Project: Full AM Radio

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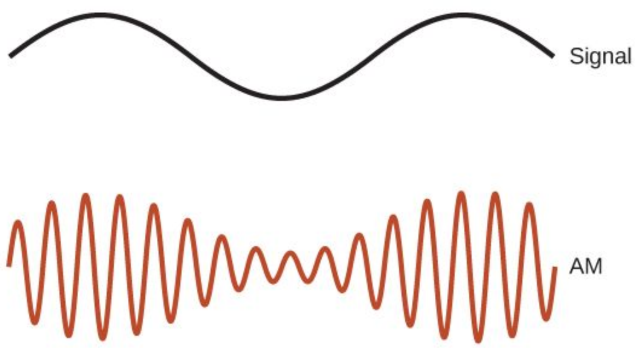
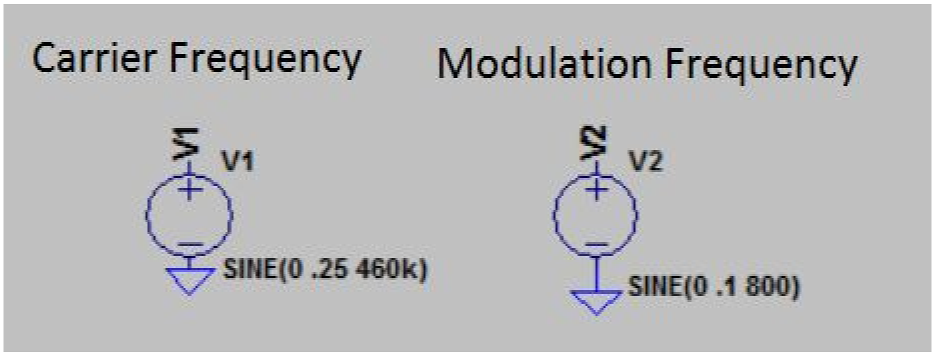
Introduction:

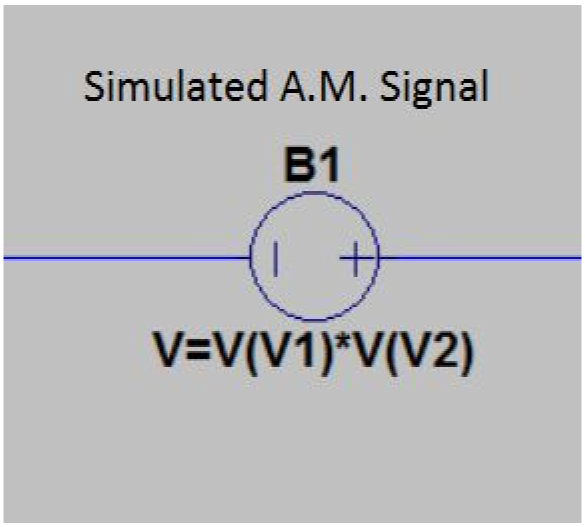
Amplitude modulation was one of the most important breakthroughs in transmission, receiving of RF signals, and communication as we know it. A.M. radio waves are historically important because they were the first method created to transmit and receive radio waves. AM radio is still used to this day despite the advancements in F.M. and satellite radio. A.M. radio is especially good as transmitting its signal over large distances. Amplitude modulation describes the shape and features of the A.M. radio signal in which the amplitude of the signal varies from zero to its maximum amplitude continuously. One reason A.M. radio is phasing out is that it is more susceptible to interference. Another reason is that it has lower audio quality compared to F.M. signals.



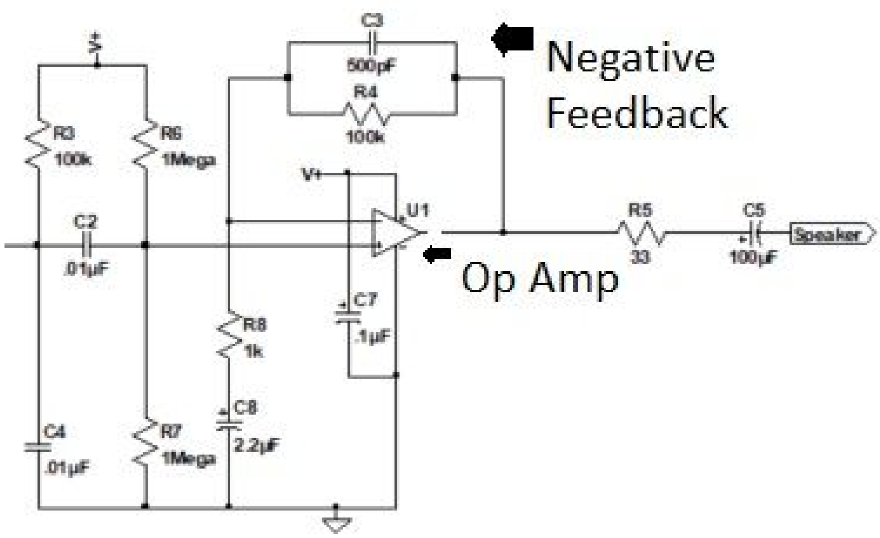
For our project, we decided to build a full A.M. radio in which we had to receive a simulated signal, amplify the signal, and then add two features of our choosing. We decided that the two features we wanted to add were a volume control and a tuner control in order to “tune” our radio to a specific band of frequencies.

In order to simulate an A.M. radio wave in LTSpice, we had to get creative. In order to achieve this, we separated the carrier frequency from the modulation frequency. The carrier and modulation frequency was used as the frequencies to two separate AC voltage sources. We then multiplied these two voltages sources together to complete the A.M. signal simulation.

