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ELEC 301 Homework 1 Report

Question 1

a) The given speech signal was first upsampled 100 times in order to prepare the signal's frequency for modulation. Then the signal was modulated according to the equation $y(t) = (2 + m(t))cos(2\pi f_c t)$, i.e. asynchronous amplitude modulation, where f_c = 160 kHz. The Fourier magnitude spectrum of the modulated signal can be observed in Fig. 1 below, where the zero-frequency component of the signal is shifted to the center.

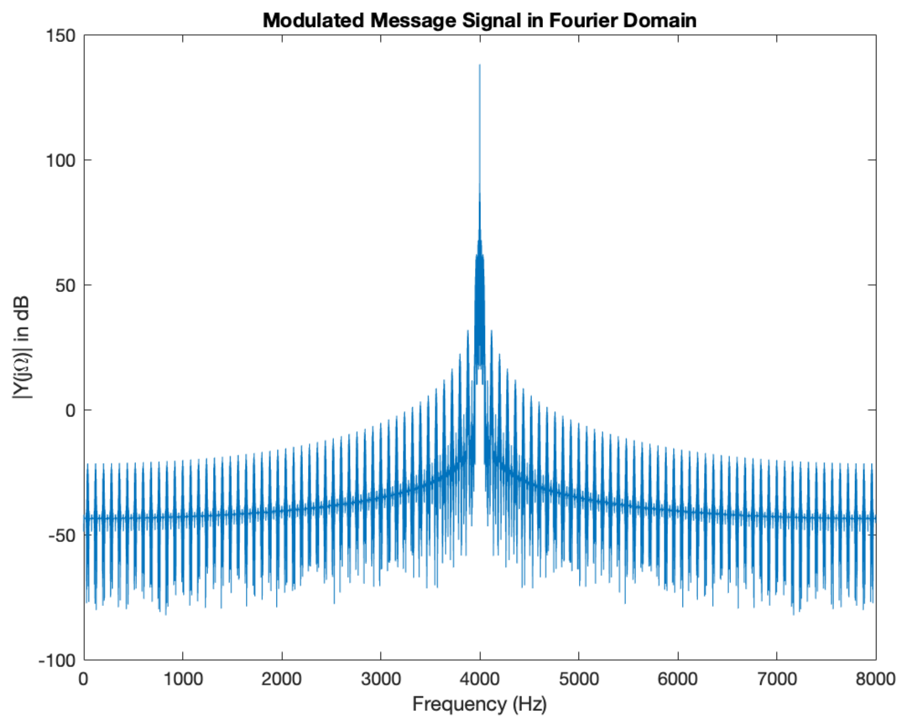

Figure 1: Modulated Message Signal in the Frequency Domain

b) The modulated message signal was then demodulated using an envelope detector circuit. In order to perform the demodulation, the signal was first passed through an ideal diode model (i.e. its negative components were zeroed), and then it was passed through an RC circuit that is equivalent to a low pass filter (LPF) with the transfer function $e^{-\frac{t}{10^{-4}}}$. Comparison of the demodulated signal with the original signal both in time and frequency domains can be seen in Fig.s 2 and 3. There doesn't seem to be much difference when the signals are compared in the frequency domain, except a slight difference in amplitude. This can be caused by the constant added when modulation the signal. On the other hand, in the time domain, there's an apparent shift in the amplitude (y-axis). This can, again, be caused by the constant added in synchronous amplitude modulation. Also the accuracy of the modeled RC circuit and its transfer function has a big role. When the demodulated signal was listened, it was clear to see that the original message was recovered.

