onto the larger DC signal. In turn, the laser intensity varies correspondingly. These variations in laser intensity allows the receiving phototransistor to demodulate, or reconstruct this signal. This is the concept behind the project's wireless transmission section.

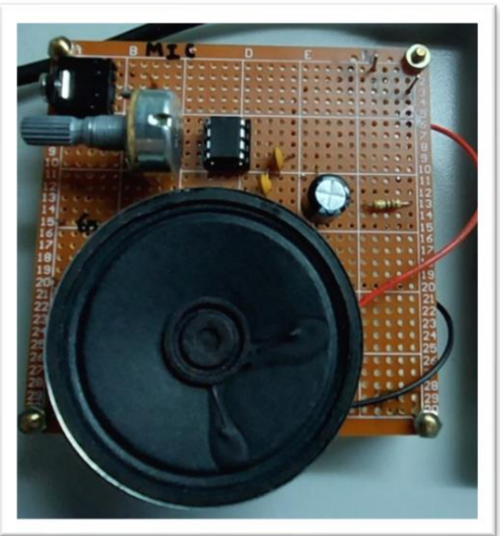


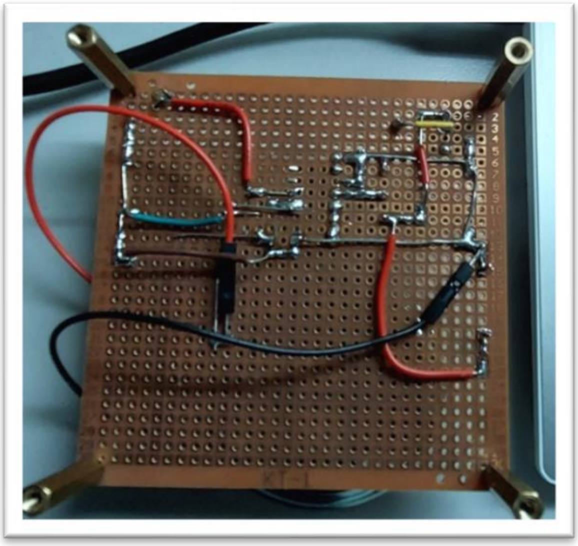
However, the **signal** received by the **phototransistor is much smaller** compared to the original. Therefore, we must amplify it. I can't calculate the exact gain of this amplifier because we do not know the resistance value of the diode. Even so, a good estimate would be that that the BPW34's should not be more than a couple hundred Ω. This means that **the gain is likely around $-(10^5 \sim 10^6)$.** The amplified signal is than **passed onto the LM386** on our perfboard for further amplification. The rest is the exact same as the wired configuration.

Breadboard Implementation:



Perfboard Implementation:





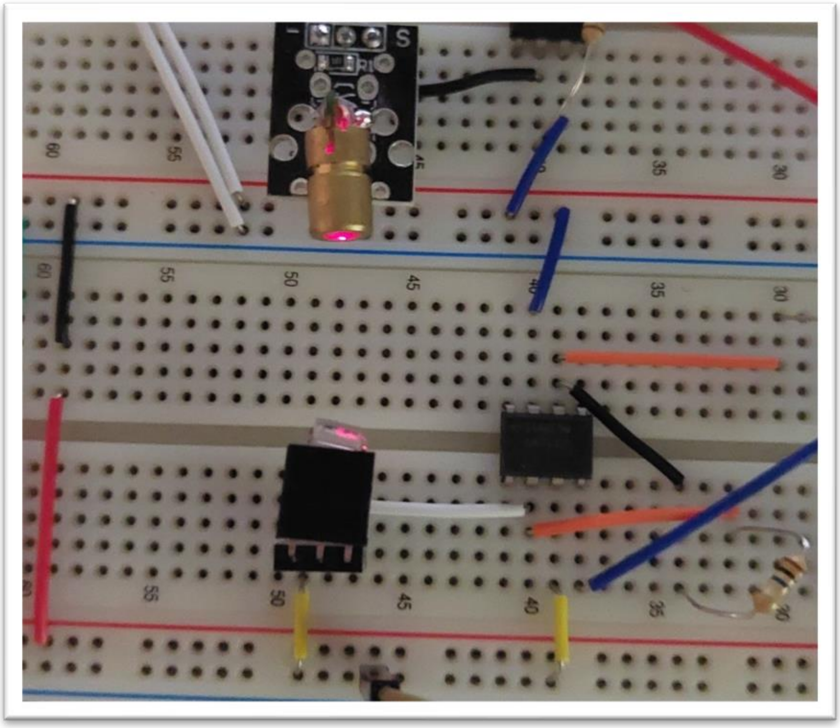
Discussion

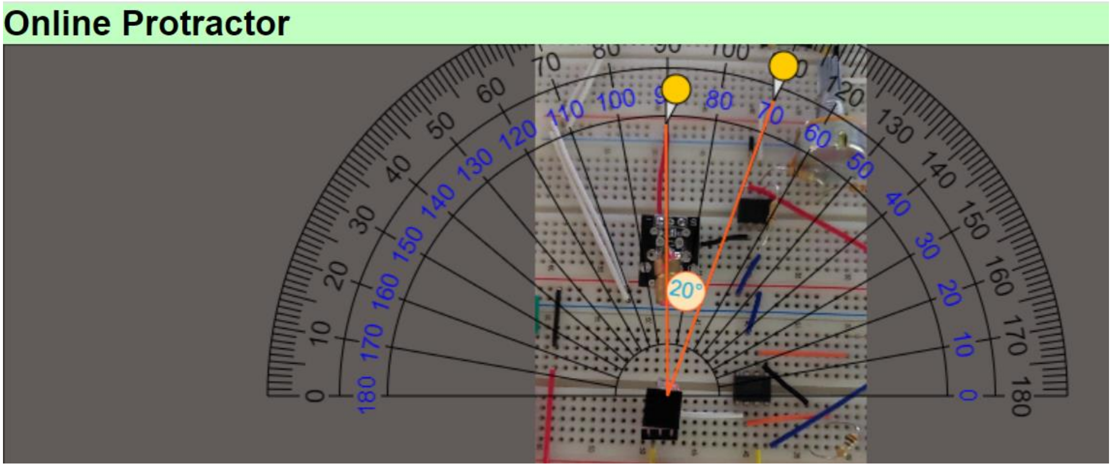
Laser Bias Point

A major problem I struggled with initially was finding a proper bias point for the laser. The intensity of the laser can't be too strong or too weak. This is something that takes trial and error to figure out. There was immeasurable joy when I first got it working. There were a couple factors to take into account when finding the perfect bias point.

1. Distance: The laser must not be too close to the phototransistor. It was recommended by our TA that they be kept at least **5cm apart** from each other.

2. Angle: It may not be the most effective to have the laser shine directly onto the photoresistor. There should be an **angle of 20° ~ 30° between the two**.





