Boston University

Electrical & Computer Engineering

First Prototype Testing Report

Better Bot

by

Team #15

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Introduction

In our first prototype test, we tested three essential modules of our AM radio localization system: active antenna, isolation amplifier, and tracking filter. We started with simulating them in LTSpice. Then, we implemented them on breadboards to determine if they work the same as we expect. Their circuit simulation, expected result, and prototype test procedures and results are addressed in detail in the following sections of this report.

Active Antenna

Set up

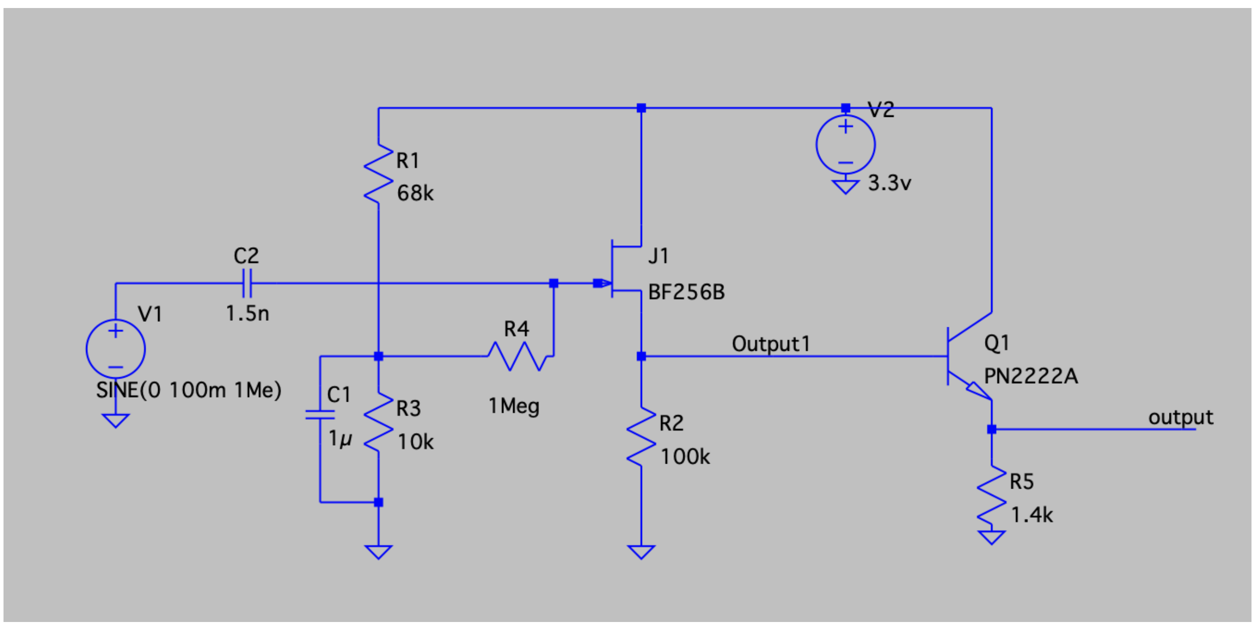

Fig 1. Schematic of Active Antenna

Fig1 shows the schematic for active antennas. It is made up of a JFET (BF256B) as an emitter follower that will amplify the input signal and is followed by a BJT (PN2222A) in order to have a high output impedance. A voltage divider is added before the JFET in order to control the output voltage to be around 1.65V ($V_{dd}/2$), and to prevent the JFET from falling into saturation.

Testing Procedure

We first powered up the antenna with a 3.3V DC voltage source. Then, we connected a 1MHz sine wave with 100 mV to the input by using the waveform generator. Next, we connected the oscilloscope to the output. We were supposed to see an amplified sine wave. By pressing the FFT button on an oscilloscope, we are able to detect the frequency of the input signal. FFT is fast fourier transform function avaailble on the oscilloscope that will automatically transform time domain singal into frequency domain. By using this function, we are able to detect the

Result

Fig 2. FFT of Output Signal

On this graph, we can see that there is a little spike on the right side of the screen which is corresponding to the 1 Mhz input signal. It shows that the circuit we built is correct, and we will able to detect the surrounding AM radio inside the building by using this circuit.

