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| Brigham Young University - Idaho |
| ECEN 250 - Circuits Laboratory Lab #6 |
| Microphone Pre-Amp and Mixer Simulation, Solder, and Performance Evaluation |
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| **11/9/2022** |

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# Objectives

Choose resistor values for your pre-amp and mixer PCB to conform to design specifications. When this lab is complete, your stereo system will contain separate volume controls for audio and microphone input, as well as balance control.

# Principles to be studied

* High gain amplifier design
* Microphone output impedance
* Thévenin equivalents
* Op-amp virtual short characteristics and input impedance
* Summing amplifier design

# Background

As discussed in Lab 4, this stereo system will have a microphone input, but this creates 2 issues: the input signal from the microphone is incredibly small and must be amplified, and the microphone is only a single channel. The pre-amp will solve the first problem, and the mixer will integrate the single-channel signal into both the left and right channels. With the volume control module situated before the mixer stage, the microphone and audio signals will have separate and independent volume controls.

# Design Specifications

* Frequency Response: Within for
* Pre-amp input impedance: Matched to mic, ~600Ω
* for all other amplifier stages
* All equivalent

# Design

Diagram

Description automatically generated

Figure 1 – Stereo System (Right and Left Channel) Block Diagram

The Power Op Amp on the Mother PCB frequency contributes to noise in the audio signal. We believe it is due to insufficient decoupling capacitors. Since we are using powered speakers, the power op amp can be bypassed using the header jumper pins so that the output of the balance goes directly to the 1/8” output port, as shown:

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# Simulate the Pre-Amp

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| --- |
|  |
| Figure 2 – Simulation Model for Microphone with Output Impedance (in yellow) and Device Under Test (DUT) - Pre-amp |

The voltage source should be a sinusoidal voltage with an amplitude of However, the microphone has an output impedance specified on the box, so make sure and put this output impedance in series with your microphone source in your simulation. See Figure 2 for how to model this impedance. Your simulation should include a Transient Analysis for each amplifier stage, as well as the overall gain (if you used a multi-stage amplifier design). Use the first 5 columns of Table 1 to help you gather the information you need (the values currently in the table serve as an example – delete them and enter the information pertinent to your circuit). Add or delete rows as needed. Include the simulation and Table 1 in your lab report.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Description** |  | |  |  |  | **Vin(actual)** |  |  |
| Pre-Amp, Stage 1 | 38.75 | | 4mv | 155mV | 65mV | 4.3mV | 166mV | 38.7 |
| Pre-Amp, Stage 2 | 38.75 | | 4mv | 155mV | 65mV | 31mV | 1.2V | 38.7 |
| Pre-Amp, Total | 277 | | 4mV | 1.1V | 1.2V | 4.3mV | 1.2 | 279 |
|  | | Table 1 – Calculated, Simulated, and Actual Results for Each Amplifier Stage | | | | | | |

# Performance Evaluation

Solder the components to your board if you have not done so already. Once you have done this, configure the oscilloscope and the function generator with your circuit to emulate the simulations you ran for the microphone pre-amp. Compare your expected (simulated) results with the actual (measured) results. Include screenshots of the oscilloscope in your report and indicate the correlation between your expected and actual results. Then complete *Table 2* to help you verify that your circuit meets the frequency response specifications.

As shown in Figure 3 Microphone input DC blocking capacitor, there is a DC blocking capacitor on the microphone input line. If you apply a sinusoidal signal from the function generator before this capacitor, it will attenuate the lower frequency signals and you will not see the gain that was designed for your pre-amplifier at these lower frequencies. To avoid this attenuation from affecting your gain calculations of your pre-amp circuit, you can either temporarily short out the capacitor or you can carefully apply the signal from the function generator directly to the Min header pin while you make your gain calculations. You can also just allow the signal to be attenuated by the capacitor and then measure the attenuated signal at Min as the new input voltage to the pre-amp and use this value when calculating the gain.

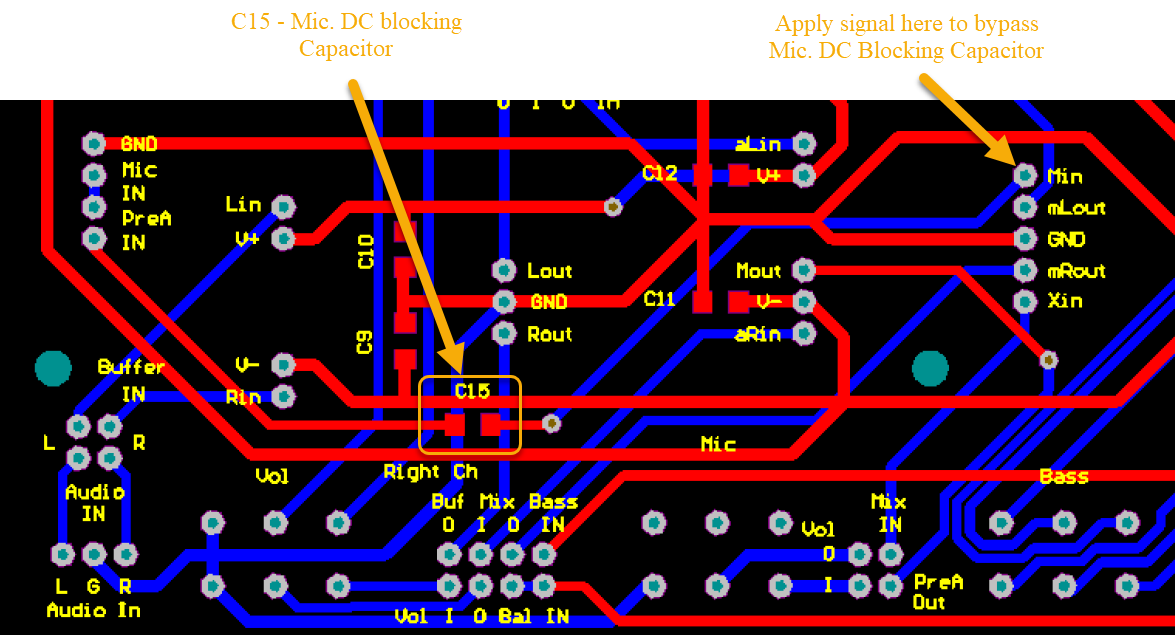


Figure Microphone input DC blocking capacitor

To evaluate the performance of the mixer, use the same input signal for both the audio and microphone input. Since the input signal is the same, and the output signal should be the sum of both inputs, the output voltage should be twice the value of the input signal.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Amplifier** | **Frequency (Hz)** |  |  |  |  |  | **Error** |
| **Pre-Amp** |  | 4mV | 1.1V | 30.8V | 277 | 198.7 | 78.3 |
|  | 4mV | 1.1V | 30.8V | 277 | 198.7 | 78.3 |
|  | 4mV | 1.1V | 30.8V | 277 | 198.7 | 78.3 |
|  | 4mV | 1.1V | 30.8V | 277 | 198.7 | 78.3 |
| **Mixer Left Channel** |  | 1V | 2V | 2.48V | 2 | 2.04 | .04 |
|  | 1V | 2V | 2.48V | 2 | 2.05 | .05 |
|  | 1V | 2V | 2.48V | 2 | 2.05 | .05 |
|  | 1V | 2V | 2.48V | 2 | 2.05 | .05 |
| **Mixer Right Channel** |  | 1V | 2V | 2.48V | 2 | 2.04 | .05 |
|  | 1V | 2V | 2.48V | 2 | 2.05 | .05 |
|  | 1V | 2V | 2.48V | 2 | 2.05 | .05 |
|  | 1V | 2V | 2.48V | 2 | 2.05 | .05 |
| Table 2 – Pre-Amp and Mixer Frequency Response | | | | | | | |

Verify that the frequency response of your circuit meets design specifications by completing *Table 2* and Table 3.

|  |  |  |  |
| --- | --- | --- | --- |
| **Amplifier** |  |  | **Frequency Response** |
| **Pre-Amp** | 78.3 | 78.3 | 0 |
| **Mixer (L)** | 2.04 | 2.05 | .01 |
| **Mixer (R)** | 2.05 | 2.05 | 0 |
| Table 3 – Frequency Response Verification | | | |

# Pass Off

Integrate the pre-amp and mixers in with the rest of your system by inserting it into its corresponding slot, and by configuring the header jumpers in a fashion consistent with Figure 4. In the jacks provided on the chassis, hook up the powered speakers, an audio source, and the microphone. Make sure to short the ‘Bal Out’ pins to the ‘Out’ pins on the rightmost headers. You should be able to control the microphone volume independent of the audio volume with the two different knobs on the chassis. Make sure the audio and microphone signals are reasonably balanced (one does not overpower the other). Once you test your system and it sounds good, have the teacher or a lab assistant pass off your circuit.

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| Figure 4 – Lab 5 Jumper Configuration |

# Lab Report

Your grade on this lab is based on the lab pass-off (verifiable from the pass of page included in your lab report) and the lab report itself. Lab report requirements can be found on I-Learn. The grading rubric is below. Include a schematic of your entire system in your report. This can be in multiple sheets or a single sheet.

|  |  |
| --- | --- |
| **Points** | **Description** |
| 50 | Pass-off |
| 5 | PCB Design Steps Summarized   * Schematic * Design Verification Simulation * Screenshot from JLCPCB |
| 10 | Simulations   * Pre-Amp * Table 1 * Mixer |
| 25 | Design specifications met   * Appropriate Oscilloscope screenshots (5) * Table 2 (10) * Table 3 (10) |
| 5 | Conclusion |
| 5 | Lab report quality (see iLearn - Lab 1 Module) |
| **100** | **Total** |

Appendix

# Male Headers Jumper Configuration

There are 49 male header pins that allow modular functionality for the kit. Starting from the top left, you’ll notice three pins labeled “Power input.” These are used to provide DC power to the kit, or as test points for the power rails (when plugged into the wall). Never supply power from both the AC inlet and a DC source. The rest of the headers serve to enable the different stages of the circuit. All the pictures represent the circuit under normal operation (all stages enabled).

On the lower left, the ‘Buffer IN’ header connects the audio left and right input with the buffer left and right inputs. If debugging the circuit, you may disconnect this jumper and use the buffer input pin to connect an alternate input into the buffer (i.e., a function generator). The ‘PreA IN’ jumper connects the microphone to the preamp input.

Next are two symmetrical 8-pin headers above and beneath the Line buffer. These correspond to the left and right channels respectively. “Vol I O” represents the input and output pins for the volume potentiometer. “Buf O” represents the output of the line buffer. Similarly, “Mix I O” represents the input and output of the audio mixer. Both pins by “Bal In” are balance pot inputs. The last one corresponds to the bass input. You may bypass the volume pot, for example, by taking the buffer output and shorting it to the mixer input. Likewise, you may bypass the bass & treble by placing the shunt over the mixer out and balance in. If only the volume and balance control is desired, then the volume output may be shorted directly to the balance input. Lastly, you may use female to female DuPont cables to set other configurations (i.e., buffer to bass).

On the right side of the board we find the “Pwr EN” header. This connects the positive and negative supply rails to the power-amp. Therefore, the power-amp is disabled if the shunts are not present. You’ll want to keep it disabled whenever you bypass the power-amp stage so that it does not distort the output signal.

For the last two headers, “B O,” “T O,” “P O,” and “Bal Out,” correspond to the Bass, Treble, Power-Amp, Balance outputs respectively. Similarly, an “I” represents the input pin for those stages. The “Out” pin represents the output jack’s connection. Whenever you want to bypass the power-amp, you connect directly to this pin.