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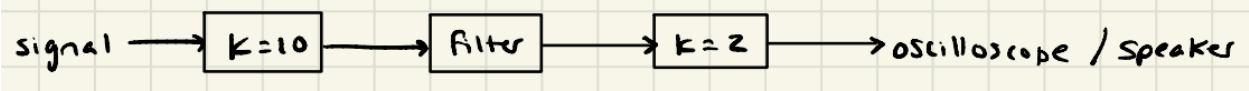
EE202 Project

Introduction

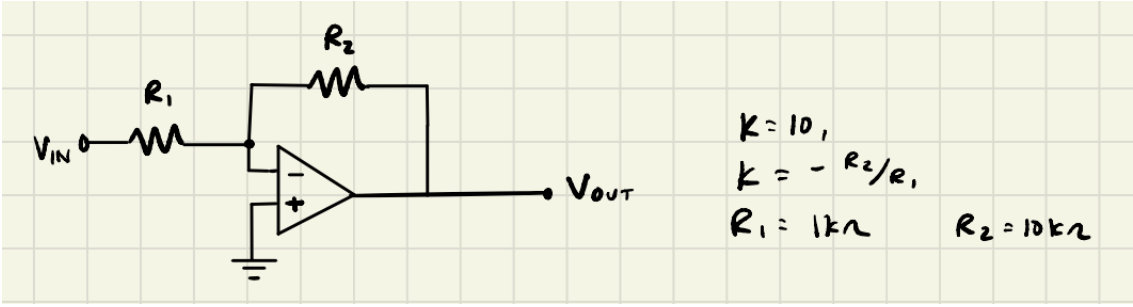
The basic function of an electric guitar relies on converting the oscillating motion of guitar strings into an electric signal for a speaker. To accomplish this, an array of magnetic pickups generate an electric current when the metal guitar strings are plucked. The output signal must then be amplified and filtered to ensure that only the necessary frequencies are passed to the speaker at a sufficient voltage level. In this project, electronic amplifier theory and filter circuit theory were used to design, analyze, simulate, construct, and test a cigar box electric guitar.

Design

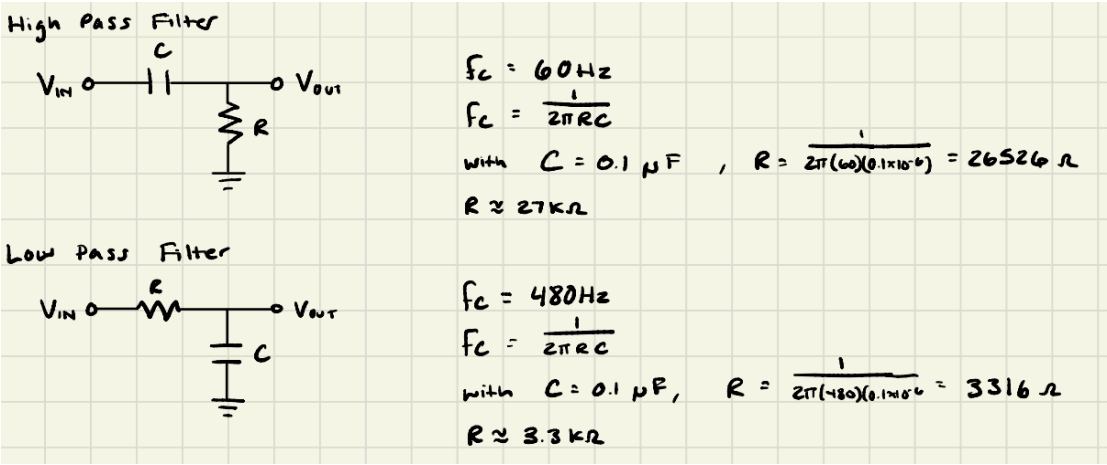
The circuit designed for the electric guitar takes a small input voltage from the magnetic pickups and outputs directly to a speaker. In order to ensure that the signals received from the pickups are able to play through the speaker and that the correct frequencies are played, a four stage circuit is necessary. The four stages are an amplifier for the input signal, a passive low pass filter, and passive high pass filter, and an amplifier for the output signal. A block diagram of the stages is shown below.



