Karaoke Final Project

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EE210 Section 1
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Introduction

We have been tasked to put together a karaoke machine that consists of 5 total blocks: A Mixer, Tone Control, Volume Control, LED Volume Display, and Attenuator/Output Driver. The karaoke machine should be able to toggle lyrics, adjust base and treble values, adjust and display the current volume, and output the sound to an audio jack device. The components of each block will be soldered onto one breadboard and can either be powered by a 15V power source or a pair of 9V batteries.

Design and Simulation

Block 1: Mixer

Design Objective

The purpose of this block is to function as a mixer/separator for the audio input received from a 3 mm jack. A built-in switch allows the user to toggle the inclusion or removal of the lyrics from the audio track. This block uses a dynamic circuit that enables the op amp to operate either as an inverting summing amplifier or as a subtracting amplifier.
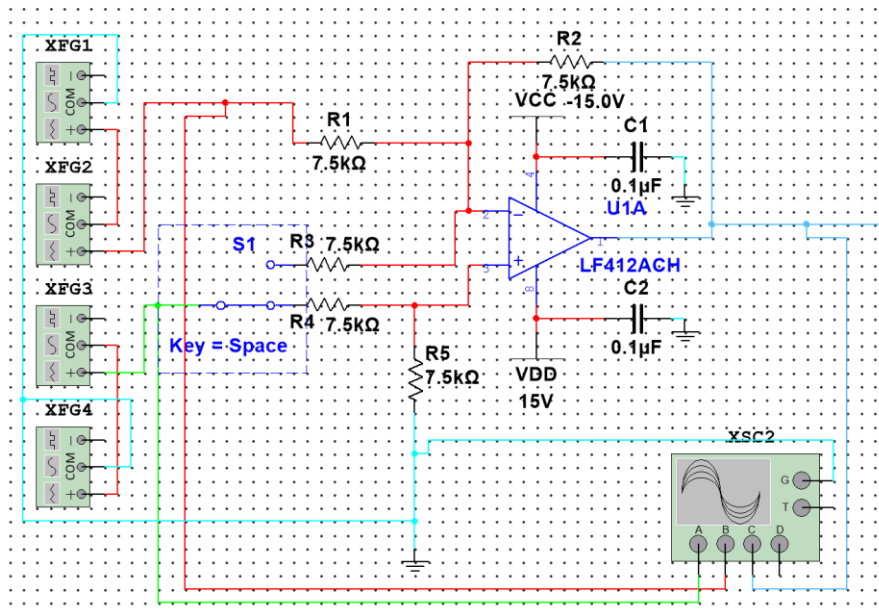
Schematic

Figure 1: Multisim schematic for Block1

Theory of Operation

The circuit uses a dynamic amplifier that can operate as either a summing amplifier or a subtracting amplifier, depending on the position of a switch. In the schematic, the top function generators (XFG1 & XFG2) represent the right channel input from the audio jack (110 Hz + 880 Hz), while the bottom function generators (XFG3 & XFG4) represent the left channel input (3520 Hz + 880 Hz). Switch S1 toggles between the two amplifier configurations. When the switch is in the up position, connected to the negative terminal, the circuit functions as an inverting summing amplifier (L + R). When the switch is in the down position, it operates as a subtracting amplifier (L − R). In subtracting mode, the circuit is in Karaoke mode, removing vocals from the track; in summing mode, the track and vocals are combined. As specified in the project manual, it was essential to use resistors with closely matched values, so components with a 1% tolerance were ideal.

Derivations/Calculations

When calculating the required resistor values, it was essential to ensure that both the left and right inputs were mixed equally. Equal mixing was necessary in both Karaoke mode and mixed mode, which meant that all resistor values had to be identical. While any equal values could have been used, 7.5k Ω resistors were selected because they were the only 1% tolerance resistors available in the provided materials.

