EEET - 313: Communication Electronics
Final Project

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Introduction

This final project compiled everything learned from this semester to create a transmitter and receiver. The transmitter takes an input from a phone to generate a low power AM signal, in which the receiver receives the signal, demodulates it, and then plays it out a speaker. The project will also demonstrate how an interferer can be rejected by a 1kHz modulating frequency with a 420kHz carrier.

Transmitter

Part 1 - Transmitter power: Wiring for power was added to the board.

Part 2 - Transmitter: Input Audio Amplifier and Low Pass Filter

Input Audio Amplifier and Sallen Key Low Pass Filter:

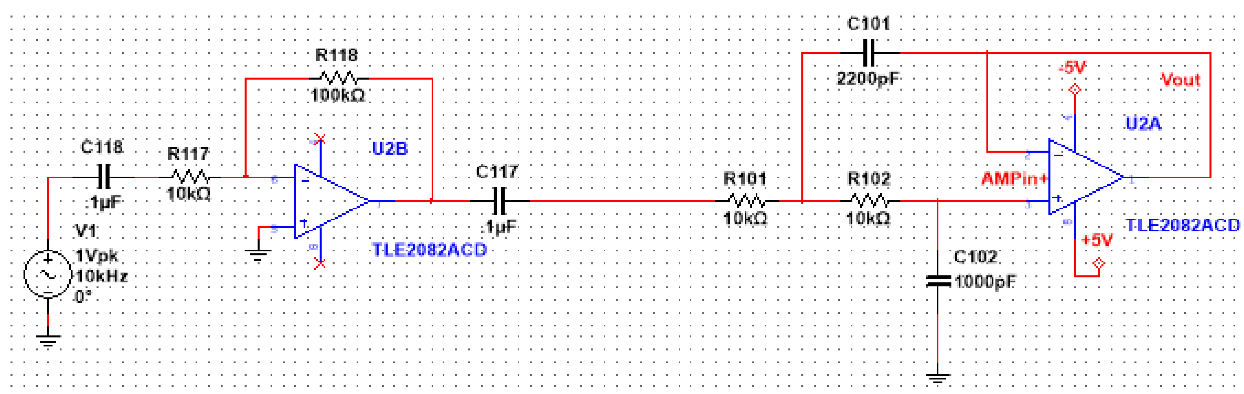
Designing the Amplifier:

Gain = 10, input impedance = 10kOhm

Av = 10 = - Rf/Ri = -(R118/R117) = - 100k/10k

Ri = R117 = 10kOhm

Rf = R118 = 100kOhm

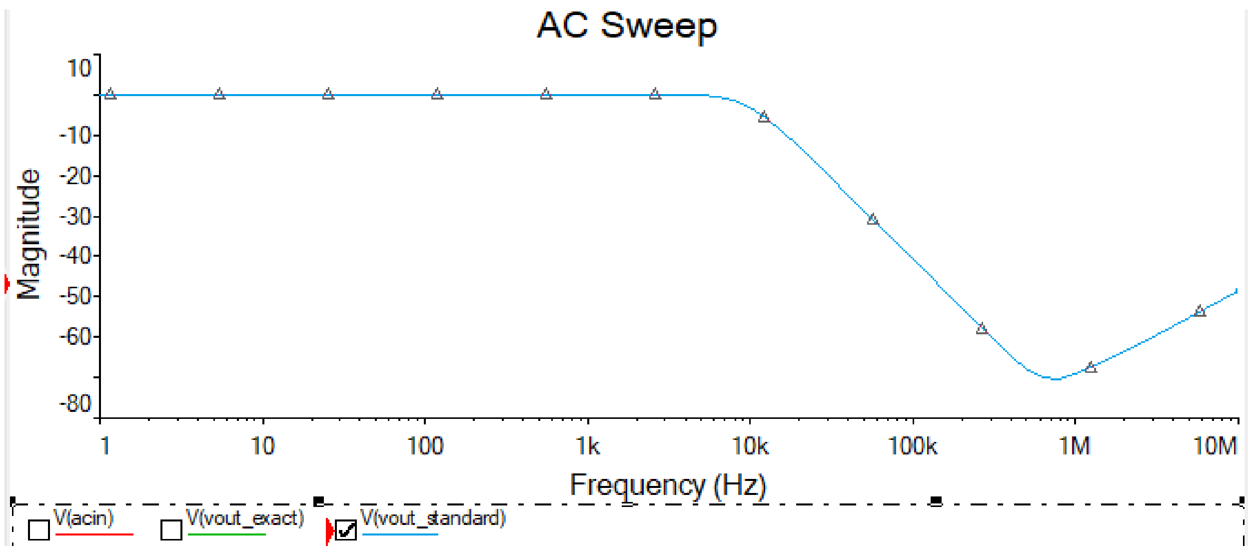


Sallen Key Filter Design

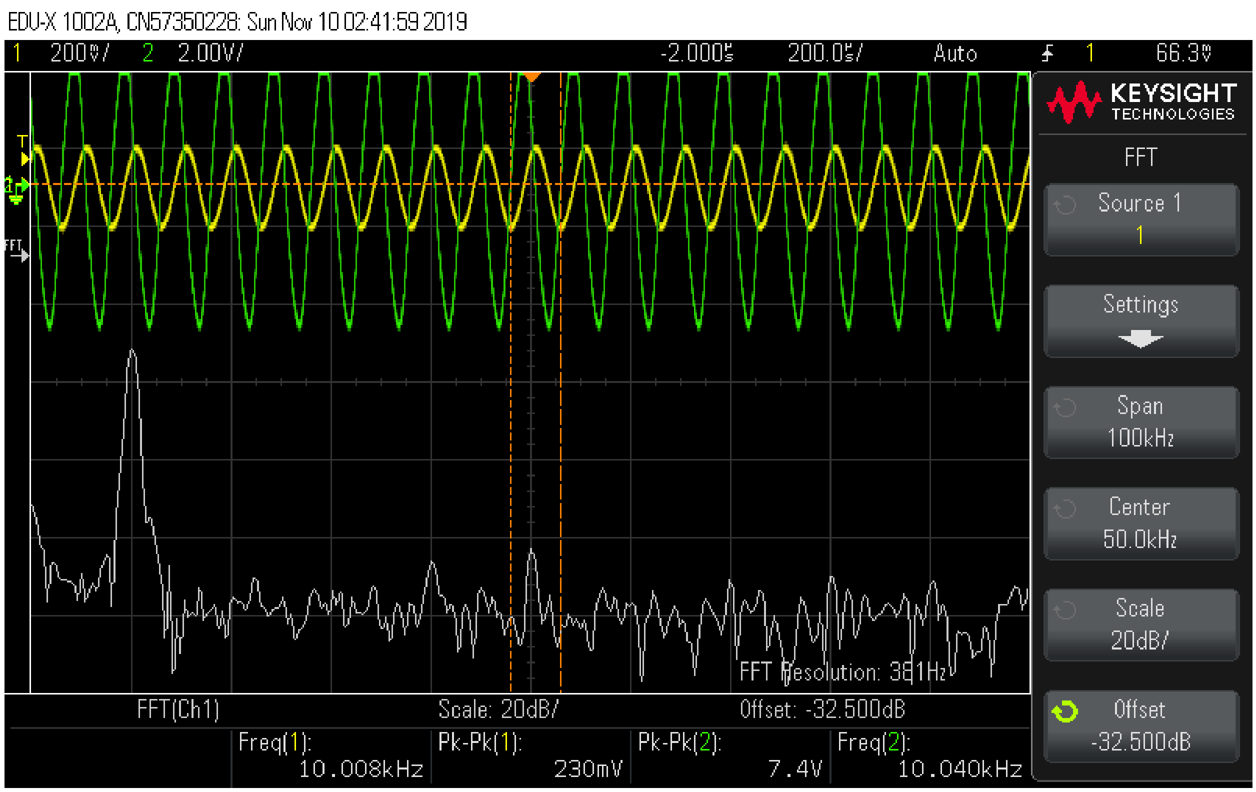
For Standardized values R1 = R101 = 12k, and R2 = R102 = 12k

