Boston University

Electrical & Computer Engineering

Final Prototype Testing Report

Better Bot

by

Team #15

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Introduction

The primary objective of AM Radio Localization system is to accurately determine the location of AM radio sources in a given area. The active antenna amplifies the radio signals, while the isolation amplifier ensures that the amplified signals are isolated from the noise in the range of 100kHz to 10MHz. The tracking filter then applies a filter to the enhanced signals to eliminate any unwanted interference and improve the signal quality. The triode mixer takes radio frequency and local oscillator signal (function generator signal) and multiplies them to produce a new intermediate frequency. For our final prototype testing, we combined four circuits: an active antenna, isolation amplifier, tracking filter, and triode mixer to generate an intermediate frequency. The report details the design and implementation of the four main circuits of the system, including the circuit diagrams, testing procedure, and performance evaluation.

Isolation Amplifier

Overview:

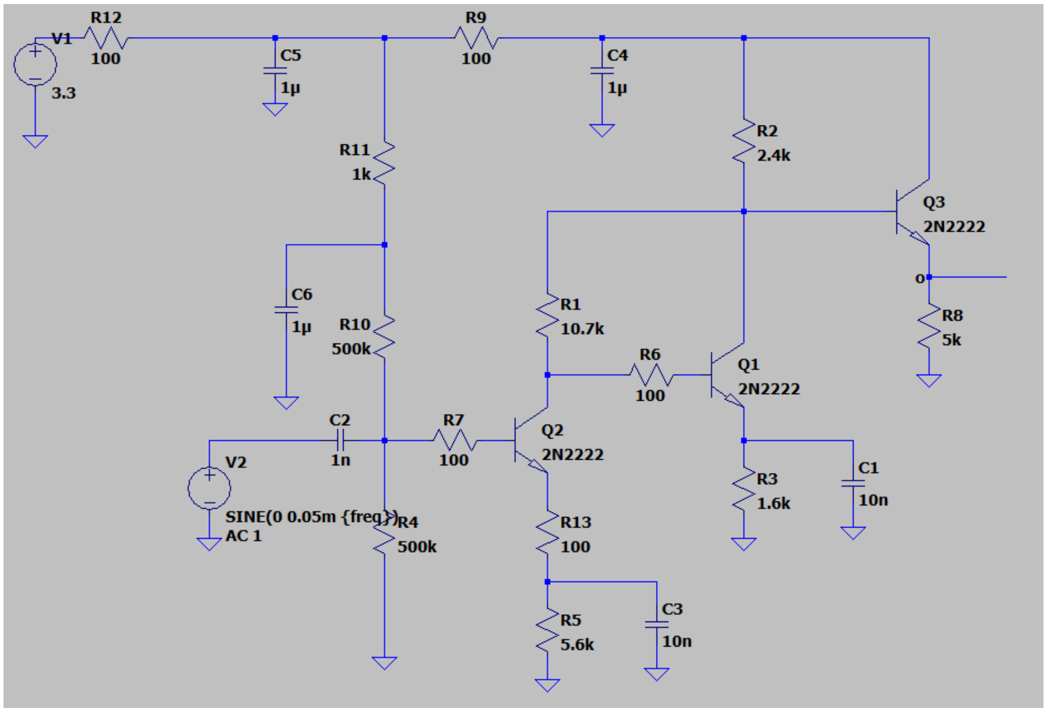

Fig. 1 Circuit Diagram of Isolation Amplifier

The purpose of the isolation amplifier is to amplify the active antenna signal output and reduce the negative feedback signal. The implementation of this circuit uses only discrete components. A small value of resistors R6 and R7 will keep the transistors stable. R10 and R4 will increase the input impedance of the amplifier to prevent the circuit from overloading. Q2 will drive low impedance to Q1 this will eliminate the noise and generate a high-frequency response. Another important factor of an isolation amplifier is to amplify voltage gains, the signal gain factor is mainly dependent on R1 and R13. Q3 reduces the output impedance, which is required/recommended for signal amplification. This step is important because high output impedance will tend to result in loss of the signal and distortion.

Equipment and Setup:

To complete powering up and measuring the output gain of the isolation amplifier requires a power supply, function generator, and oscilloscope. The AC input is connected to the function generator with a frequency of 850 kHz. The DC input is connected to the power supply with 3.3V. Then we can check the gain by measuring the output voltage signal with an oscilloscope hooked up to the output end of the amplifier.

Simulation Results:

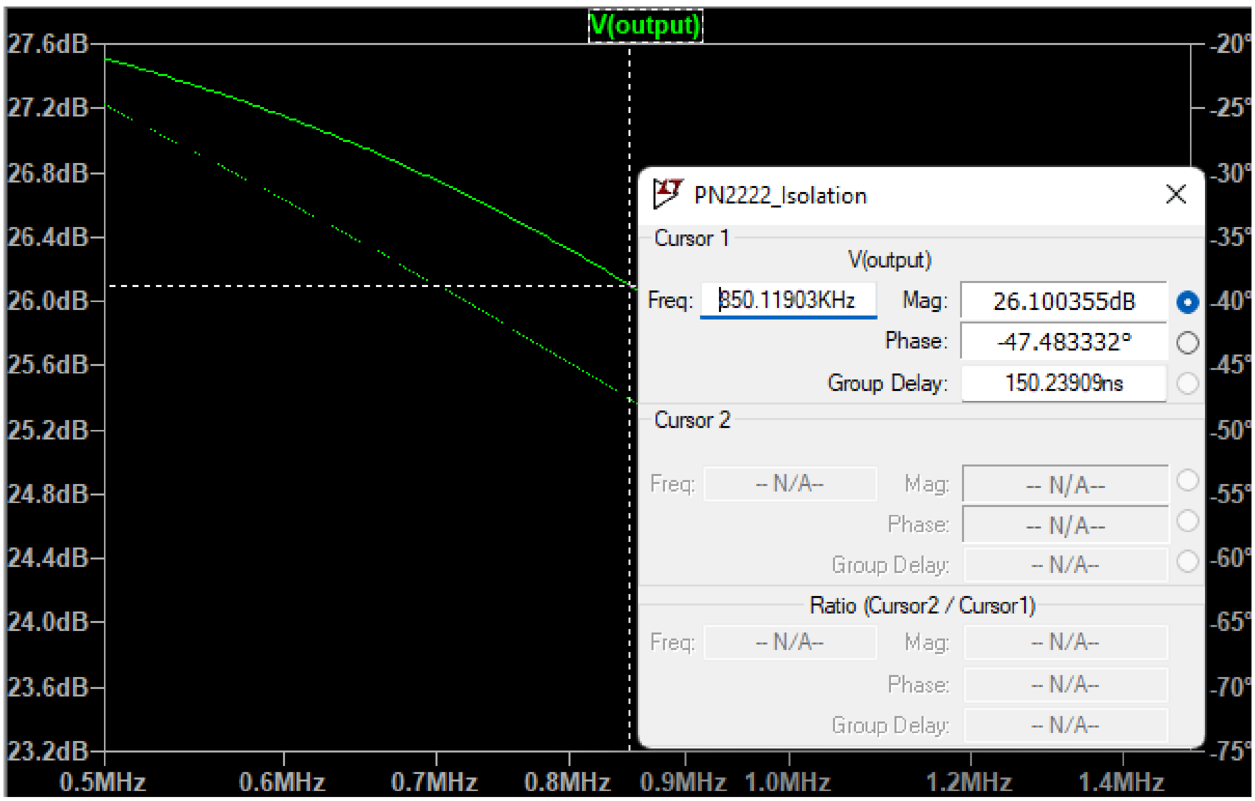

Fig.2 Voltage gain bode diagram of Isolation Amplifier from 500kHz-1.5MHz

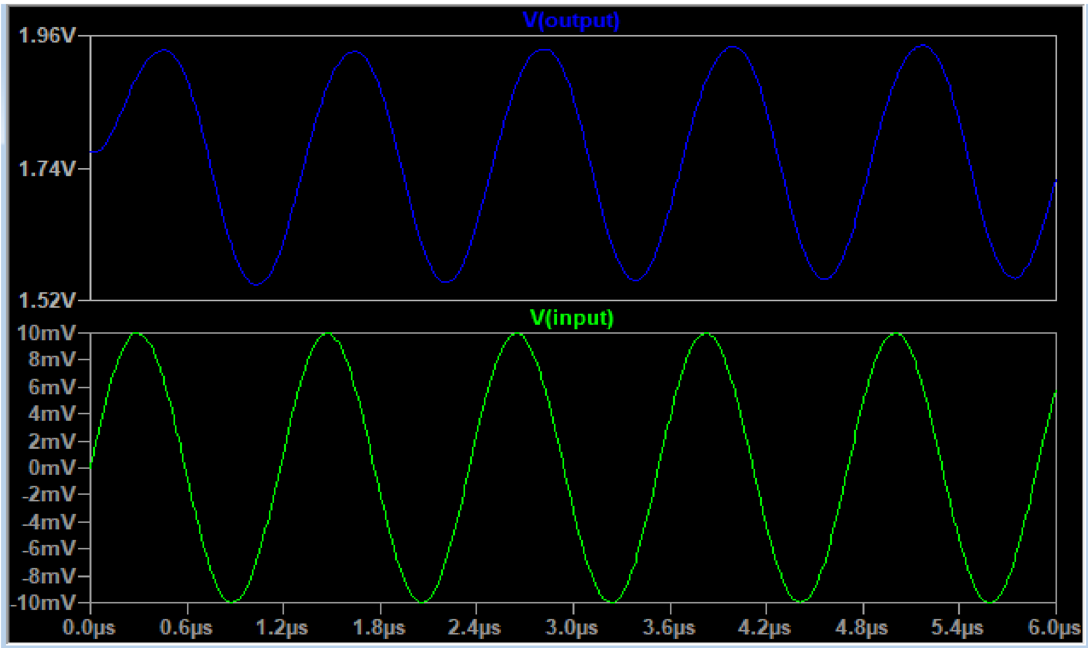

Fig.3 Transient Analysis of Isolation Amplifier with the input of 850 kHz & 10mV

Test Output/Measurements:

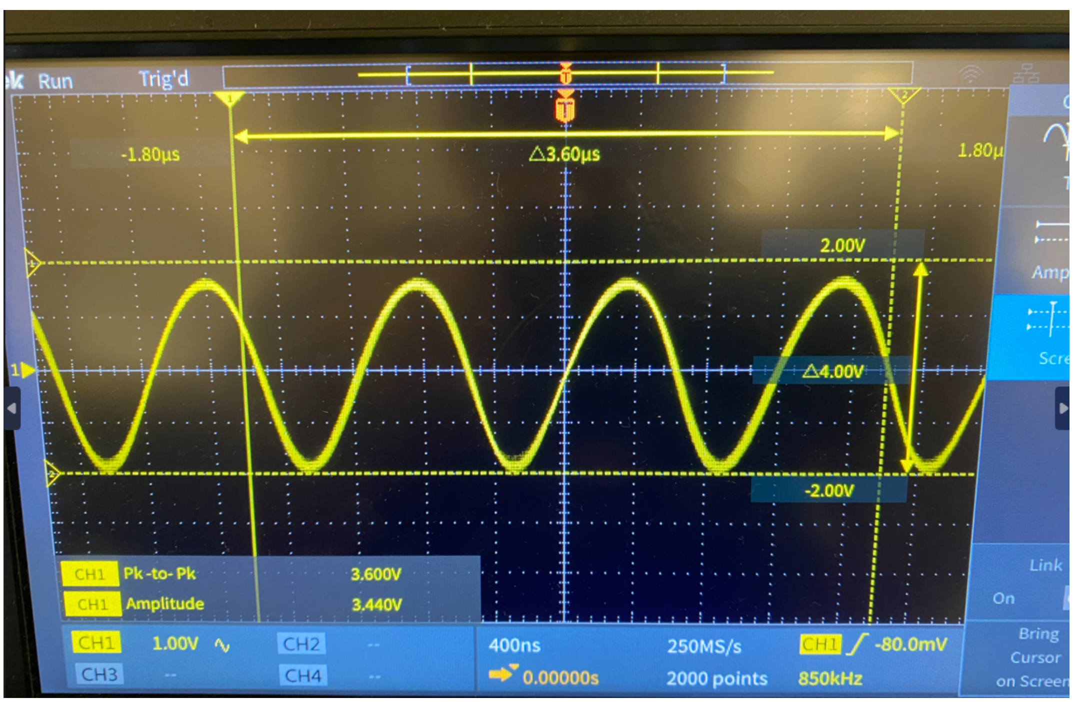

Fig.4 Isolation Amplifier Oscilloscope Output Waveform

The output generated by the isolation amplifier is within the range of our expected output. In Fig. is the Voltage output from INA, we can see that the output with Pk-to-Pk of 3.6V, and our input amplitude is set to 10mV, this indicates the gain is 18. The expected gain range for our test plan is from 15-20. The isolation amplifier is working properly.

Tracking Filter

Overview:

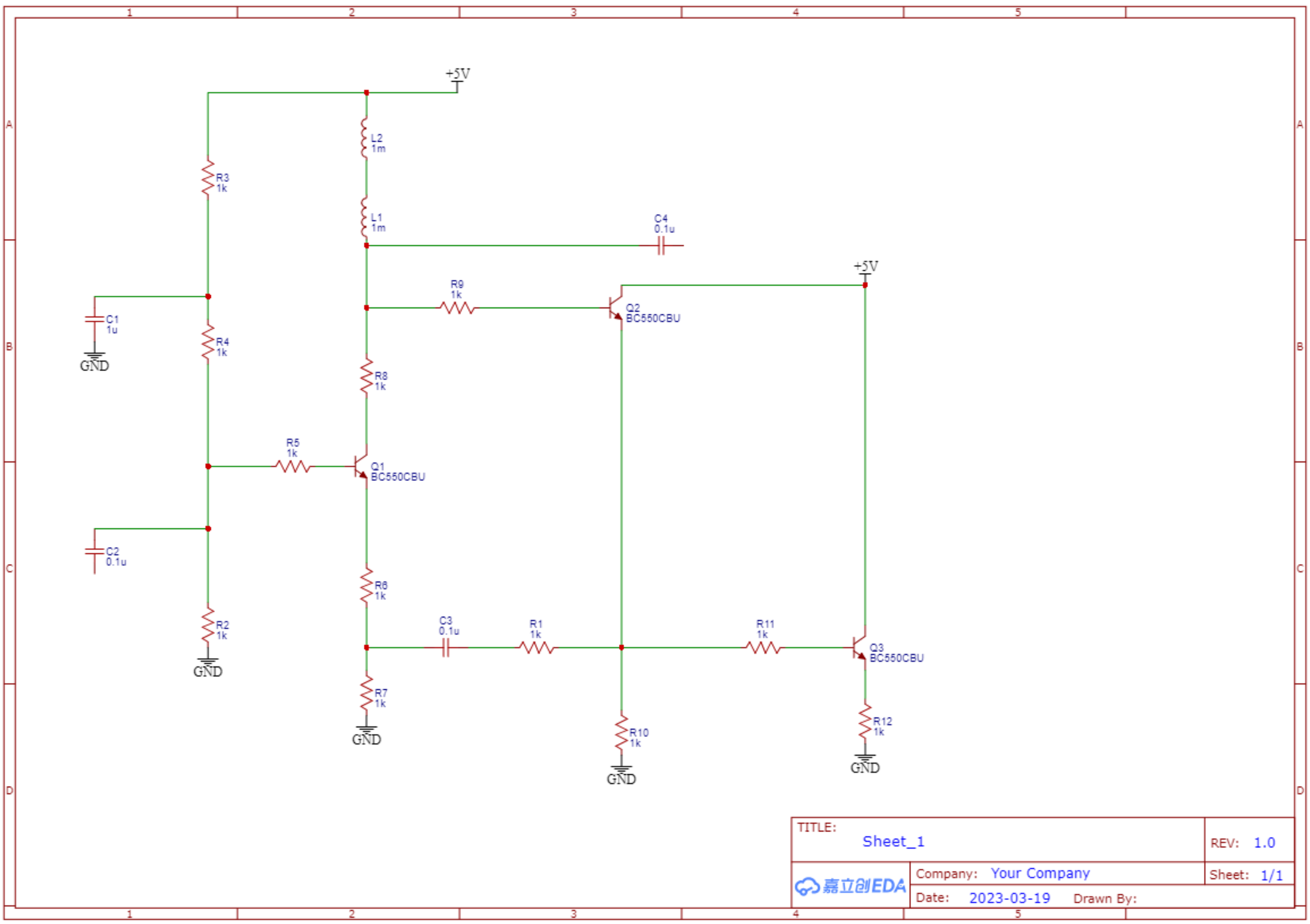

Fig. 5 Tracking Filter Schematic

The purpose of the tracking filter is to accept, filter, and further amplify the signal received from the isolation amplifier. On a more practical implementation the capacitor C4 would be replaced by varactors in order to have a voltage-controlled variable capacitance, in order to ease the testing process we opted to use a manually adjustable capacitor. In order to set the target frequency that the filter will amplify we must first use a simulation of the same circuit for guidance on what parameters should be used.

Equipment and setup:

We use the LTSpice simulation in order to have an approximate capacitance necessary for centering the 850KHz signal that will be used in next testing stages.

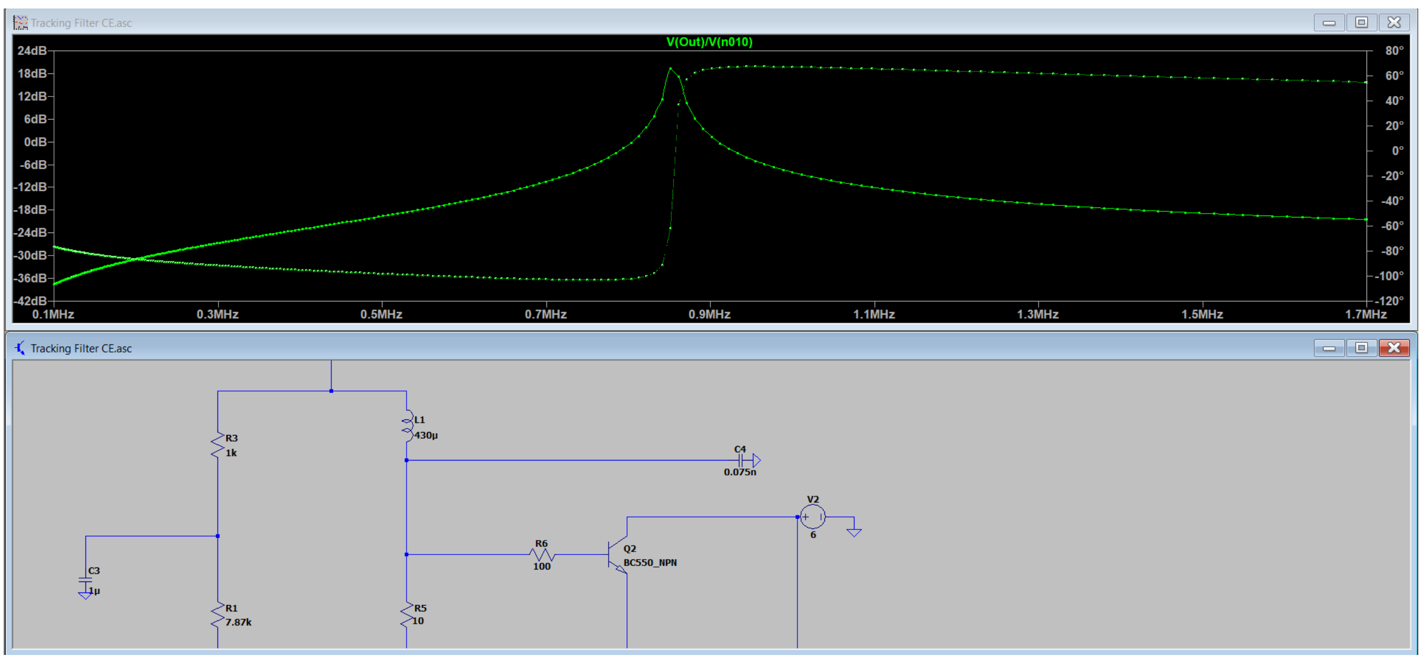

Fig.6 Tracking Filter Setup Simulation

As we can see in the simulation, a capacitance of 0.075nF is appropriate for the signal we desire to isolate. It also indicates (rather optimistically) a gain around 19dB and a 'gain clearance' of 2dB 10KHz away.

We plug in the tracking filter to the DC power supply as well as to a signal generator and the oscilloscope. The input for calibration will be a 20mVpp sine wave with a frequency of 850KHz.

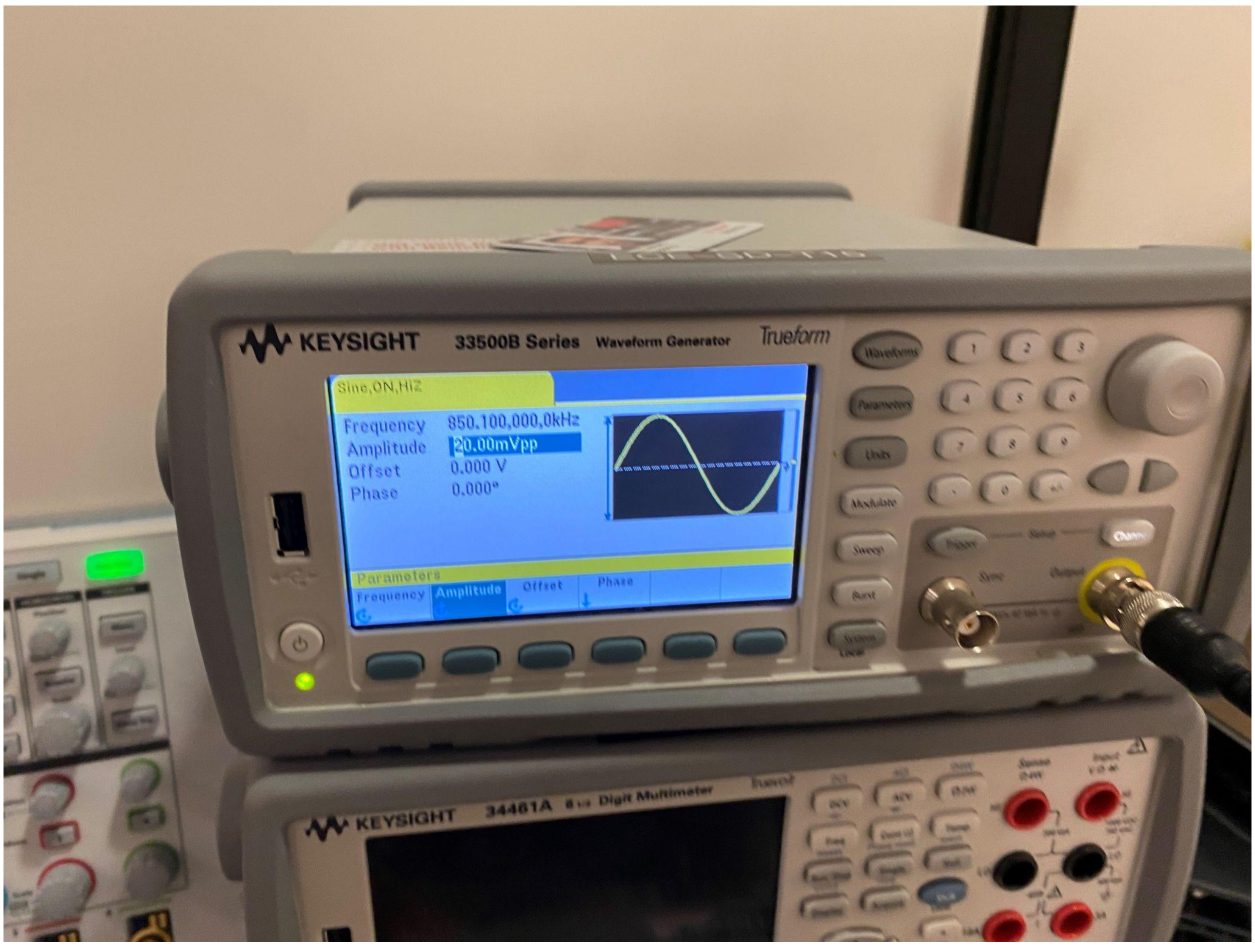

Fig. 7 Calibration Input

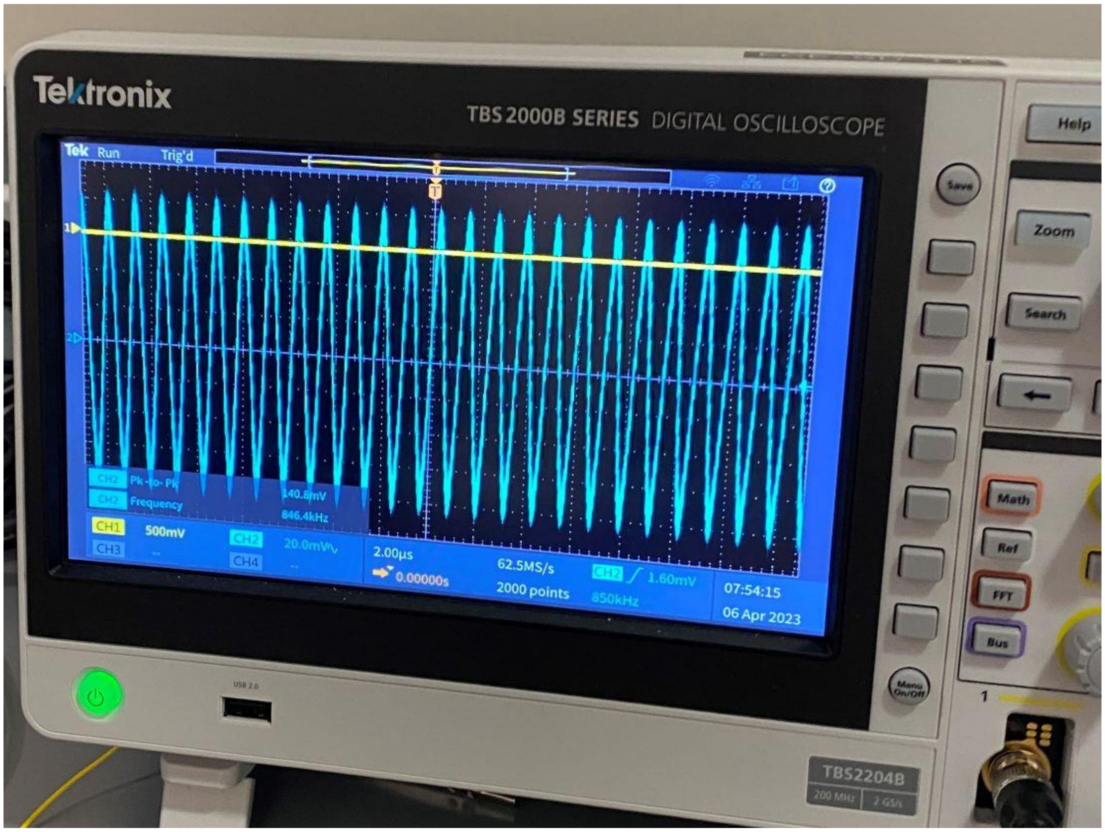

Fig. 8 Tracking Filter Output

We can observe the tracking filter outputs the same sinusoidal with a gain of 17dB, however it is important to clarify that because of the nature of the circuit it is extremely unstable. In order to have a proper measurement one would need to isolate the whole circuit leaving only exposed input and output terminals. Just the act of waving one's hand on top of the capacitor is enough to make the gain fluctuate by 30mV. The output signal had a 'clearance' of 3dB, meaning that frequencies 10KHz from the target frequency were amplified by 14dB or less, meaning that it is satisfactory and according to engineering conventions.

Combined System(Active Antenna, INA, Tracking Filter, and Triode Mixer)

Overview:

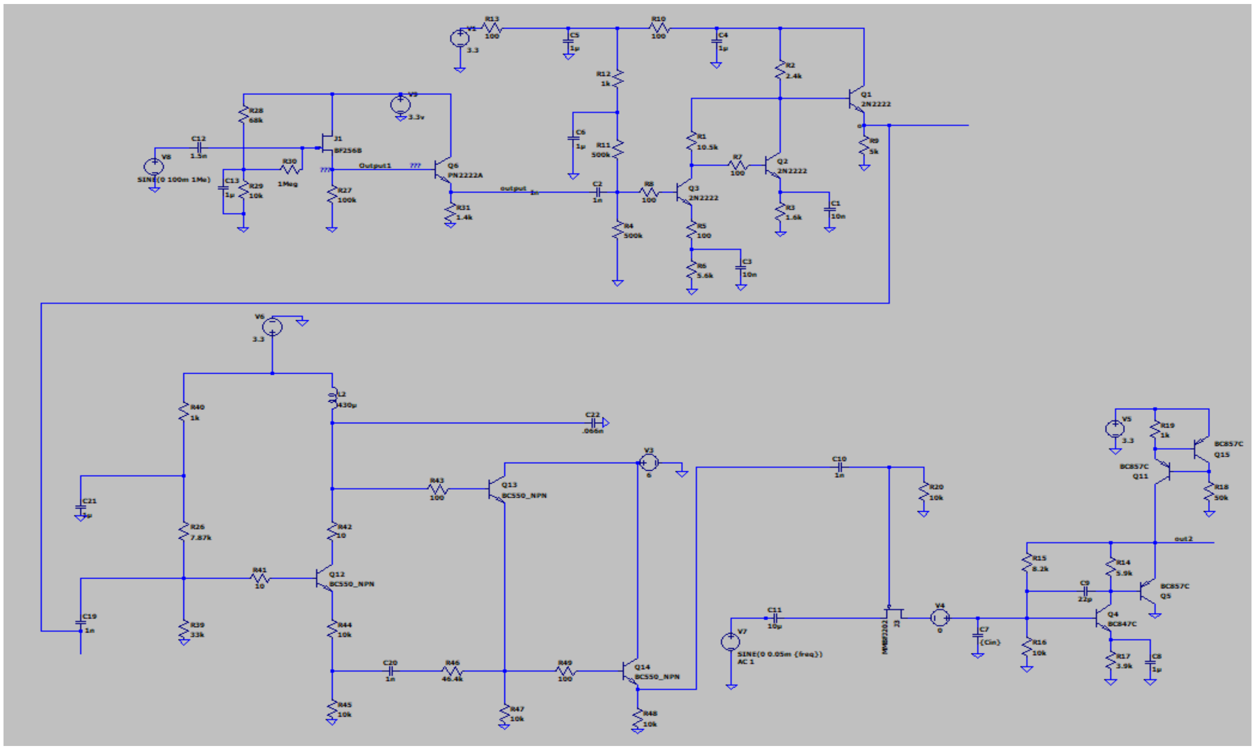

Fig. 9 Overview of the system schematic

Equipment and Setup:

We combined and tested the four circuits we made. The circuits that are being tested are Active Antenna, Isolation Amplifier, Tracking Filter, and Triode Mixer. The schematic of the combined system is in Fig.. The required hardware is a function generator, power supply, and oscilloscope. First, we powered up the active antenna and hook it with up to 10 ft 28 gauge wire to the input of the active antenna, then connect 3.3V DC voltage to power up the antenna. The isolation amplifier's input will then be connected to the output of the active antenna and powered up by a 3.3V DC power supply, the isolation amplifier should be able to amplify the input signals by a factor of 15. Then the input of the tracking filter will be connected to the output of the isolation amplifier, and the output of the tracking filter will serve as an input for the triode mixer.

Simulation Result:

1. Tracking Filter FFT: variable capacitor = 0.071n (Sets RF = 850KHz)

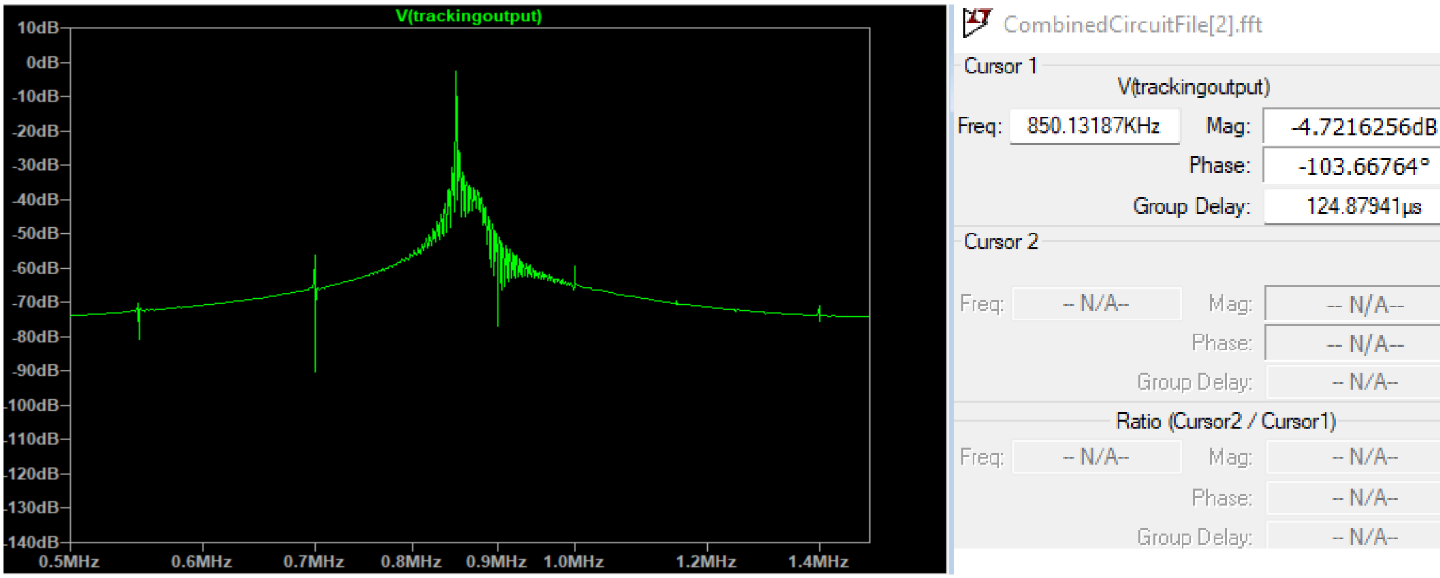

Fig. 10 FFT of Tracking Filter output

2. Triode Mixer FFT: Input of 860KHz from a function generator (LF = 860KHz)

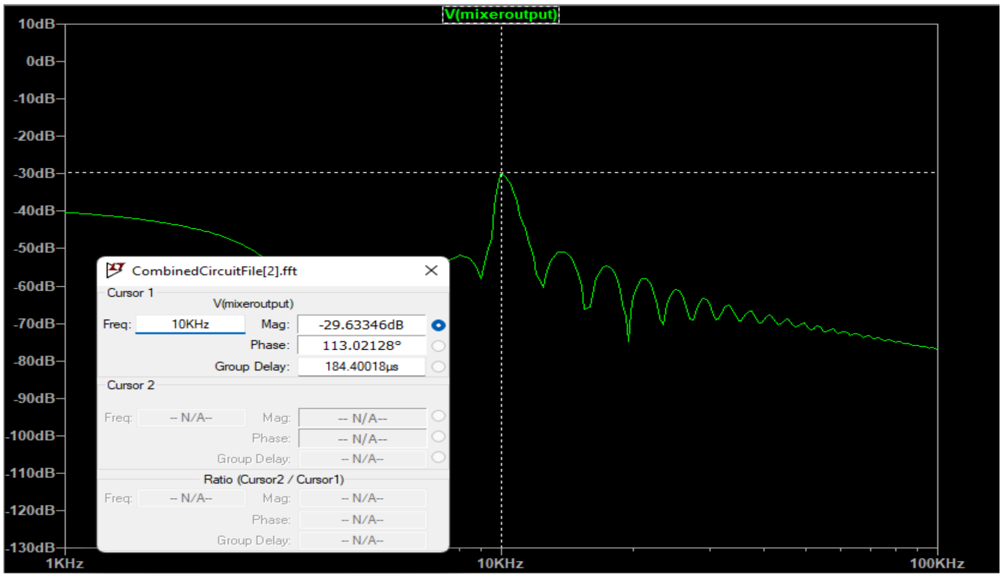

Fig. 11 FFT of Triode Mixer output

The simulation gives an accurate intermediate frequency output given by the table in Fig. of 10KHz, in which the intermediate frequency response is calculated by the local oscillator frequency of 860KHz(input from the function generator) minus the radio frequency of 850 KHz.