3. Intensity: The most straightforward aspect. The laser can be neither too bright nor too dark.

Noise Interference

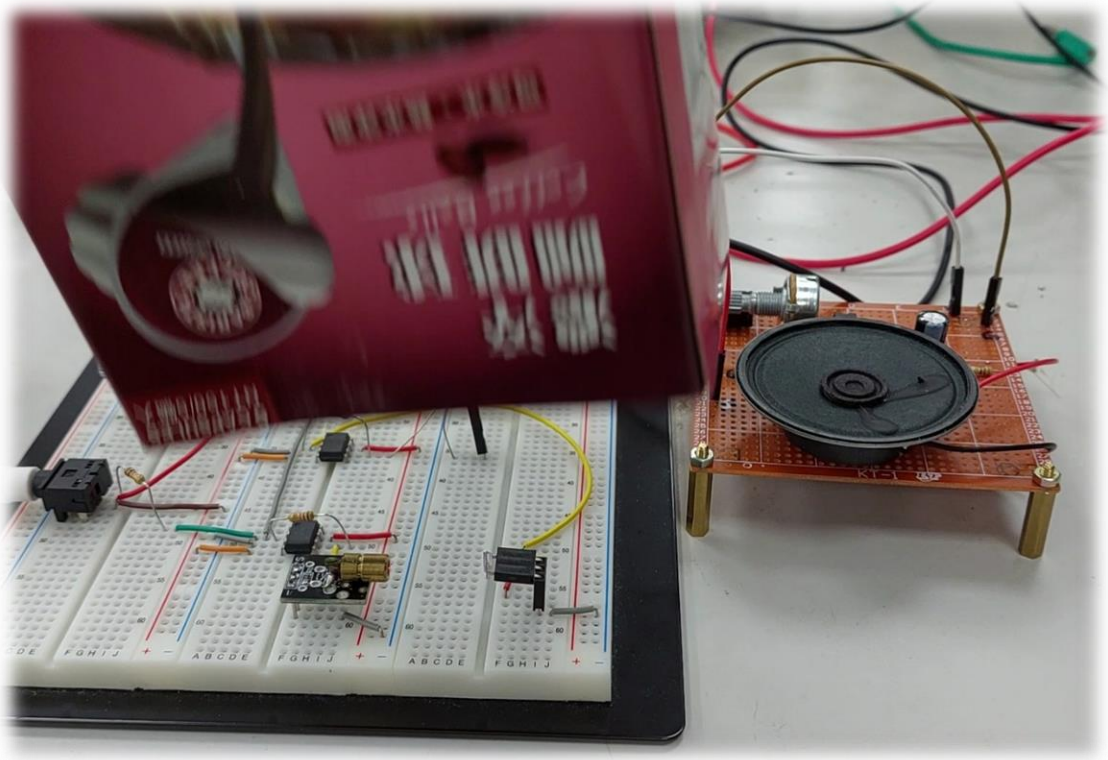
The night before the demo of level 1 & 2. I made sure to double check that my wireless mode was working well. However, I could not get it working during the actual demo. I spent 2 hours adjusting the knob on my potentiometer but to no avail. Eventually, I managed to pass the demo with subpar wireless performance. Frustrated, I conducted further testing after class, and concluded that the culprit behind my pain and suffering was the **bright light** above my seat at the lab. I've recorded several instances of how bright light may disrupt signal transmission, the video links are as follow:

Video 1: https://www.youtube.com/shorts/mlM9gworWgA

Video 2: https://www.youtube.com/shorts/KqW_fE6d56o

Video 3: https://www.youtube.com/shorts/uQvWU3UNIbQ

Since the laser & phototransistor setup is out in the open, this system is extremely susceptible to interference from external lighting. Realizing this, I used a small cardboard container to shield the laser & phototransistor. **Noise was reduced and the audio quality improved substantially.** You will be able to easily notice the difference in my video.



Bypass Pin

Another potential solution to the noise problem is to connect a capacitor to the **bypass pin** (pin 7) of the LM386. This should also help filter out the hissing noise. **A 10μF capacitor** would typically work best.

Conclusion

This project was mostly fun and interesting. The challenging part was finding the optimal laser bias point and mitigating noise interference. I felt a sense of accomplishment when I solved the problem through trial and error. Overall, it was a great opportunity to practice my soldering and problem-solving skills. I look forward to what we will be doing next semester.

References

1. How2Electronics - LM386 Audio Amplifier IC Pins, Working, Circuit & Applications: https://how2electronics.com/lm386-audio-amplifier-ic-pins-working-circuit-applications/#google_vignette
2. Wavelength Electronics - Modulation Basics: https://www.teamwavelength.com/modulation-basics/
3. Audio Amplifier Using LM386 With Noise Removal: https://www.youtube.com/watch?v=gIlH1p35CJk