Project Report

Project: Karaoke Machine

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1.0 Introduction

The aim of this project was to gain experience in designing and implementing an electronic system. The project that was done involves the development of a karaoke system.

Components were provided such as microphones, speakers, potentiometers, integrated circuits such as op-amps, capacitors, and resistors. However, for this design high power components were used as an optional requirement. Three inputs were used two mic inputs as well as an aux input, these signals were fed into a summing amplifier to combine the mic signals to the left and right audio signals while maintaining the separate left and right audio. The two signals were fed into a pan pot circuit where the user could shift the signal to only be output at one or the other speaker or any ratio in-between. After the pan pot circuit, the two signals could then be amplified using the high-power audio amplifier. Finally, the output is fed into the two sets of speakers.

2.0 Project Requirements

Table 1. Requirements

Req. #	Description	Customer Req #	Verification
1	No less than 2 input	1	Verified
2	Microphone with preamplifier	2	Verified
3	Aux channel	3	Verified
4	The audio signals from these channels will be mixed and sent to two speakers	4	Verified
5	Ac power delivered matches speakers	5	Verified
6	Speaker output free of noise	6	Verified
7	Volume control	7	Verified
8	Mic gain control	8	Verified
9	Input protection for audio amp	9	Verified
10	Power supplied via wall outlet	10	Verified
11	Components contained via fixture	11	Verified
12	Separated left and right aux channels	Optional 1	Verified
13	Steer between Left and Right channels	Optional 2	Verified
14	Higher powered IC's Speakers	Optional 3	Verified

3.0 System Design and Implementation

3.1 System Block Diagram

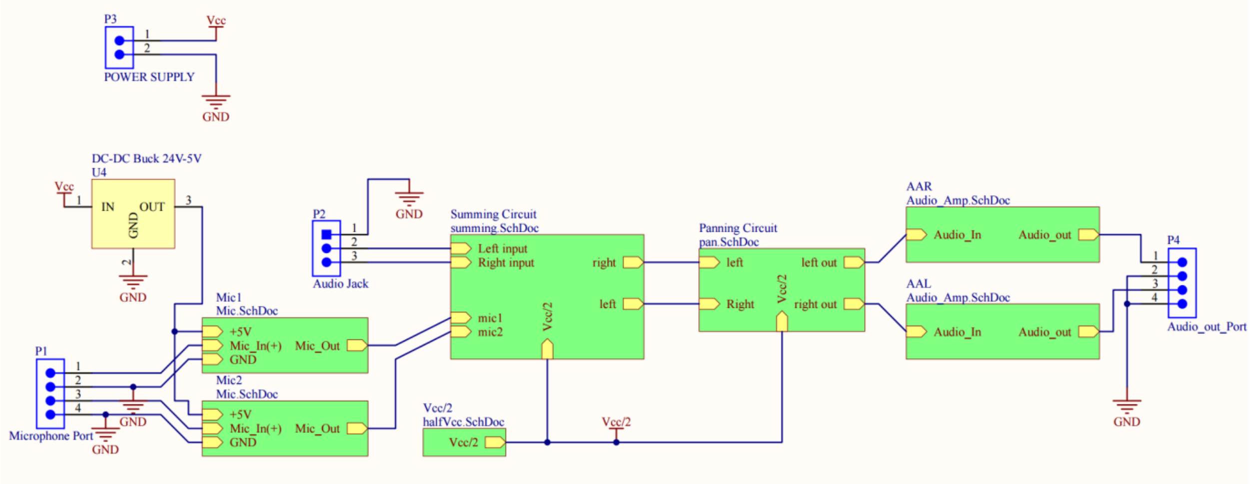

Figure 1. High Level Block Diagram

3.2 Hardware Design and Implementation

3.2.1 Audio/Power Amplifier Subcircuit

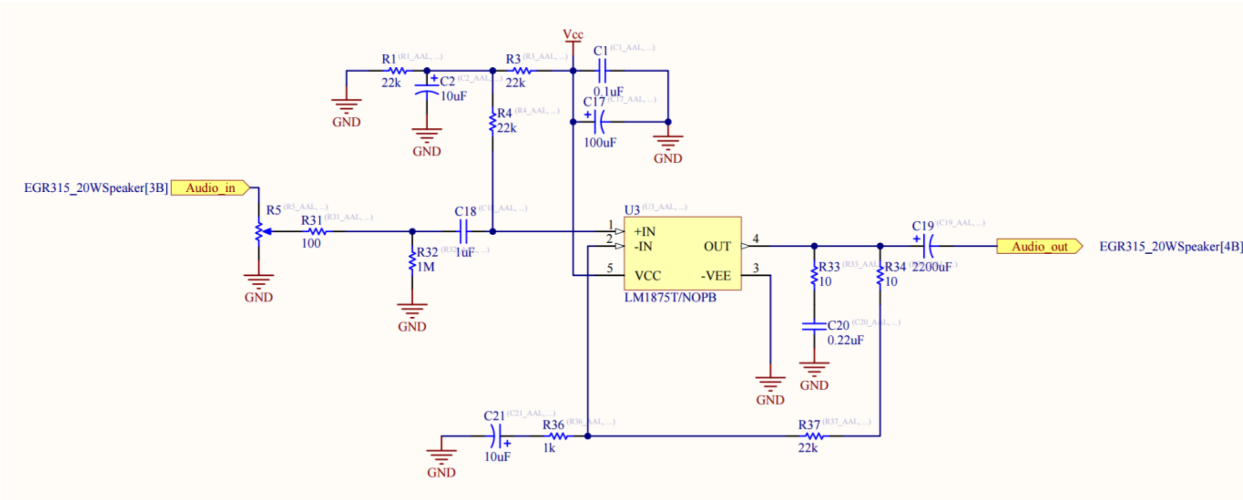

Figure 2. Audio/Power Amplifier Subcircuit

The LM1875 power amplifier circuit was implemented in the karaoke machine project to serve as the final stage of audio amplification. This circuit received a low-level audio signal, consisting of the combined microphone input and backing track, and amplified it to a power level sufficient to drive a 20W speaker. Operating with a single 24V supply, the amplifier simplified power management by eliminating the need for a dual-supply configuration, making it suitable for a compact and portable karaoke system.

The design incorporated essential components to ensure optimal performance, stability, and noise reduction. The input stage utilized resistors and capacitors to establish appropriate biasing conditions and minimize unwanted noise. Specifically, R36 and R37 set the gain of the circuit, providing a typical gain of 22x without introducing unwanted noise, which ensured the amplified audio signal remained clean and distortion-free.

To maintain power supply stability, C1 and C17 were employed as decoupling capacitors to filter high-frequency noise and smooth voltage variations. Additionally, a Zobel network composed of R33 and C20 provided a constant load at the amplifier output. This network effectively suppressed high-frequency oscillations and prevented radio frequency signals from interfering with the circuit, ensuring overall stability. This configuration enabled the LM1875 to deliver clear and powerful audio output, essential for enhancing the user experience during karaoke performances.

For stereo sound output, two identical LM1875 amplifier circuits were used, one dedicated to the left channel and the other to the right channel. This configuration enabled the karaoke machine to deliver full, immersive stereo audio experience.

3.2.2 Summing Amplifier Subcircuit

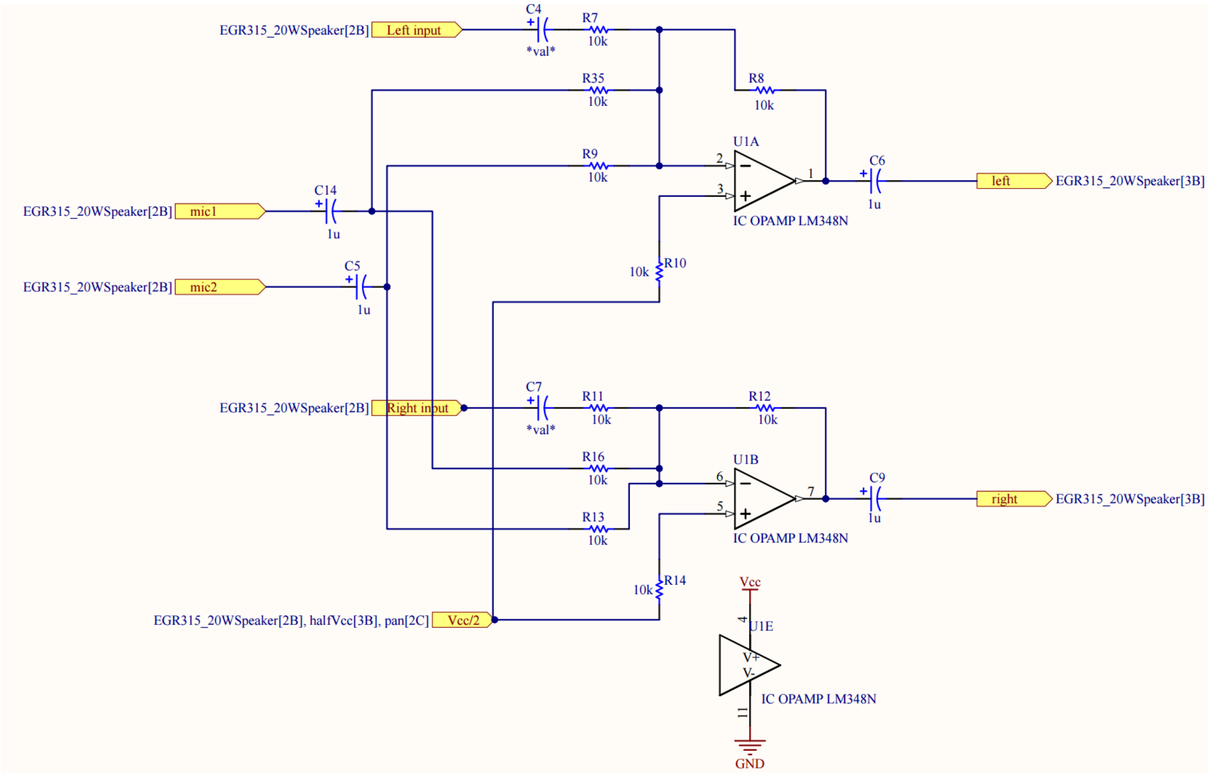

Figure 3. Summing Amplifier Subcircuit

The summing amplifier circuits in the karaoke machine project served to combine multiple audio inputs for each channel, specifically mic1, mic2, and the respective left or right channel audio input. These summing amplifiers allowed for seamless mixing of the microphone signals with the stereo audio track, ensuring that both the user's vocals and the backing music were combined and sent to the appropriate output channel.