C101 = 2200pF

C102 = 1000pF

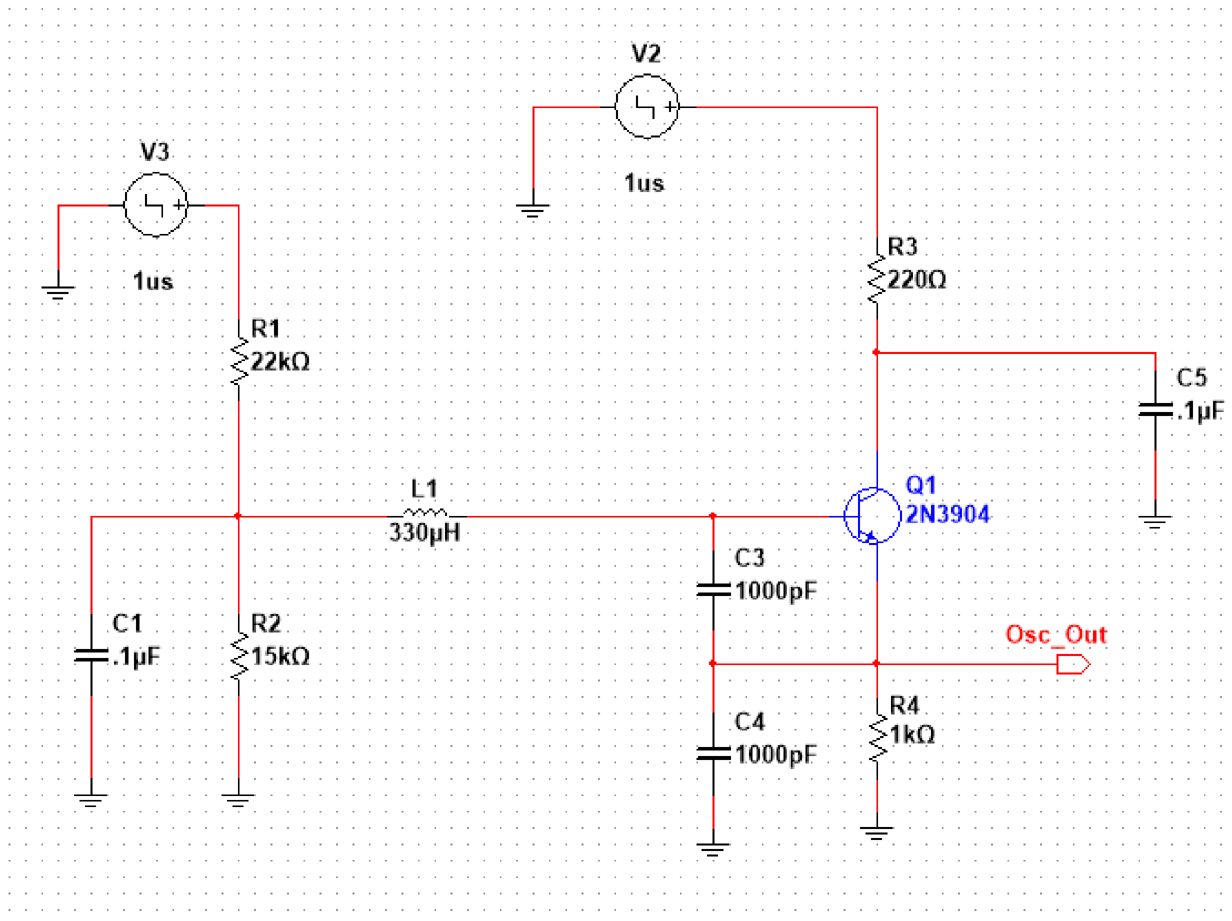


Multisim simulation of input filter

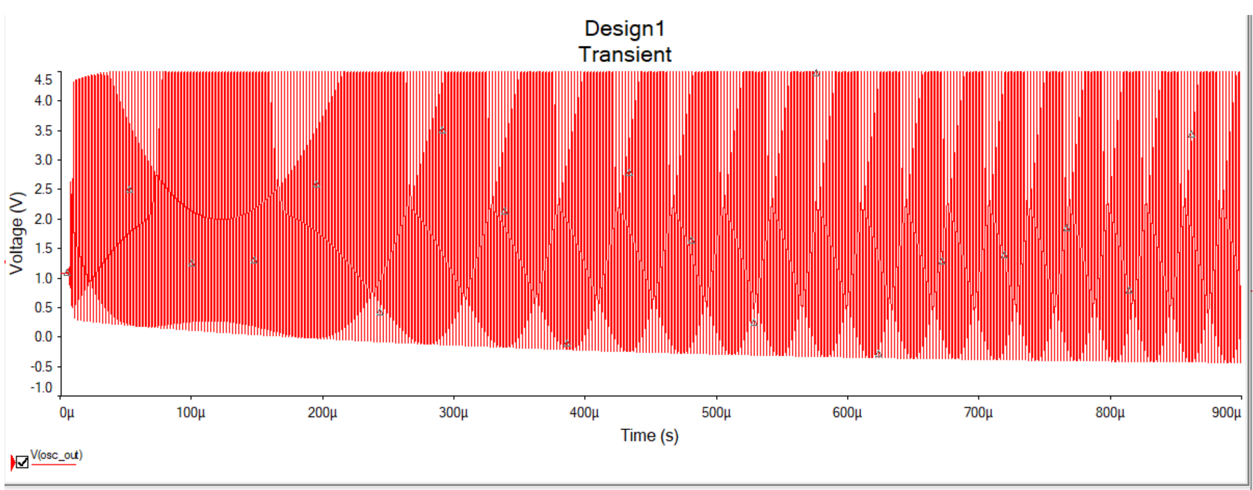


Frequency Response of the Amplifier/Filter Combination

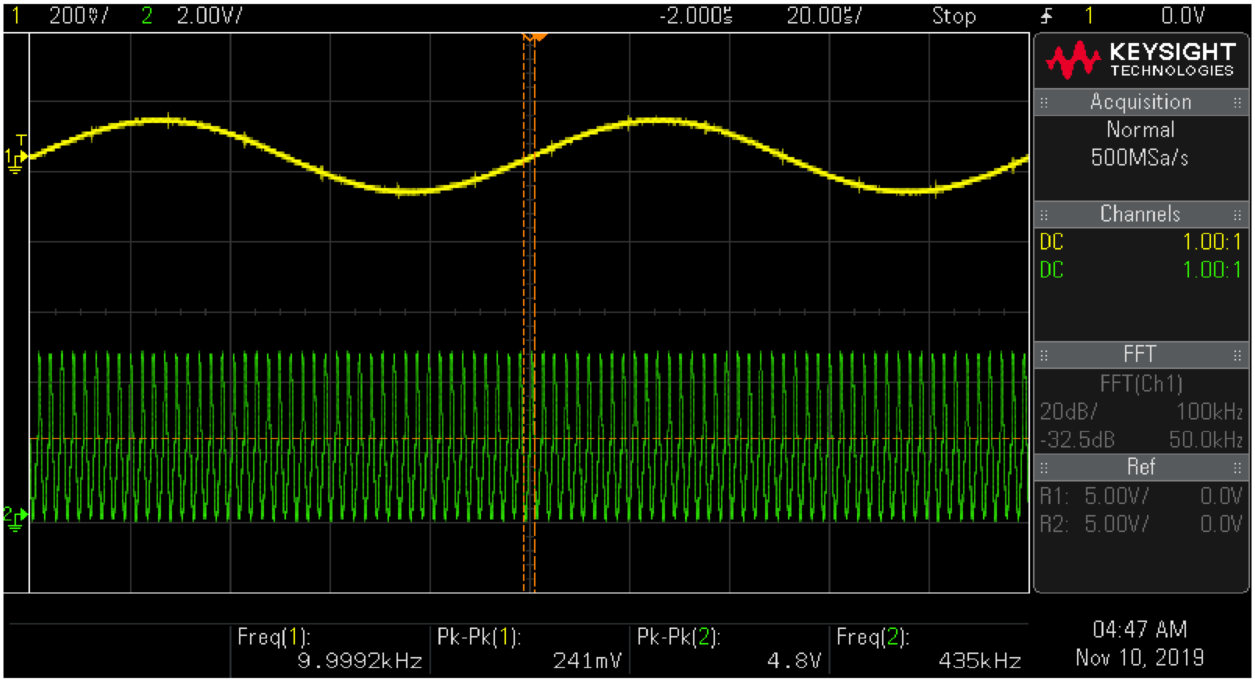
Part 3 - Transmitter: Local Oscillator



Oscillator Circuit



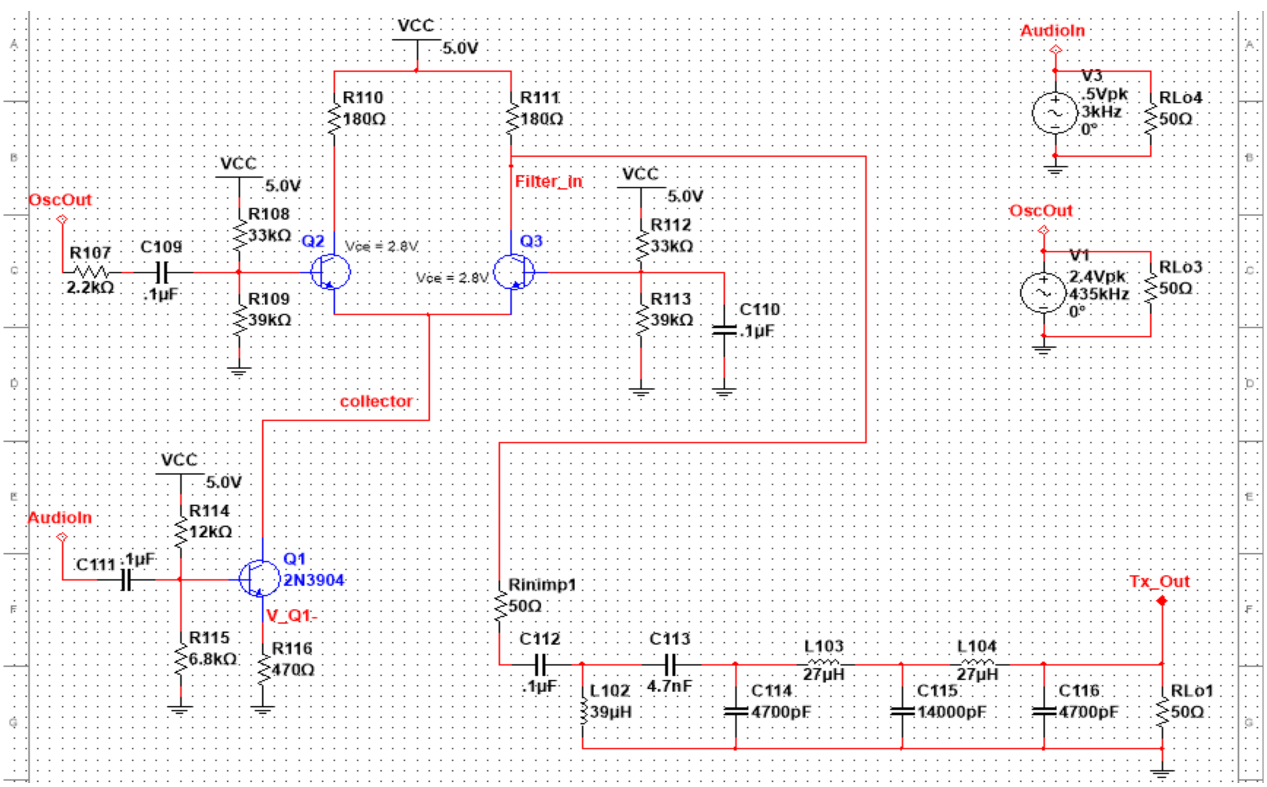
Transient Analysis of the Oscillator

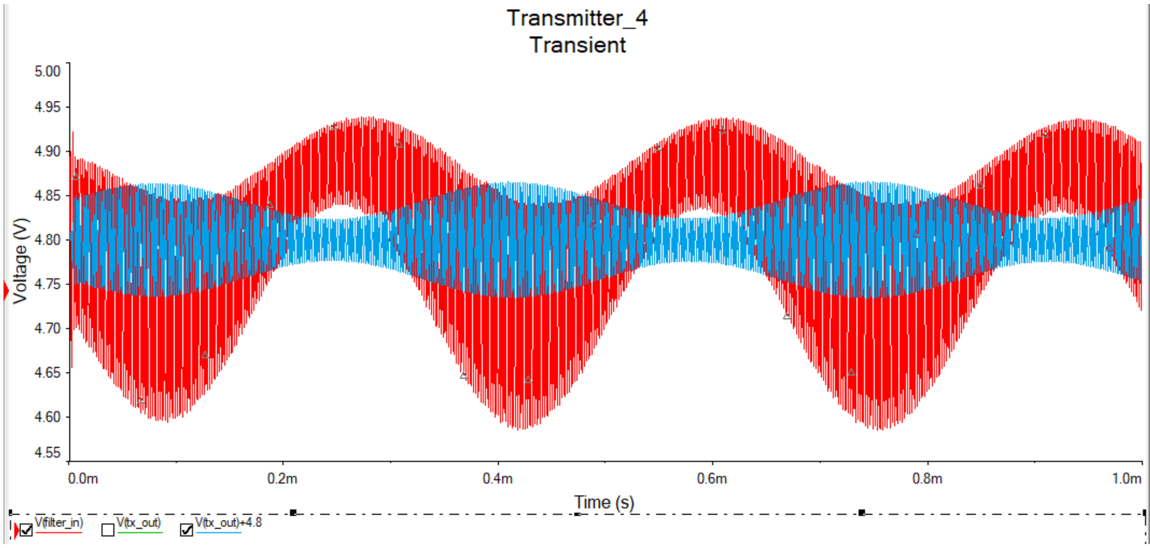


Oscillator Operating at 435kHz with 47nF

Initially, the oscillator was measuring at too high a frequency, around 450kHz. An extra capacitor C104 of 47nF was added in parallel with the C105 and C106 branch to bring the oscillating frequency down to 435kHz.

Part 4 - Transmitter: Amplitude Modulator and Part 5 - Transmitter: RF Matching Network/Output Filter