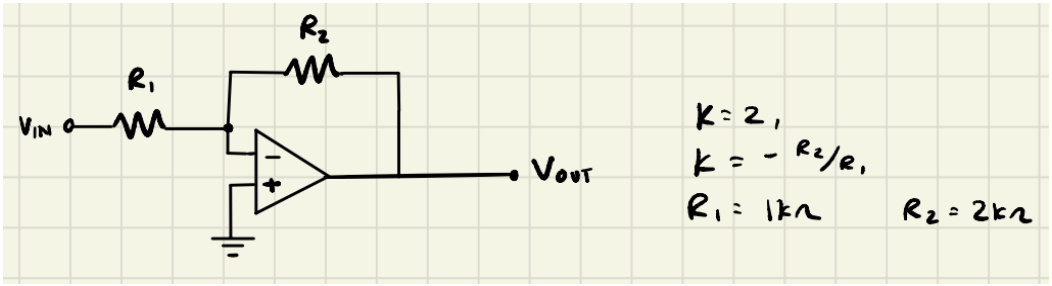
For the first amplifier stage, a gain of 10 was chosen to increase the voltage of the input signal from the millivolt values produced by the magnetic pickups. Using an inverting op amp circuit, this was achieved using a 1kΩ and 10kΩ resistor, as shown below.



To filter out the correct frequencies from each guitar string, a band pass filter allowing only the range of frequencies for each note was needed. The band pass filter is composed of a high pass filter stage and a low pass filter stage. The high pass filter cut off was selected to be 60Hz and the low pass filter cutoff was selected to be 480Hz, creating a band of 60Hz-480Hz which encompasses all of the note frequencies. The two stages are shown below:

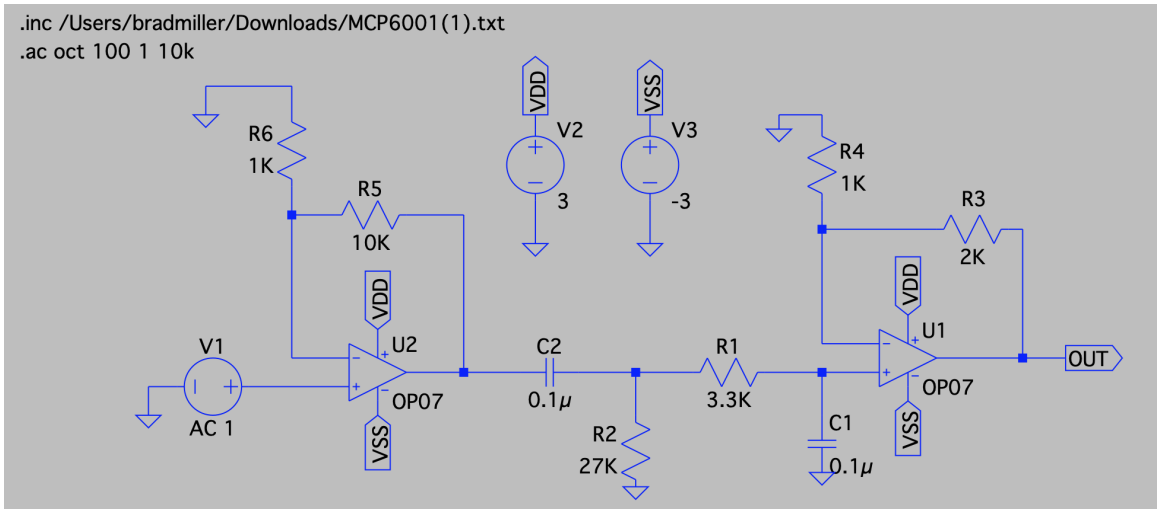


Finally, a second amplifier circuit was used to make up for voltage losses due to the filter circuitry, providing a gain of 2 using a 1kΩ and a 2kΩ resistor. The amplifier is shown below:

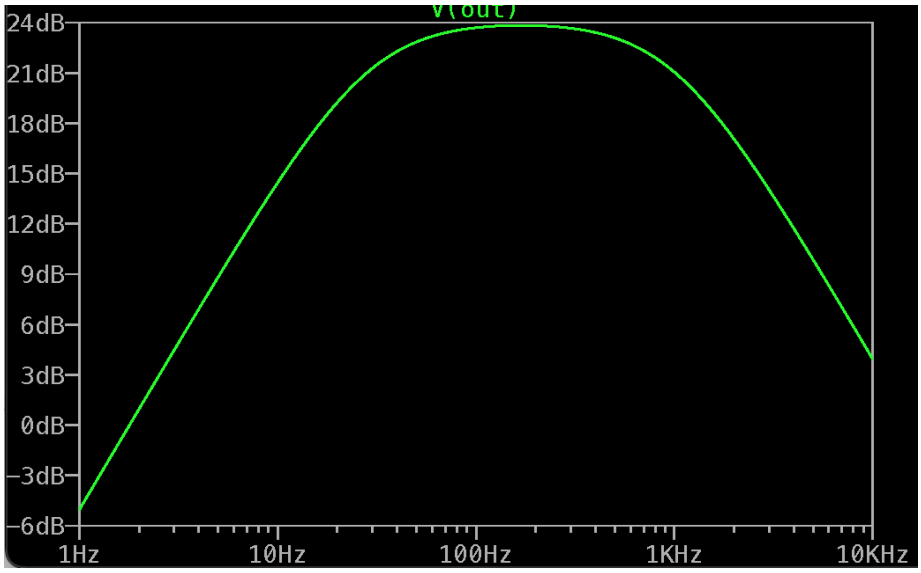


Simulation

LTSpice was used to conduct a simulation of the circuit designed on paper. Using LTSpice built in components, an imported MCP6001 Op Amp component, and a simple AC input command, the circuit could be visualized and tested. The constructed circuit with the imported components and AC signal command are shown below:



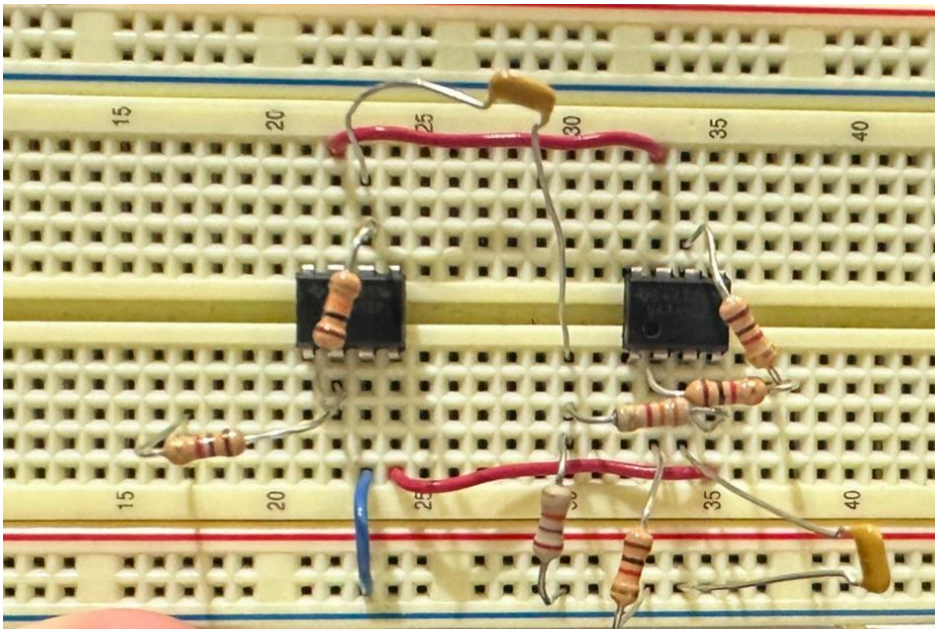
To test the proper functioning of the circuit, the AC input signal was tested from 1Hz to 10Khz. The power of each frequency at Vout was measured and graphed, as shown below:



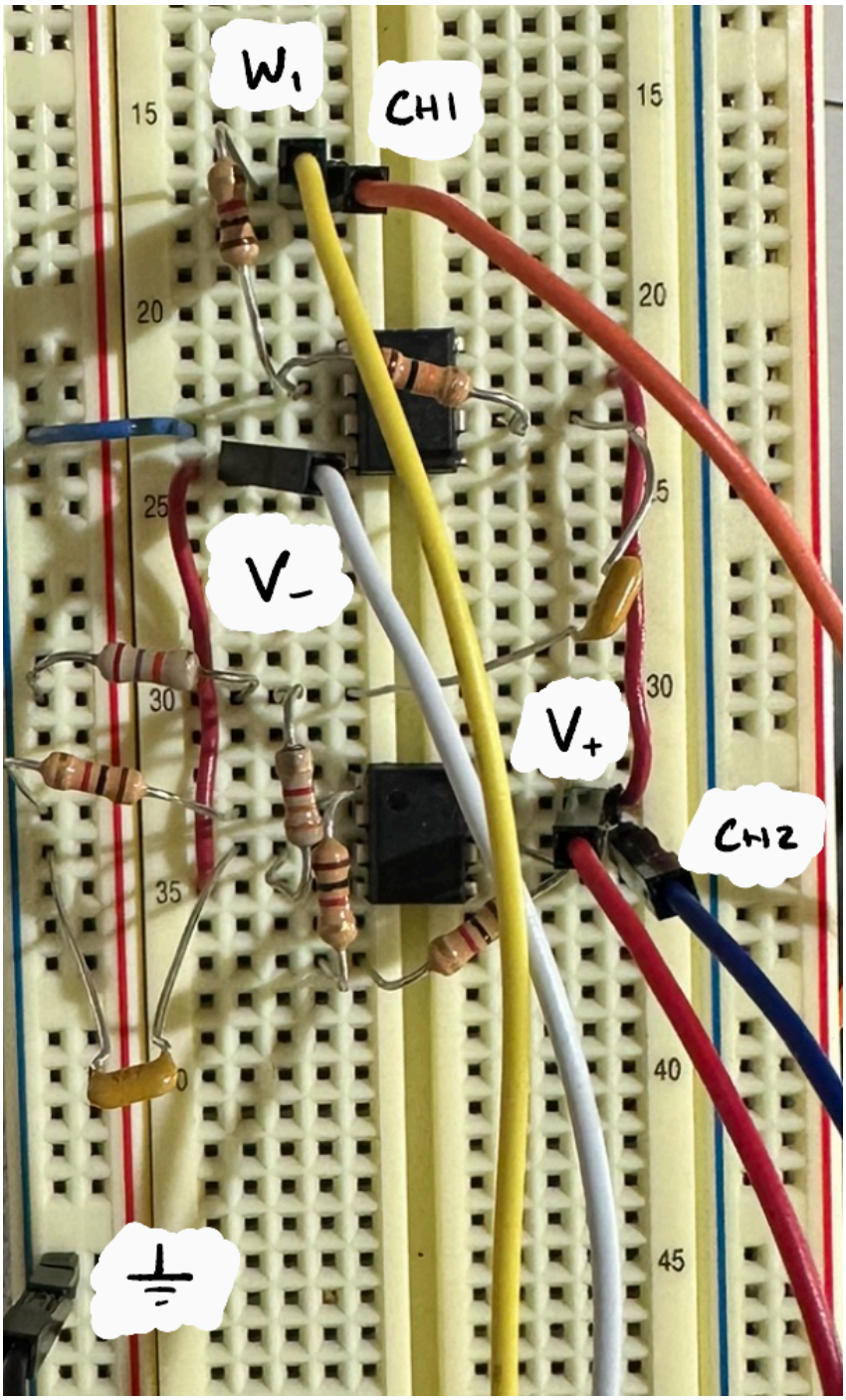
Through this graph, it is apparent that the frequencies between 60Hz and 480Hz are the most powerful ones. This is in line with the theoretical design and constraints required for the project.