Isolation Amplifier

Set Up

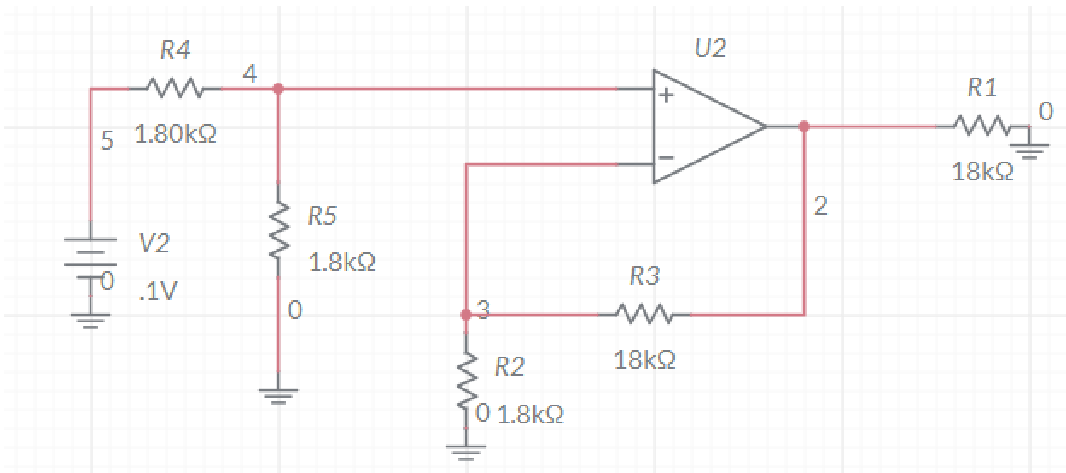

Fig 3. Circuit Diagram of Isolation Amplifier

The purpose of inserting an isolation amplifier is to amplify the active antenna signal output and reduce negative feedback signal. The implementation of this circuit uses OP-AMP(MCP6002) to amplify the output signal, the resistor R4 and R5 are inserted and work as a voltage divider to lower the Op-Amp input voltage. R2 and R3's functionality is to increase the gain (K) of the Op-Amp circuit.

$$K=1+\frac{R3}{R2}$$

R2 and R3 will also reduce the negative feedback from the input since the Op-Amp will obtain a greater gain.

Testing Procedure

To perform the task, Pins 1, 2, 3, 4, and 8 will be used for the implementing process. Pin 1 will be connected to an oscilloscope for measuring the output signal. Pin2 will be connected to the 1.8kΩ resistor. Pin 3 is V_{INA^+} which will be connected to a DC power source of 100mV. Pin4 is the power pin of V_{ss} which will be set to -5V. Pin 8 is the power pin of V_{DD}=this value is set to 5V.