Simulation Results

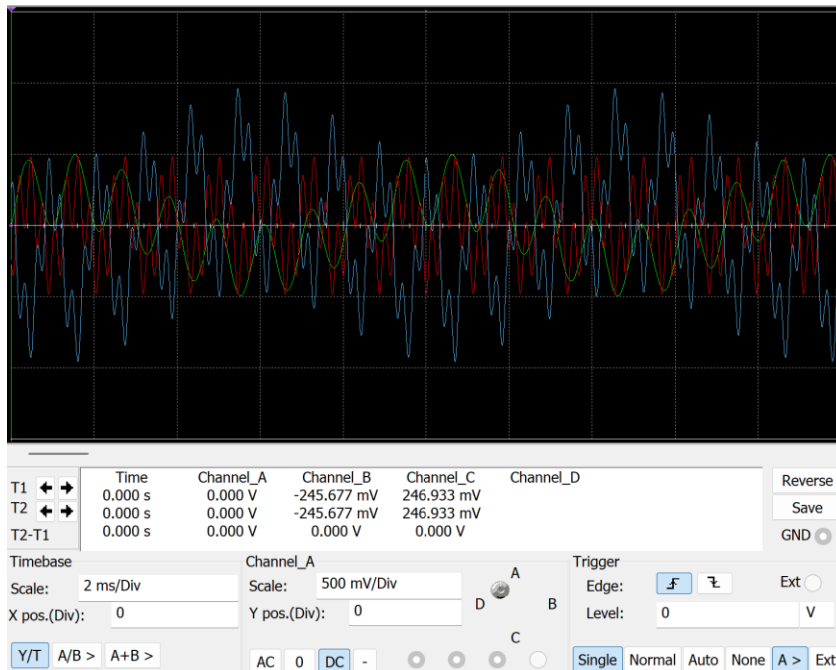For both graphs red shows the V_Right input, green shows the V_Left input, and blue shows the output.
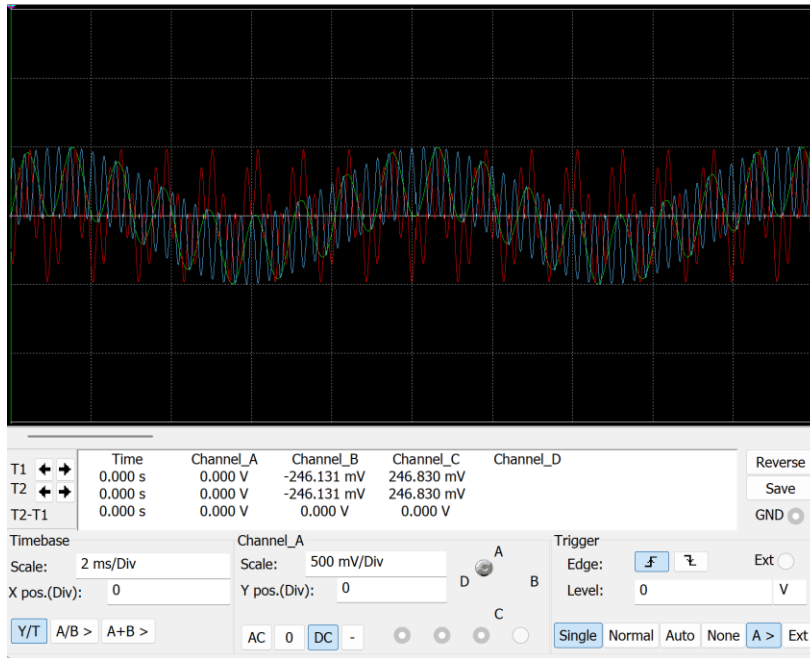