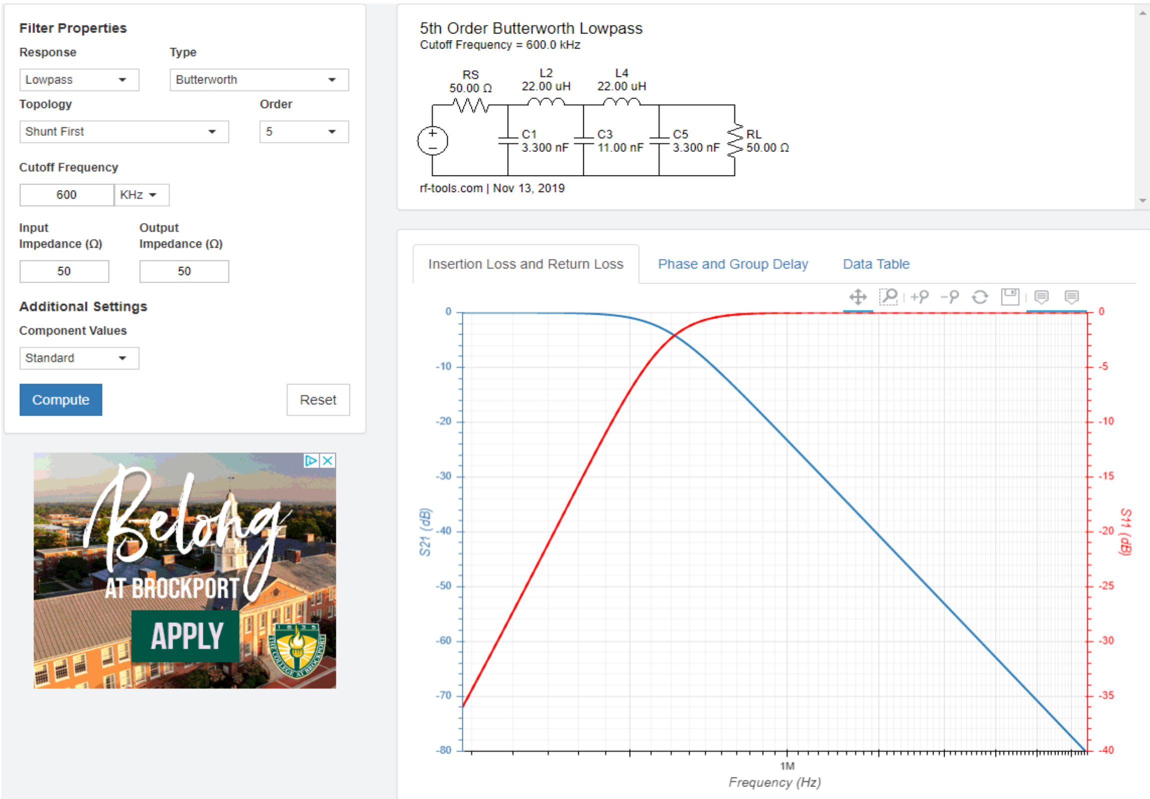


Multisim simulation of AM Modulator and RF Matching Network/Output Filter

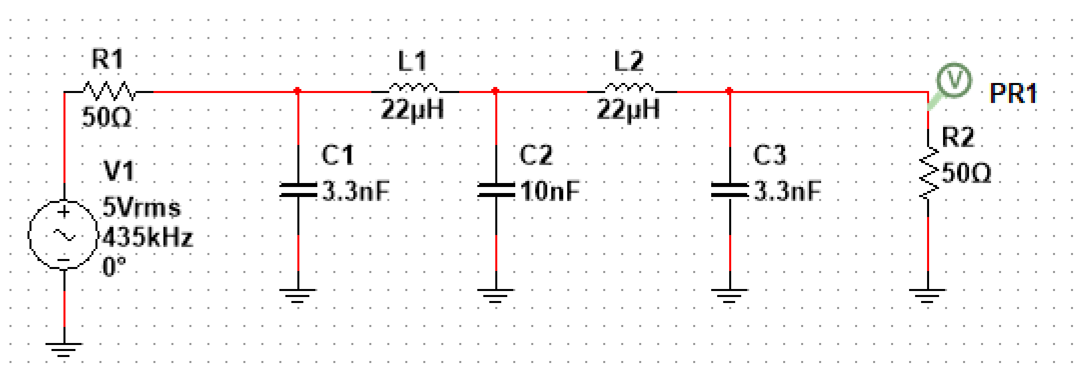
Testing Approach of Part 4 and 5:
Monitoring the output of the oscillator(collector of Q3) on the oscilloscope, we powered the circuit and measured the frequency of the output using the measurement tools on the scope. Since the oscillator was already measured to be at the exact frequency, there wasn't any trouble confirming that the demodulator and low pass filter was also running correctly given the correct input. No adjustments were needed.

Receiver

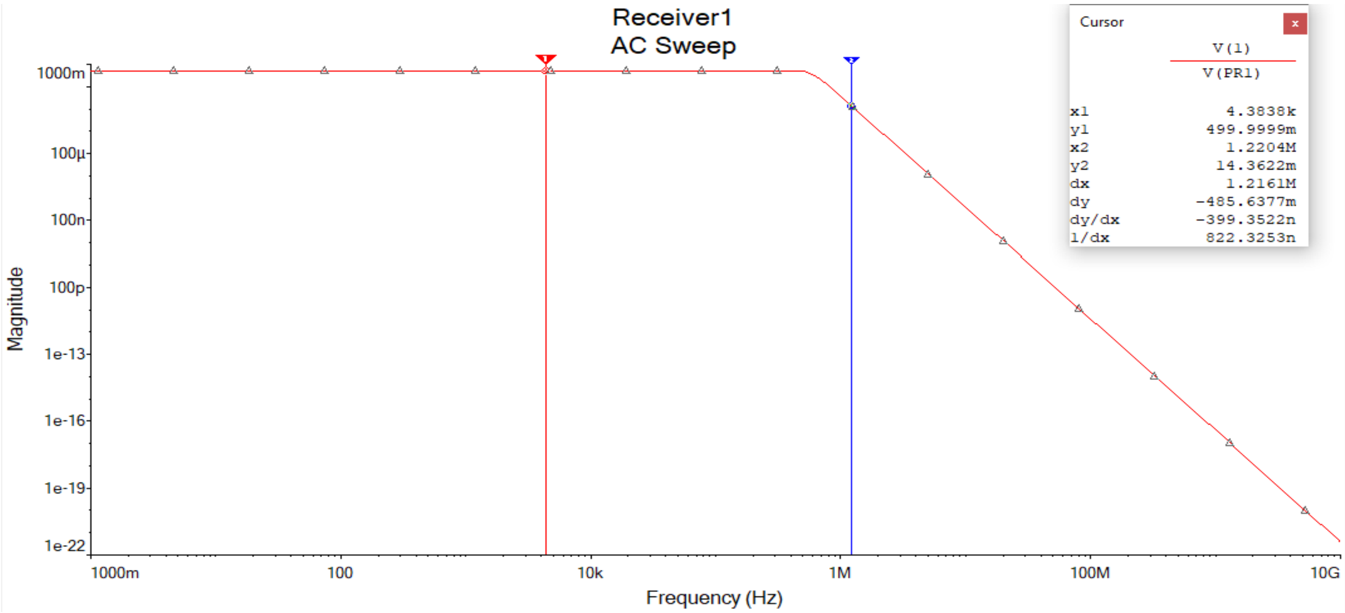
Part 1 - Receiver: Receiver Front End Filter