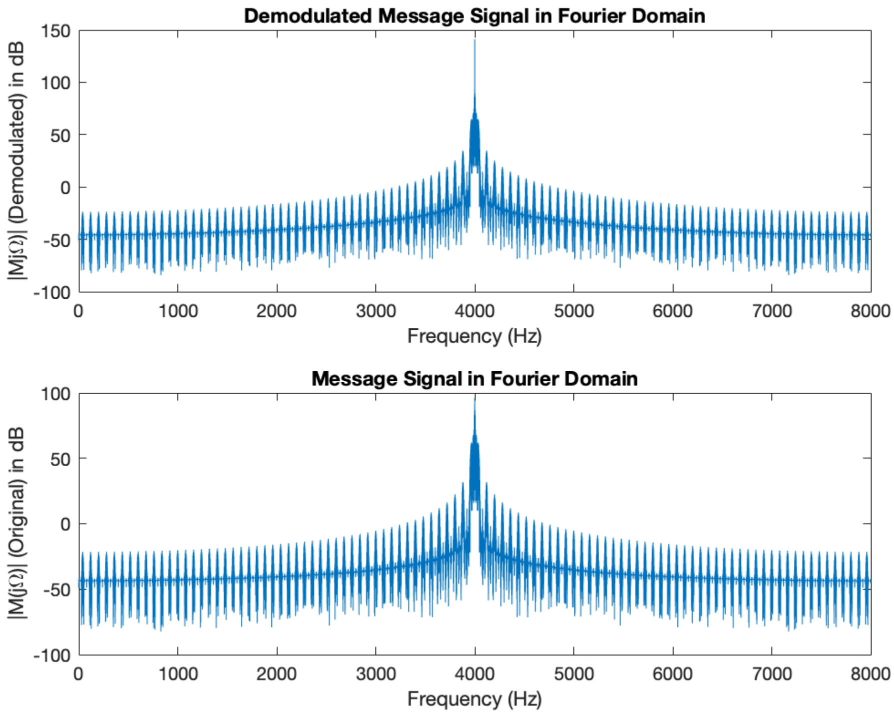

Figure 2: Demodulated Message Signal and Original Message Signal in the Frequency Domain

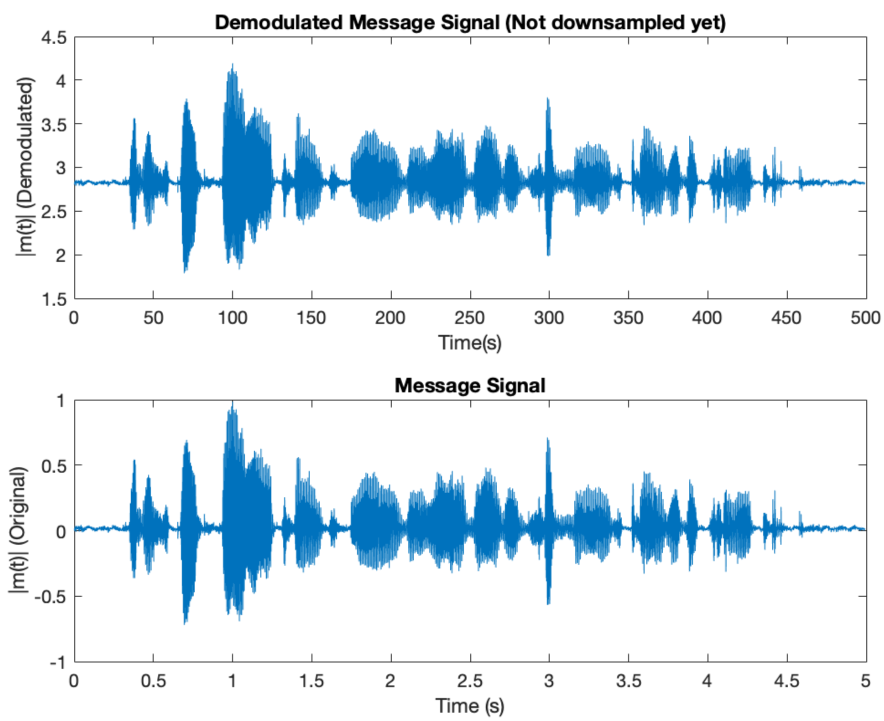

Figure 3: Demodulated Message Signal and Original Message Signal in the Time Domain

c) The same operation was performed on the operation with the same carrier frequency, but this time with the equation $y(t) = m(t)cos(2\pi f_c t)$, i.e. synchronous modulation. Comparison of plots of the demodulated and the original message signal can be found in Fig. 4. There seems to be an apparent difference between these signals: the demodulated signal does not have any component below zero. This can be caused by the fact that this signal does not satisfy the condition (A + m(t)) >= 0, and while passing through the diode, the negative parts of the signal have been eliminated. Also, when the recovered signal was listened, it was again clear to see that the original message was recovered.