Figure 2: Mixed mode Oscilloscope Results

Figure 3: Karaoke Mode Oscilloscope Results

Block 2: Tone Control

Design Objective

This block is a Baxandall tone-control circuit that provides adjustable high-pass and low-pass filtering, allowing amplification or attenuation of bass and treble frequencies. With the potentiometers in their neutral positions, the gain for both bass and treble signals is 1:1. Rotating the potentiometers to their extremes adjusts the gain to either 10:1 or 1:10 for each frequency band.
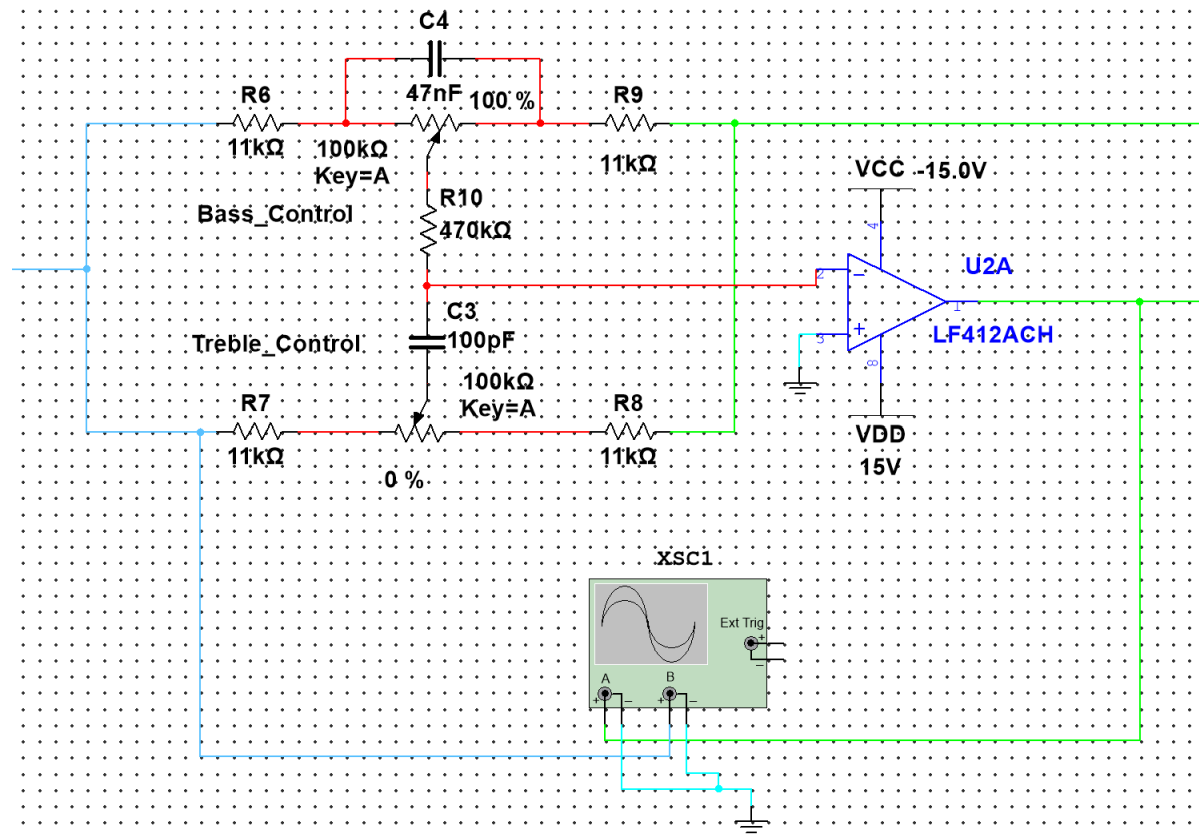
Schematic

Figure 4: Block 2 Multisim Schematic

Theory of Operation

The purpose of this block is to gain separate control over the high band and low band frequencies that exist in music. This is done by creating a high band and low band pass filter using the unique behavior of capacitors; they behave like open circuits at low frequencies and like short circuits at high frequencies. At low frequencies, both capacitors act as open circuits, making the output voltage dependent only on resistor R10 and the top potentiometer. At midrange frequencies, C3 behaves as a short circuit while C4 remains an open circuit due to C3's larger capacitance, resulting in the configuration acting as an inverting op amp. At high frequencies, both capacitors act as short circuits, and the output is determined solely by the bottom two resistors and the bottom potentiometer. These behaviors allow the Baxandall

tone-control circuit to adjust bass using the top potentiometer and treble using the bottom potentiometer.

Derivations/Calculations

Because we wanted all the inputs to magnify equally R6=R7=R8=R9=R. We then take the calculation that our $Gain_{min}=-R/(R+R_P)$ and $Gain_{max}=-(R+)/R$. We know that we want our minimum gain to be 0.1 and our maximum gain to be 10, so we find a ratio of $R_P = 9*R$. Since the only potentiometer values we have are 100k Ω, our R=100k/9 meaning R=11.11k Ω. We know that the capacitor C4 must be much smaller in value than C3 and simply took the capacitors that correspond with previous experiments with a large enough difference.