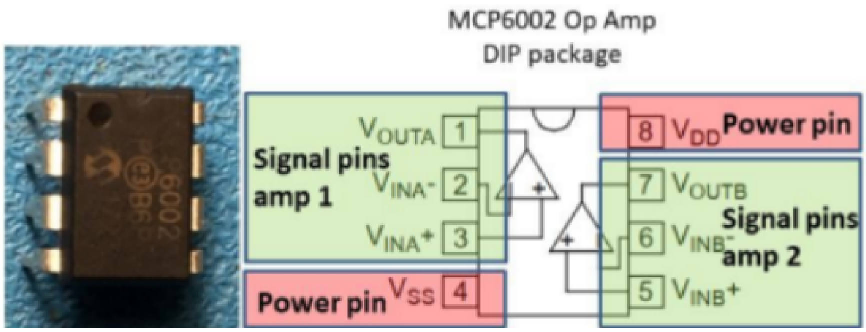

Fig 4. MCP6002 Pin Functions

Result

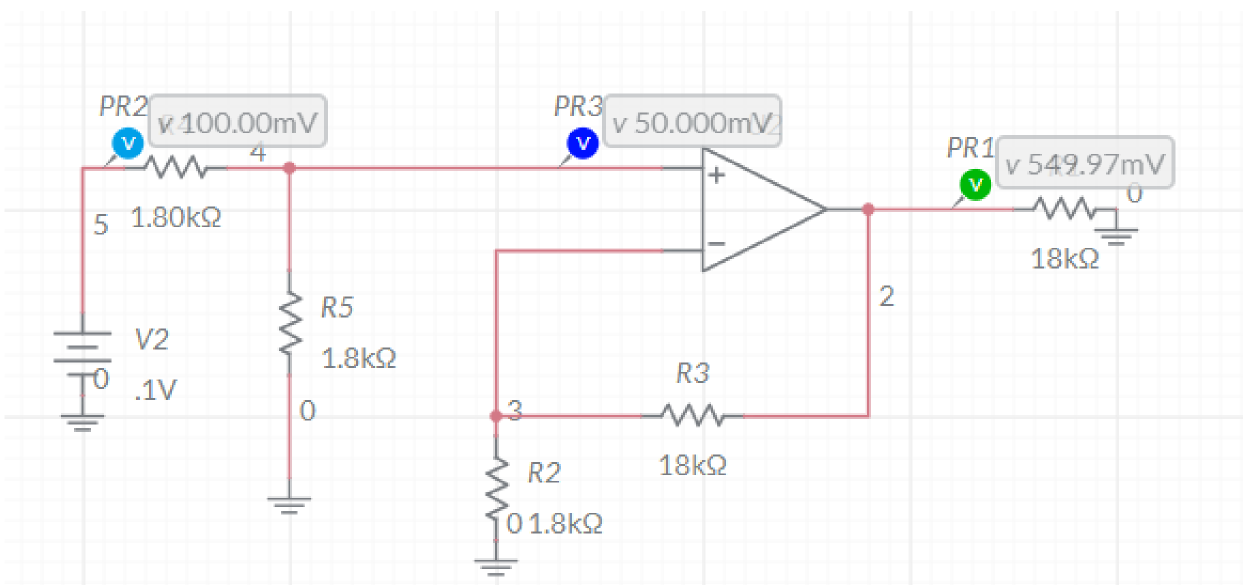

Fig 5. Isolation Amplifier Voltage Outputs

From the output values, the input 100mV has a gain of K=5.5, which is ideal to our anticipated gain result in the range of 4-5.