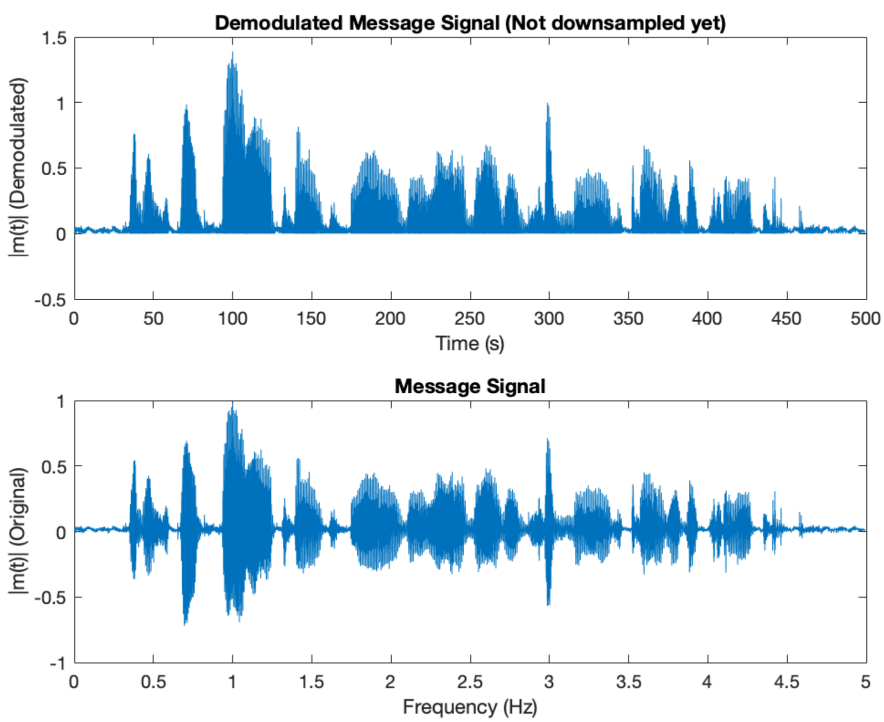

Figure 4: Demodulated Message Signal and Original Message Signal in the Time Domain

Question 2

a) The given speech signal was first upsampled 200 times in order to prepare the signal's frequency for modulation. Then the signal was modulated according to the equation $y(t) = (2 + m(t))cos(2\pi f_c t + \int_{-inf}^{t} x(\tau))d\tau)$, i.e. frequency modulation, where f_c = 280 kHz. The Fourier magnitude spectrum of the modulated signal can be observed in Fig. 5 below, where the zero-frequency component of the signal is shifted to the center. I have estimated the signals bandwidth as $2 * (\Delta f + B)$ = 2*(1.193 + 8) = 18.386 kHz, where Δf = kf/2π. It is greater than the AM bandwidth (2*8 = 16 kHz) as expected, and a bit less than my expected value, which is 20 kHz. But that is natural since it is an ideal approximation.

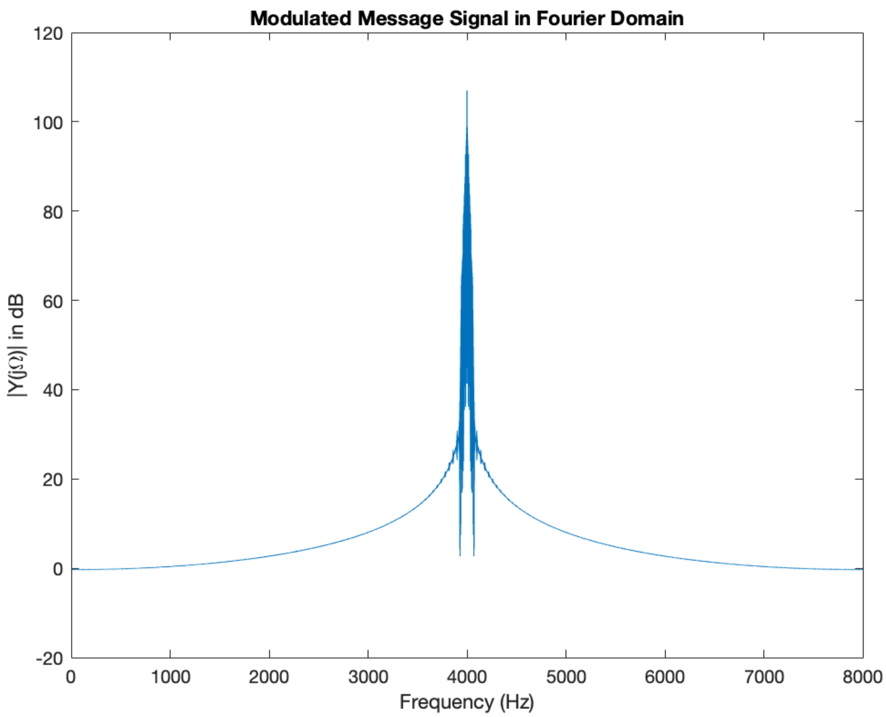

Figure 5: Modulated Message Signal in the Frequency Domain

b) The modulated message signal was then demodulated using first a differentiator and then an envelope detector circuit. In order to perform the demodulation, the signal was first passed through a differentiator circuit. Then, it was passed through an ideal diode to zero its negative components, and then it was passed through an RC circuit that is equivalent to a low pass filter (LPF) with the transfer function $e^{-\frac{t}{10^{-3}}}$. Comparison of the demodulated signal with the original signal both in time and frequency domains can be seen in Fig.s 6 and 7. When compared in the frequency domain, it can be seen that the demodulated signal has a wider bandwidth, and is more dense in terms of noise and components. On the other hand, in the time domain, the demodulated message doesn't have any negative components. This is probably caused by passing the signal through an ideal diode. There's also a notable amount of noise that can be observed in both domains.

