EECE 315

Final Project Report: AM Radio Receiver

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Group 26
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Introduction

AM demodulation addresses the challenge of a signal containing multiple frequency components. **Amplitude Modulation (AM)** simplifies this by converting these components into a single carrier frequency, where the message or information is encoded in the varying amplitude of the signal. This is particularly advantageous because the demodulation circuit can focus on recovering the message by targeting this single carrier frequency.

An **AM demodulator** consists of three stages: an **envelope detector**, a **filter**, and an **amplifier**. The envelope detector extracts the message signal by following the peaks of the modulated waveform. The time constant tau for the envelope detector is carefully chosen to satisfy: $\mathbf{1}/f carrier \ll \tau \ll \mathbf{1}/f max$ where *fcarrier* is the frequency of the modulated signal, and *fmax* is the highest frequency present within the data of the modulated signal.

Following the envelope detection, the signal often retains some high-frequency carrier components. To remove these unwanted frequencies, the signal passes through a **low-pass filter** with a cutoff frequency defined as: $fc = \mathbf{1/2\pi} RC$ The cutoff frequency fcf_cfc is adjusted based on the carrier and message signal frequencies to allow the desired message signal to pass while attenuating the high-frequency components.

Finally, the demodulated signal requires amplification to produce a usable output. Instead of using an NPN transistor, we implemented a non-inverting operational amplifier (Op-Amp) configuration. This approach allows for easy gain adjustment using resistors while maintaining signal integrity.

Design Procedure

We decided on carrier and message frequencies to test a circuit simulation. For this, we decided to go with $f_{carrier} = \mathbf{2}KHz$**,** $f_{max} = \mathbf{100}Hz$ This then allows us to find suitable values for Tau of the envelope detector, as well as the cutoff frequency of the low pass filter. $1/f_{carrier} << RC << 1/f_{message}$ *let* $R = 10kohm$, $C = 0.01nF$ Then plugging these values in we get

5µs≪100µs≪10,000µs.

Likewise, for the cutoff frequency of the low pass filter, we want the cutoff frequency, or our bandwidth to be around our message's highest frequency so as not to get any unwanted high-frequency throughput. This is then found using $f_c = 1/2\pi RC$ *Let* $R = 10kohm$, $C = 0.01uF$.

Then,f**≈1.59*KHz*** allows the message signal to pass through relatively unimpeded.

For the Amplifier R1 and R2 are adjusted for correct gain,

$$Amplifier\ Gain = 1 + \frac{R1}{R2} = 1 + \frac{100k\Omega}{47k\Omega} \approx 3.12$$

