University of Massachusetts Lowell, ECE Department
EECE 5430 Theory of Communication
Take Home Project # 1
AM Modulation and Demodulation

Objectives: To create in MATLAB AM-LC modulated signals and then to demodulate the signals. This project is worth 5% of your total grade and will be used as a differentiator if you are between grades. You may work together with 1 or 2 people, but you must hand in a separate paper, and you must indicate at the beginning of your paper, with whom you worked. Failure to honestly disclose with whom you worked is grounds for 0 credit.

It is due before the mid-term exam, and you will be penalized 1% each week beginning with the mid-term, for late submissions. Submissions must be neat and show graduate student levels of professionalism. You must include all code as an appendix.

Amplitude Modulation.

A. Create a 20 second time axis sampling at 100000 Hz (Δt =0.00001 second).
   a. Create a 5 Hz sinusoid, y, using the time axis, plot (t,y).
   b. Create a 40 Hz carrier sinusoid, z, using the time axis. Plot (t,z)
   c. On a point-by-point basis multiply (1+0.5y).*z to form an AM/LC signal with modulation index 0.5. Plot this. Zoom in and look at it over several cycles of the modulating signal.
   d. On a point-by-point basis multiply (1+1.0*y).*z to form an AM/LC signal with modulation index 1. Plot this. Zoom in and look at over several cycles of the modulating signal.
   e. On a point-by-point basis multiply (1+1.5y).*z to form an AM/LC signal which is over modulated. Plot this. Zoom in and look at over several cycles of the modulating signal. Plot this.
   f. Using the SpectrumAnalyzer.m function as explained in class,
      A. Compute the spectra for parts c, d, e. Plot these in terms of magnitude. Observe the presence of the 40 Hz carrier.
      B. Measure and compute the modulation index from the spectral amplitudes and compare results to that in your self-study tool for each part (c, d, e)

B. Coherent Demodulation.
   a. Multiply the modulated waveform by the vector containing the carrier (z) and design a low pass filter to recover the original signal. Plot the output in the spectral domain before and after filtering. Plot some in the time domain.

C. Envelope detection
    a. An envelope detector is a simple device consisting of a diode (ideal) and a low pass filter. An ideal diode can be modeled as y=(x>0).*x. Try a different non-linearity with the modulated waveform and form abs(x). Plot this in the time and frequency domains before and after low pass filtering.
    b. Design low pass filters and filter the waveform until you recover the original waveform.
D. Use Real waveforms
    a. Load the standard audio file “Handel” or some other .wav file of your choice
    b. Listen to it using Soundsc function and Fs=8192 Hz
    c. Design a low pass filter with BW=2000 Hz and cutoff at 2500 Hz, filter the signal and listen again, 40 dB of attenuation is fine for this application.
    d. You need to up-sample the function. Resample the function using the following commands Newout=resample(yoursignal, 5,1). These actions will up-sample the rate from 8192 to 5 times that which is 40960. That means instead of 8192 points/sec there will be 40960, and the sampling rate is now 40960 Hz.
    e. Listen to the new signal but with a new sampling rate, should sound the same.
    f. Create a time axis equal to the length of the new signal with a delta T of 1/40960. Make sure that dimensions of matrices match.
    g. Create a carrier at a frequency of 15000 Hz (cos(2*pi*time*15000)
    h. Create large carrier AM (1+yoursignal).*carrier
    i. Look at using your spectrum analyzer, both your AM large carrier signal, and your modulating signal “yoursignal”: you may have to do some transposing to get the matrix dimensions to match. You will see the upper and lower sidebands and the carrier signal.
    j. Now detect the signal using coherent detection (e.g. multiply by the carrier again)
    k. Design a new filter with the same bandwidth as before (2000,2500), but now with a sampling frequency of 40960 and filter your signal.
    l. Now do the same non-coherent demodulation (that means using an ideal diode out=in.*(in>0). Do this and refilter and listen to it.
    m. Listen to both, and look at it in the spectral domain.