EE161 — Spring 2025 **San José State University**
Homework # 10 **Due: Thu. 5/8/25**

1. Error floors with OFDM transmission

   Form Canvas, download MATLAB script `run_OFDM_2024b.m` and its associated Simulink model `OFDM_system_QPSKmod_2024b.slx`. This simulates the transmission of QPSK modulation over a non-fading AWGN channel using CP-OFDM (cyclic-prefix OFDM) with K carriers and a cyclic prefix of $K/4$ symbols (or a 25% overhead). Moreover, the model uses knowledge of *all* data symbols to perfectly estimate the subchannel gains. With the same mulitipath channel coefficients `[1 0 0 1]/sqrt(2)`, run the scrip three times[1], once for each the following values of number of carriers [2]:

   (a) $K = 16$

   (b) $K = 128$

   (c) $K = 2048$

   This will produce three bit error rate curves. Label each curve with the associated channel coefficients. Attach the figure to your solution and comment on the effect that the number of subcarriers K has on the error performance of OFDM over a multipath channel.

2. Software-radio demo # 2

   Download the procedure (`demo2.pdf` file) and MATLAB simulink models located in Canvas under `Files/Lab demos/Demo 2`. You must answer all of the *"for the report"* questions in the procedure, as well as section 5 results, and attach them to your homework (even though the lab demo is performed in a group.)

3. Channel estimation errors in Alamouti's scheme

   Download script `alamouti_bpsk2_chest_errors_v2.m` from Canvas. The script will simulate the transmission of BPSK symbols using Alamouti's transmit diversity scheme with perfect channel estimation and with channel estimation errors. These errors are modeled as zero-mean Gaussian random variables of standard deviation σ_e. Use your student ID number to run the script once for each of the values below.

   (i) $\sigma_e = 0.2$

   (ii) $\sigma_e = 0.03$

   (iii) $\sigma_e = 0.005$

   For each run do the following:

   (a) Sketch carefully or print the figure produced by the script

   (b) Evaluate the approximated value of the diversity order D_e under channel estimation errors

   Comment on the effects that channel estimation errors have on the diversity order.

[1] Ignore the warnings in the command window.

[2] Enter, for example, `K=16`

4. Channel estimation errors in a 2×2 MIMO system with 16-QAM modulation

   Download and run the Matlab script `mimo2x2_chest.m` from the web site of the class. The script simulates the performance of a 2×2 MIMO system under flat fading and non-ideal channel estimation.

   (a) Run the script, for 16-QAM modulation, for 15000 symbols and SNR from 15 dB to 55 dB in increments of 5 dB, for each of the following cases:

      i. Estimation errors with $\sigma_e^2 = 0.03$
      ii. Estimation errors with $\sigma_e^2 = 0.0003$
      iii. Ideal estimation

      Do not close the figure after the script finishes. After each run, take note of the position/values of the curve and run the script again.

   (b) From the results from part (a) do the following.

      i. Verify that with ideal channel estimation the diversity order is $D = 1$. In other words, in return to doubling the data rate, there is no diversity improvement with respect to a single antenna system.
      ii. Comment on the effects that estimation errors have on the error performance. In particular, what happens to diversity?