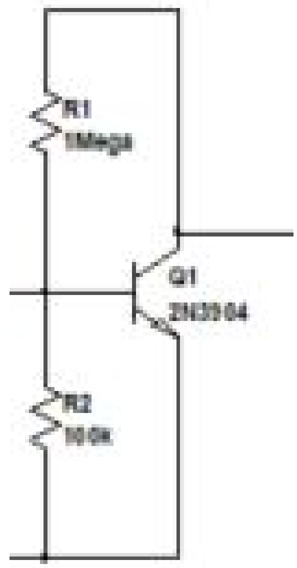




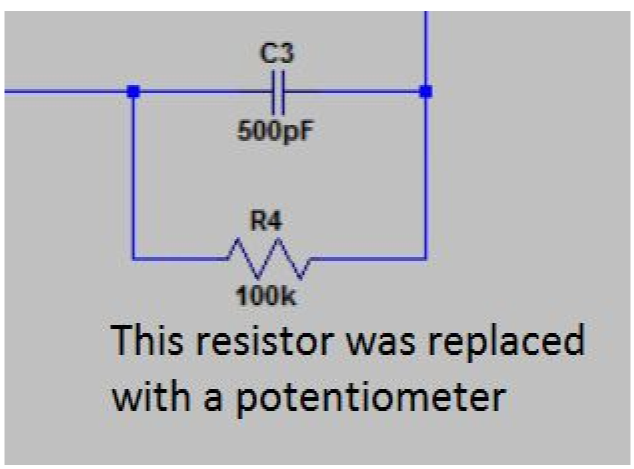
We then were tasked with amplifying this fairly weak simulation to make it more reasonable and easier to work with. We amplified our simulated signal through a MOSFET filter then into an OP-amp which amplified the magnitude of the simulated signal.



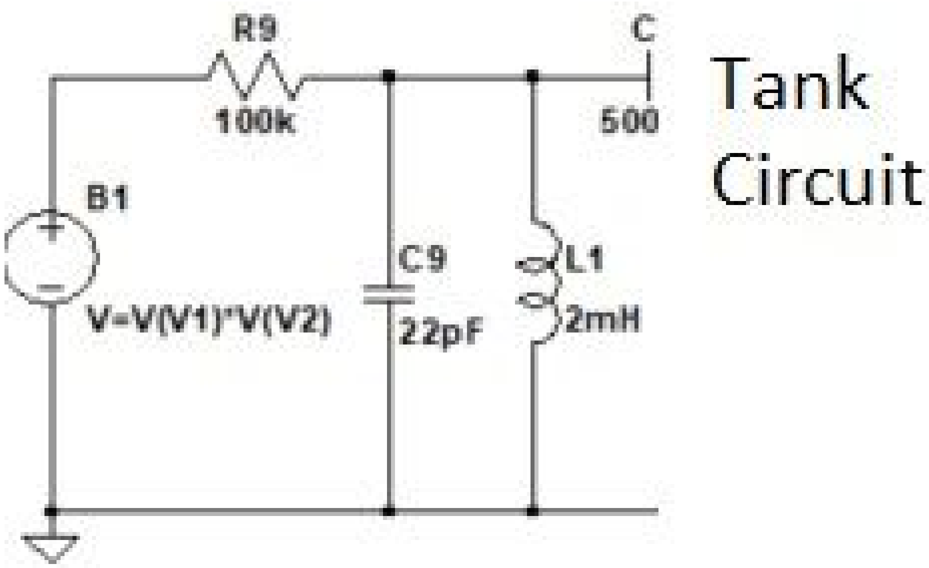
Cosine Amplifier:



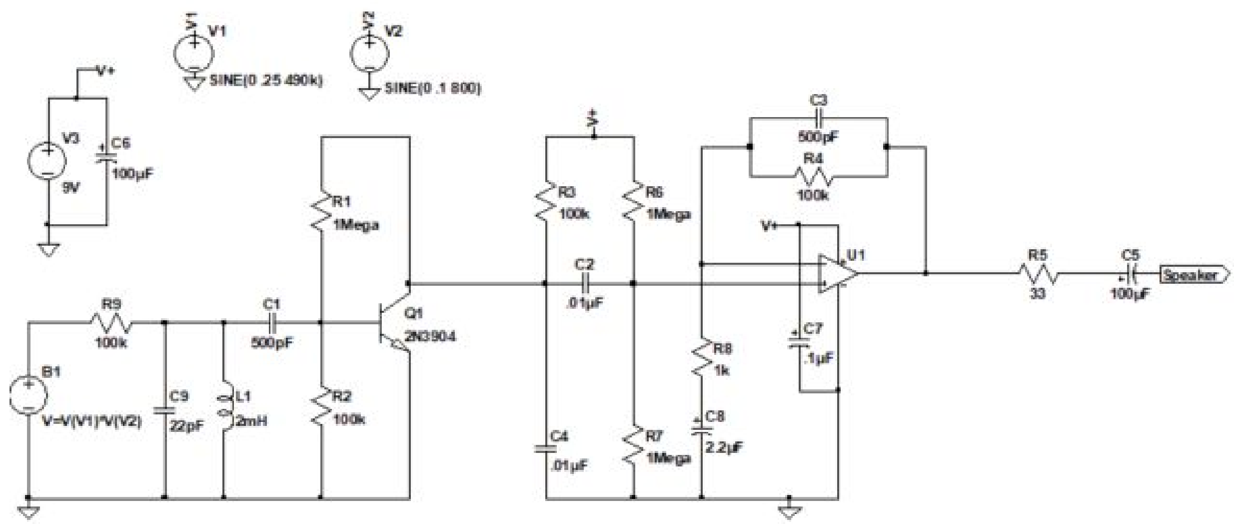
In order to manipulate volume on our A.M. radio, we replaced the resistor that was in parallel with a capacitor. We replaced this resistor because it is the one that controls the negative feedback into the OP-amp. This resistor was replaced by a potentiometer in order to vary the resistance at the turn of a dial. As we raised the resistance the volume increased and as the resistance was lowered so did the volume.



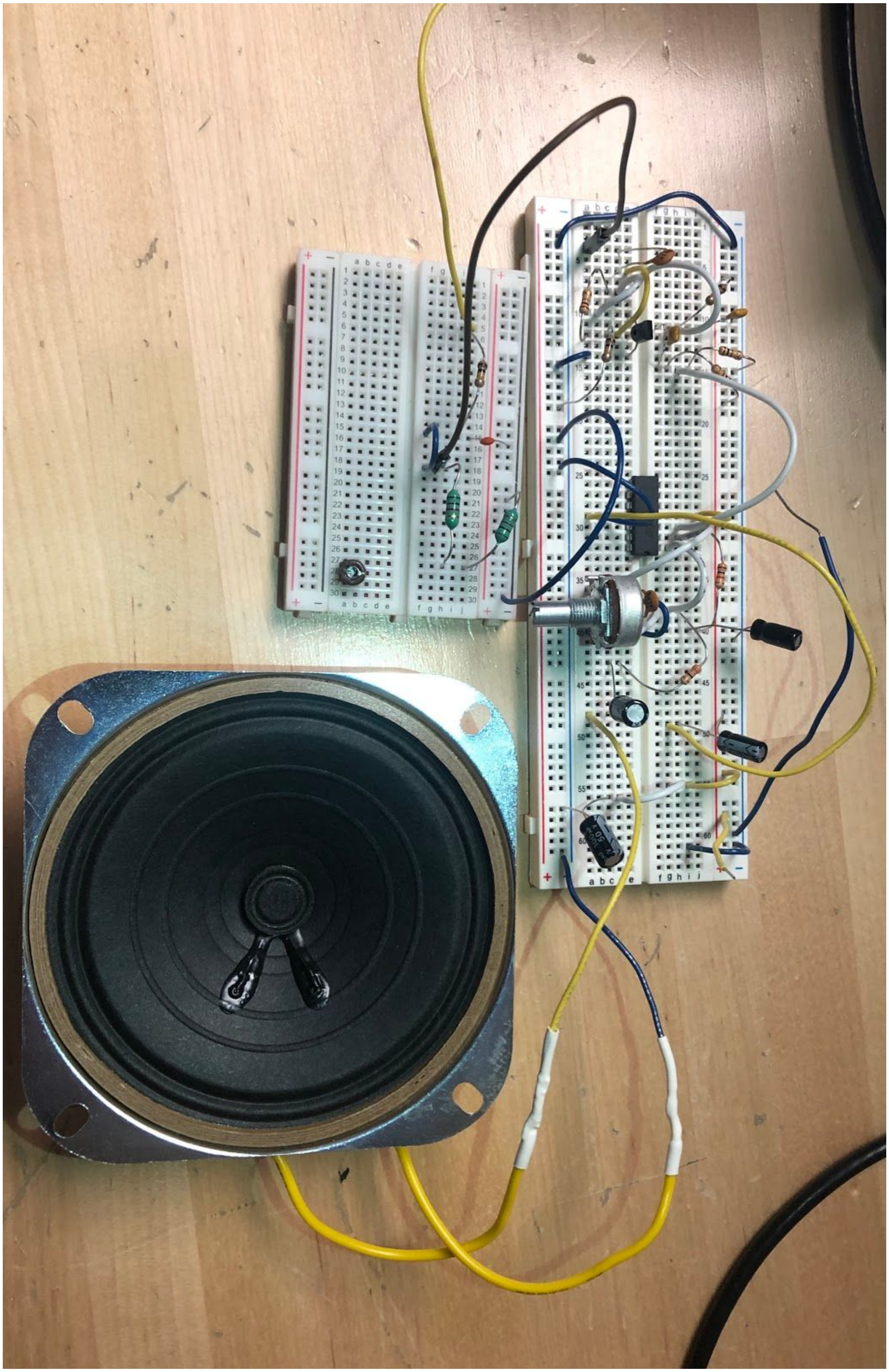
The final feature we added to our A.M. radio was the ability to tune our radio to a specific range of frequencies. We achieved this by designing and implementing a tank circuit. A tank circuit is a capacitor and inductor in parallel with each other. This arrangement of components creates a bandpass filter. This type of filter allows your desired frequencies to pass through it while suppressing frequencies outside of your desired range. This means that for it will not allow any frequencies lower than the minimum or higher than the maximum to be passed through to the circuit. In order to properly calculate what values of L and C we need to put into the tank circuit we used the equation $f=1/(2\pi\sqrt{(LC)})$. This equation allows us to find the center frequency value for our range. We were able to successfully use this equation to set our center frequency value to 490,000 Hz in practice. Our pass band allowed frequencies from about 290,000 Hz to about 690,000 Hz. This means that our filter passed all frequencies between those two frequencies and suppressed all values smaller than 290k Hz and larger than 690k Hz. This lead to our radio producing noise within the range and not producing any noise of the frequency was outside of this range. As the frequency got closer to the center frequency the volume increased and as it got further away from the center value the volume decreased until it eventually did not produce a noise, this happened when it was outside of the passband bounds. We also changed the modulation frequency which controlled the pitch of the noise. Higher frequency resulted in higher pitches and lower frequencies resulted in lower pitches.



Whole Circuit:

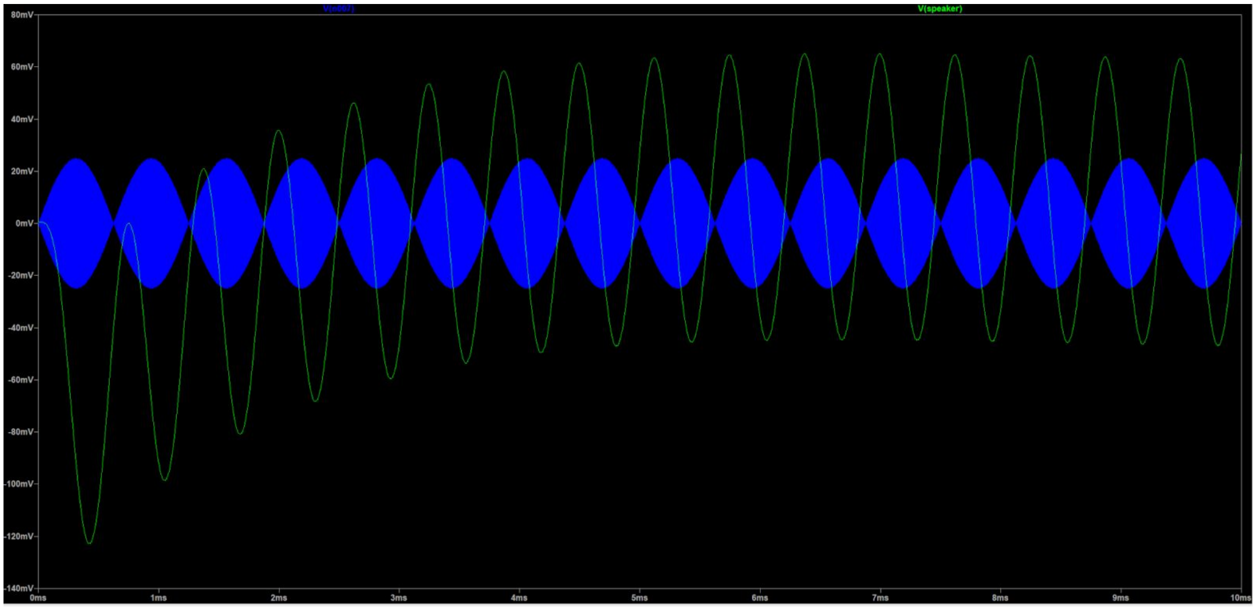


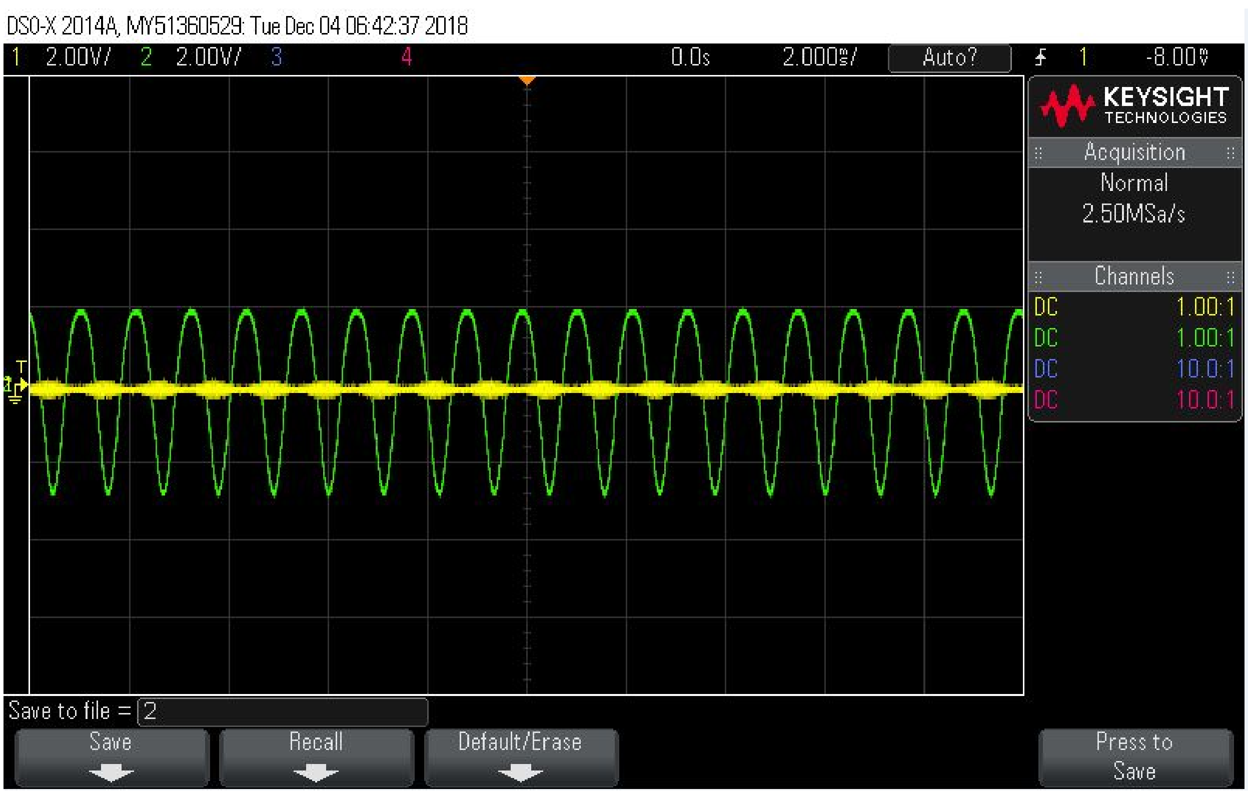
Built Circuit:



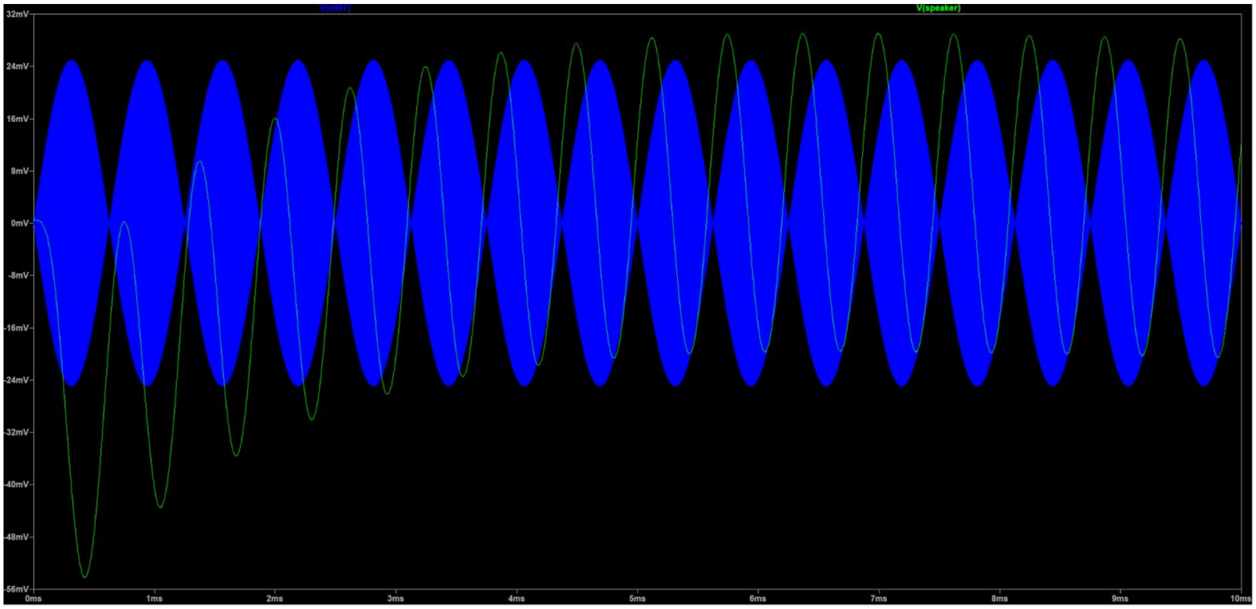
The following images are taken from the oscilloscope at different modulation and carrier frequencies. Green is the output signal and yellow is the input signal. The top pictures for each case represent the LTSpice simulation of each case.

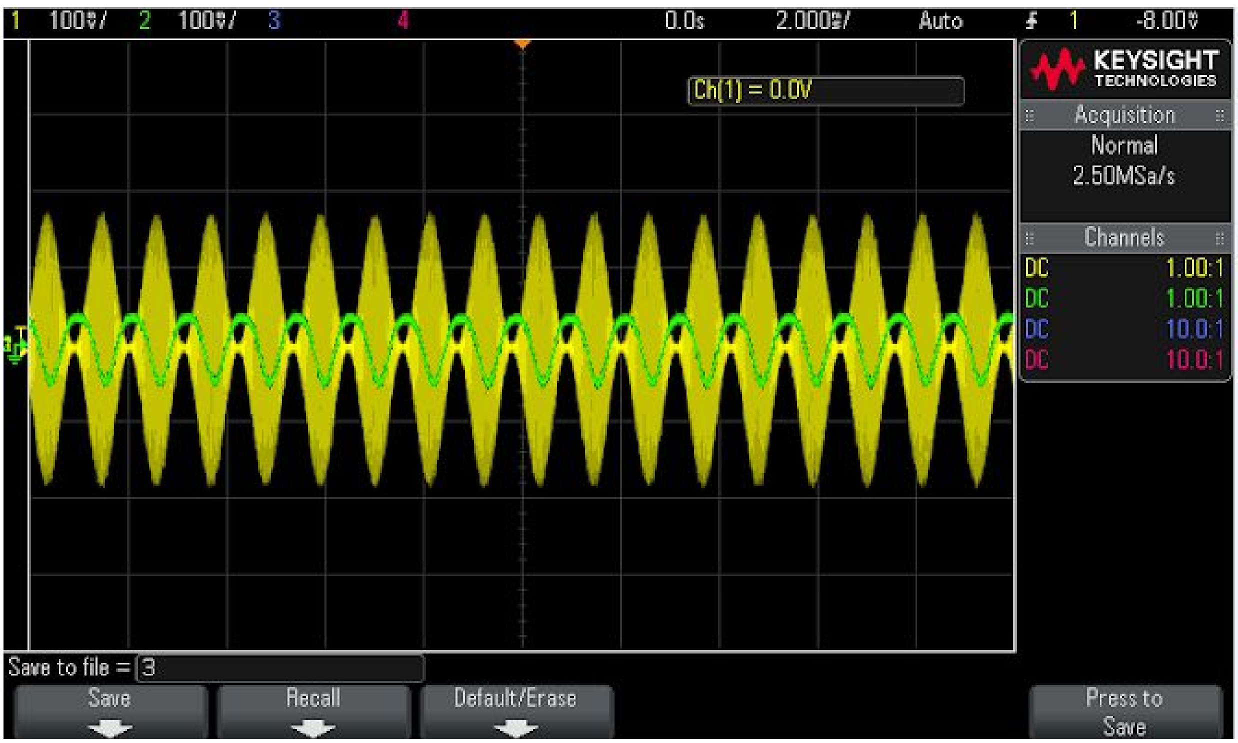
Here we are displaying the input versus output at a frequency of 490k Hz. The signal is able to be demodulated and amplified because it is within the pass band.



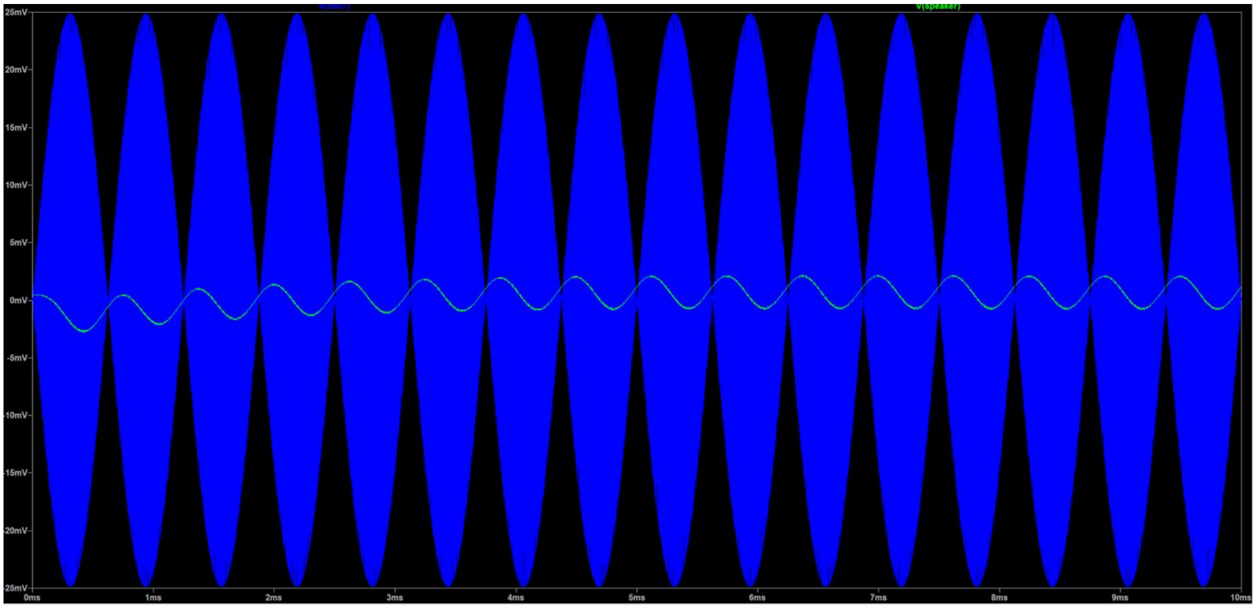


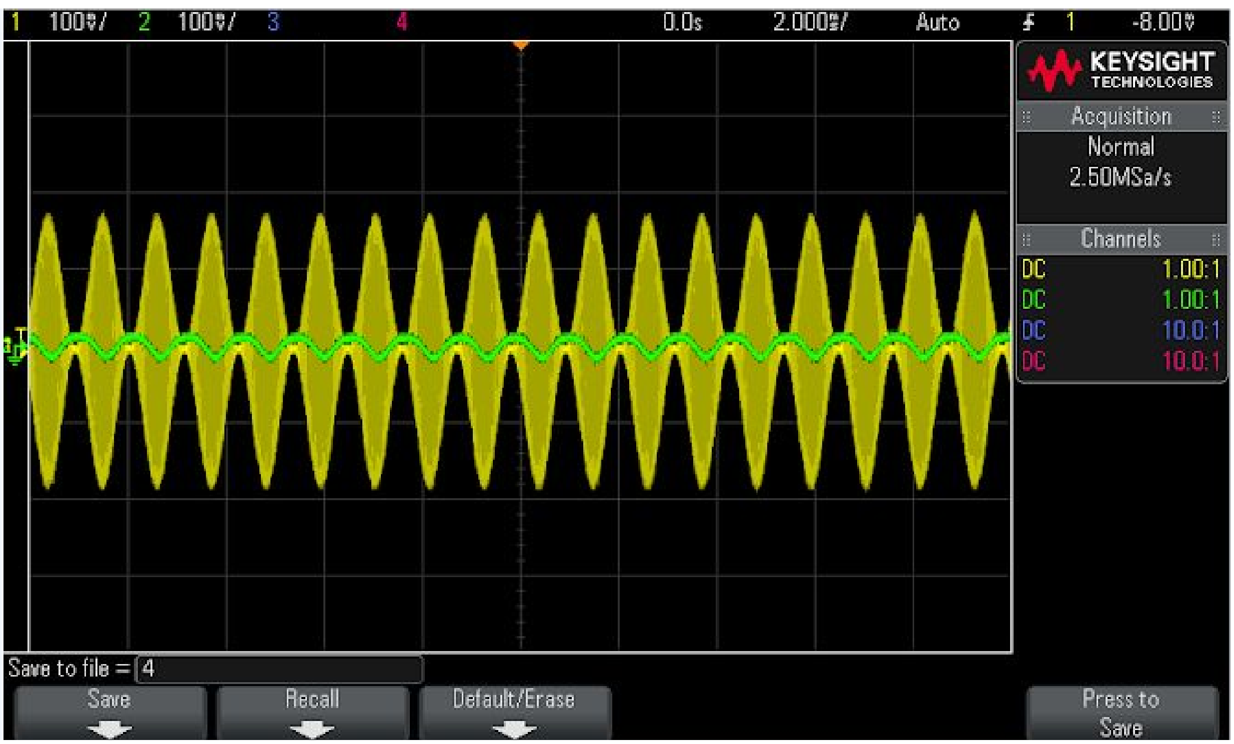
In the figure below we are at a frequency of 800k Hz which was outside of our pass band thus effectively making the output essentially zero. The signal to the speaker has a lower power heard making the noise from the speaker barely audible even at max volume on the volume control.