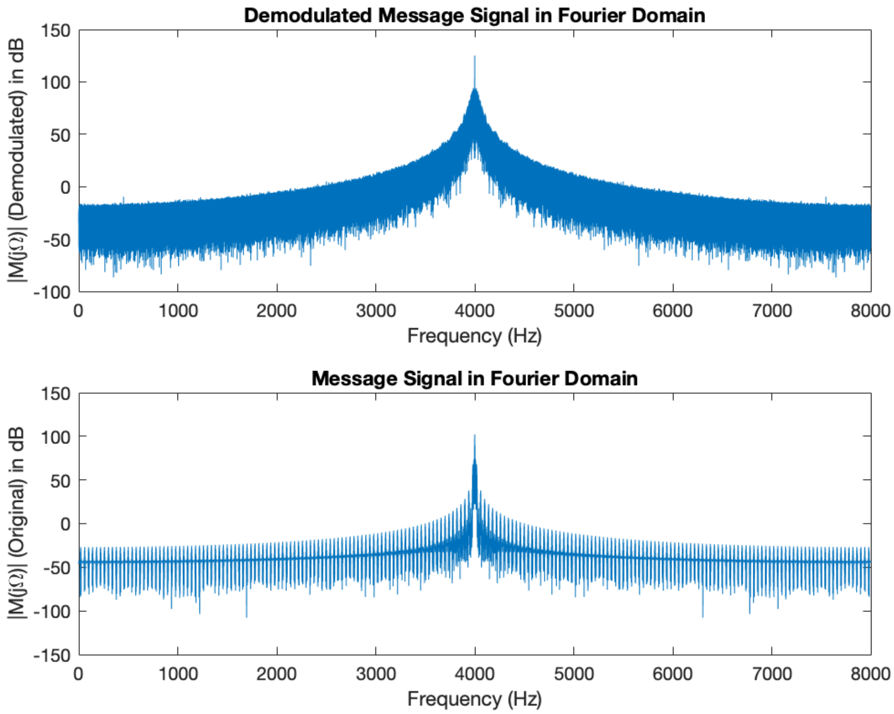

Figure 2: Demodulated Message Signal and Original Message Signal in the Frequency Domain

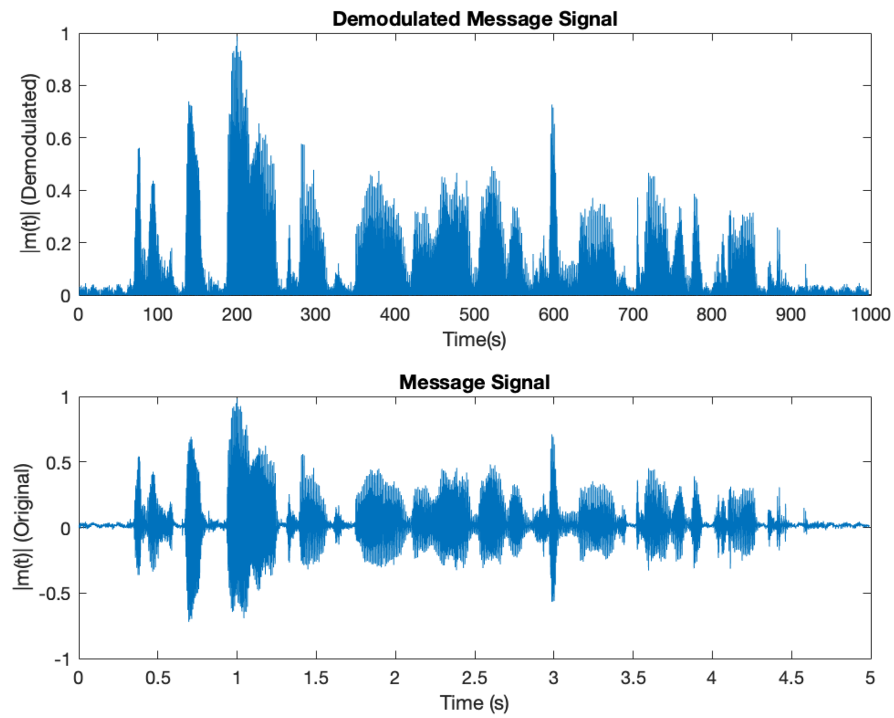

Figure 3: Demodulated Message Signal and Original Message Signal in the Time Domain