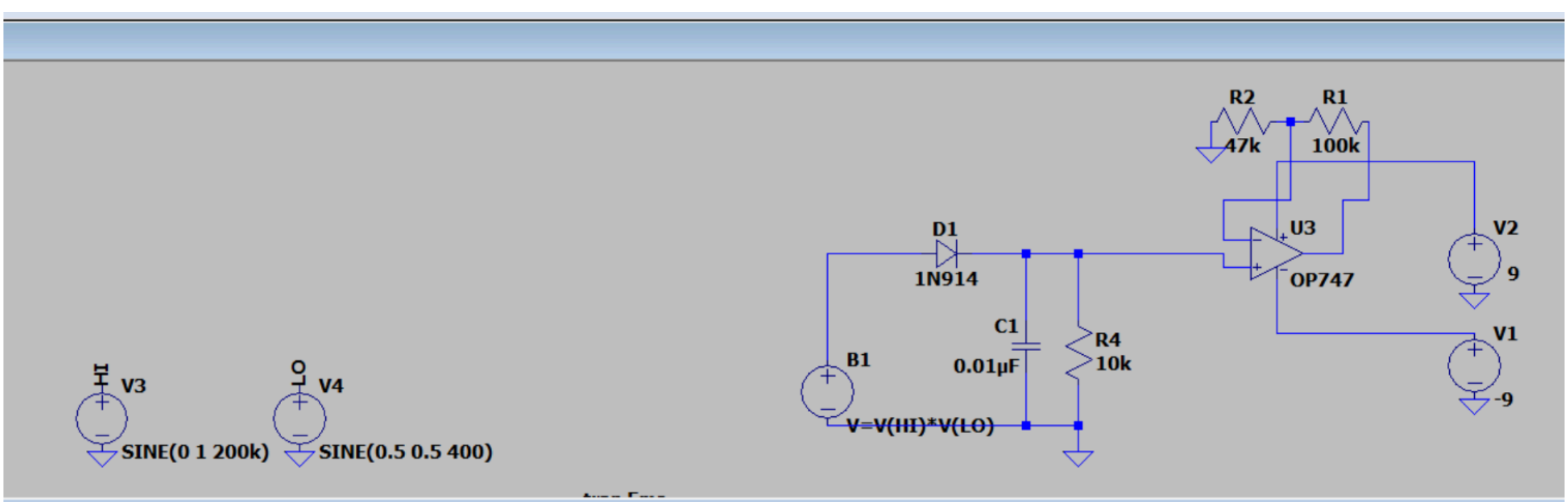

Figure 1 LT Spice Schematic

Simulated circuit within LT Spice used for testing purposes.

Verification and Results

Input AM Signal: The Modulated AM signal was generated by the function generator at 100Hz at 1Vpp, with an 80% depth.

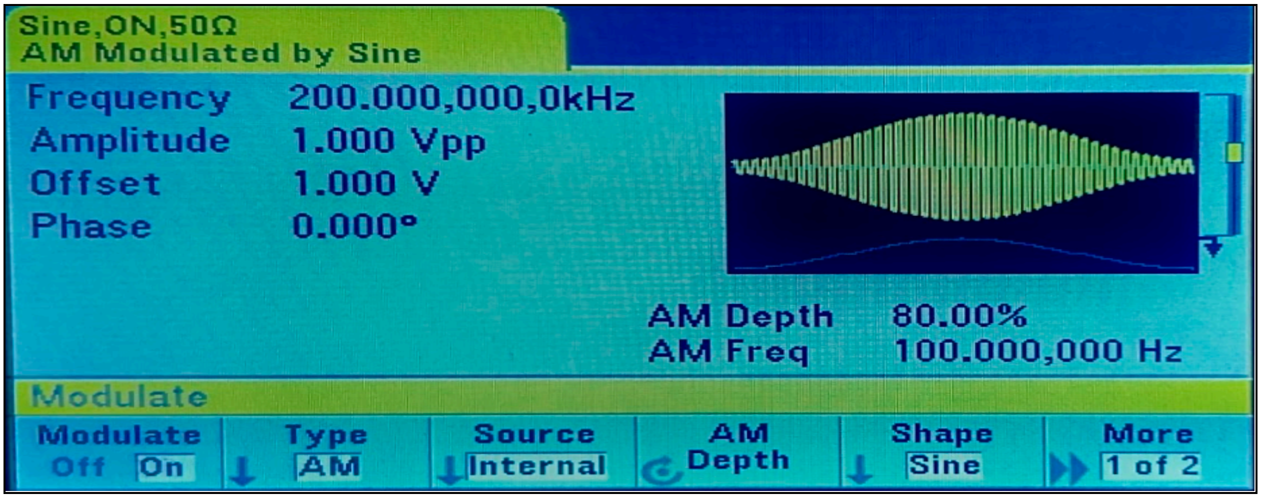

Figure 2 Imput AM Signal

Demodulated Signal: The rectifier stage extracted the envelope, isolating the positive peaks of the carrier. The output of the low-pass filter further smoothed the waveform to recover the original message signal.

(Blue wave in LTSpice simulation in Figure 3, Yellow wave in oscilloscope in Figure 4)

Amplified Signal: The operational amplifier boosted the recovered signal by a factor of 3.12, as designed