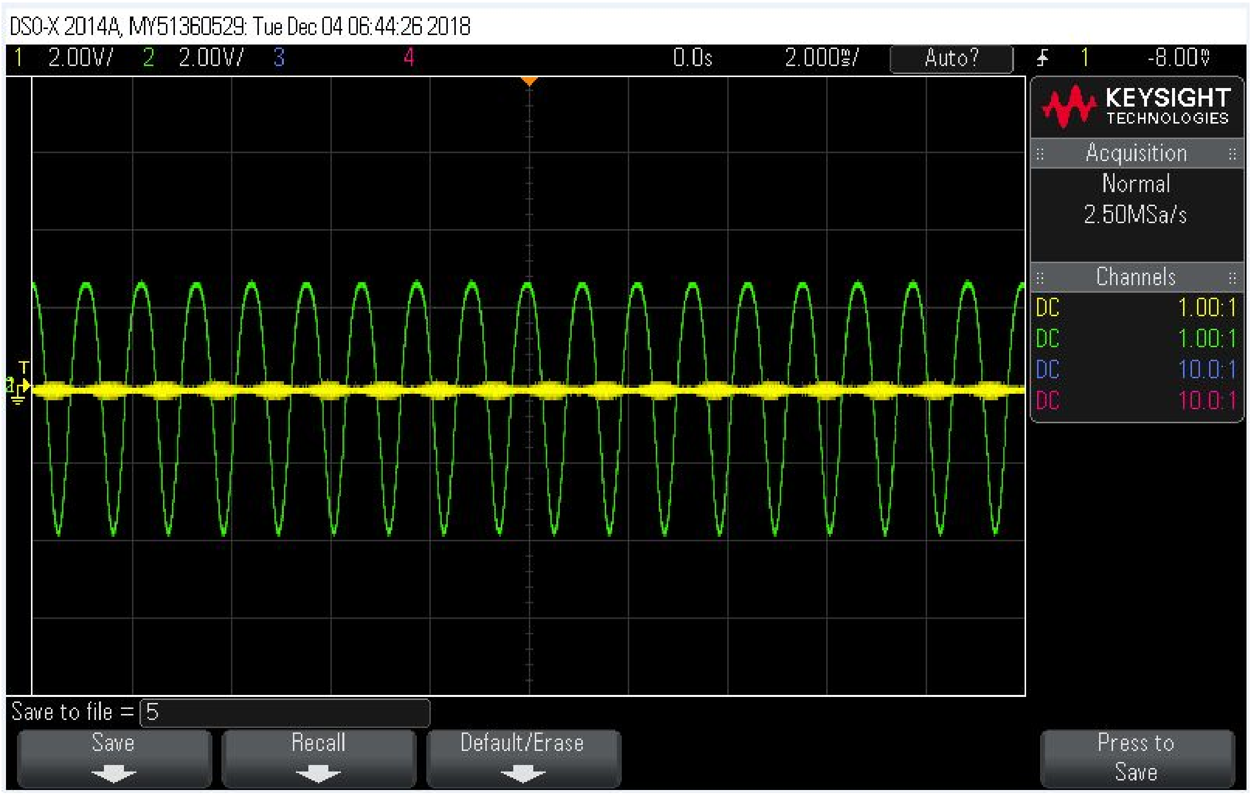


In the figure below we are at a frequency of 200k Hz which is again outside of our pass band. Similar to the picture above our output at this frequency will be effectively zero. Since the signals frequency is outside the pass band very little signal is transmitted to the speaker. This exhibits the same characteristics as the 800kHz case because both frequencies lie outside the pass band.

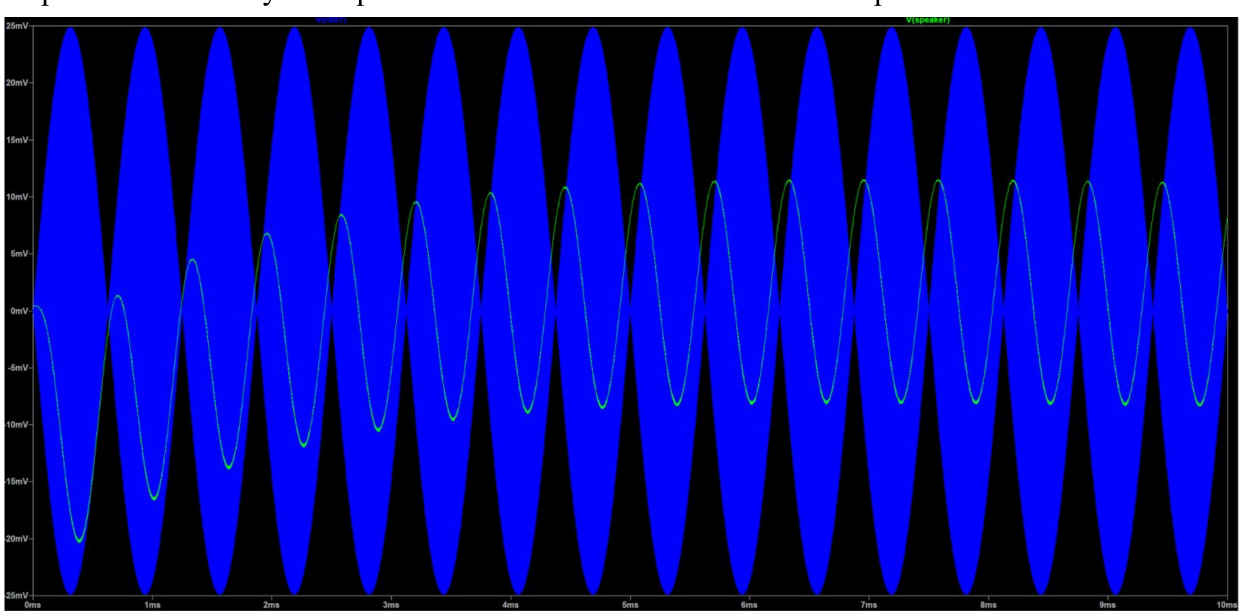


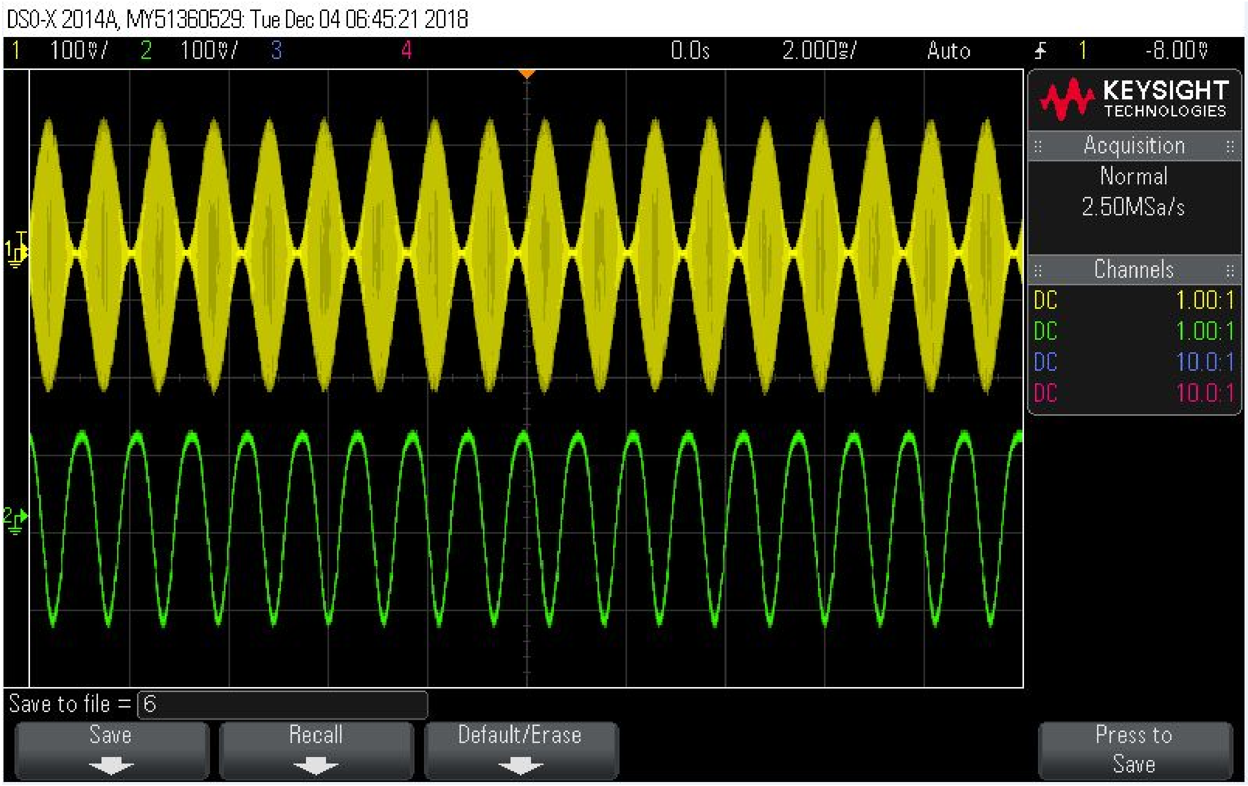


Pictured below is a frequency inside the pass band with the volume all the way up. As the potentiometer is turned to a higher resistance the gain of the amplifier is increased allowing the signal to the speaker to increase in power.



In this picture we are within the pass band frequency range with the volume turned very low. As you can see in the pictures below the peak to peak of the following signals are very low and will output a low intensity in respect to the situation above where the output volume is at its max.





Included with the write up are 3 sound files which show when the signal goes in and out of the passband, when the modulation frequency is changed (changes the pitch), and the volume is increased and decreased.