Lab 7 - AM Demodulation Edward Enriquez
ECE 4705-L

Introduction:

<u>Background Theory</u>

To demodulate an AM signal, an envelope detector must be used. The detector used in the lab contains three stages. The first stage consists of a diode, capacitor, and resistor combination which follows the input signal as it increases, but decays exponentially when the input signal decreases. The rate of exponentially decay of the output signal determined the capacitor and resistor combination, follows the expression $V_0 e^{-t/RC}$ where V_0 is the initial voltage, t is time, R is the resistor value, and C is the capacitor value. The rate of decay can be adjusted by changing the resistor and capacitor values. The product of these two values is known as the time constant or τ. If the time constant is set correctly, the output signal will decay at just the right rate to detect the peaks of the transmitted signal while providing smooth transitions from one peak to another. Outlining the peaks will give the resulting envelope. The second stage is an RC high pass filter used to remove any DC offset the envelope might have. The third stage is a low pass filter which helps reduce the ripples caused by the decay periods from the first stage. The modulating signal for this lab will be a 5kHz cosine wave and the carrier signal will be a 80kHz cosine wave.

<u>Prelab</u>

In the prelab appropriate values for first stage capacitor and resistor were found. The general equation to find resistor and capacitor values for an envelope detector is given by $\tau = RC < \frac{\sqrt{1-\mu_2}}{\mu\,\omega_m}$. Here μ is the modulation index and ω_m is the message frequency. Since this gives an upper limit, PSPICE was used to determine practical values which would work in a real life circuit. Here μ was set to be .5. All other capacitor/resistor values were tweaked to get a good demodulated signal. The PSPICE model and simulation results are shown below.