Each summing amplifier utilized an LM324N operational amplifier and was configured with a voltage gain of 1. This configuration ensured that the input signals were combined without any additional amplification, maintaining the original signal levels to avoid distortion or clipping. The resistors in the feedback and input paths (e.g., R7, R8, R9, R10, R35 for the left channel and R11, R12, R13, R14, R16 for the right channel) were chosen to achieve this unity gain, ensuring balanced and accurate mixing.

The output of each summing amplifier was then coupled through capacitors (C6 and C9) to block any DC offset, delivering a clean mixed audio signal to the subsequent power amplifier stage. This approach enabled the karaoke machine to provide a smooth blend of vocals and music, delivering a cohesive and high-quality stereo audio experience for users.

3.2.3 Microphone Subcircuit

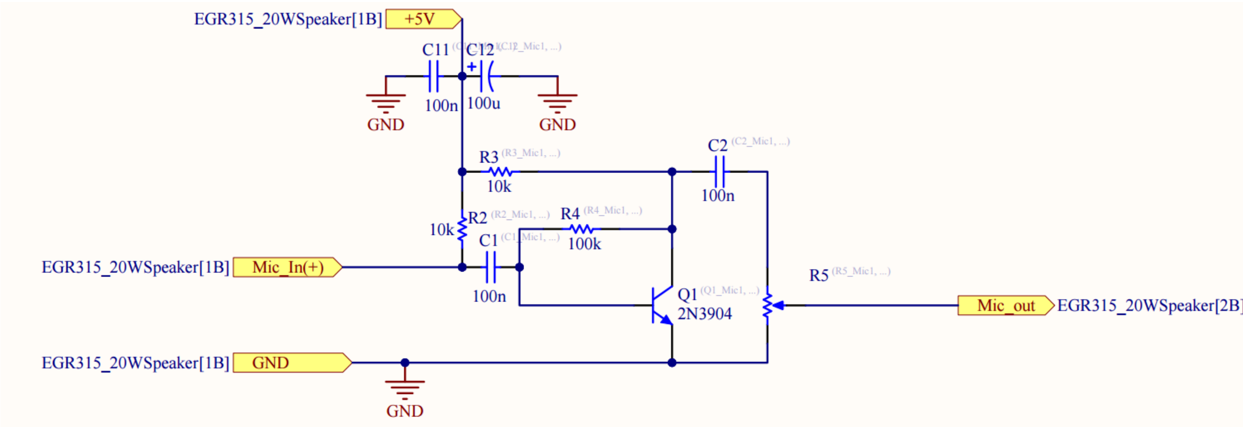

Figure 4. Microphone Preamp Subcircuit

The electric microphone preamp circuit shown was designed to amplify the low-level signal from an electret microphone to a level suitable for further processing in the karaoke machine. This circuit uses a 2N3904 NPN transistor in a common-emitter configuration to achieve the necessary amplification while maintaining low noise and reliable performance.

The microphone signal is fed into the base of the transistor through a coupling capacitor (C1) and biasing resistors (R2 and R3), which set the appropriate operating point for the transistor. R4 provides the necessary load resistance, while C2 decouples any high-frequency noise at the output. The output signal is taken from the collector of the transistor through R5, a potentiometer that allows for adjustable gain control. This enables the user to fine-tune the level of the microphone signal to match the desired output level for mixing.

The circuit is powered by a stable 5V supply, which is derived from a DC-DC buck converter (as shown in Figure 1). Decoupling capacitors C11 and C12 filter the 5V supply to remove noise and ensure a clean power source for the preamp. This configuration ensures the microphone signal is amplified with minimal distortion, allowing clear and intelligible vocal input for the karaoke system.

The preamp circuit has an approximate voltage gain of 360.

3.2.4 Power Supply Subcircuits

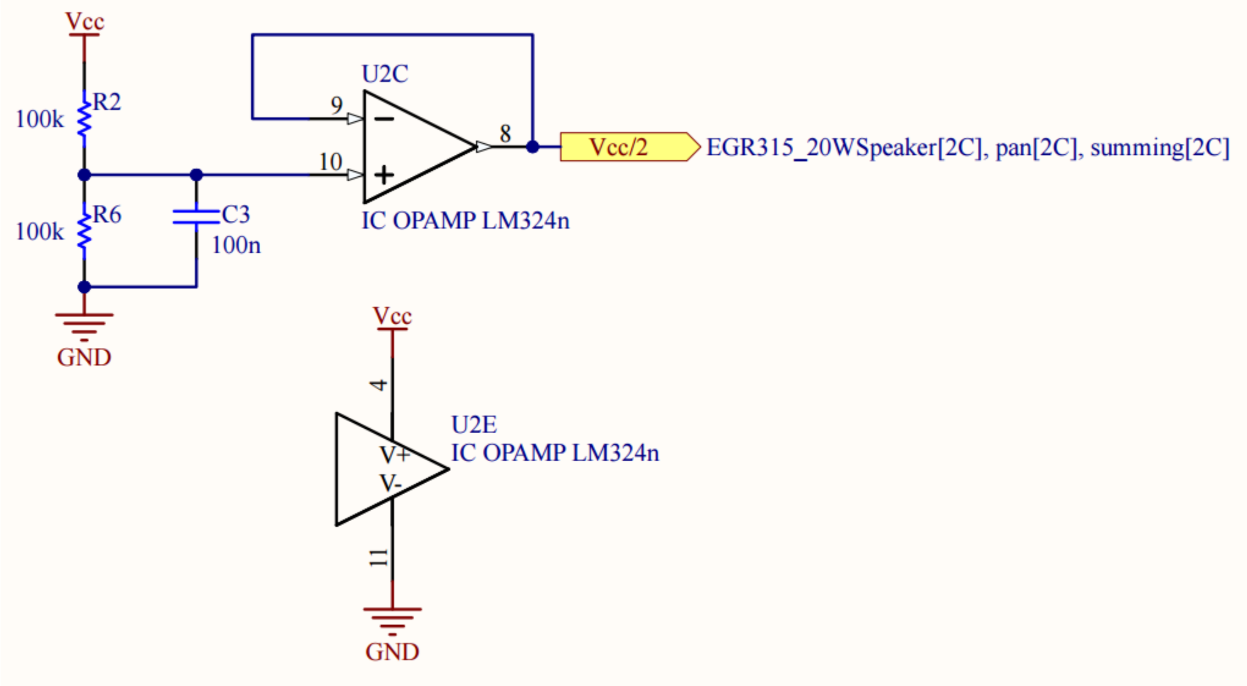

Figure 5. Vcc/2 For Single Op Amp Configuration

This circuit is designed to provide virtual ground (Vcc/2) for the operational amplifiers, allowing them to operate in single-supply mode. The virtual ground sits at half the supply voltage, enabling the op-amps to handle both positive and negative signal swings relative to this midpoint.

4.0 Circuit Testing Results

4.1 Test 1: Audio Pan Voltage Gain Measurement

Audio Pan control set to middle and a $0.5V_p$ 10kHz sine wave from the function generator applied to both Left (yellow) and Right(blue) channels. Volume Knob set to max.

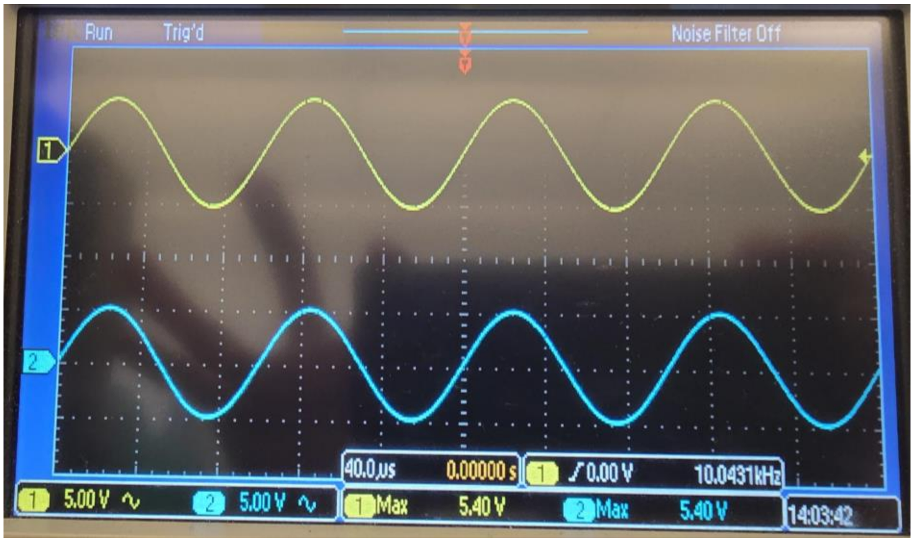

Figure 6. Left and Right Channel Output w/ $0.5V_p$ @ 10kHz Audio Pan Set to Middle

$$A_v = \frac{5.4}{.5} = 10.8\frac{V}{V}$$

Gain from this test is 10.8.

$$P = \frac{5.4^2}{4} = 7.29W$$

The Power output from the LM1875 was measured at 7.29 per channel.

Audio Pan control set to Full Right and a $0.5V_p$ 10kHz sine wave from the function generator applied to both Left (yellow) and Right(blue) channels. Volume Knob set to max.

