AM Radio Receiver with Variable Amplitude Output

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I. Introduction

In the ever-evolving world of technology, amplitude modulation remains a fundamental and important modulation technique. It is widely employed in long distance and broadcasting communication.

An *Amplitude Modulation* (AM) detector is capable of converting an AM radio signal into an audible audio signal. It plays a crucial role in extracting the original information signal from the modulated carrier wave. At the core, they involve the artful manipulation of a carrier wave's amplitude to encode and carry valuable data.

This project holds crucial significance in advancing our comprehension of AM demodulation techniques and their practical implications by merging theoretical insights with hands-on implementation. We aim to contribute to the development of efficient demodulation technologies, potentially revolutionizing signal reception and transmission methods.

II. Background

An AM demodulator is a fundamental principle of how information is transmitted through radio waves. When information, like music or speech, is sent through signals we need a way to encode it onto a carrier wave. The AM demodulator receiver does just that. This is done by separating and decoding the information from the original wave so that the music or speech can be heard. Understanding the basic concepts of AM signals while also recognizing the importance of it allows the ability to explore ways to make AM demodulation as efficient as possible.

This project aims to learn about the design and implementation of a sophisticated AM demodulator receiver with variable amplitude output. This was done by implementing LTspice simulations and physical circuits. Comparing and learning from the results obtained from the simulations and the physical circuit exhibited how an AM demodulator functions and varies an amplitude output. Designing the circuit allowed us to see what components of the circuit demodulate the circuit versus what components vary the amplitude output.

III. Procedure

We started our circuit by first designing our demodulator. We used a diode going into a capacitor and resistor in parallel to create an envelope detector. The diode acts as a rectifier while the resistor and capacitor in parallel act as a low pass filter. This outputs the positive part of the input signal (seen in figure 4). Once the signal is demodulated, it goes through an amplifier. To create an amplifier we used an NPN transistor and resistors with various values. These resistor values dictated how smooth the signal was and how high it was amplified. In order to simulate an AM signal in LTSpice, we used three AC signals in series with various frequencies. Figure 1 shows the LTSpice circuit with all of these components put together.

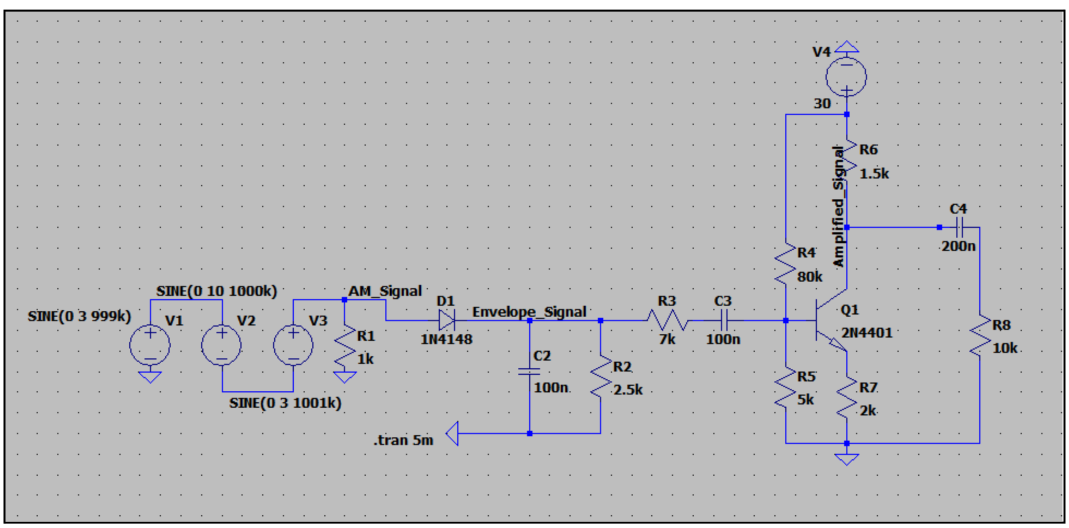

Figure 1: LTSpice Circuit

Once we had our LTSpice simulation working, we moved onto the physical circuit. Not all of the resistor values we used in the simulation were available in the lab so we had to make some adjustments. We found that putting resistors in series to get a value as close as we could to our simulation was the best way to go about this. We started out by building and testing only the demodulator first to make sure that it was working properly (test results seen in Figure 5). Then we added on the amplifier and continued with testing (test results seen in Figure 6). We did not have to change any of our components because our physical test results were very close to our simulation results. Our physical circuit with where we connected our waveform generator and AM signal can be seen below in Figure 2.

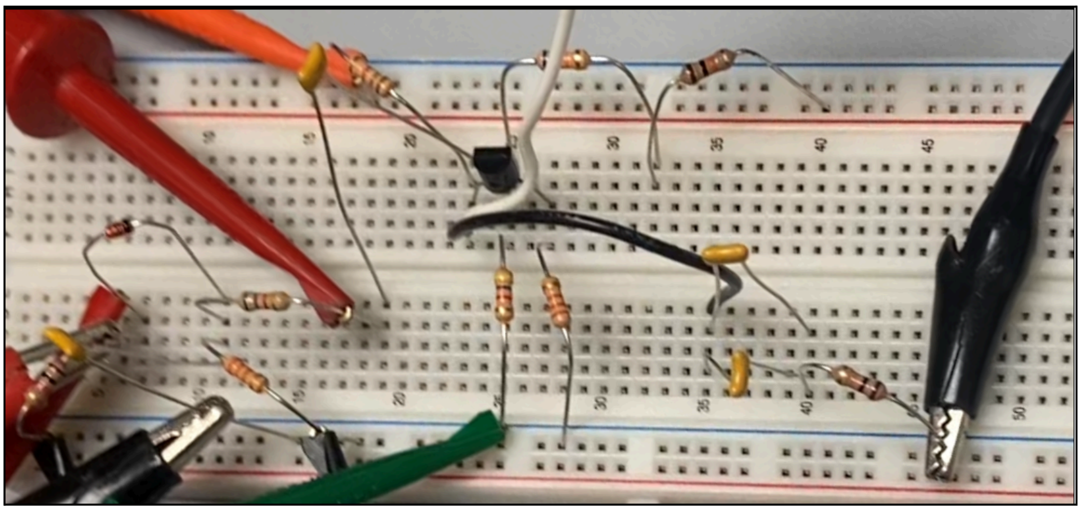

Figure 2: Photograph of Circuit

The complete Bill of Materials that was used to build our physical circuit can be seen in Figure 3.

Component	**Value(s)**	**Amount**
Resistor	1 kΩ	1
Resistor	1.5 kΩ	1
Resistor	2.2 kΩ	2
Resistor	4.7 kΩ	1
Resistor	6.8 kΩ	1

Resistor	10 kΩ	2
Resistor	68 kΩ	1
Capacitor	100 nF	4
Diode	1N4148	1
Transistor	2N4401	1

Figure 3: Bill of Materials

IV. Results and Discussion

Our simulated results in LTspice (shown in figure 3 below) for our designed circuit display our AM signal, envelope signal, and amplified signal. The AM signal can be seen in figure 3 as the blue waveform, the envelope signal is represented by the red line overlapping at the top of the AM signal, and the green line above is the amplified signal. By altering the values in the amplifier portion of the LTspice circuit, we were able to obtain an amplified signal with a gain of about 20V.

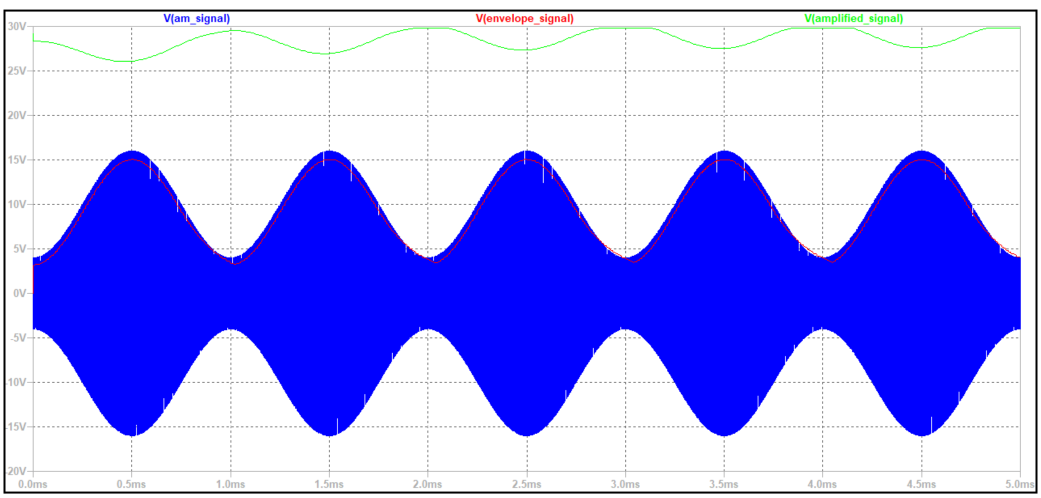

Figure 4: Simulation Results of LTSpice Circuit

We had to use slightly altered resistor values in our physical circuit, and generating the AM signal was accomplished using the signal generator so it didn't match our simulation perfectly. However, we were able to successfully modulate an AM signal, which can be seen in figure 4 below, and amplify that signal about 20V higher. The amplified signal (shown in figure 5 as the blue line) had a maximum value of 25.305V, and the amplitude of our AM signal was 3.67V, hence around a 20V amplification. Figure 5 displays all three of our measurements, the AM signal, envelope signal, and amplified signal. In the image from the oscilloscope, the three signals are not shown in relation to the same zero, so the measurements we added demonstrate the values used to analyze the relation between the signals.

We originally ran into some issues with scaling the signals from our physical circuit, but after analyzing the results, we had a functioning AM modulator and amplifier. The envelope signal sits perfectly on top of the AM signal, and the amplified signal is about 20V higher than the original AM signal.

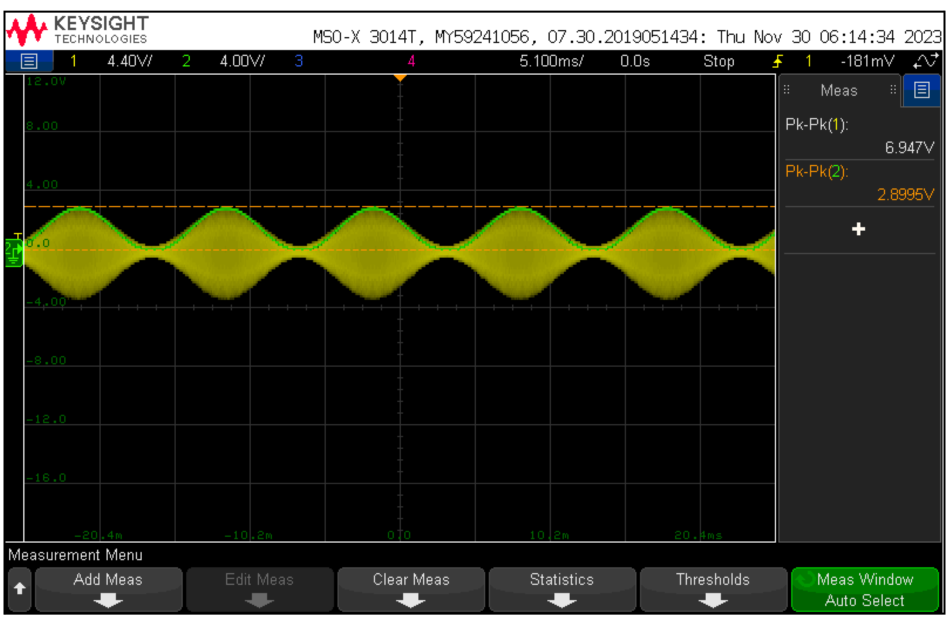

Figure 5: Demonstration of the AM Signal Demodulator

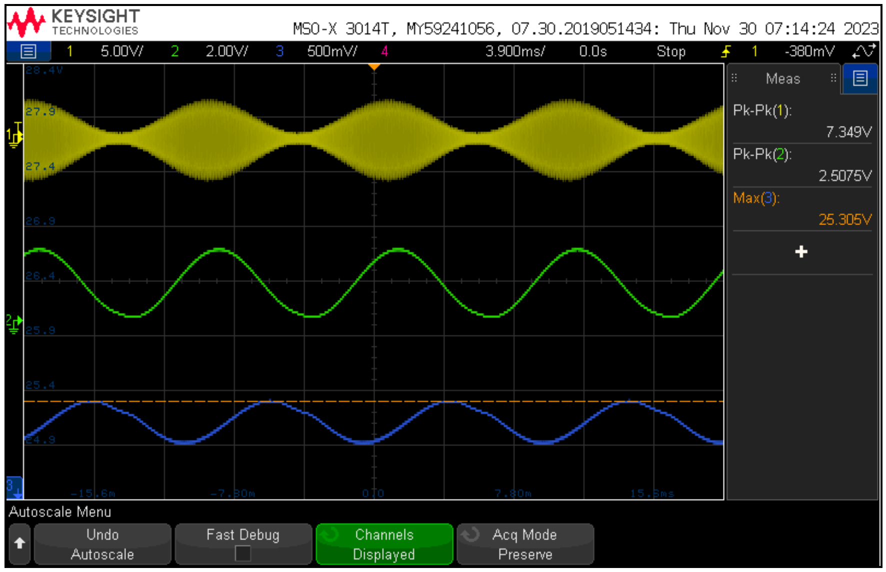

Figure 6: Demonstration of AM Demodulator and Amplifier of the AM Signal

V. Conclusion

In conclusion, this project unfolds the intricacies of AM demodulation from its theoretical foundations to practical implementation. Through the designing, testing and comparing with existing technologies, we aim to not only deepen our understanding of AM demodulation, but also to present visible solutions for enhanced signal reception in various communication applications.