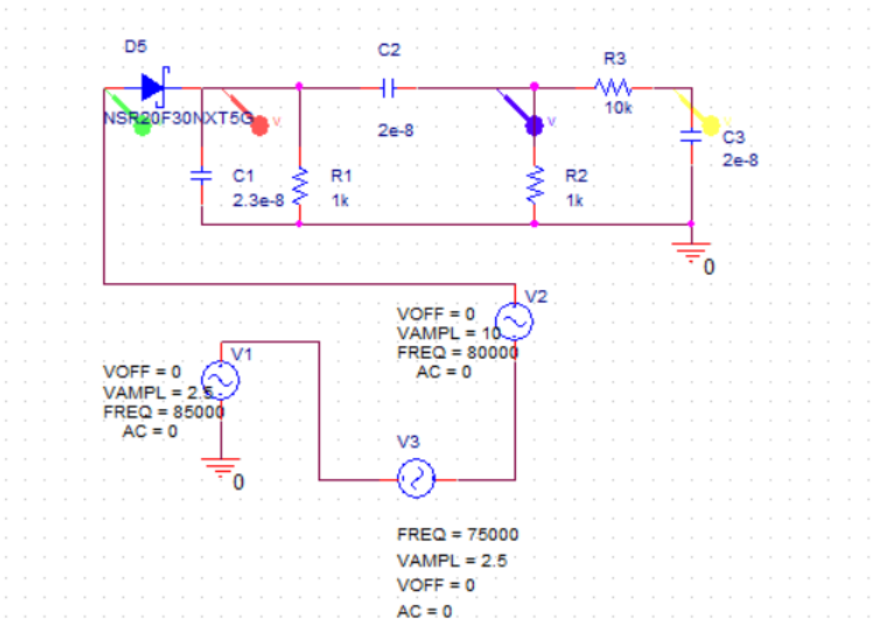

Figure 1 - PSPICE Simulation Circuit

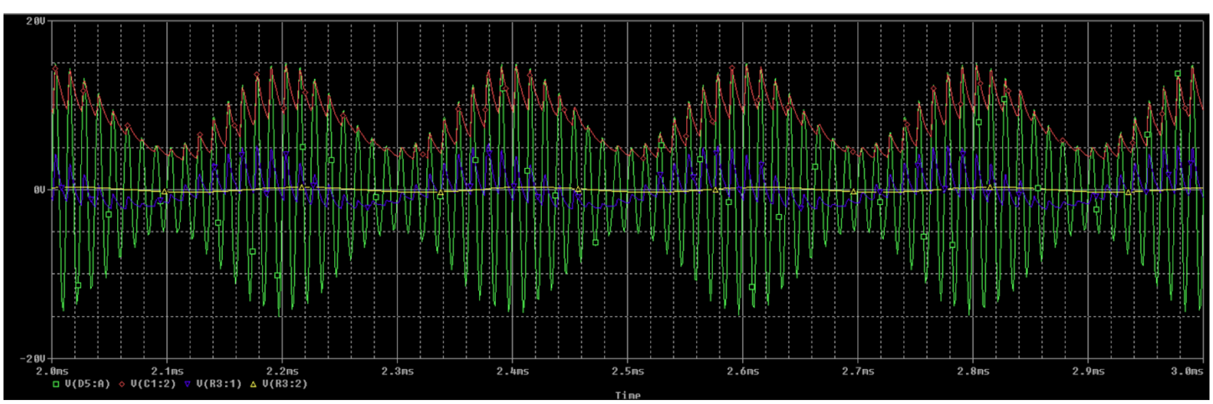

Figure 2 - Simulation Results at Each Stage

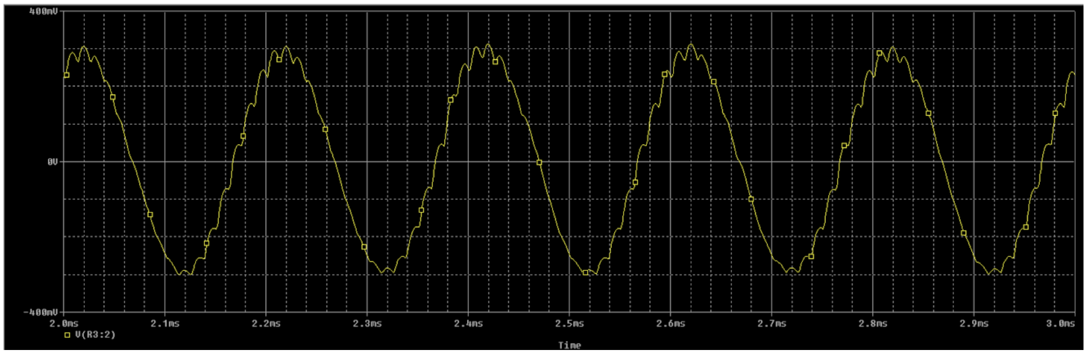

Figure 3 - Simulated Output Signal

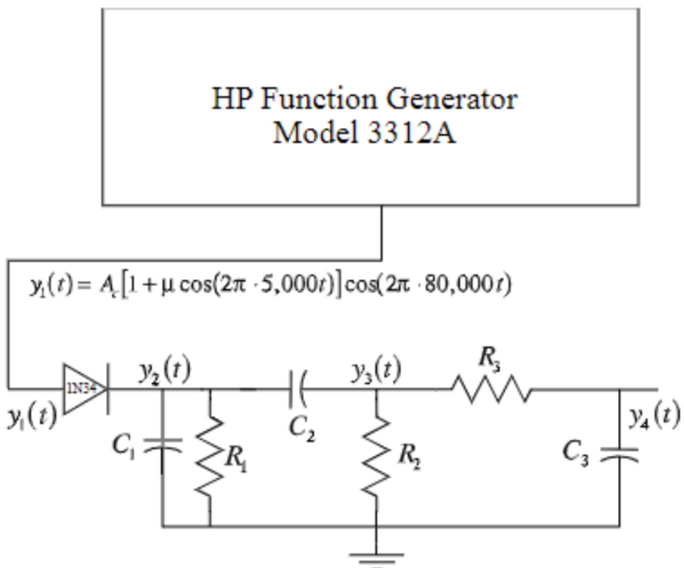

Figure 4 - AM Demodulation Circuit Schematic

Lab/Results:

The circuit analyzed in the prelab was built with the found capacitor/resistor values. $1 k\Omega$ resistors were used for all the resistors in the circuit and 20 nF capacitors were used for all capacitors. The signal was viewed through the oscilloscope at each stage of the demodulation.