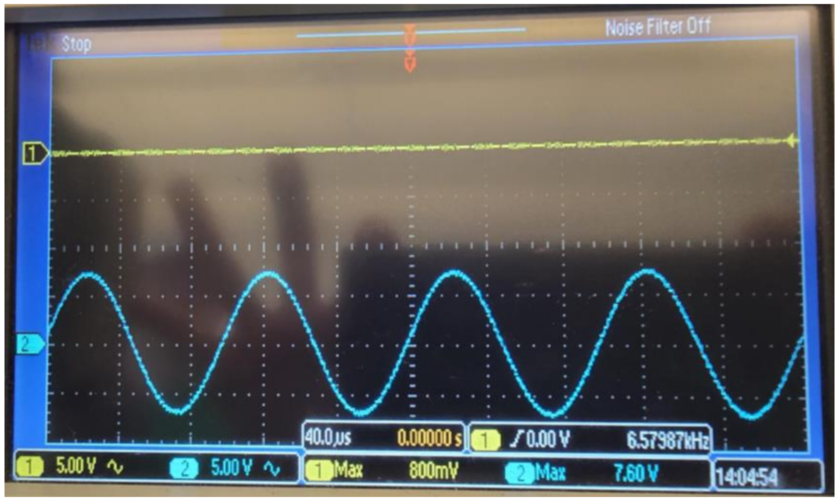

Figure 7. Left and Right Channel Output w/ $0.5V_p$ @ 10kHz Audio Pan Set to Right

$$A_v = \frac{7.6}{.5} = 15.2\frac{V}{V}$$

Gain from this test is 15.2

Audio Pan control set to Full Right and a $0.5V_p$ 10kHz sine wave from the function generator applied to both Left (yellow) and Right(blue) channels. Volume Knob set to max.

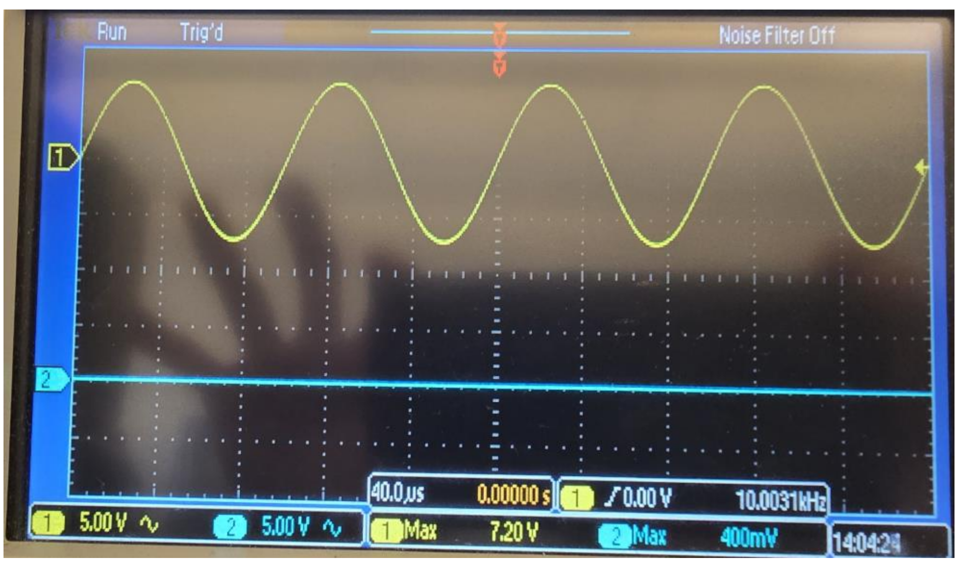

Figure 7. Left and Right Channel Output w/ $0.5V_p$ @ 10kHz Audio Pan Set to Left

$$A_v = \frac{7.2}{.5} = 14.4\frac{V}{V}$$

Gain from this test is 15.2

Audio Pan control set between middle and left with a $0.5V_p$ 10kHz sine wave from the function generator applied to both Left (yellow) and Right(blue) channels. Volume Knob set to max.

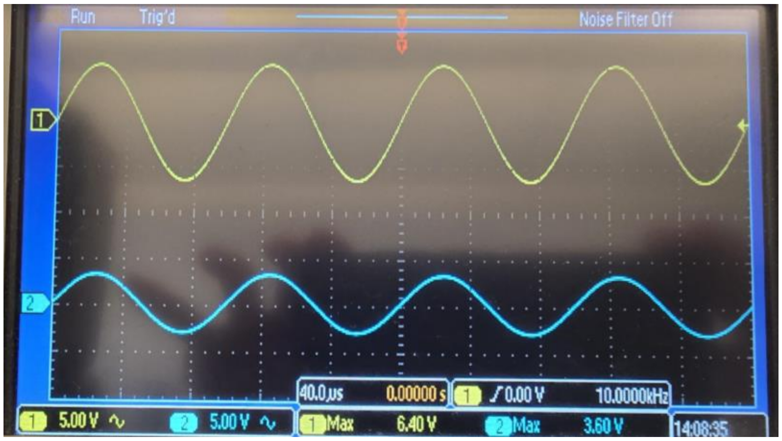

Figure 7. Left and Right Channel Output w/ $0.5V_p$ @ 10kHz Audio Pan Set between Middle and Left

Audio Pan control set between middle and left with a $0.5V_p$ 10kHz sine wave from the function generator applied to both Left (yellow) and Right(blue) channels. Volume Knob set to max.

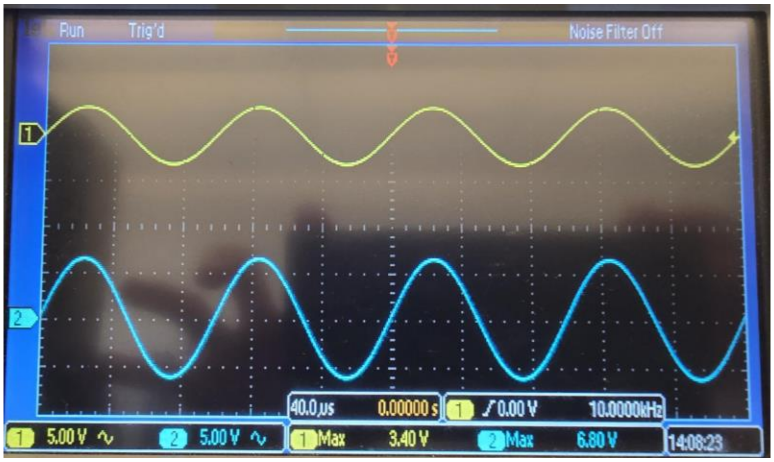

Figure 7. Left and Right Channel Output w/ $0.5V_p$ @ 10kHz Audio Pan Set between Middle and Right

Based on the results of the tests conducted, it can be concluded that the Audio Pan function operates as intended, providing smooth and accurate control over the distribution of the audio signal between the left and right channels. When the pan control was set to the middle position, the left and right channels exhibited equal gain and produced balanced output levels, confirming that the signal was evenly distributed. As the pan control was adjusted to full right, the output from the right channel increased significantly while the left channel output decreased, demonstrating that the audio signal was directed predominantly to the right channel. Conversely, when the pan control was set to full left, the left channel output increased while the right channel output decreased accordingly. Intermediate positions between the middle and full left or right showed proportional variations in output levels, reflecting precise panning behavior.

4.2 Test 2: Frequency Response Range

Obtained Voltage gains for input frequencies of 100Hz, 500Hz, 800Hz, 2kHz, 6kHz, 10kHz. With Volume Knob set to max and Audio Pan set to middle. Gain was calculated for each of these values detailed below each of the figures.