Implementation

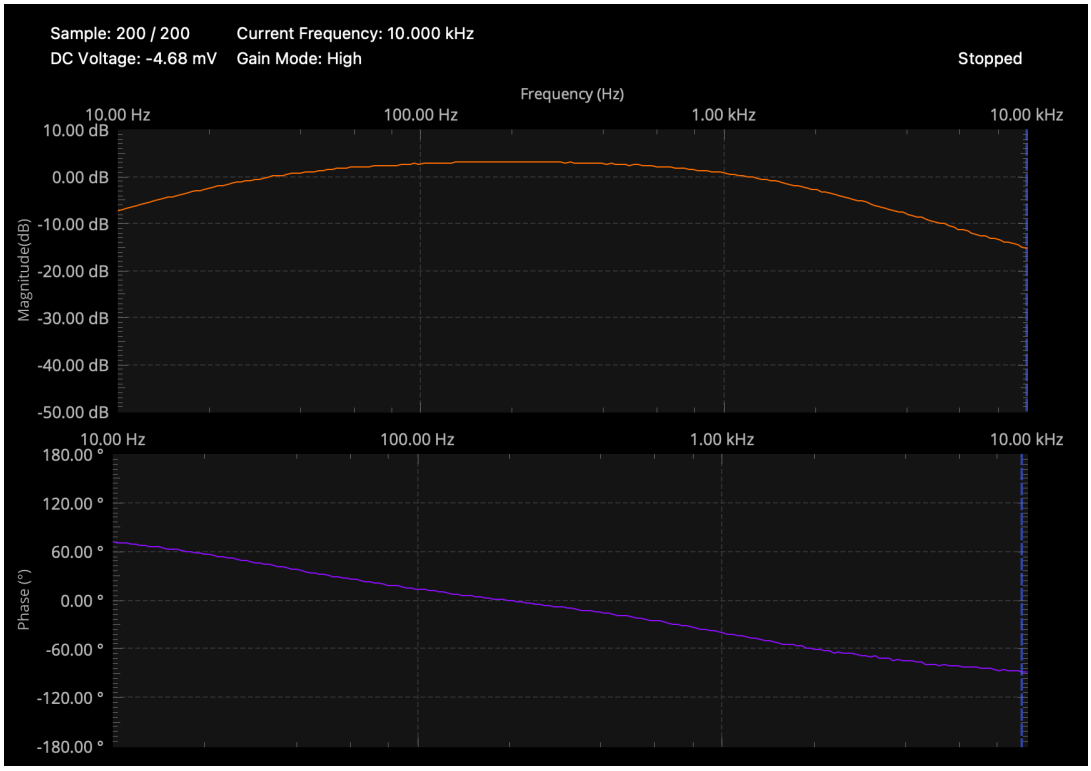
Using the simulation verified design, a physical implementation was built on a breadboard. A functionally similar 741CP op amp IC was used in place of the MCP6001 from the simulated circuit. The constructed circuit with no inputs is shown below:



To verify the functionality of the physical circuit, the ADALM2000 interface was used to power the ICs and conduct a signal analysis. The connected and labeled circuit is shown below:



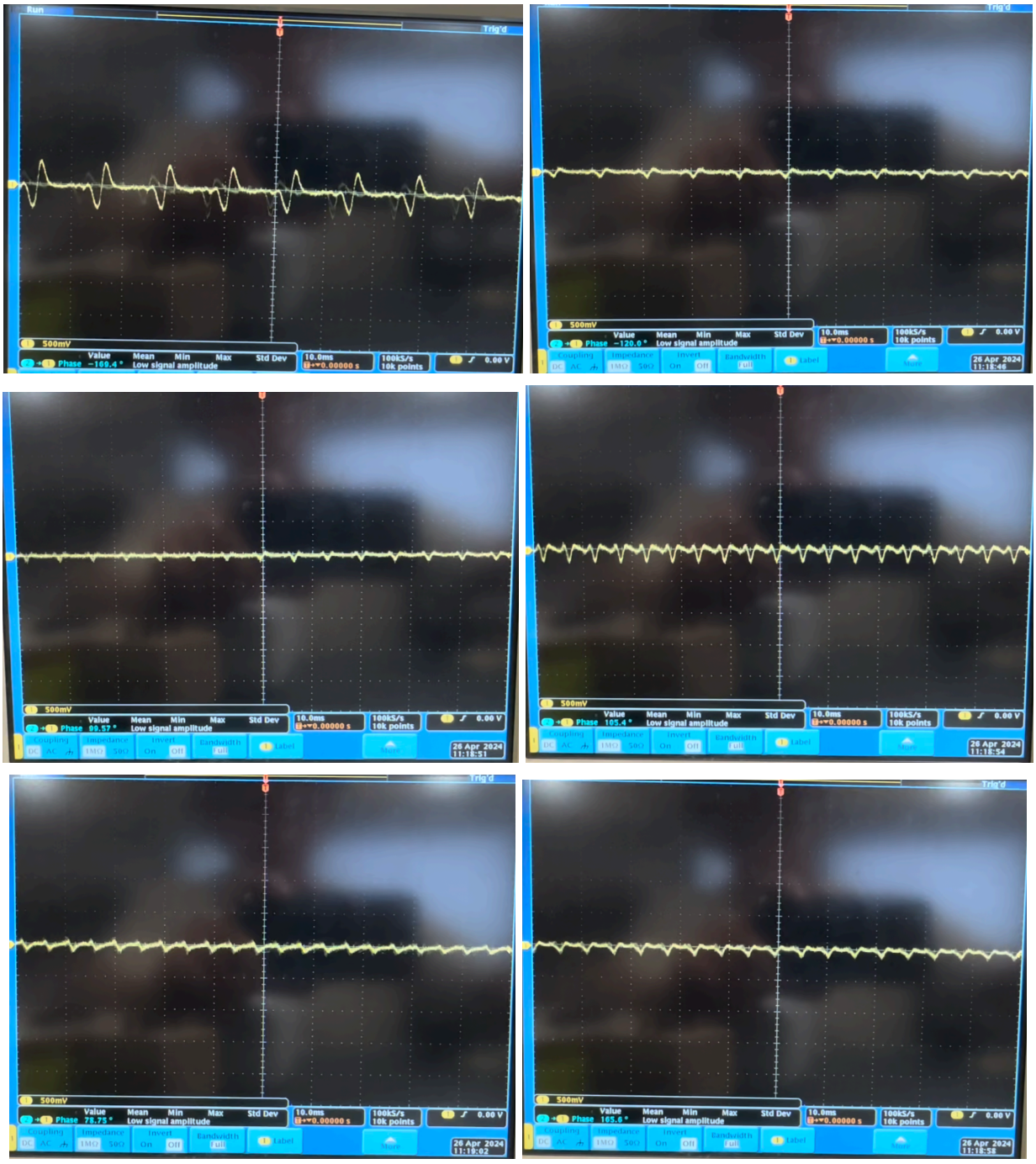
The signal analysis results were as expected, lining up with the findings from the simulated circuit. The Scopy results are shown below:



Testing

After verifying the physical circuit, it was possible to use it with the constructed guitar and speaker to produce amplified notes from the guitar strings. The connected circuit and guitar are pictured below:

To ensure that the notes produced by the guitar are properly filtered by the circuit, an oscilloscope was used to observe the waveform produced at the output of the circuit. The six images below show the output from strumming each of the six strings



The sounds produced by the speaker from each waveform sounded like singular notes and are clearly distinguishable from one another. The sound produced by the guitar is demonstrated in the video file attached to this assignment.

Conclusion

Overall, this project brought together a number of the concepts taught in EE202 and provided a deeper understanding of the theoretical concepts and actual hardware used in amplifier and filter circuits. The calculations and simulations helped with the creation of the circuits and verification of the designs. Testing the physical circuit was successful and it was very rewarding to finally hear the guitar produce sounds through the speaker.