Lab - 4

Instructions:

1. Please plot so that we are able to understand, i.e., with legends, axis labels, titles etc.
2. Observations pertaining to each plot is expected below the same.
3. Kindly number your answers correctly.
4. **NO PLAGIARISM.**
5. **Put all the code in the Appendix at the end of the report.**
6. Ask any questions in class or via LMS so that it will be beneficial to all (us and you).

Questions:

Software Lab 3.1: Amplitude modulation and envelope detection

Lab Objectives: The goal of this lab to illustrate amplitude modulation and envelope detection using digitally modulated messages. In addition to using envelope detection to demodulate conventional amplitude modulation, we also illustrate how it can be used for I/Q downconversion when quadrature mixers are not available.

Reading: Section 3.2 (amplitude modulation).

Laboratory Assignment

1) Generate a message signal m(t) using binary digital modulation with a sine pulse by modifying Code Fragment 2.3.2 to use random bits. Set the symbol time T to 1 millisecond. Take a waveform segment spanning n_s symbols and take its Fourier transform by modifying Code Fragment 2.5.1 (or using the code from Lab 1), choosing the length of the FFT (and hence n_s) so as to get a frequency resolution of 1 Hz. Plot the magnitude squared of the Fourier transform, divided by n_sT , the length of the observation interval. This is an estimate of the power spectral density (PSD) $S_m(f)$, which is formally defined later, in Chapters 4 and 5.

2) Repeat the PSD estimation in 1) over multiple runs and average the estimates, choosing the number of runs large enough so as to get a smooth estimate of the PSD. Eyeball the PSD to estimate the bandwidth of the signal (the units should be consistent with our assumption of T = 1 ms).

3) Now, generate the DSB signal $u(t) = m(t) \cos 2\pi f_c t$, where $f_c = 10/T$. Choose the sampling rate for generating discrete time samples as $4f_c$. Plot the DSB signal over 4 symbols.

4) Estimate the PSD $S_u(f)$ of the DSB signal generated in 3) by choosing a large enough number of symbols as in 1), and averaging over several runs as in 2). What is the relationship with the PSD obtained in 2)?

5) Repeat 3) and 4) for the AM signal $u(t) = (A_c + m(t)) \cos 2\pi f_c t$, where $f_c = 10/T$ and A_c is chosen to have the smallest possible value that allows envelope detection. As before, choose the sampling rate for generating discrete time samples as $4f_c$. Do you run into difficulty when computing the PSD? Explain.

6) Starting with an AM signal as in 5), implement an envelope detector as follows:

(a) Pass u(t) through an idealized diode to obtain $u_+(t) = u(t)I_{u(t)\geq 0}$.

(b) Pass $u_+(t)$ through an RC filter with impulse response $h(t) = e^{-RC/t} I_{t\geq 0}$. You can use the contconv function in Lab 1 for this purpose. Choose the value of RC based on the design rule of thumb discussed in Chapter 3.

(c) Implement a DC block simply by subtracting out the empirical mean from the output of (b). Plot the output of the envelope detector, along with the original message m(t).

7) Repeat 6) for different values of RC (both too large and too small), and comment on how the resulting message estimate is affected by the value of RC.

NOTE: For the following excercises you are requested to use the .wav file attached along with the lab document as m(t).

8) Use the DSB signal, u(t) to explore what happens when there is a frequency difference between what is used to modulate the message vs. what is used to demodulate, i.e, do:

$$rcvd(t) = m(t) \cos(2\pi(f_c+\Delta f)t)$$

9) Use the DSB signal, u(t) to explore what happens when there is a phase difference between what is used to modulate the message vs. what is used to demodulate, i.e, do:

$$rcvd(t) = m(t) \cos(2\pi f_c t + \Theta)$$

10) Further to explore the effects of noise, try adding the following noises to u(t) and after attempt to demodulate it the usual way, i.e, multiplying it with the carrier wave and passing it via a LPF.

i) AWGN - Additive White Gaussian Noise

ii) Coloured Noise

iii) Impulse Noise