ENGN/PHYS 207—Fall 2018
Assignment #4
Final Report Due Date: 5pm Wed Oct 24, 2018

Circuits You'll Build

1. 2-channel audio mixer with volume control, op-amp based
2. Strain measurement system: Instrumentation amplifier interfaced to Wheatstone Bridge and Arduino

Lab Skills You'll Learn

1. Wiring basic op-amp configurations (inverting amp, buffer)
2. Implementing Instrumentation Amplifiers
3. Arduino `if-else` logic to respond to measurements

1 Mix It Up: 2-channel Audio Mixer with master volume control

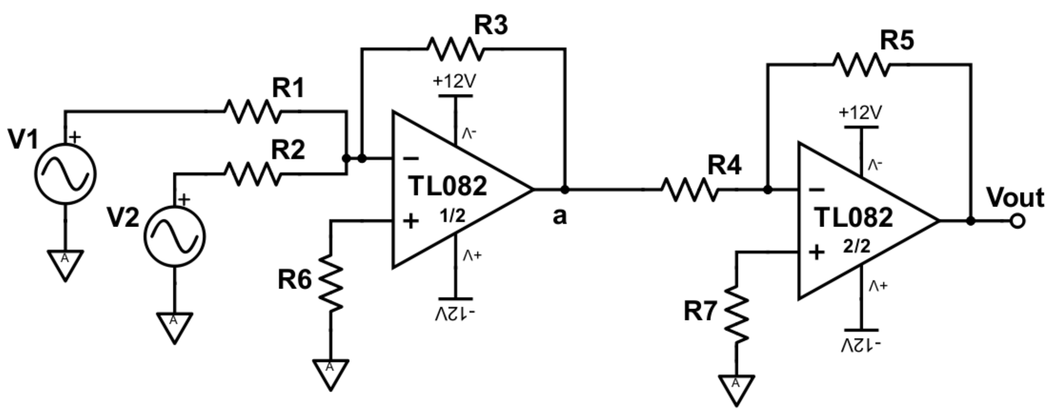

Figure 1: Generic topology of 2-channel audio mixer cascaded with master volume control built around a TL082 dual op-amp. V_1 and V_2 represent the two independent inputs (think: vocals and guitar). The TL082 is chosen for its high slew-rate. The dual power supply is indicated as ±12 V (though this is overkill, given we only want an max output of 1.5 V pk-pk.

We saw in class how to make a basic audio mixer. The general idea is to use an ***inverting summer*** configuration (Figure 1, first section), where the output inverting summer is given by:

$$V_a = -\left(\frac{R_3}{R_1}V_1 + \frac{R_3}{R_2}V_2\right)$$

Just like we can cascade filter sections, we can also cascade op-amp building blocks. So we can cascade the output of the mixer onto a master volume control, configured as ***inverting amplifier***.

The relationship between the output and input of the master volume control section is given by:

$$\frac{V_{out}}{V_a} = -\frac{R_5}{R_4}$$

Conveniently, we invert as we sum, then invert again through the volume control, such that the overall configuration is non-inverting.

A few notes about the general design shown in Figure 1. A TL082 op-amp is chosen because it features a high ***slew-rate*** of $13V/\mu s$. The slew rate is the maximum rate of change at the output (feedback takes time, the op-amp takes some time to adjust the output based on the input, just like your car has some lag time as it accelerates to the desired speed).

The resistors R_6 and R_7 are optional, but always good form to include. They should be chosen to be approximately equal to the parallel equivalent of the other resistors wired around the op-amp.

1.1 Problem Statement

Your objective is to design an audio mixer such that the relative strength of each source can be varied strictly between 1/10 and 10. Combined with a master volume control, the maximum output V_{out} should not exceed 3 V pk-pk =1.5 V amplitude. (This max voltage is a standard used in the audio and music industry.) Your system should also include the feature that turning the master volume knob all the way down should produce essentially 0 V output, thus no sound. As a pre-requisite for your design, you'll need to know/measure your audio device's signal amplitude (hint: just hook it up to the scope and press play).

This is open-ended design problem, there is no one single correct answer. However, there are some designs that work better than others.

1.2 Equipment and Components

You may use any components found in the Circuits lab, but are limited to using a single TL082 dual op-amp ***integrated circuit***.

You'll certainly want to make use of some audio equipment to hear the output from your circuit to assess demonstrate your audio mixer is functioning as intended.

You'll also want to use the scope to view the input and output signals from each section (conceptual block) of the audio mixer.

Use 2 audio sources (e.g., two mobile devices) as two independent voltage sources. Take your system for a test-drive mashing up whatever songs you wish. Best mash-up wins a small prize! I'm calling dibs on Despacito v. Gangnam Style :)

1.3 Reporting on Your Design

You must provide a live demonstration of the your circuit to officially complete this lab. You can do this either in person (preferred) or in video format.

You should ***gather sufficient data/evidence to clearly demonstrate proof-of-concept of both the: 1) the summer/mixer and 2) and the master volume control***. It is up to you to decide the nature and how much proof-of-concept data to acquire. As a hint: for the summing section, ground one input, use a sine wave source as input for the other input, show that you can turn a knob to vary the gain between 1/10 to 10. Do the same, but swapping which input is grounded. Then show the effect of summing sources.

Your written document is strictly limited to a maximum of 4 pages (not including the appendix). It should contain all of the following, but note this is a just meant to be a quick "here's what we designed and why", and "here's some evidence that the circuitry is working as intended." There is NO need to do any comparison of experiment vs. theory (like we have done in Labs 1-3):

1. Circuit schematic for final design, indicating all component values selected
2. General overview of circuit function, highlighting how the end-user actually uses the system.
3. Rationale and sample calculations that guided the choice of your component values
4. Sufficient proof-of-concept that the device works as intended. Oscilloscope screen shots and/or hand sketches may be extremely helpful here. For example, if you turn your knob on the audio mixer all the way in one direction, clearly show you achieve a gain of 1/10; then if you turn the other direction, you achieve a gain of 10.
5. Any discussion or commentary highlighting nice features of the device and/or suggestions for future improvements.
6. Appendix should include the following:
   (a) Brief derivation of the formulas provided for V_a and V_{out}.
   (b) Slew rate considerations: Assume the music content contains a maximum audible frequency of 5 kHZ sine wave, with a possible max amplitude of 1.5 V. Show that this input signal is appropriately amplified by the TL082, i.e., that the manufacturer specified slew rate is not exceeded.