Simulation Results

The oscilloscope results below are labeled with the values of each potentiometer. Blue represents input, Green represents output
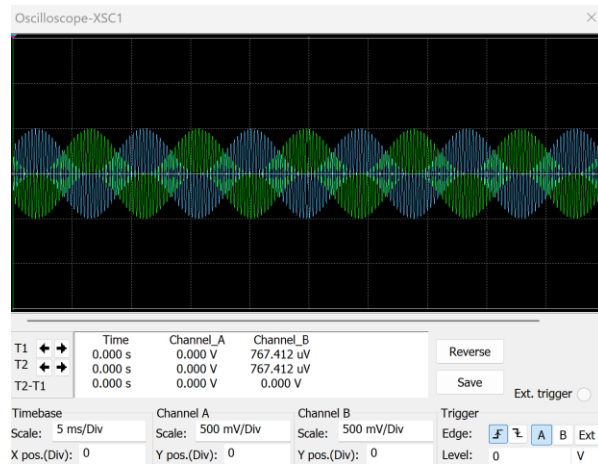

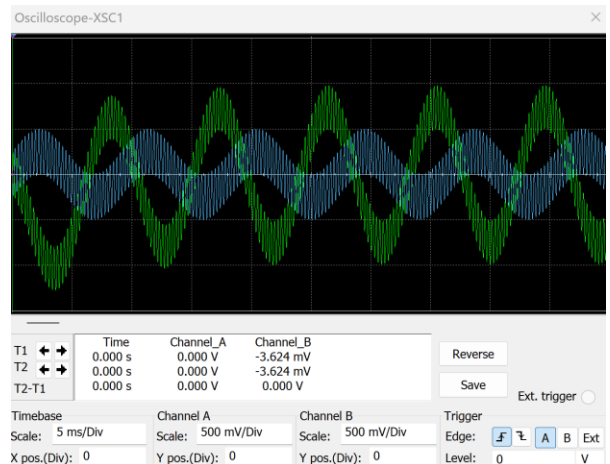Figure 5: 50% Treble Control, 50% Base Control

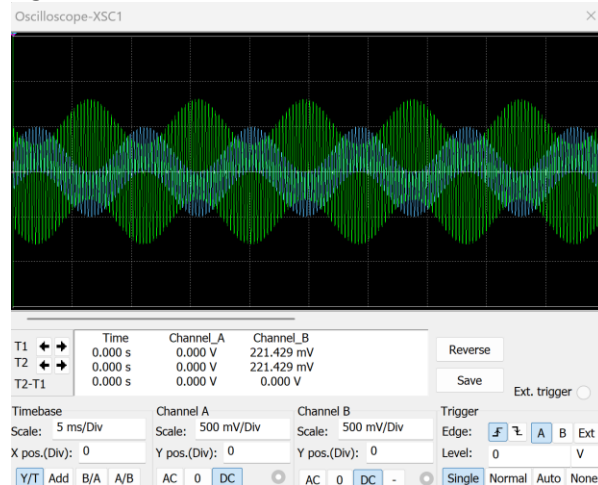Figure 6: 50% Treble Control, 100% Base Control
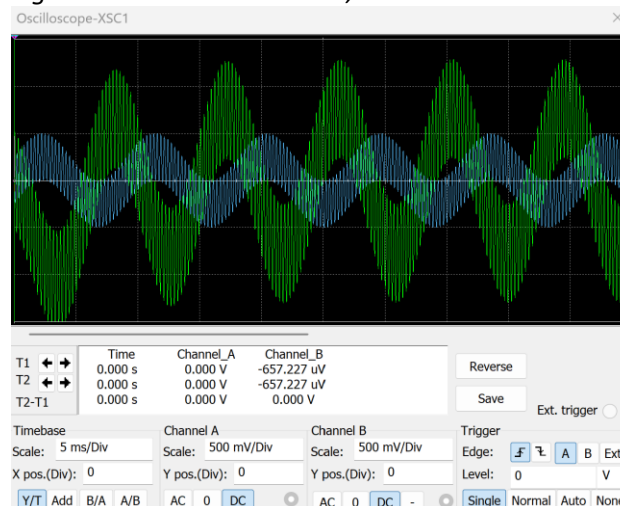

Figure 7: 100% Treble Control, 50% Base Control

Figure 8: 50% Treble Control, 100% Base Control

Block 3: Volume Control

Design Objective

This is a simple block that only consists of a potentiometer connected to ground and Blocks 4 &5. The purpose of this block is to give adjustable feedback to both the volume display and output blocks.
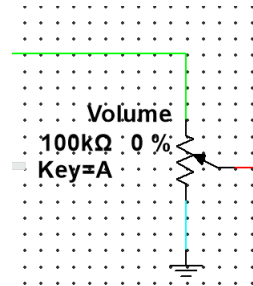
Schematic