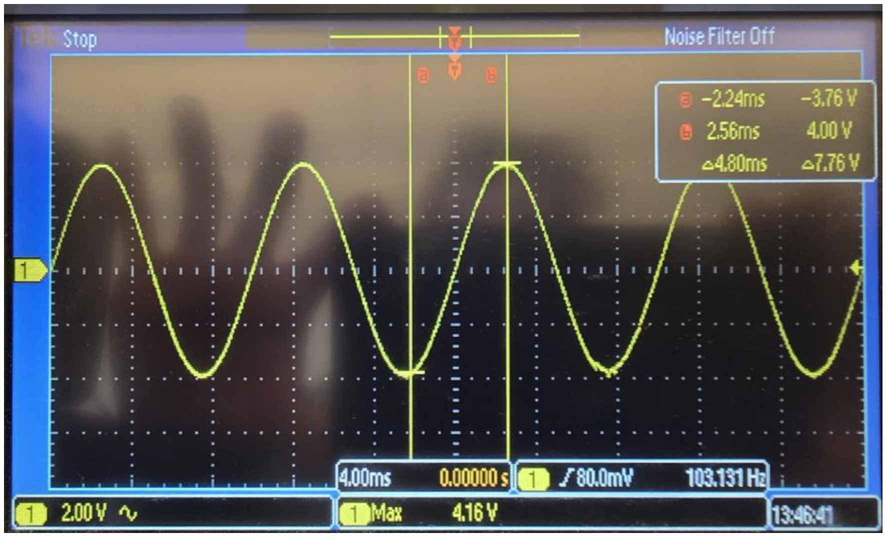

Figure 7. Circuit output w/ $0.5V_p$ input @ 100Hz

$$A_v = \frac{4.6\text{V}}{0.5\text{V}} = 9.2\ \frac{\text{V}}{\text{V}}$$

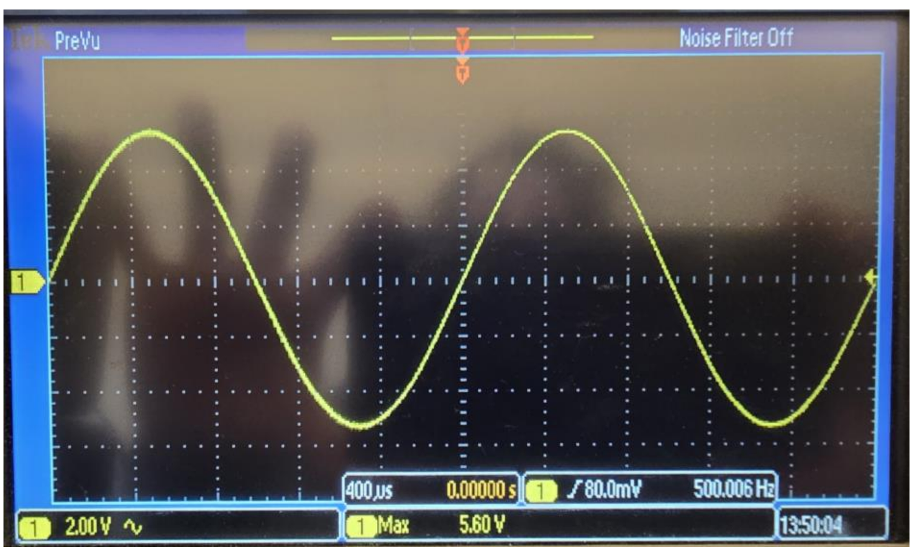

Figure 7. Circuit output w/ $0.5V_p$ input @ 500Hz

$$A_v = \frac{5.6\text{V}}{0.5\text{V}} = 11.2\ \frac{\text{V}}{\text{V}}$$

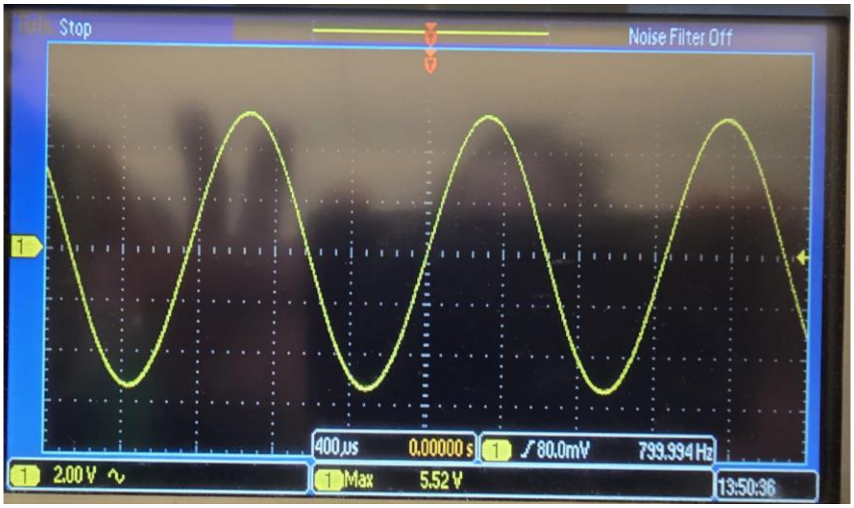

Figure 7. Circuit output w/ $0.5V_p$ input @ 800Hz

$$A_v = \frac{5.52\text{V}}{0.5\text{V}} = 11.04\ \frac{\text{V}}{\text{V}}$$

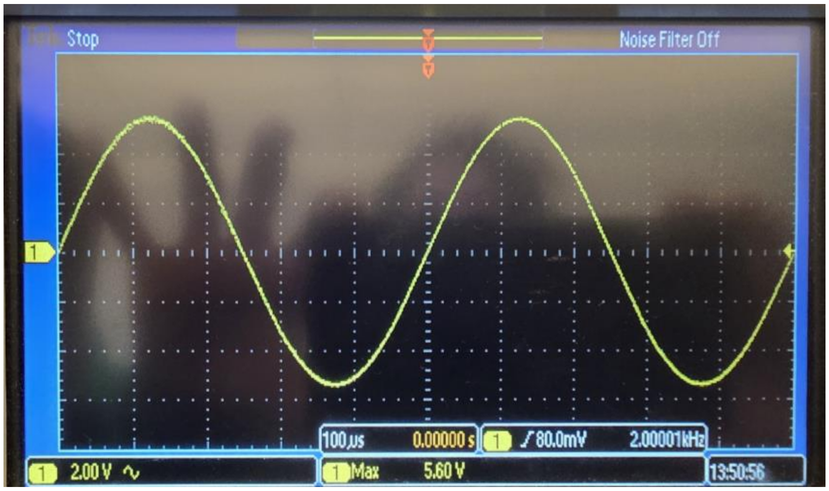

Figure 7. Circuit output w/ $0.5V_p$ input @ 2kHz

$$A_v = \frac{5.6\text{V}}{0.5\text{V}} = 11.2\ \frac{\text{V}}{\text{V}}$$

Figure 7. Circuit output w/ $0.5V_p$ input @ 6kHz

$$A_v = \frac{5.6\text{V}}{0.5\text{V}} = 11.2\ \frac{\text{V}}{\text{V}}$$

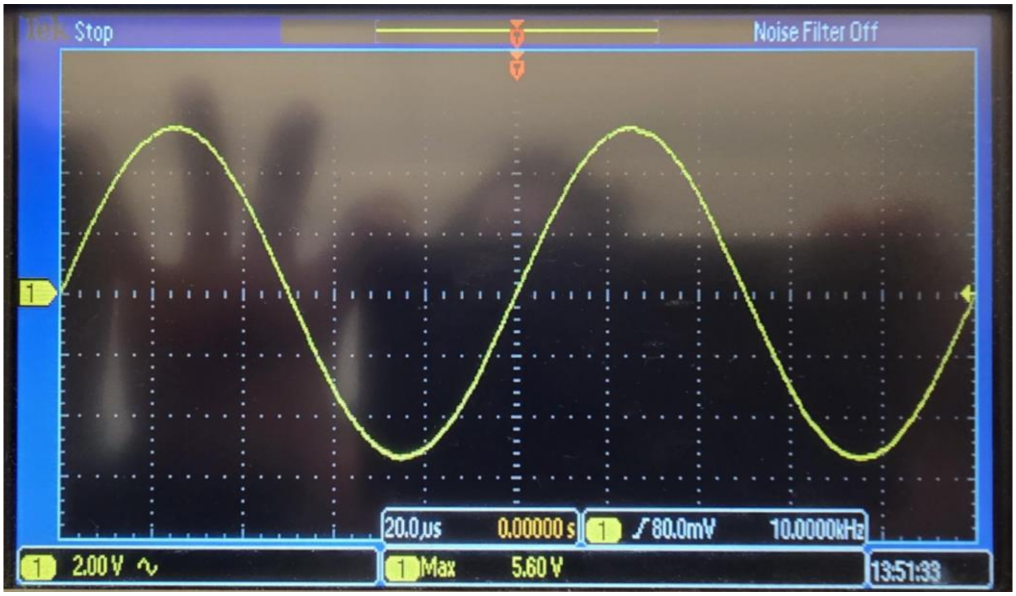

Figure 7. Circuit output w/ $0.5V_p$ input @ 10kHz

$$A_v = \frac{5.6\text{V}}{0.5\text{V}} = 11.2\ \frac{\text{V}}{\text{V}}$$

Based on the results of the tests and the peak voltage values measured on the o-scope The gain increased with higher frequencies but leveled off at 11.2 V/V or about 21 dB gain.

4.3 Test 3: Microphone Response

Tested Microphone Response by whistling into it. Volume knob set to middle, and Mic Gain Knob set to Full.

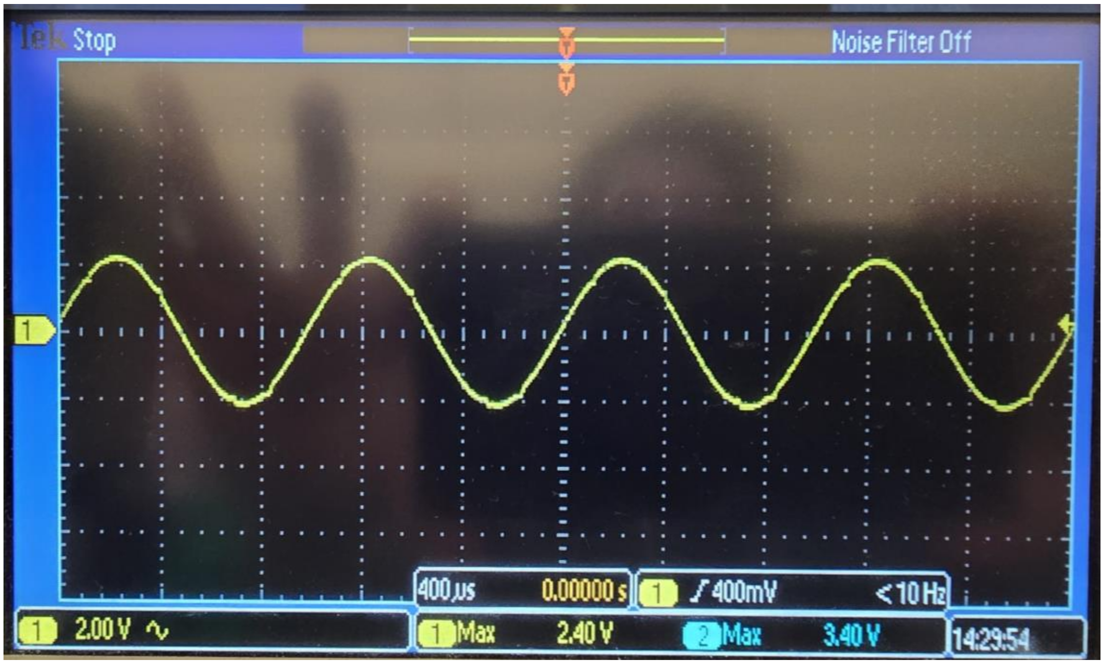

Figure 7. Whistling into Microphone output

Played 1Khz Tone from Laptop and whistled into microphone.

Figure 7. 1kHz Tone input while Whistling into Microphone

4.4 Test 4: Speaker Sound Test

Tested Sound by playing music through speakers. Volume set to quarter volume and Audio Pan set to center.

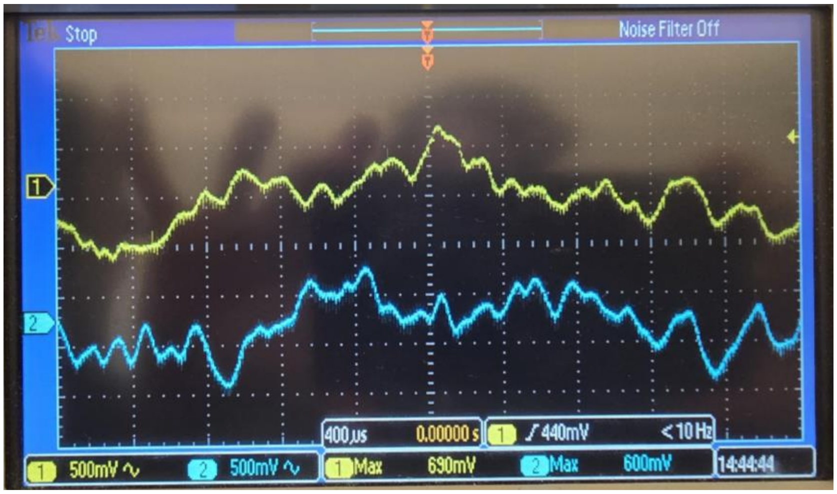

Figure 7. Playing Music Through Speaker

A series of qualitative tests were conducted to evaluate the performance of the microphone and music output through the speakers under various conditions. These tests assessed clarity, volume response, and potential issues such as feedback or distortion.

1. **Music Playback at Different Volumes**:
   Music was played through the speakers at varying volume levels. The audio output was clear and distortion-free across the entire volume range, from low to peak levels, performing as expected.

2. **Microphone Output at Half Volume with Full Microphone Gain**:
   The microphone signal was tested with the speaker volume set to half and the microphone gain set to maximum. The output was clear and free from noise, indicating that the preamp and amplification stages were functioning correctly.

3. **Microphone Output at Greater than Half Volume with Full Microphone Gain**:
   When the speaker volume was increased beyond half with the microphone gain set to maximum, a loud ringing noise (feedback) occurred. This is a typical issue caused by the microphone picking up amplified sound from the speakers.

4. **Simultaneous Music and Microphone Output at Half Volume with Full Microphone Gain**:
   Music and microphone audio were played simultaneously through the speakers with the volume set to half and the microphone gain at full. The output featured clear music playback mixed with clean microphone audio, demonstrating successful blending of the two audio sources without distortion or noise.

The results of these tests confirm that the audio system delivers high-quality sound for both music playback and microphone input under typical operating conditions. The system performs reliably when the speaker volume is kept at moderate levels with the microphone gain set appropriately. However, increasing the volume beyond half while using full microphone gain can introduce feedback (ringing noise), which is a common limitation in microphone-to-speaker systems.

5.0 Conclusions

The speaker design not only met but exceeded all system requirements by including higher power audio amplifiers and speakers. This enhancement allowed the speakers to reach significantly higher volumes, although it came with increased space requirements and heat generation.

We incorporated both the required aux input and microphone input, and we added an additional microphone input for versatility. The use of high-power audio amplifiers and speakers effectively eliminated most noise and distortion, with the only potential sources of noise and distortion being the microphones themselves.

Each microphone is equipped with its own gain control, and there is a master volume dial that allows users to adjust the overall sound level. Additionally, the system includes a feature to balance audio between the left and right speakers, providing flexible sound distribution.

Appendix A – Electrical Schematics

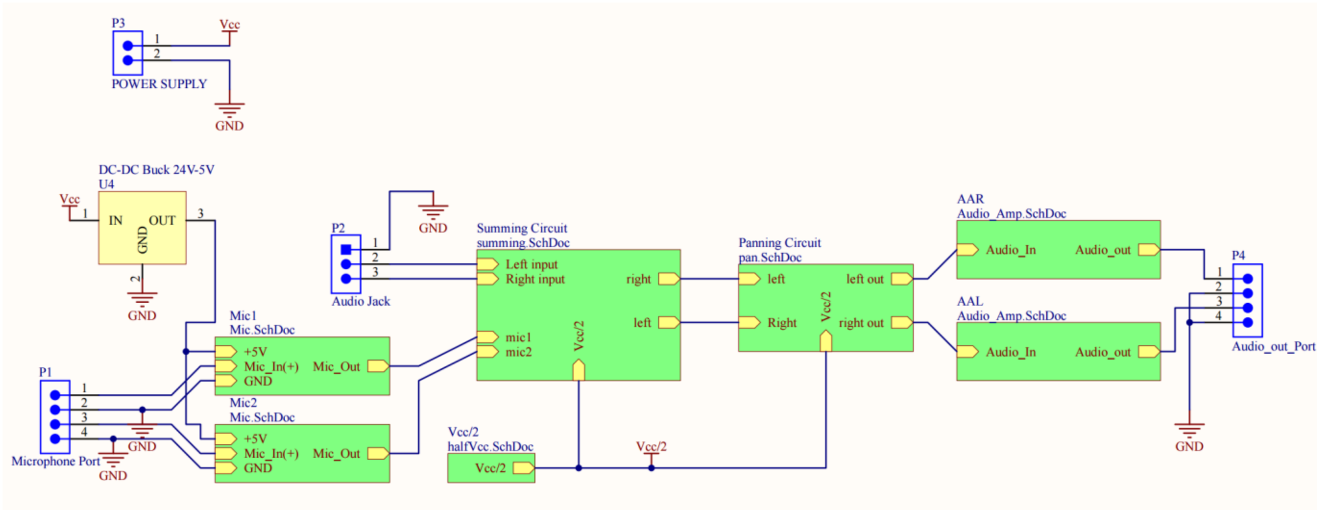

Figure A1. High Level Schematic

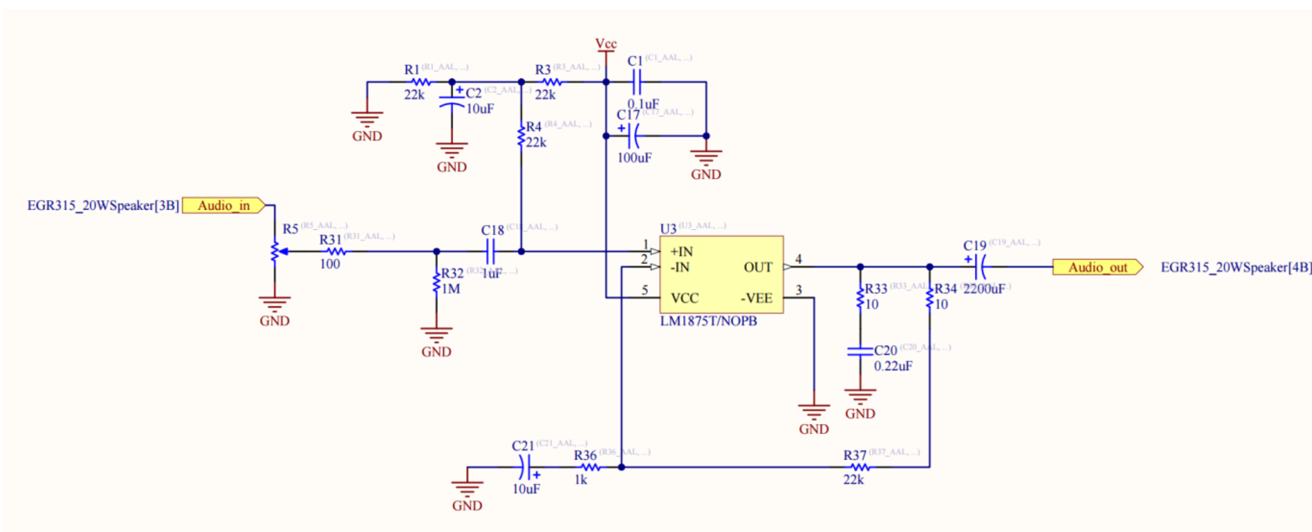

Figure A2. LM1875 Audio Amp Circuit Left and Right

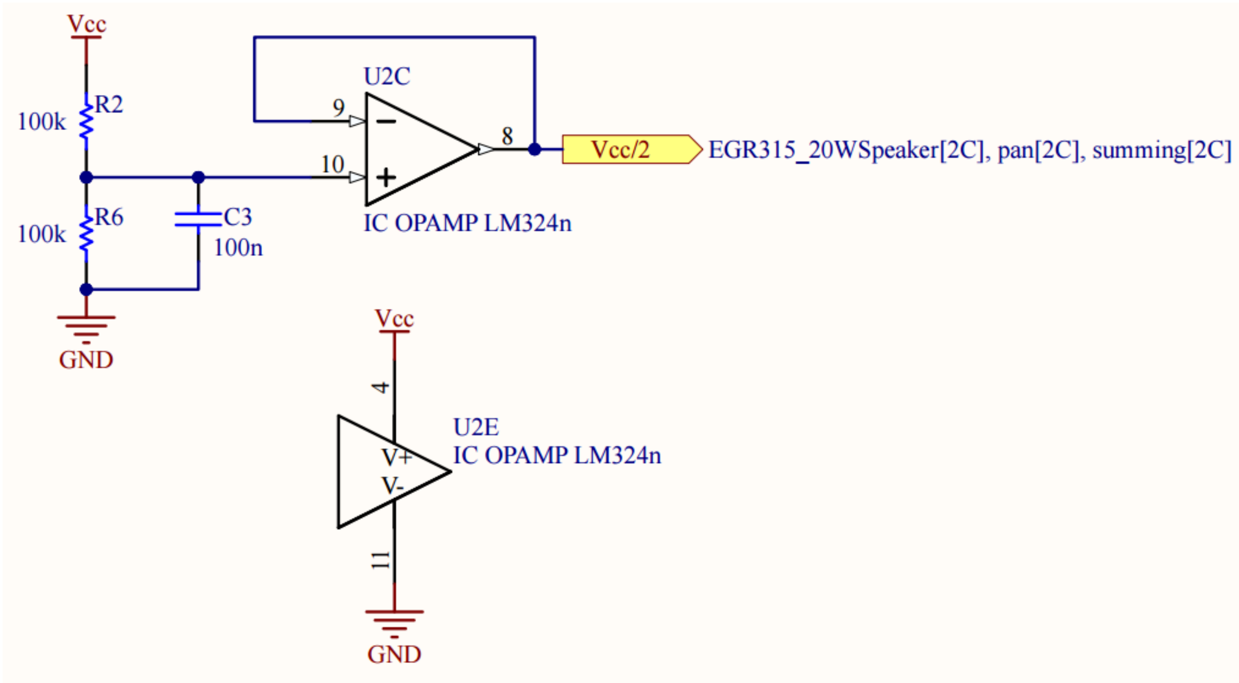

Figure A3. Vcc/2

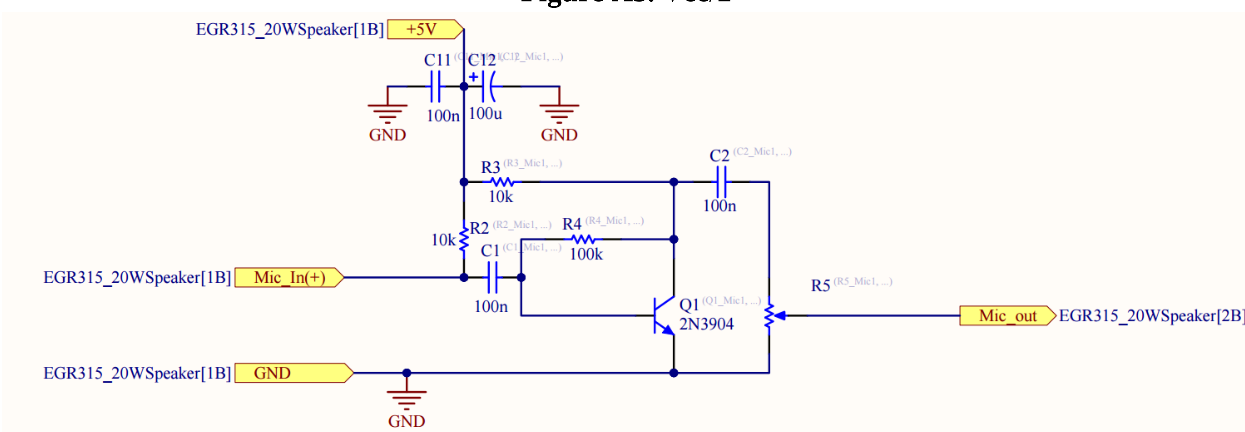

Figure A4. Electric Mic Preamp

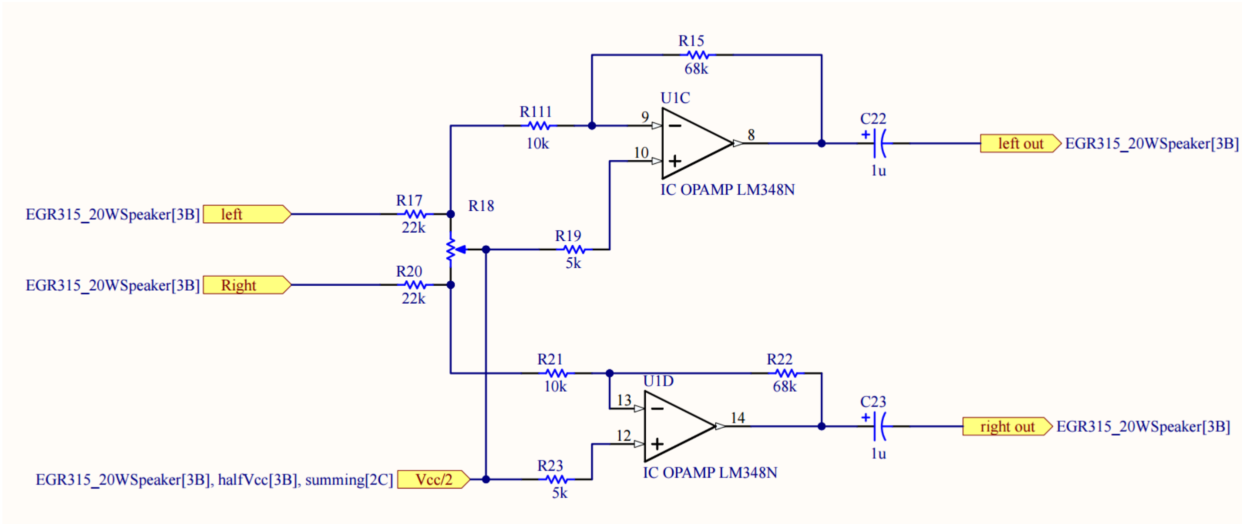

Figure A5. Audio Pan

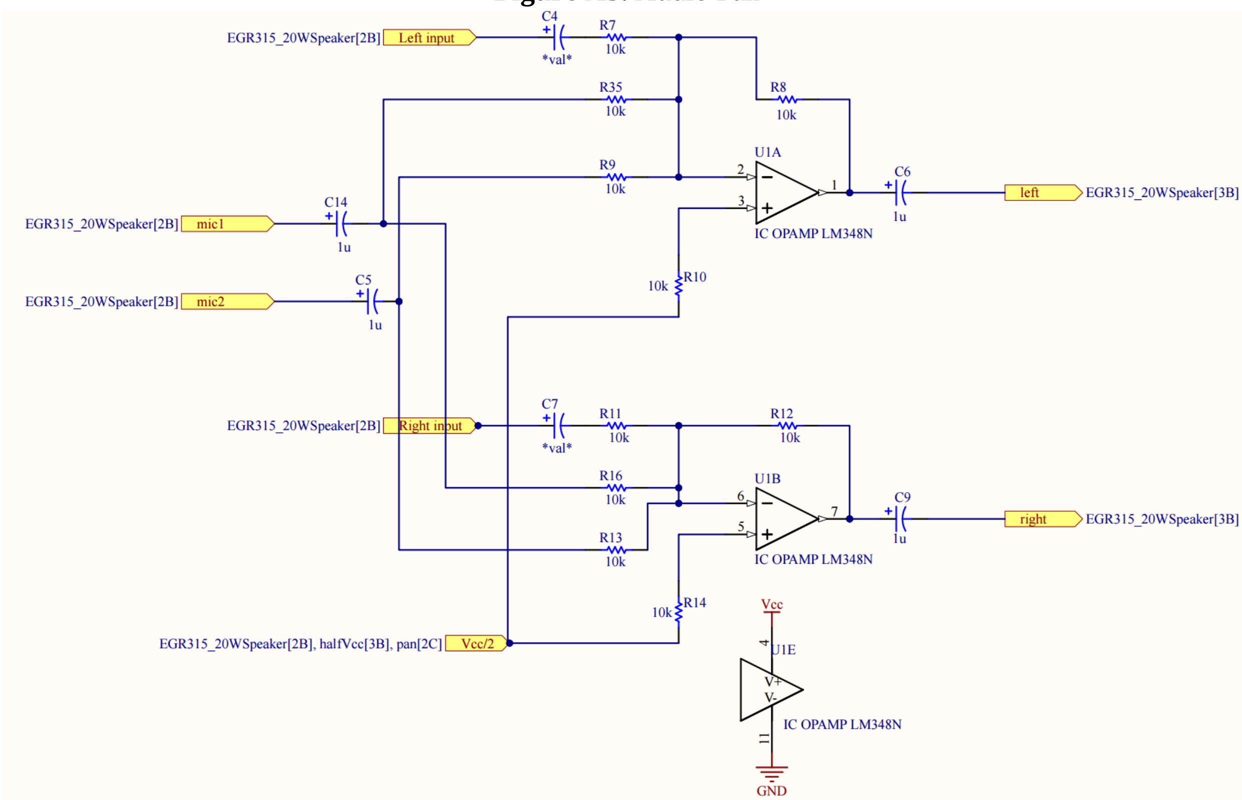

Figure A6. Audio Summing

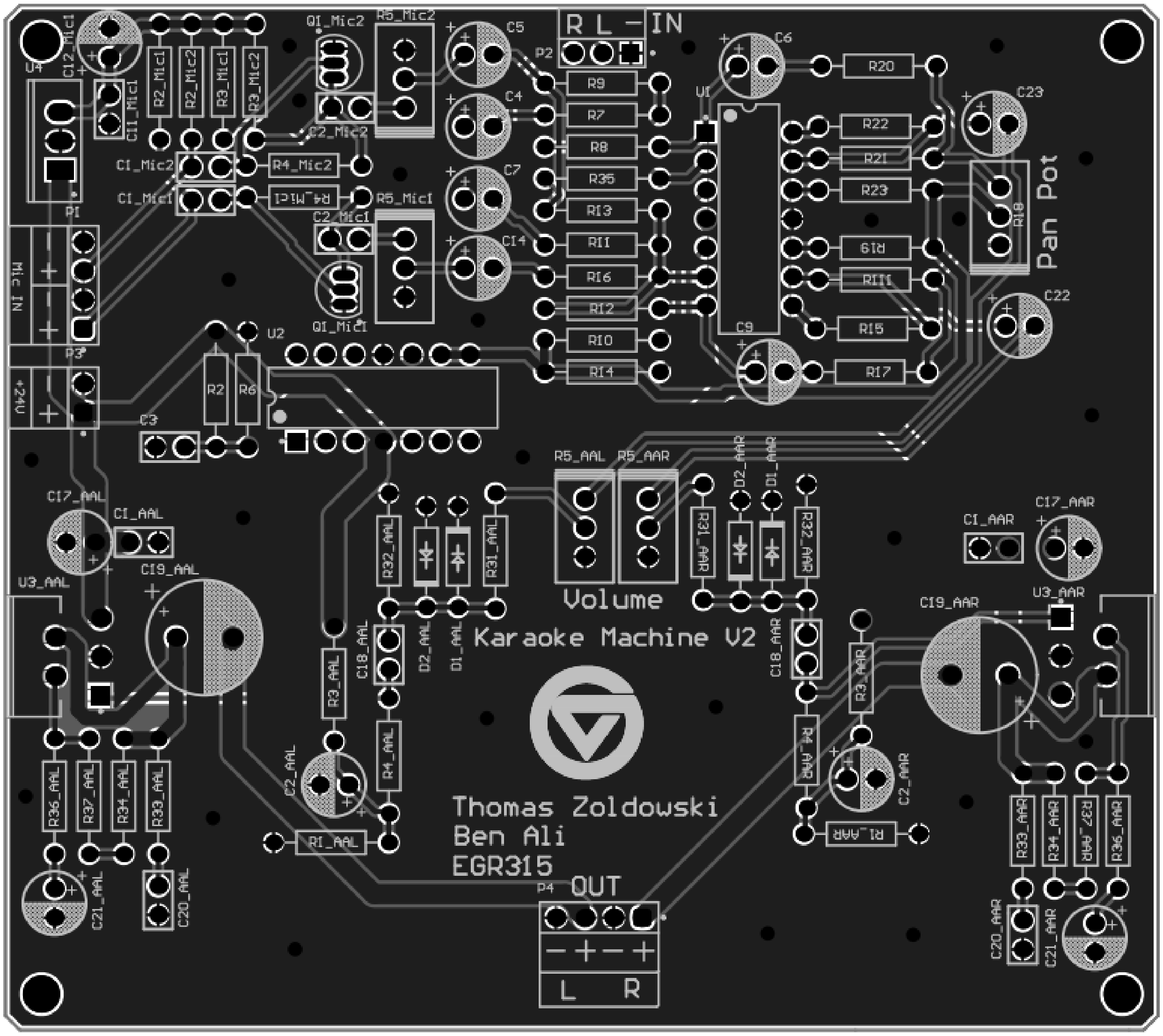

Figure A7. PCB Front

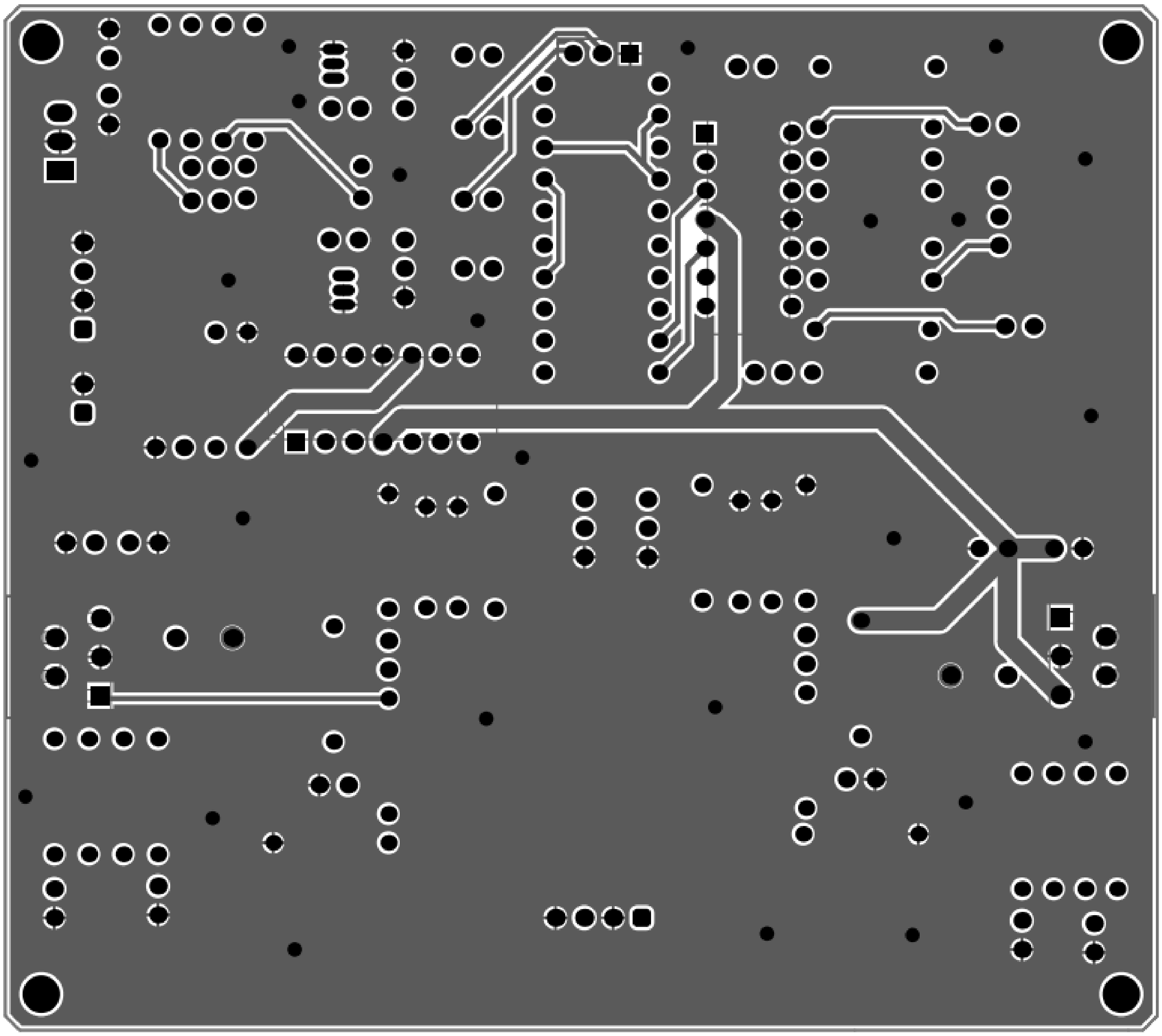

Figure A8. PCB Back

Appendix B – Bill of Materials

Table B1. BOM

Name	Description	Quantity	Value	Supplier Subtotal 1
2 Pin Header		1	-	$0.20
4 Pin Header		2	-	$0.12
RES 1/4W Carbon Axial Thru 0.400"	5% Tolerance 1/4W Carbon Axial Resistor	2	1k	$0.05
RES 1/4W Carbon Axial Thru 0.400"	5% Tolerance 1/4W Carbon Axial Resistor	2	1M	$0.02
RES 1/4W Carbon Axial Thru 0.400"	5% Tolerance 1/4W Carbon Axial Resistor	2	4.7k	$0.08
RES 1/4W Carbon Axial Thru 0.400"	5% Tolerance 1/4W Carbon Axial Resistor	2	68k	$0.01
RES 1/4W Carbon Axial Thru 0.400"	5% Tolerance 1/4W Carbon Axial Resistor	2	100	$0.01
RES 1/4W Carbon Axial Thru 0.400"	5% Tolerance 1/4W Carbon Axial Resistor	4	10	$0.01
RES 1/4W Carbon Axial Thru 0.400"	5% Tolerance 1/4W Carbon Axial Resistor	4	100k	$0.01
RES 1/4W Carbon Axial Thru 0.400"	5% Tolerance 1/4W Carbon Axial Resistor	10	22k	$0.02