Test Output/Measurements:

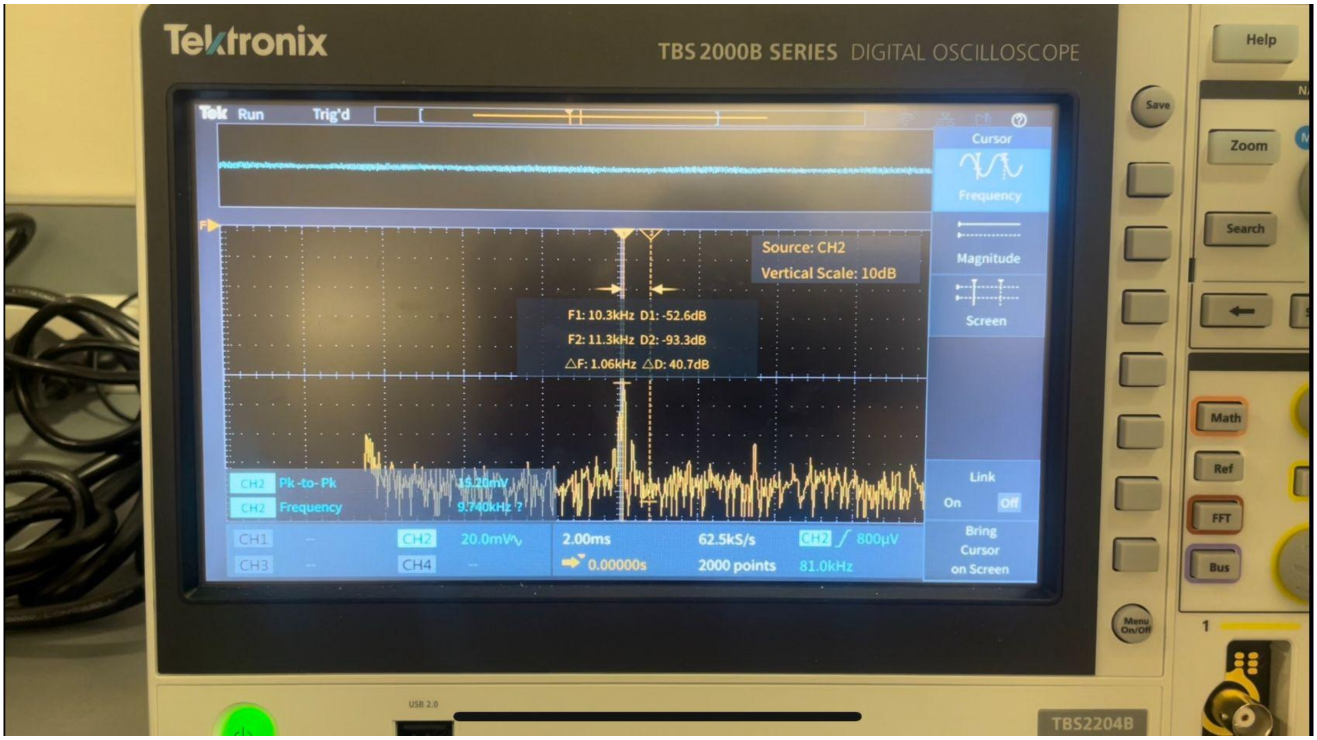

Fig. 12 FFT of Triode Mixer Oscilloscope Output

Conclusion:

From *Fig* , we can see that there is a peak at 10.3kHz which is what we expected. The result (10.3kHz) is the same as the simulation results (10kHz) with a difference of 0.3kHz and a percentage error of 3%. Since 3% is much less than 10%, we conclude that the combined circuit works properly and has met all the requirements.