Figure 9: Multisim Block 3 Schematic

Theory of Operation

This is a simple potentiometer which can be modeled by the equation Vout = (Potentiometer%) (Vin) it allows smooth linear motion and outputs either max or 0 volume at the extreme values.
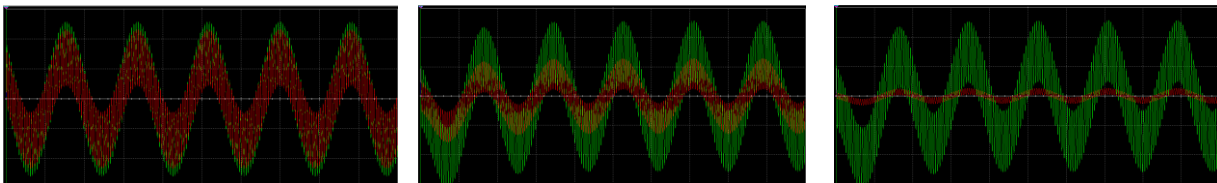
Simulation Results

Figure 10: Outputs showing 90%, 50% and 10% power output, red being power output

Block 4: Volume Display

Design Objective

This block is designed to light up at specified voltage values in rising succession. The purpose of this panel is to give a visual indication of how loud the audio is playing at a given time. The trigger values are 1.5V, 1V, 0.5V, and 0.25V.
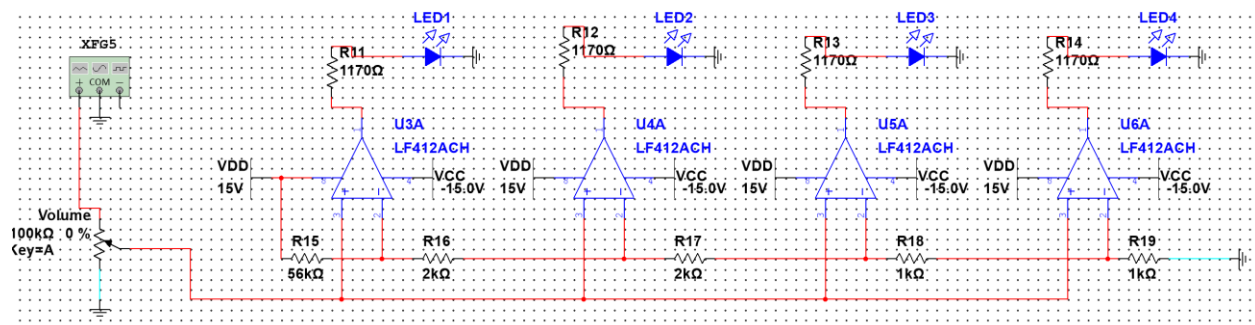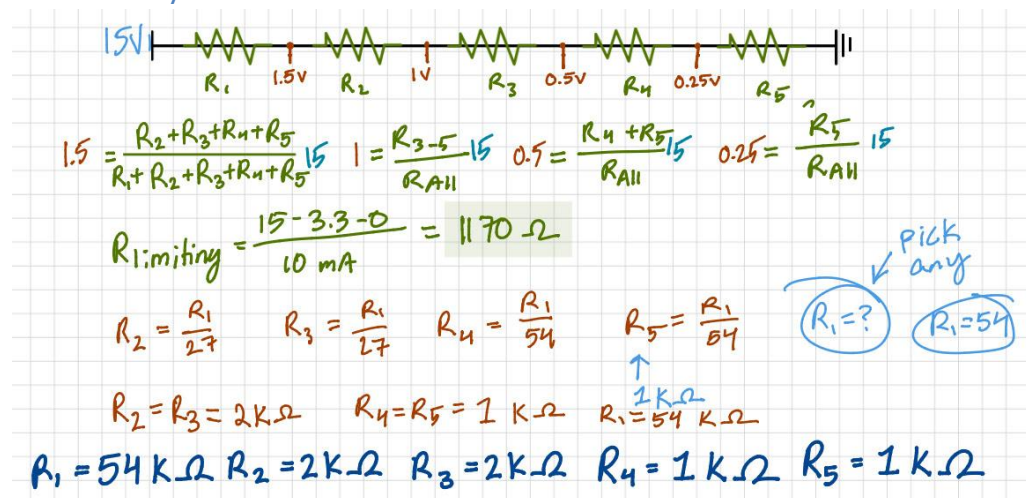
Schematic

Figure 11: Multisim Schematic of Block 3

Theory of Operation

This light block operates primarily using a level meter, which uses a voltage rail in a ladder to deliver appropriate voltage values at each junction. We take our source voltage of 15V and multiply it against the ratio of all the resistor values between our junction and ground over the sum of all total resistors in the ladder. We also need to calculate a limiting resistor for each LED to ensure they do not burn out and can still turn on when needed. By creating these two structures we can determine the needed resistor value for all the resistors.