Figure 5 - AM Modulated Signal

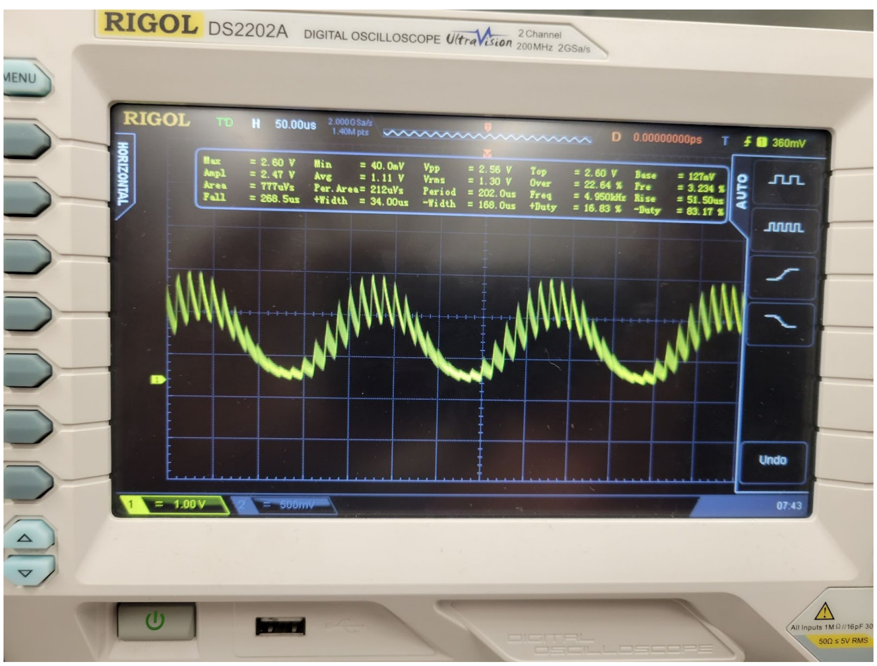

Figure 6 - Signal After First Stage (Rough Envelope Detection)

Figure 7 - Signal After Second Stage (High Pass Filtering)

Figure 8 - Signal After Third Stage (Low Pass Filtering)

Conclusion/Analysis:

The FM modulated signal produced by the HP Function Generator is shown in Figure 5. After the first stage the signal obtains the general shape of the cosine message but exhibits large ripples. Although resistor and capacitor values were chosen so that the discharging rate of the RC circuit would match the envelope, a single τ constant can not match the rate of change of the envelope at all points. Furthermore, since the initial voltage across the discharging capacitor varies, the height of the ripple (voltage drop) also varies. As seen in Figure 6, the ripples are larger at the peaks of the signal because the initial voltage across the capacitor when the diode blocks the current is larger.

After the second stage, the high pass RC filter brings the signal down to the x-axis by removing any DC offset (0 Hz frequency content) the input had. The removal of low frequencies seems to make the higher frequency content in the signal more prominent. As seen in Figure 7, the ripples have become larger compared to the desired embedded cosine signal.

The last stage helps reduce these ripples by employing an RC low pass filter removing high frequency content. The ripples are reduced but not completely gone. Figure 8, shows the received demodulated signal with some distortion still present. The output signal is representative of the 5 kHz cosine message, despite the distortion. To obtain a better signal, potentiometers could have been used instead of resistors to slightly tweak the RC / τ value to have the decay rate be more aligned with the envelope.