Front End Filter design

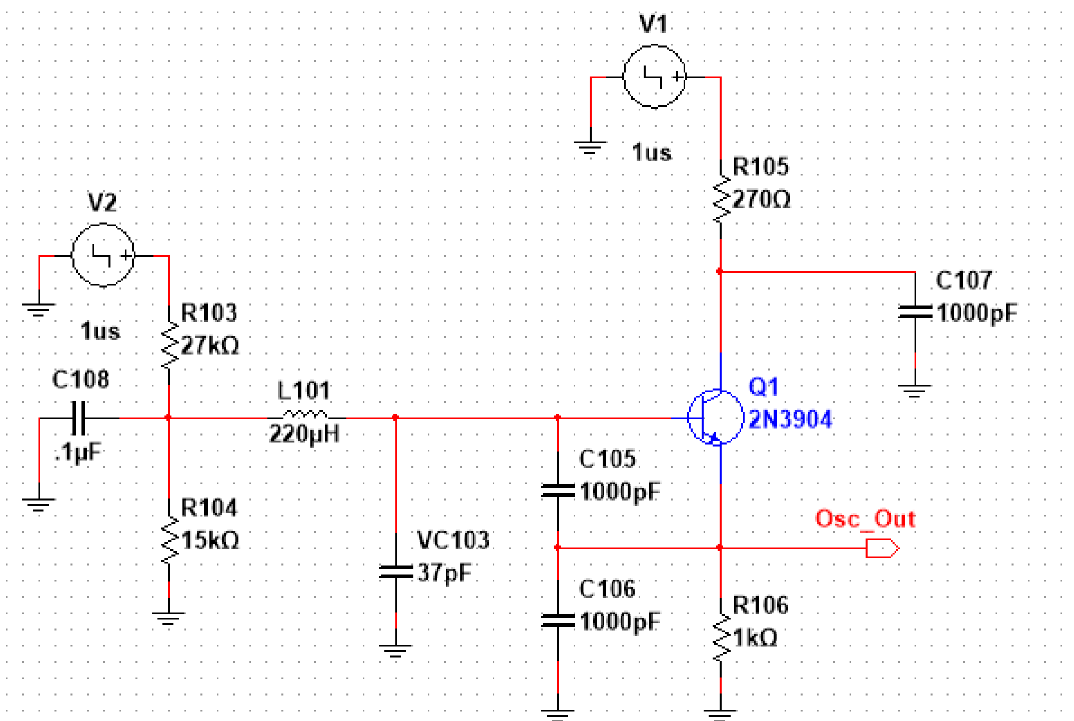


Front End Filter Schematic

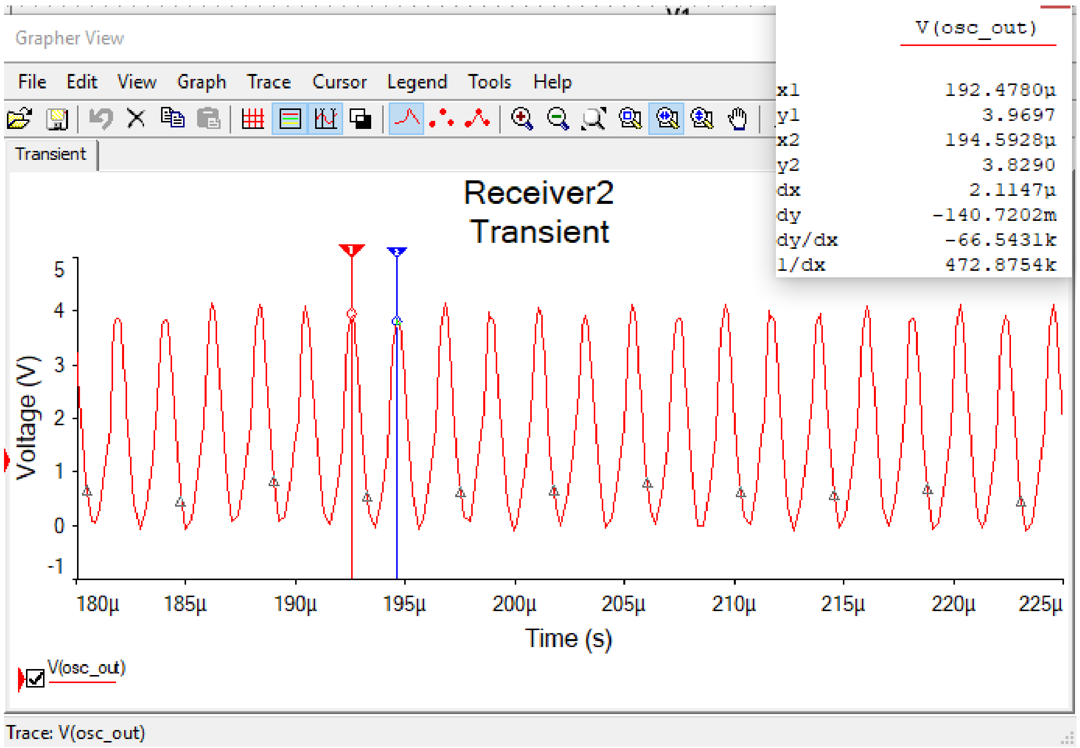


Front End Filter AC Sweep

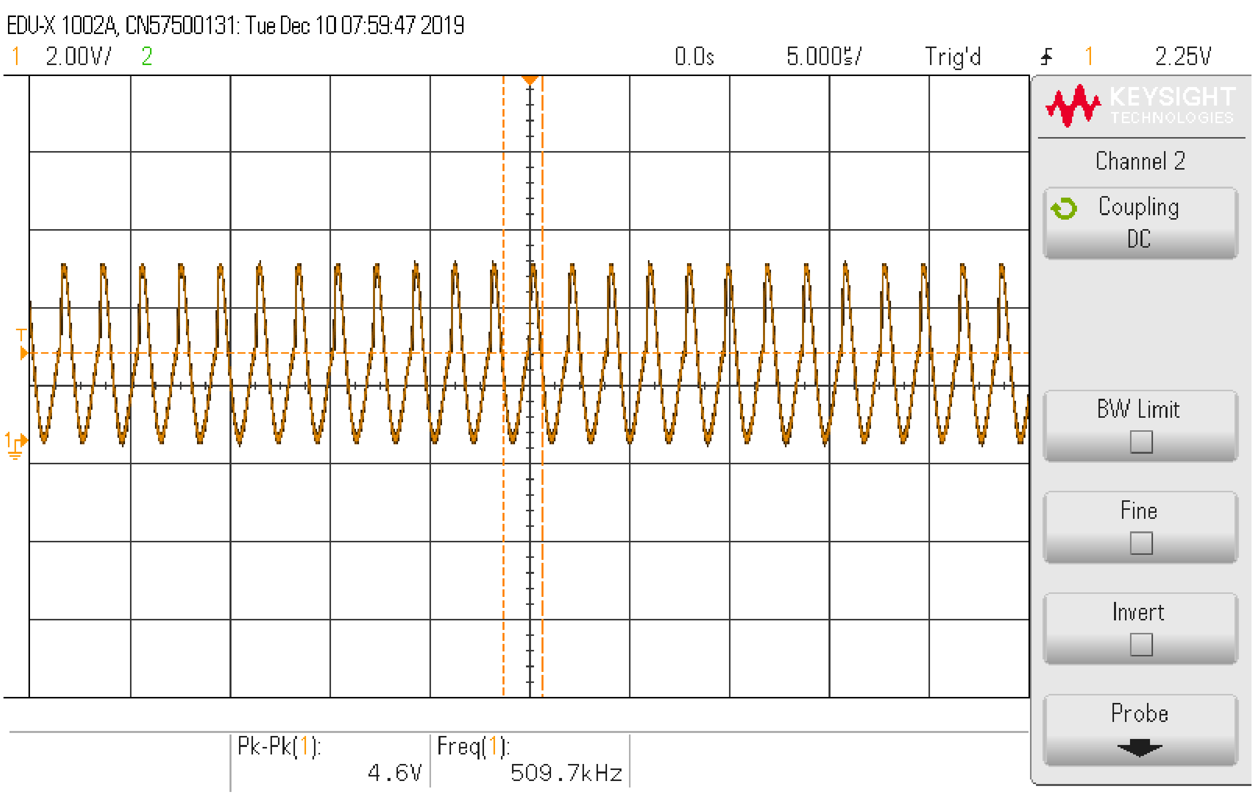
Part 2 - Receiver: Local Oscillator



Oscillator design

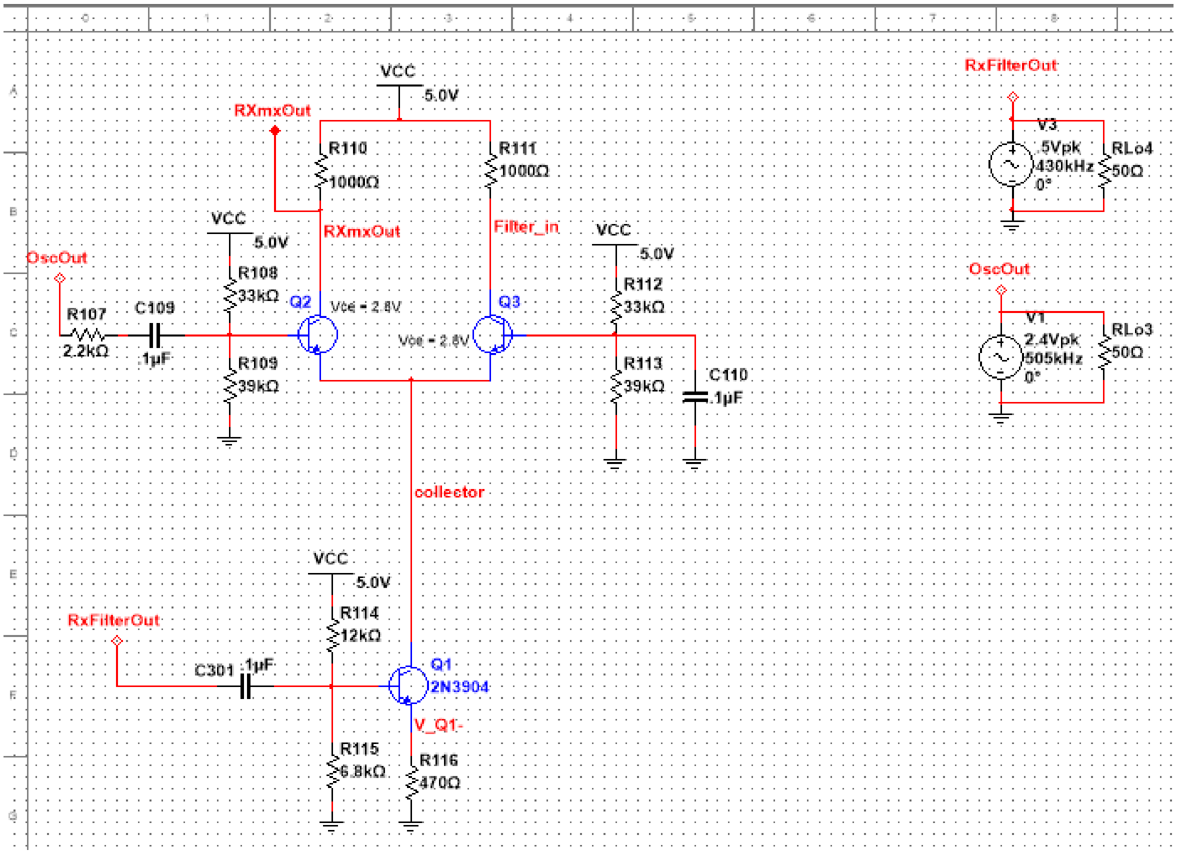


Oscillator Transient Analysis

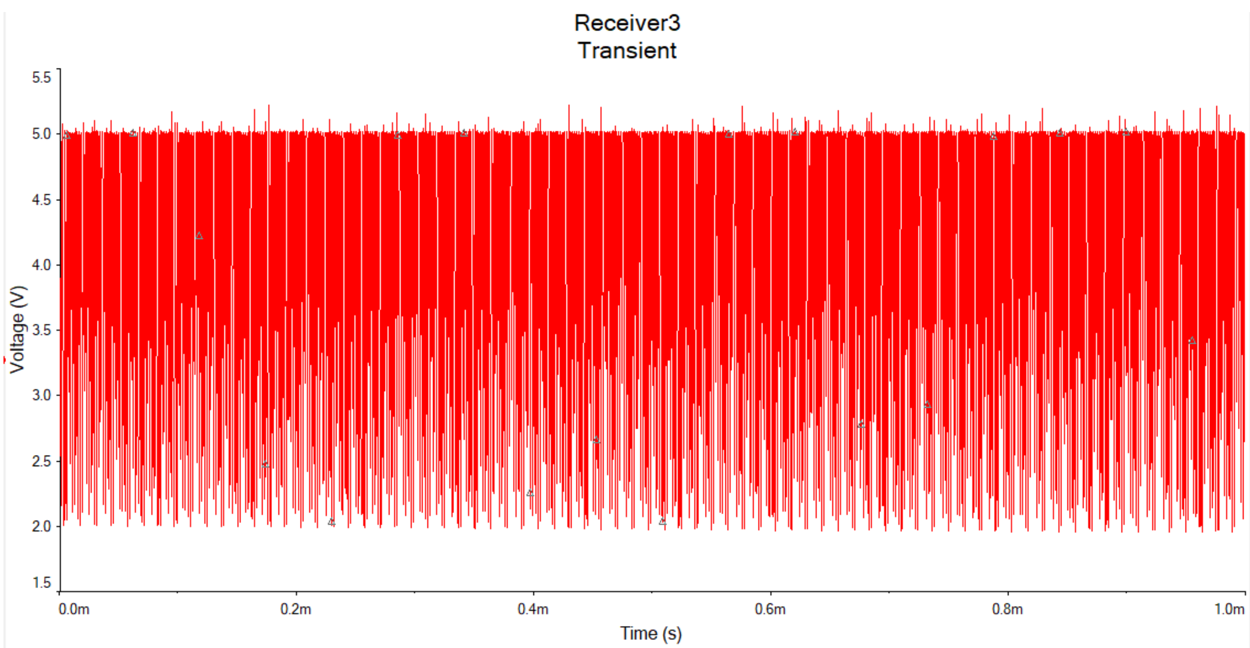


Receiver Oscillator Waveform at 510kHz