Derivations/Calculations

$$1.5 = \frac{R_2 + R_3 + R_4 + R_5}{R_1 + R_2 + R_3 + R_4 + R_5} 15 \quad 1 = \frac{R_{3-5}}{R_{All}} 15 \quad 0.5 = \frac{R_4 + R_5}{R_{All}} 15 \quad 0.25 = \frac{R_5}{R_{All}} 15$$

$$R_{limiting} = \frac{15 - 3.3 - 0}{10\,mA} = 1170\,\Omega$$

$$R_2 = \frac{R_1}{27} \quad R_3 = \frac{R_1}{27} \quad R_4 = \frac{R_1}{54} \quad R_5 = \frac{R_1}{54} \qquad R_1 = ? \quad R_1 = 54$$

pick any

$$R_2 = R_3 = 2K\Omega \quad R_4 = R_5 = 1\,K\Omega \quad R_1 = 54\,K\Omega$$

$$R_1 = 54\,K\Omega \quad R_2 = 2K\Omega \quad R_3 = 2K\Omega \quad R_4 = 1\,K\Omega \quad R_5 = 1\,K\Omega$$
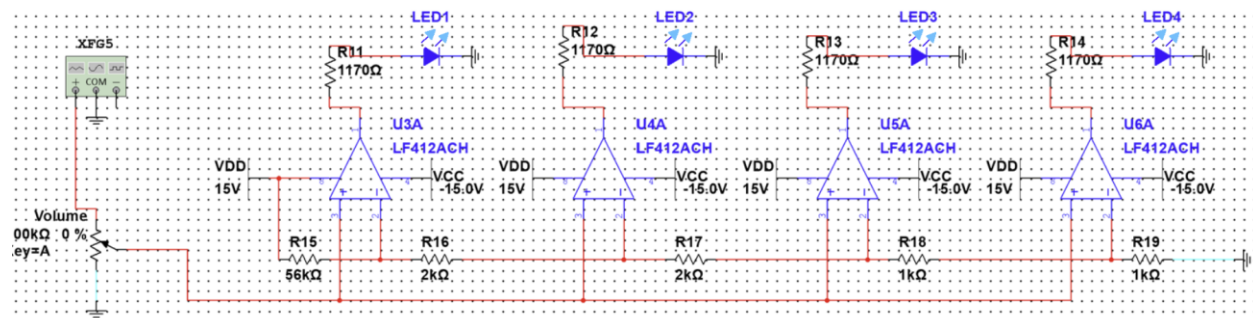
Simulation Results

Figure 12: Illuminated LEDs due to max volume (Note 0% potentiometer indicates Max Volume)

Block 5: Attenuator and Output Driver

Design Objective

This final block is designed to attenuate the audio output from block 3 into something usable for an audio jack equipped device. The theoretic max volume produced by this module is 20V, and our target voltage is ~1V. This decrease is to protect any equipment attached to the unit, and the desired gain may vary given the output, but this cautious approach ensures no harm will be done.
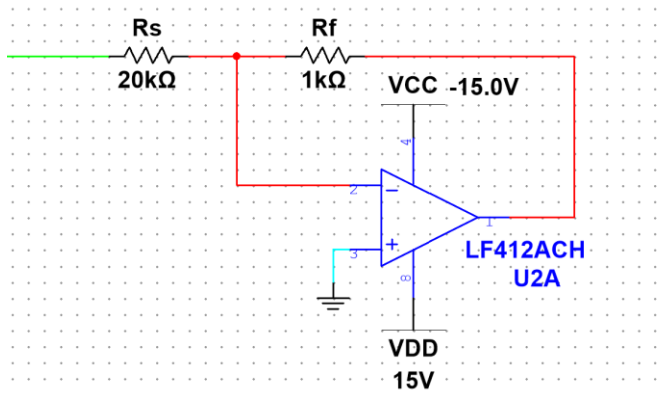
Schematic

Figure 13: Block 5 Multisim Schematic

Theory of Operation

This is an incredibly simple inverting amp that operates by taking the ratio of Rf/Rs and multiplying it by Vin to produce Vout. The reason we have chosen a 1/20 gain has to do with the operation of this circuit. The magnitude of each input voltage (V_{Left} and V_{Right}) is 1V and added together in their entirety we are left with 2V. Given our max gain from Block 3 was 10, we can multiply those together to get 20V as a theoretical maximum Voltage. The volume control and display do nothing to attenuate the final output, so this step is necessary to protect any future devices.