RES 1/4W Carbon Axial Thru 0.400"	5% Tolerance 1/4W Carbon Axial Resistor	16	10k	$0.01
LM1875T/NOPB	20-W Audio Power Amplifier, 5-pin TO-220, Pb-Free	2	-	$3.34
CAP Al Electrolytic Radial Thru 0.098"x0.197"	Aluminum Electrolytic Capacitor 0.098" Lead Spacing, 0.197" Diameter	4	10u	$0.44
CAP Al Electrolytic Radial Thru 0.098"x0.197"	Aluminum Electrolytic Capacitor 0.098" Lead Spacing, 0.197" Diameter	4	100u	$0.88
CAP Al Electrolytic Radial Thru 0.098"x0.197"	Aluminum Electrolytic Capacitor 0.098" Lead Spacing, 0.197" Diameter	8	1u	$0.44
CAP Al Electrolytic Radial Thru 0.197"x0.394"	Aluminum Electrolytic Capacitor 0.197" Lead Spacing, 0.394" Diameter	2	2200u	$0.22
2N3904	BJT NPN 80V 0.2A	2		$0.10
RES Potentiometer 3296	Bourns 3296 Potentiometer	5	10k	$8.10
CAP Ceramic Radial Thru 0.100"	Ceramic Capacitor 0.100" Pitch	2	0.1u	$0.46
CAP Ceramic Radial Thru 0.100"	Ceramic Capacitor 0.100" Pitch	2	0.22u	$1.60
CAP Ceramic Radial Thru 0.100"	Ceramic Capacitor 0.100" Pitch	2	1u	$0.46
CAP Ceramic Radial Thru 0.100"	Ceramic Capacitor 0.100" Pitch	7	100n	$0.46
IC OPAMP LM324n	IC OPAMP GP 4 CIRCUIT	2	-	$0.68
DC-DC Buck 24V-5V	IC REG LINEAR 5V 1.5A	1	-	$4.18
3 Pin Header	Male Header	1	-	$0.07
Tweeter Speaker	Dayton Audio ND25FW-4 1" Soft Dome Neodymium Tweeter	2	-	$20.70
Midbass Woofer Speaker	Dayton Audio TCP115-4 4" Treated Paper Midbass Woofer 4 Ohm	2	-	$25.96
			TOTAL	**$68.62**