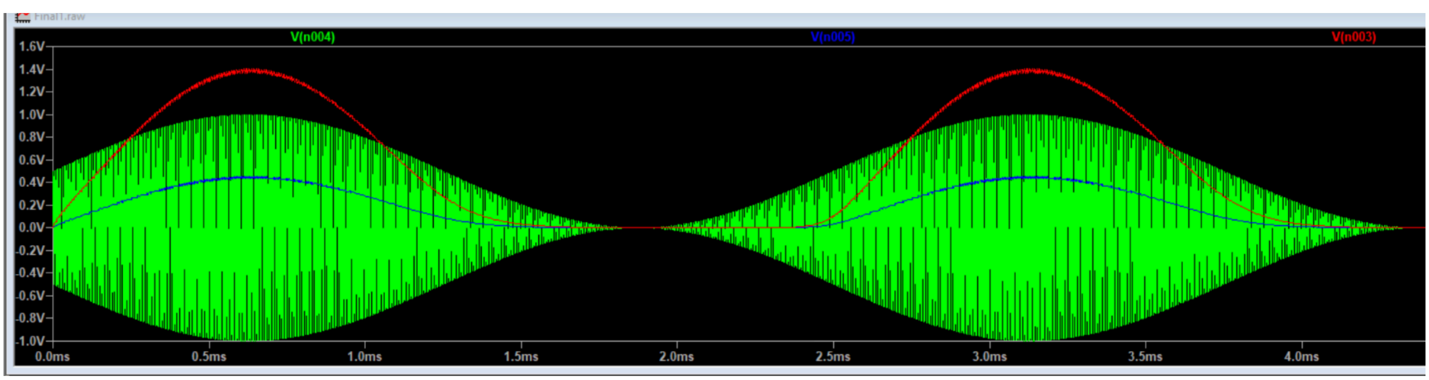

Figure 3 LT Spice Simulation

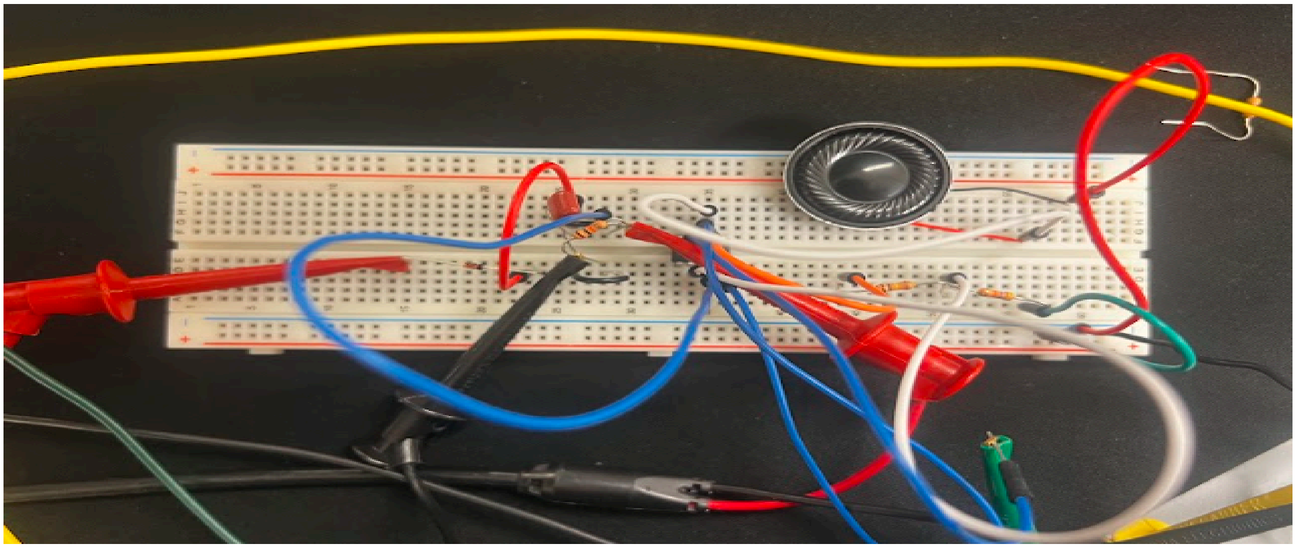

Figure 4 Photo of the actual constructed circuit

The physical circuit is then made with the LTSpice Schematic in mind.

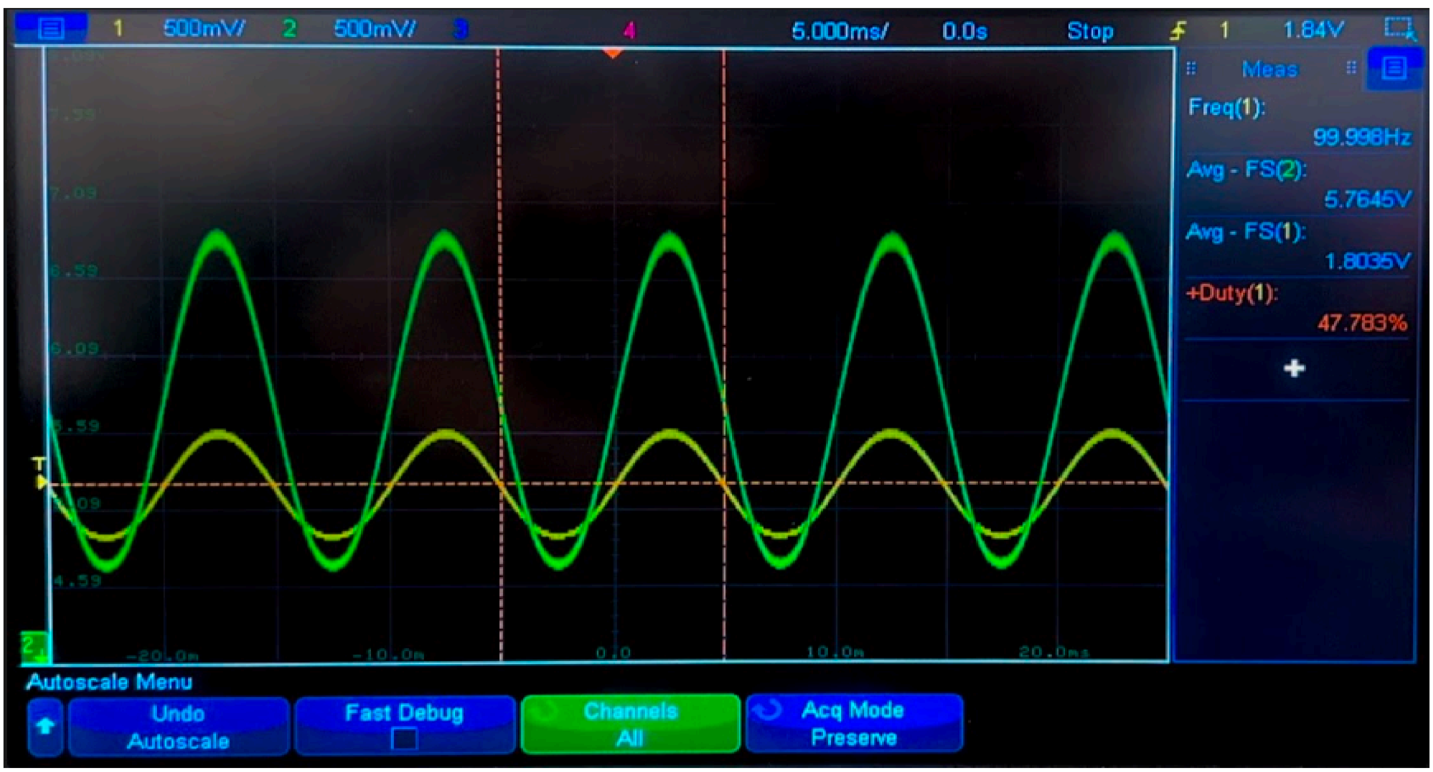

Figure 5 Oscilloscope Output Graph of Actual Circuit Measurements

In Figure 4 the Input signal is the Am Signal in Figure 1 and Yellow wave is the demodulated wave and green is the Amplified wave which has a gain of ≈3.12.

Conclusion

Overall, the circuit performed very well, and all components operated as expected for the goals of this project. The amplifier successfully boosted the signal, while the envelope detector effectively demodulated the AM waveform. The system worked as intended and demonstrated the ability to process and recover a modulated signal.

If we were to improve the design, one key adjustment would involve fine-tuning the time constant (τ) of the envelope detector. Optimizing τ\tauτ to fall between the carrier frequency and the message frequency would allow the output signal to better align with the peaks of the modulated waveform, improving the fidelity of the demodulated signal.

For future improvements, a working antenna could be incorporated to receive real AM radio signals. These signals could be passed through the amplifier to make them usable, allowing the circuit to tune into an actual AM radio station and play the audio through a speaker. Additionally, replacing the fixed resistor in the RC low-pass filter with a potentiometer would allow for an adjustable cutoff frequency. This would add a basic level of tunability to the circuit, enabling it to adapt to different message signals.

Bill of Materials			
Component Type	Value	Quantity	Component Within
Resistor	10k	1	Filter
Resistor	47k	1	Amplifier
Resistor	100k	1	Amplifier
DC Voltage Source	+9v	1	Amplifier
DC Voltage Source	-9v	1	Amplifier
Capacitor	0.1uF	1	Filter
Diode 1n4148	N/A	1	Envelope Detector
OP 474	N/A	1	Amplifier
Speaker	8 OHM	1	Output