Derivations/Calculations

The calculation to attenuate this device is very simply Rf/Rs = 1/20. This ratio can apply to any resistors, as it is not a unique pairing. In this case, 1k Ω & 20k Ω were chosen for simplicity.
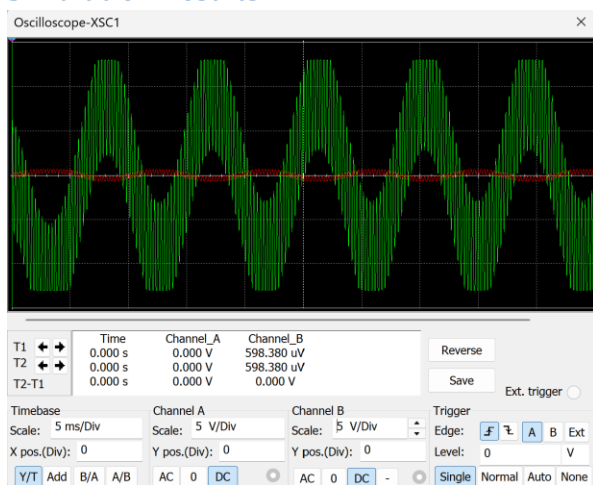
Simulation Results

Figure 14: Block 5 input (Green) VS Block 5 output (Red)

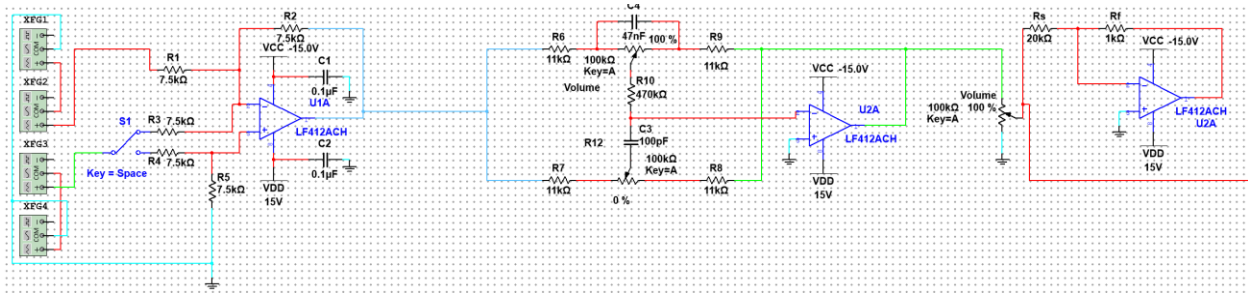# Complete Assembly and Breadboard Images

Figure 15: Entire Karaoke Schematic (LED Display Separate due to size)
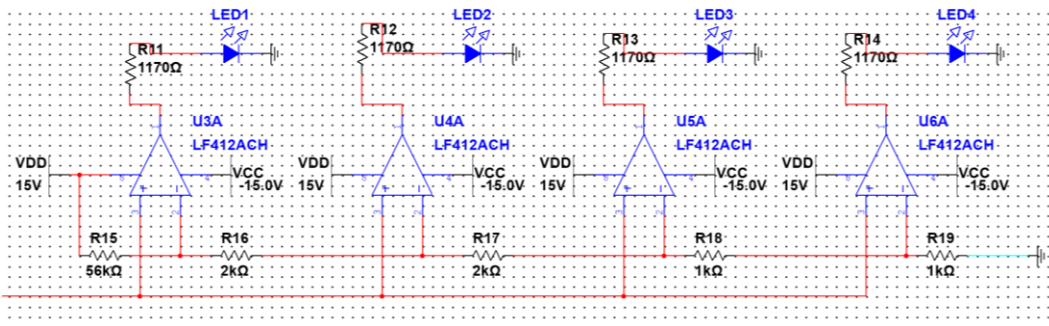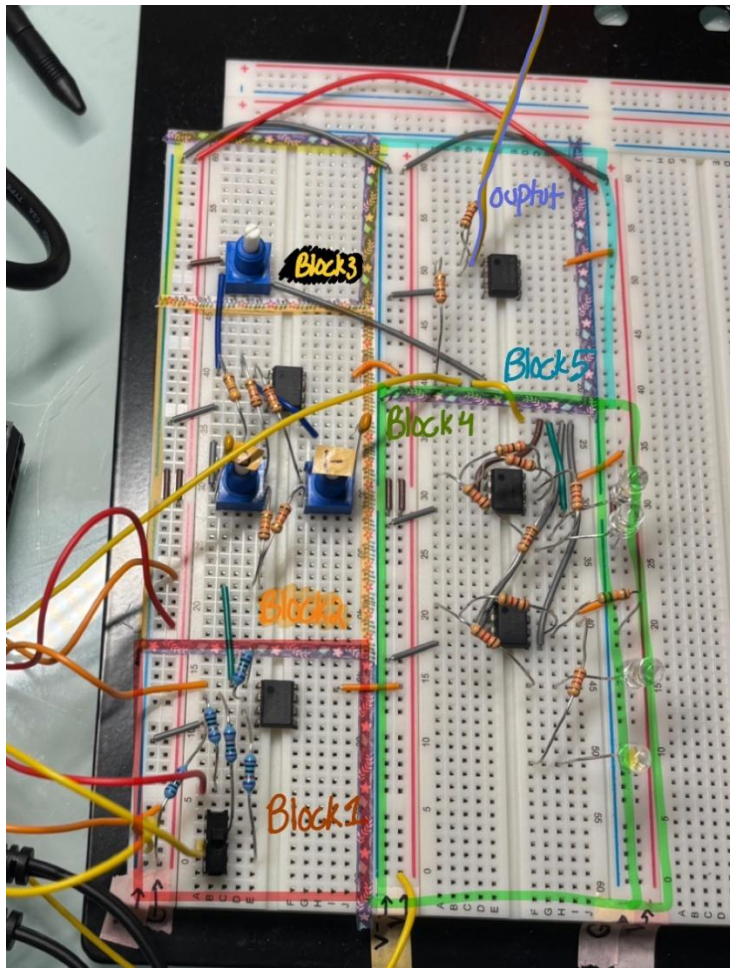

Figure 16: LED Display Schematic
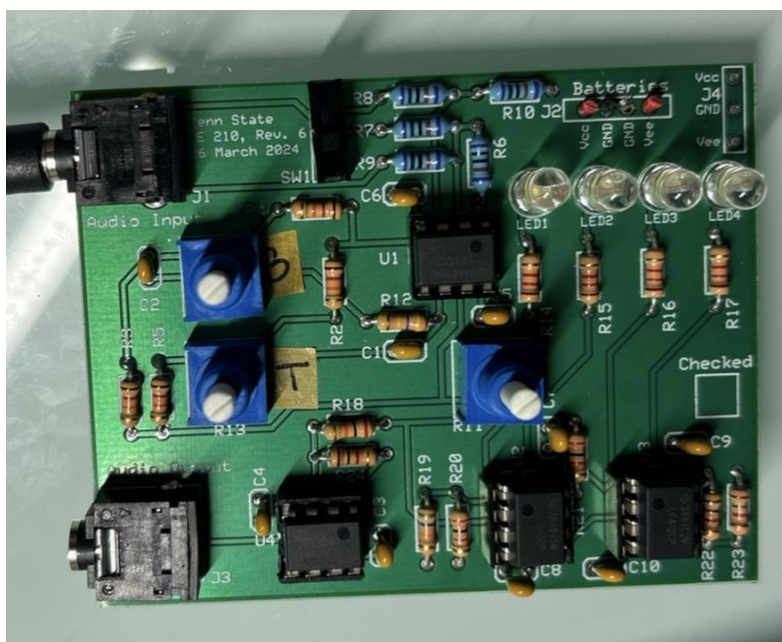
Figure 17: Labled Breadboard

Figure 18: Final Assembled PCB

Conclusion

This project was one of the first purely electronic projects I have worked on. As a mechanical engineering major, I do not often work on projects of this nature, so I found both the class and the karaoke machine to be challenging but rewarding. Ensuring that each previous block functioned correctly was essential for the entire system to work, and I often had to restart a section because of a mistake made a block or two earlier. In the end, the karaoke machine was a success, and the final product worked as expected after considerable effort in understanding the underlying principles and applying them. This experience has strengthened my interest in electrical engineering, and I look forward to continuing to expand my skills in the future.