Tracking Filter

Set Up

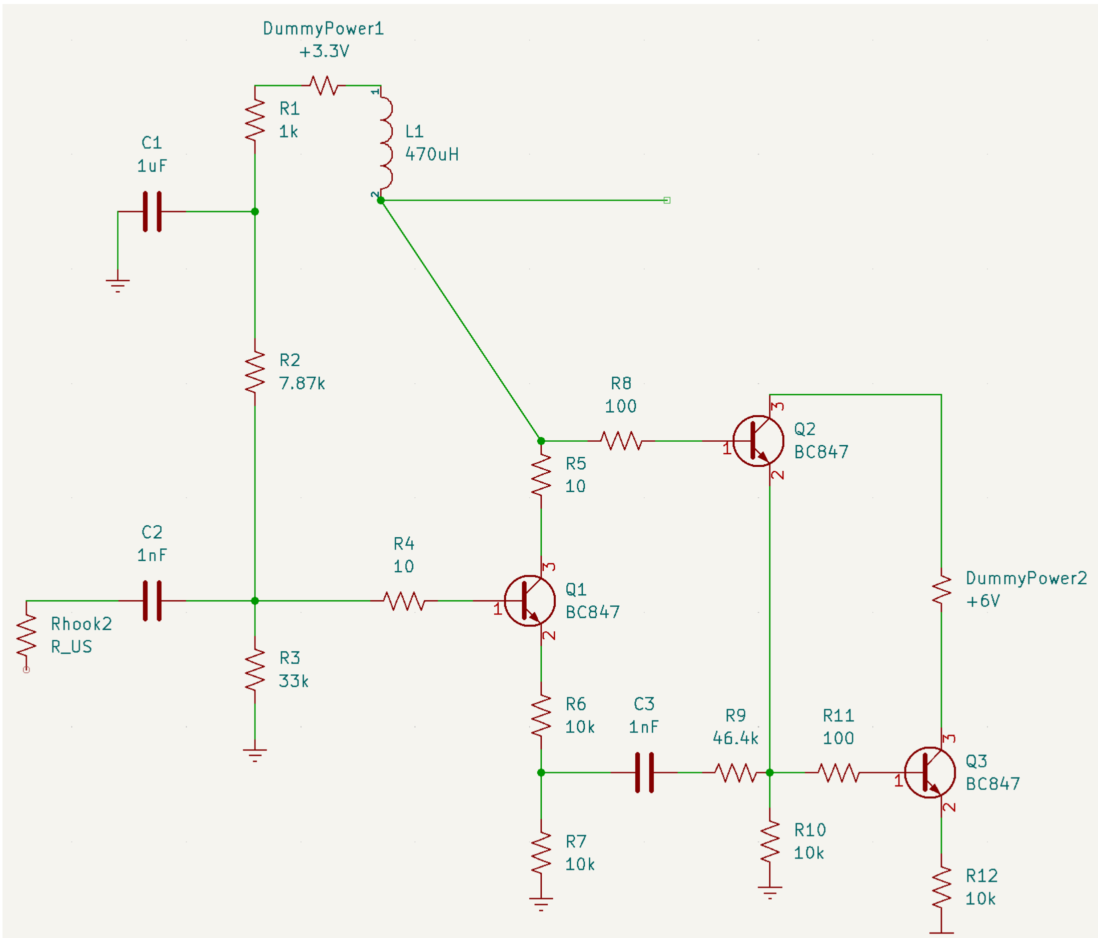

Fig 6. Circuit Diagram of tracking filter

Figure shown above is the circuit diagram of the tracking filter currently. Since we're lacking BC847 transistors, and unable to solder the tiny varactor SMV1801 (not shown on the diagram) to a breadboard, this circuit is largely different from the original design. We will add the transistors and varactors as soon as possible. We also tried PCB for tracking filter to ease the soldering process, however, due to the fault of the PCB milling machine in PHO 105, the PCB comes too late for the prototype testing

The design of PCB is posted below.

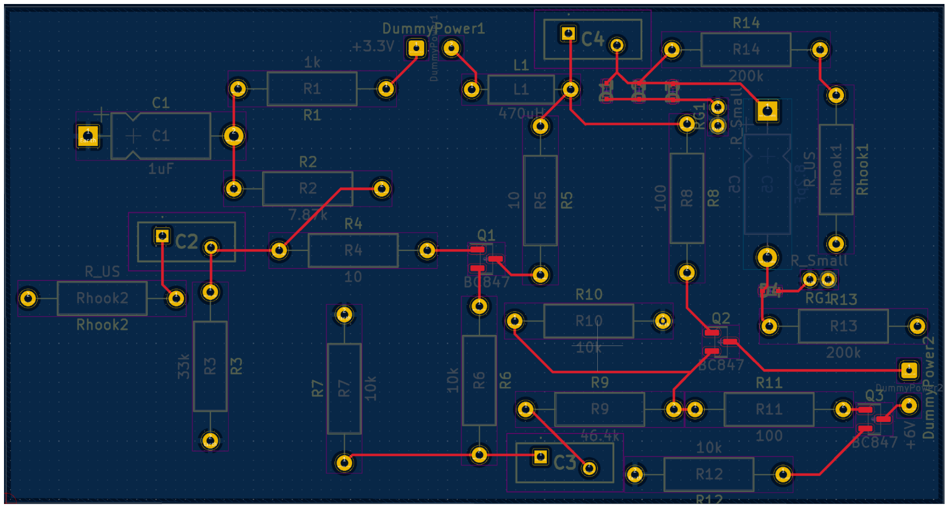

Fig 7. PCB design of tracking filter

Expected Output Result

In the simulation of LTspice, extra power supplies and passive components were used to simulate the input from other parts of the circuit. Additionally, the varactor part of the filter is deleted as the breadboard circuit does. The BC847 transistors are changed to transistors with closest parameters. The circuit diagram and bold diagram of simulation results are shown below.