Part 3 - Receiver: Downconverter

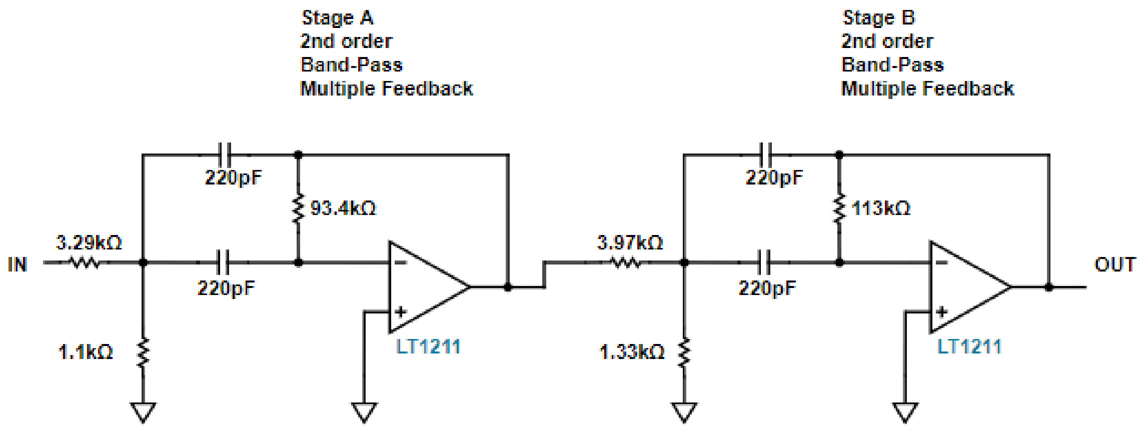


Downconverter Schematic

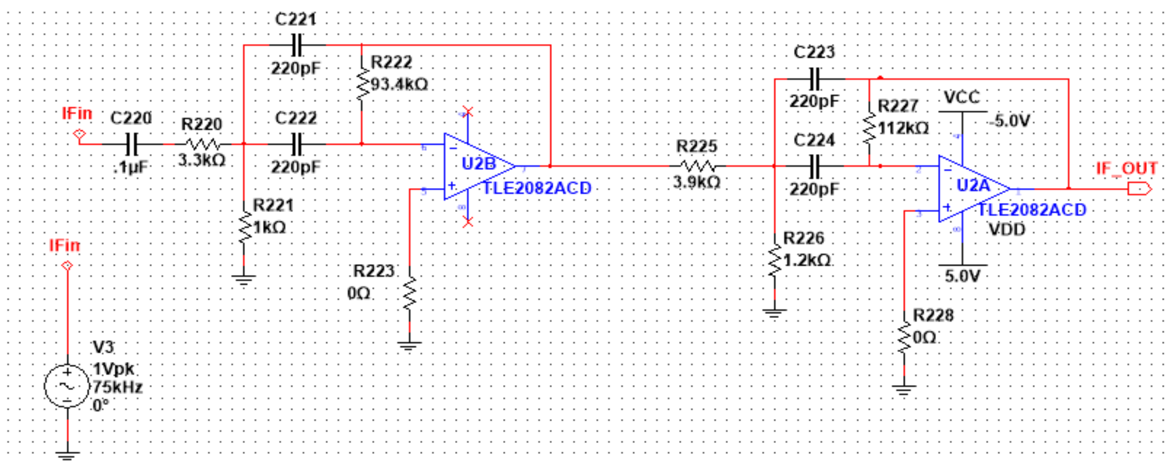


Downconverter Transient Analysis

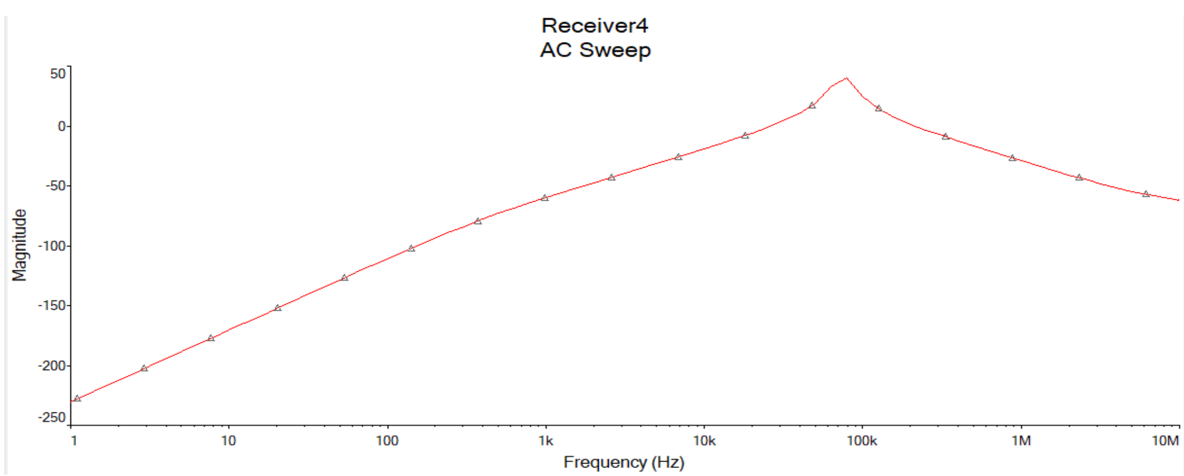
Part 4 - Receiver: IF Filter



IF Filter Design Using Filter Wizard

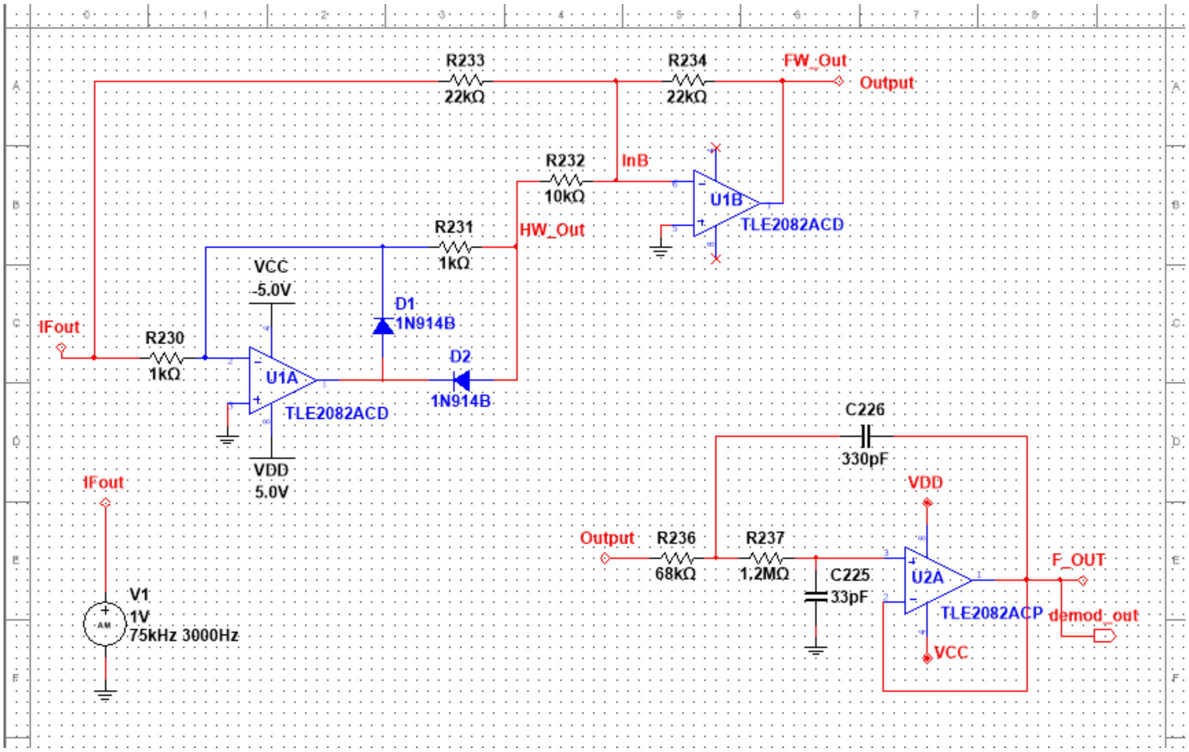


IF Filter Design with MultiSim

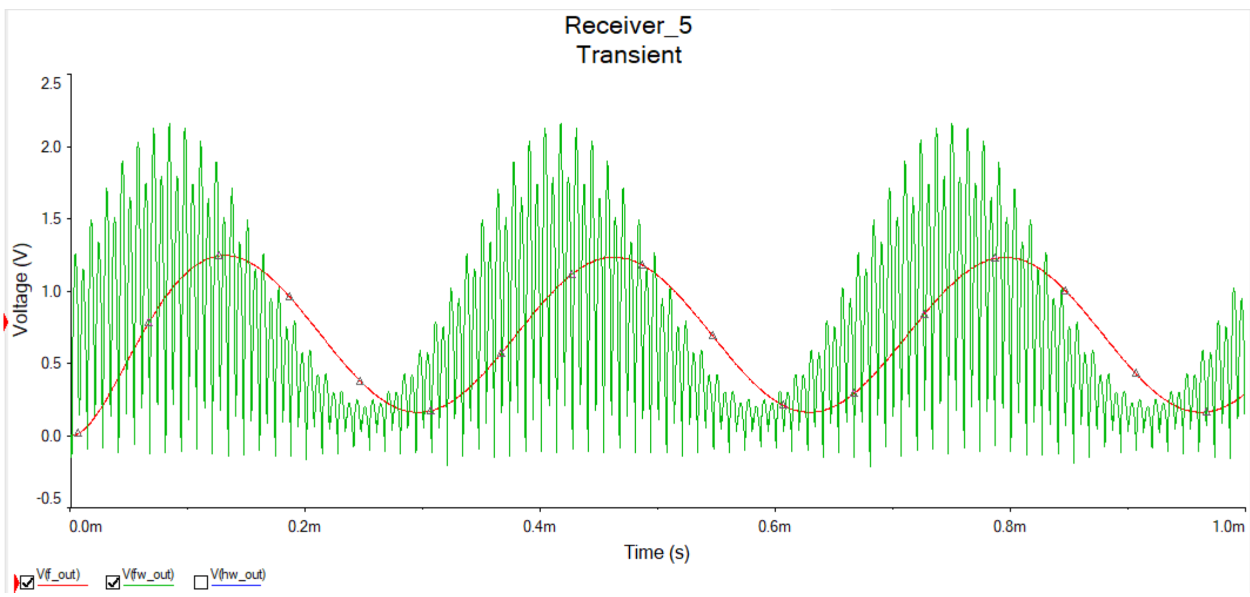


