Homework 3 Spring 2025

Use two pulse shapes for baseband modulation p(t) and $p_s(t)$. p(t) is a square pulse of duration T and height A and $p_s(t)$ is a raised cosine pulse with r=5 function whose main lobe width is T and height A. T is also the bit time. Use A carrier tone of frequency fc = 5Hz.
In the following assume T = 2 seconds and A = 1 Volt. Also, assume the sampling rate T_s = 0.02 seconds for MATLAB emulation. All computations of energies and bandwidths should be numerical with appropriate scaling.

For an extra bonus 2 points you can also compute (and label) the energies/bandwidths analytically.

0. Write your RUID
1. Set random seed in MATLAB using your RUID (using **rng(RUID)** function) and generate a random sequence of 1000 bits using a rand function and denote with **bb**.
2. Generate two baseband signals, both using the same bit sequence **bb** from, one using pulse shape **p(t)**, call it **s(t)** and the other one using the pulse shape $\mathbf{p_s(t)}$, call it $\mathbf{s_s(t)}$.
   a. Whenever you are transmitting **"1"**, transmit p(t) ($p_s(t)$) and if you transmit **"0"**, transmit a negative pulse -p(t) ($-p_s(t)$).
3. Plot the initial segments of both s(t) and $s_s(t)$ corresponding to the first 10 bits. The x-label should be the time in seconds.
   Label both plots with:
   a. bits used to generate the signal
   b. the energy per bit for that signal
4. Up-convert the signals s(t) and $s_s(t)$ by modulating with a cosine of carrier frequency fc and call the signals u(t) and $u_c(t)$, find the Fast Fourier Transform (FFTs) of u(t) and $u_c(t)$, called S(f) and $S_c(f)$. Plot the energy spectral densities in dB as $10\log_{10}(|\ S(f)\ |^2)$ and $10\log_{10}(|\ S_c(f)\ |^2)$.
   The x-label which should be in Hz in the range -fs/2 to fs/2, where fs = 1/Ts is the sampling rate (Note that to achieve this you might have to manipulate the MATLAB FFT output.)
   Label the two plots with the signal energy per bit**.**

5. Down-convert the signals u(t) and $u_s(t)$ by modulating with a cosine of carrier frequency fc and filter the signals with a LPF FIR filter using L number of taps call the signals d(t) and $d_c(t)$.
   Plot the two signals d(t) and $d_c(t)$ for a duration corresponding to 10 bits for filter lengths
   a) L=2
   b) L=10
   (Note that you should design a suitable filter to reconstruct the original signals as best as you can.)
6. Build a detector/decoder of choice. Use signals filtered with filters 5a) and 5b) above to determine what bits have been sent. Draw the block diagram of the decoder (use equations if needed). Draw a table which will list the number of bit errors that your decoder has achieved.

Report submission/output:

Labelled plots requested and MATLAB code (executable via copy and paste) in a single pdf. MATLAB code should generate all the plots in that single run together with the labels.

Late submission:

- Grace period will be given till the next date of the due date.
- 2 points from the total points will be deducted on the 2nd day.
- After the 2nd day, no submission will not be accepted.