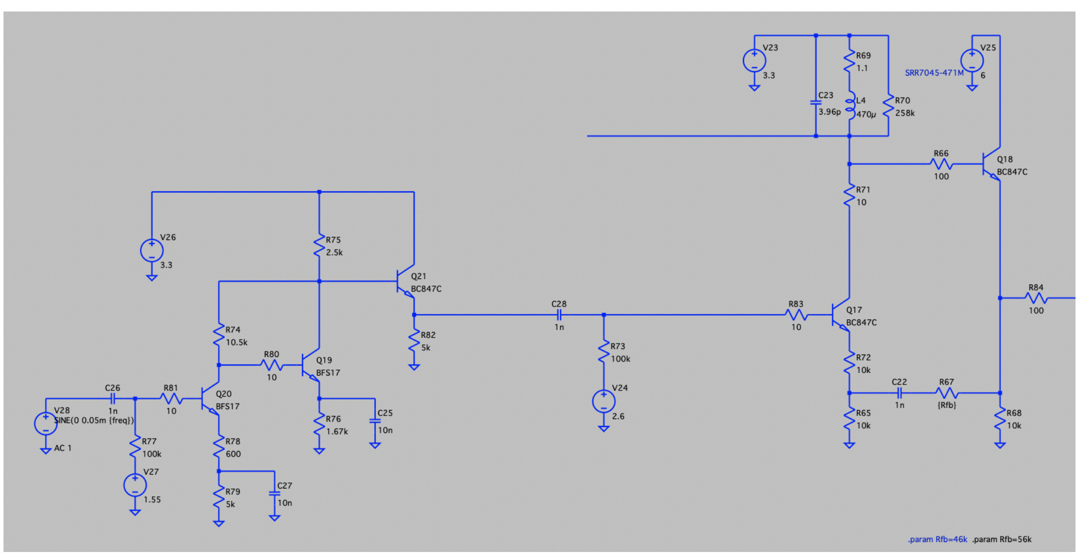

Fig8. Schematic of Tracking Filter

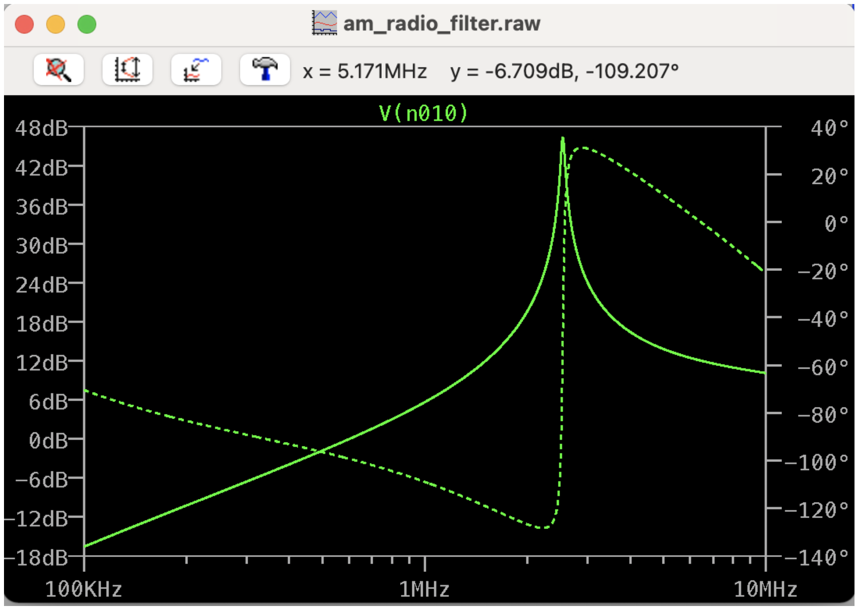

Fig 9. LTspice Simulation of Tracking Filter

As shown in the diagram, the expected result should be that only waves with frequency near 2MHz can pass the tracking filter. However, due to wiring problems on the breadboard, we expect our output to be near 600KHz. The filter still works, but we still need to work on and fix existing problems on it.

Testing output

Given our inability to access an spectrum analyzer, as well as the team's inexperience with the oscilloscope and signal generator models present in the senior design lab, the team had opted for a 'simplified' testing approach to be used with data in the time domain. For this we used an oscilloscope as well as a signal generator. The signal generator was connected via a coaxial cable in conjunction with a **BNC T** to the oscilloscope, giving us a reference 'raw' signal, and allowing us to use the other output port of the BNC T as an input for the tracking filter.

Once set up, with the tracking filter connected to the oscilloscope, signal generator and respective power supply, testing consisted of delivering a signal wave to the prototype circuit. The signal wave transmitted was a sine wave generated with a $1V_{pp}$ amplitude, an arbitrary number since the filter's criteria is based on the frequency of the signal, that was changed in frequency throughout the experiment. We created a 'manual sweep' around the 0.6MHz range and as expected, the closer the input's frequency was to the 0.6MHz range the higher the amplitude of the output until the input frequency matched the target frequency, in which case the output would mirror the input signal.

It is important to note that during testing Professor Pisano made the observation that instead of a tracking filter, our circuit appeared to be more resemblant of a notch filter, given how it would only let signals orbiting or target frequency through.

Future Plan

During this prototype test, the active antenna works perfectly. While there are problems with the tracking filter and isolation amplifiers. Those problems are within our expectations. They can be fixed soon.

For our future plan, for the following week, we will replace the waveform generator with a long wire (about 5 feet) to mimic the active antenna in the real life application scenario. We expect to see a couple of spikes on the FFT graph representing the frequency of AM radio inside the room. Also, we want to fix the circuit problems existing on the tracking filter and Isolation amplifier to get more desired output. Then, we will focus on implementing other parts of AM radio localization circuits on breadboards and test them out.