IF Filter AC Sweep with 75kHz

Part 5 - Receiver: AM Demodulator

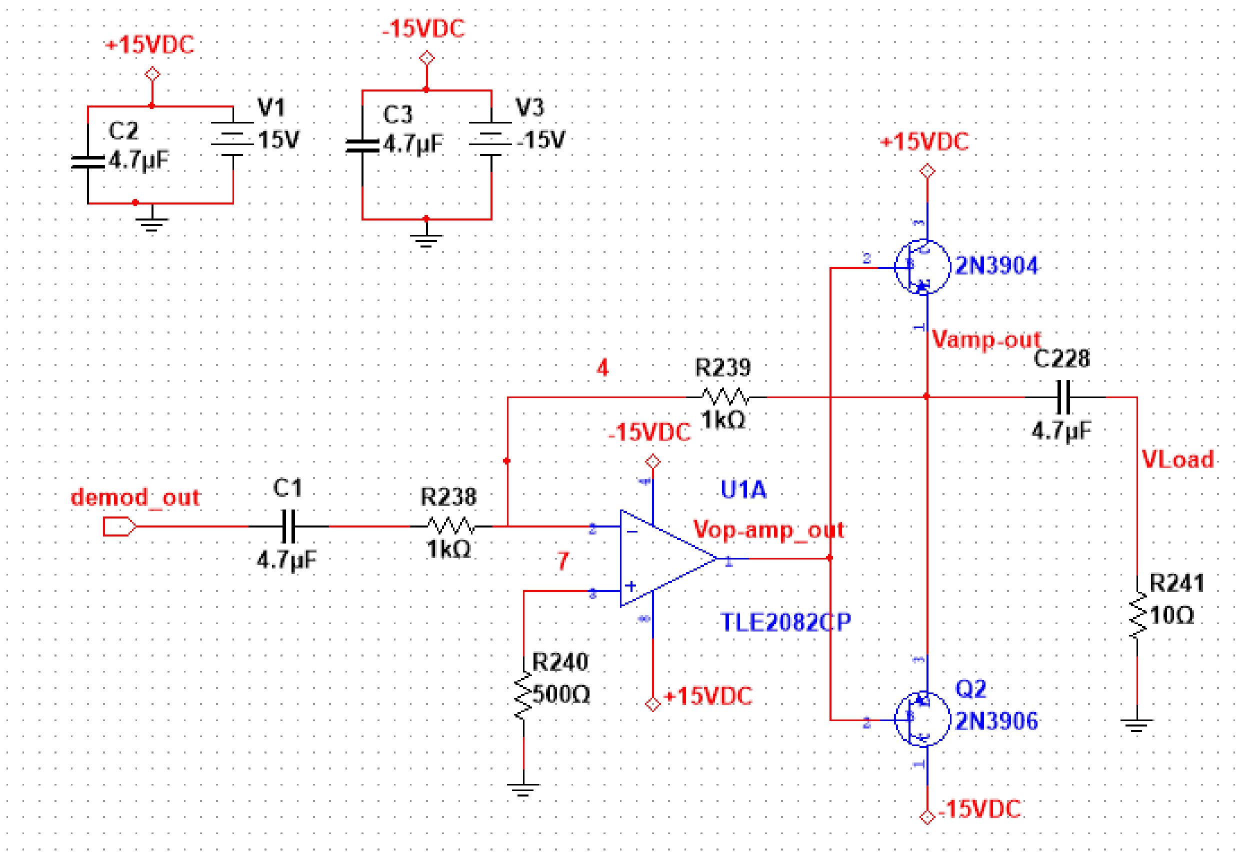


AM Demodulator Design

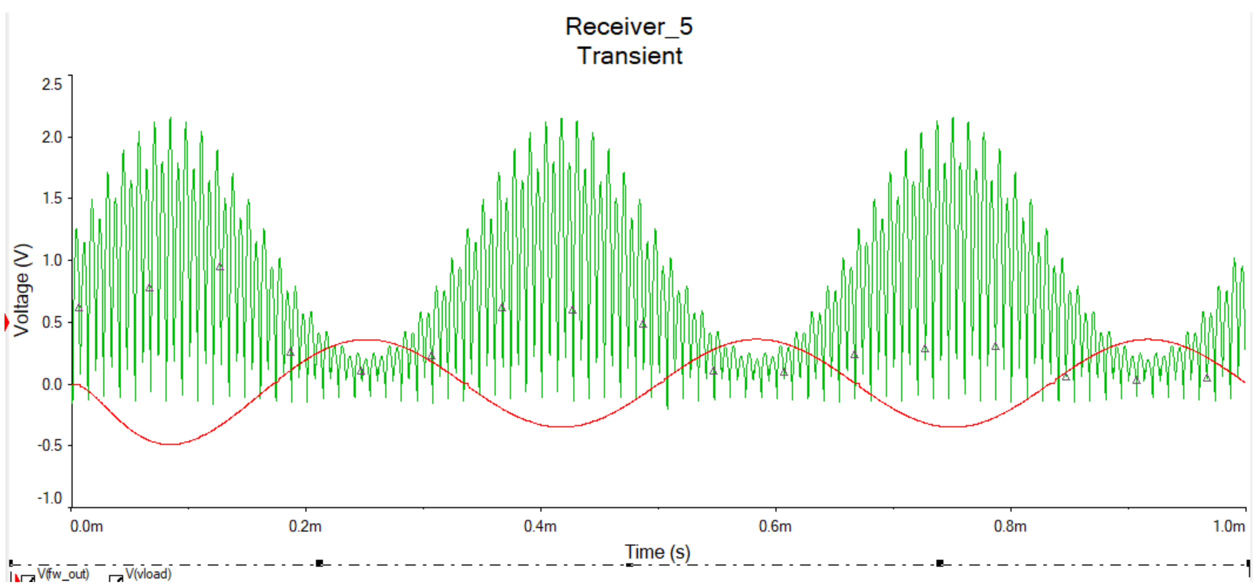


AM Demodulator Transient Analysis

Part 6 - Receiver: Speaker Amplifier



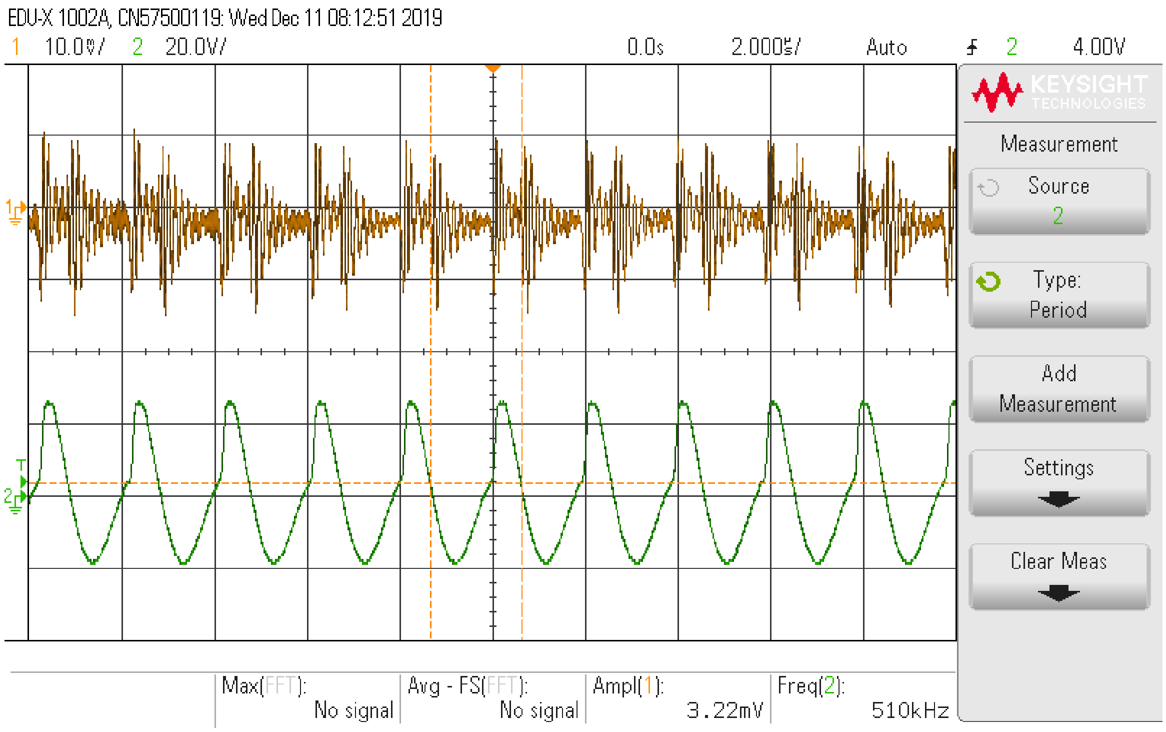
Speaker Amplifier Design



Speaker Amplifier Transient Analysis

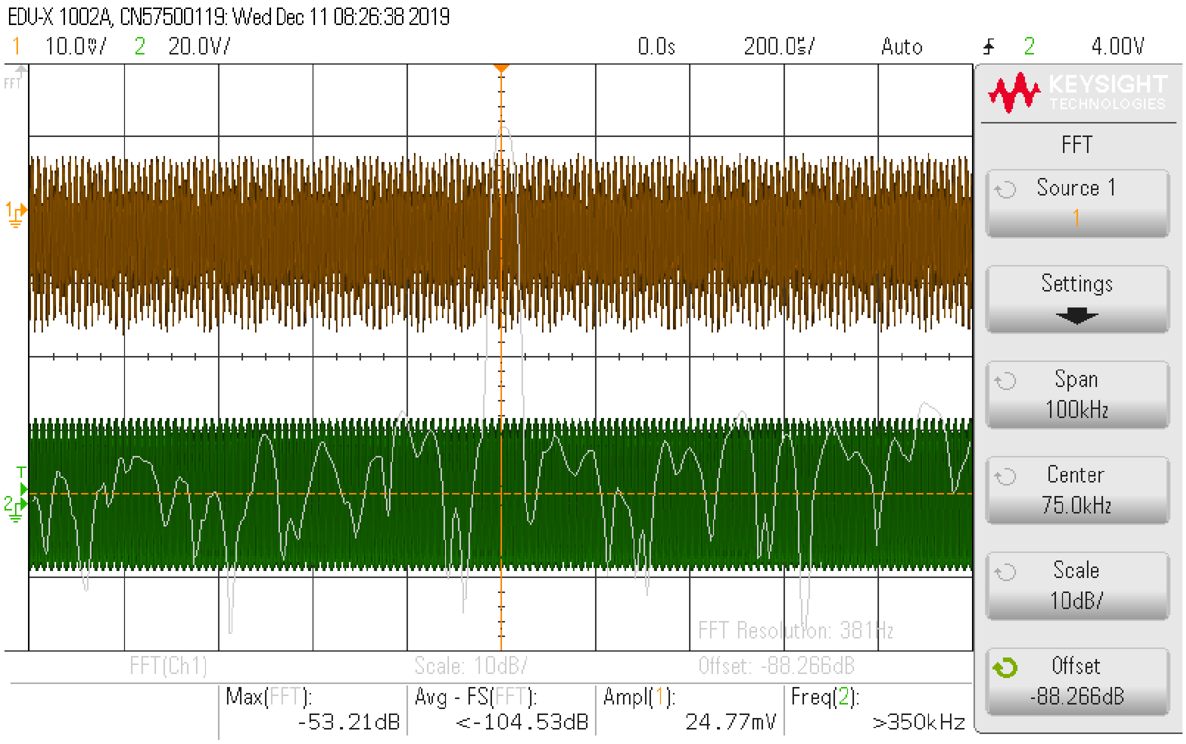
Integration