Appendix C – Mechanical Drawings

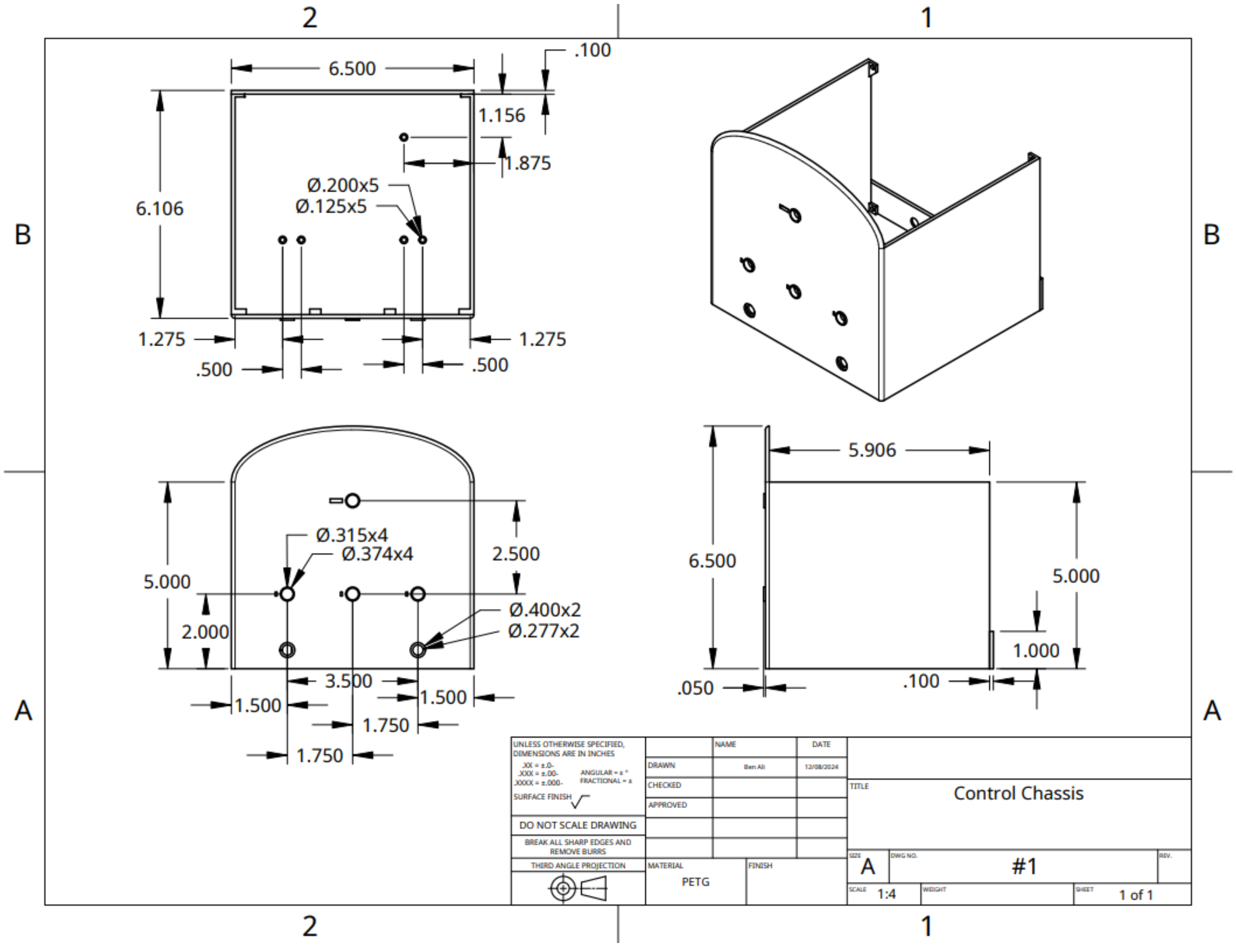

Figure C1. Control Chassis Mechanical Drawing

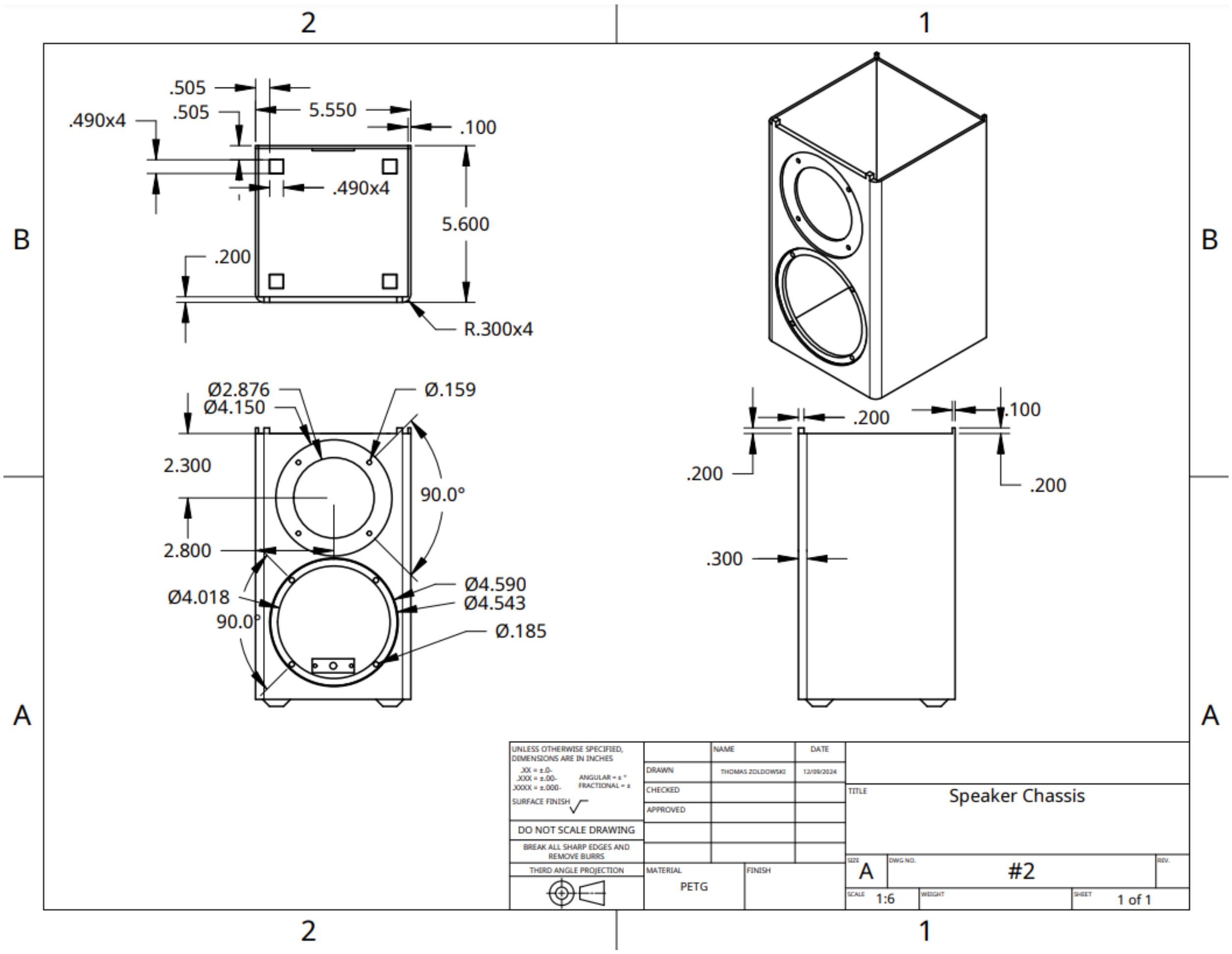

Figure C2. Speaker Chassis Mechanical Drawing

Appendix D – Project Day

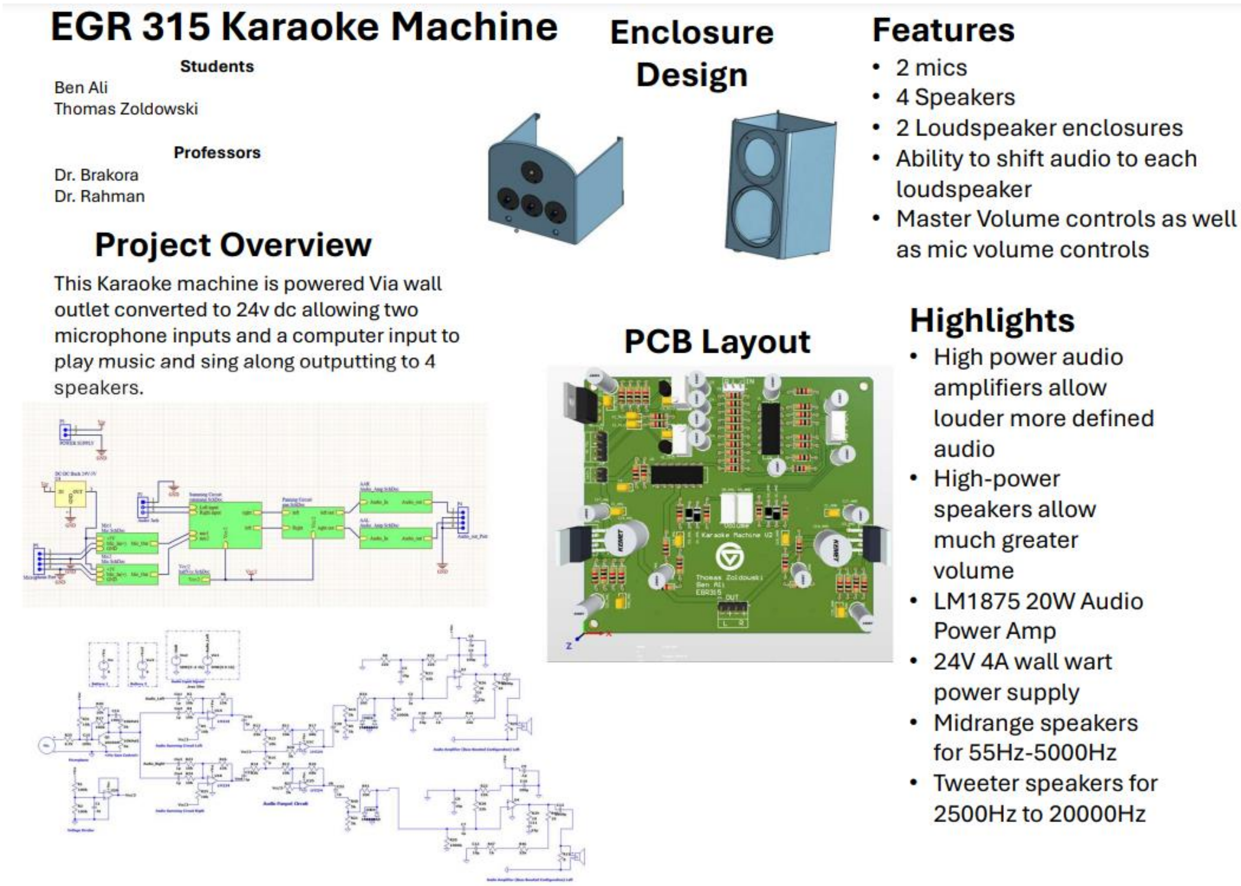

Figure D1. Project Day Poster