1. Unmodulated input signal @ 435kHz amplitude 80mVpp



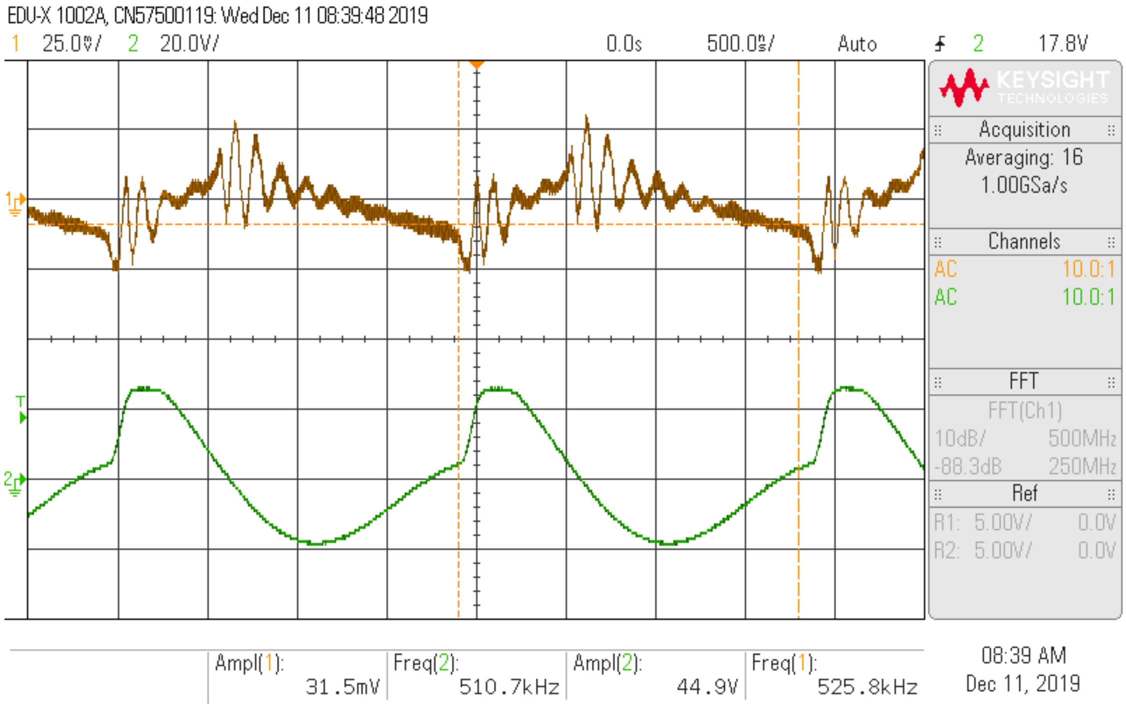
Receiver Integration

2. Tune oscillator to receive freq by monitoring IF filter output (FFT on scope)



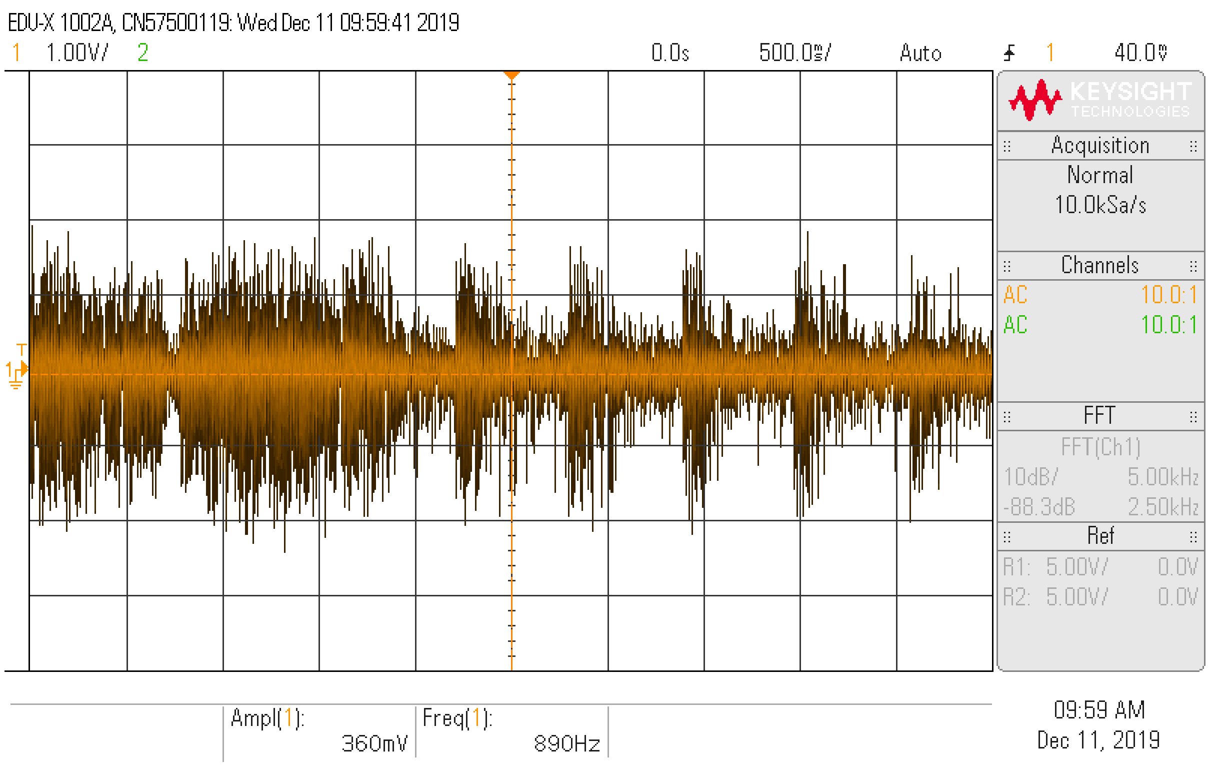
Tuning the RX local oscillator to receive the desired input signal by monitoring the output of the IF filter using the oscilloscope and the FFT capability centered at the IF frequency (75kHz).

3. Put AM modulated input into demodulator to check if it works



Triangle of 20kHz at 80% Modulation

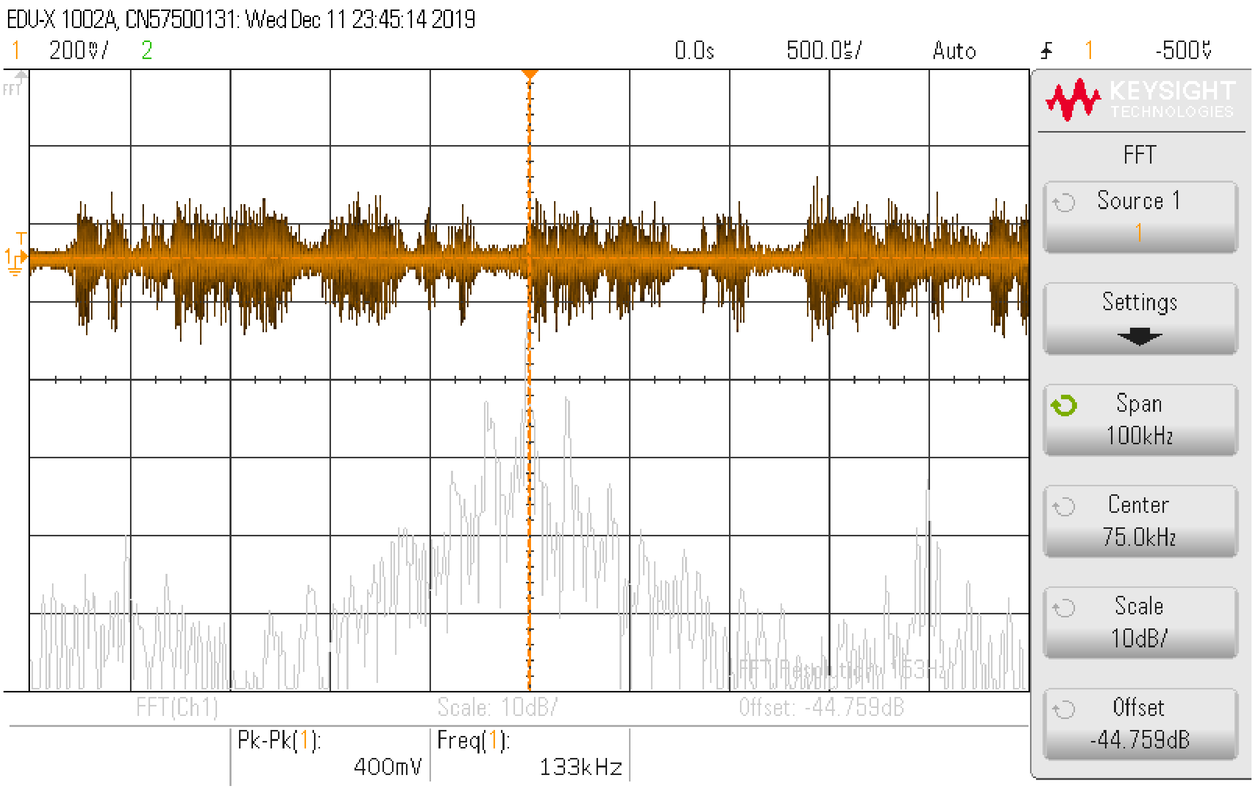
4. Put AM modulated tone in receiver to check whole receiver



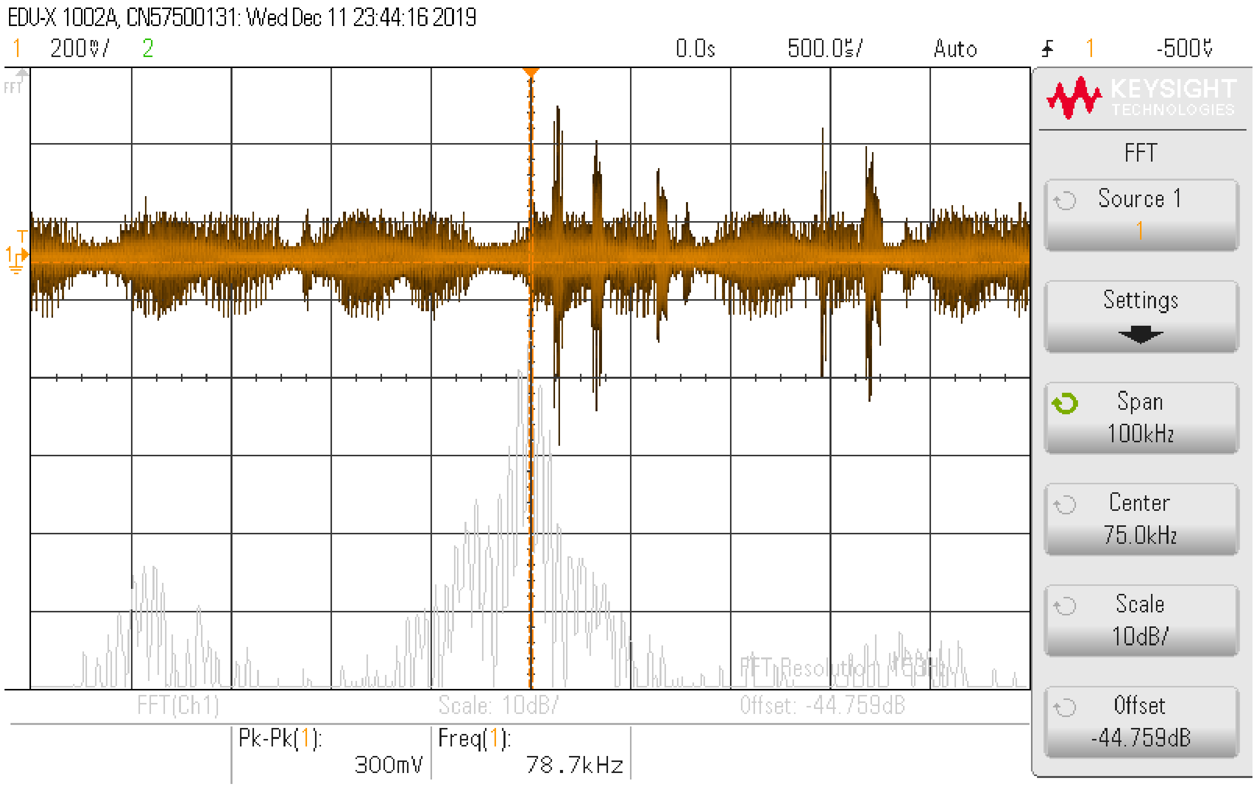
Waveform while music is playing

5. Verify IF filter rejection by using receive frequency that's right but moving LO Freq & Implement Interferer

   410kHZ carrier with 1kHz modulating signal
   400mVpp



Tuned: 410kHZ carrier with 1kHz modulating signal, 400mVpp



Untuned: 410kHZ carrier with 1kHz modulating signal, 400mVpp

Successfully tuning between the interfering signal and the desired music playing speaks to the level of rejection in the IF filter. At a frequency offset of 30kHz, the entire 400mVpp interfering signal was rejected and only the desired audio was heard. The beginning of distortion on the desired audio signal using an interferer at a frequency offset of 30kHz only began when the interfering frequency was 1.2Vpp, which suggests a very effective IF filter.

Final Observations and Project Evaluation

The final project worked as expected. Our speaker, when correctly integrated with the receiver and transmitter, played audible music. To make this project successful, component values were carefully calculated, circuits were simulated before build, and each section of the board was tested as it was built. The project was tested and successful with and without an interferer. When connected to the function generator to produce and intereferer, the receiver of the oscillator was able to be tuned to receive the interfering signal and the desired signal, producing audible music.

Summary of the Process

Several hours of work went into successfully completing this project. In order to reduce the amount of possible errors during integration, we simulated every circuit on Multisim. On Multisim we were able to view the simulated transient analysis or AC sweep to determine if it was or wasn't what we expected based on our previous labs from earlier in the semester. When the output wasn't desired, we evaluated our component calculations for mistakes or determined if the standard component sizes were close enough to our calculated ones. Most issues were fixed usually by examining these two things. Another issue was when the component did not make a strong enough connection with the board, which was resolved by checking all solder points.

We believe that we did a good job on the project. We believe it is the best as we could have made it with the time and resources available. We did not encounter any build issues, just issues with connecting the boards together. This was resolved by checking first on how to connect the boards properly before giving the project power to ensure that we wouldn't damage our project. We spent a lot of time with the design upfront so that we could take our time with the build. By doing this, we believed we saved ourselves from hours of troubleshooting our boards and redoing calculations.

If we had to redo this project again, we would design for the standard resistor values we had available, so that compromises would not have to be made. Some of our resistors were not quarter watt resistors, which could have had an impact on the overall project.

Grading Rubric for Kayleen & Sarah

Lab Section	Result Description	Points Available	Instructor Sign Off	Points Obtained
1	Design, Simulate, Build and Test of the transmitter. Relevant simulation output	25		
2	Design, Simulate, Build and Test of the receiver. Relevant simulation output	25		
3	Integration and test of the TX/RX Pair	40		
4	Final Observations and Evaluation Completed schematic file	10		

Instructor Comments: