EE161 — Spring 2025 **San José State University**
Homework # 9 **Due: Thu. 5/1/25**

1. Four-finger RAKE demodulator over a four-path channel under Rayleigh fading

   Download files `run_RAKE_Rayleigh_2024b.m` and `RAKE_SS_4F_Rayleigh_2024b.slx` from Canvas[1]. The channel model has four symbol-spaced paths with gains input in the command window when running the script. The channel gain estimates need also to be input.

   (a) Run the script `run_RAKE_Rayleigh_2024b.m` for a channel with path gains:

   `[1 0 1 1]/sqrt(3)`

   using as estimated path gains

   `[1 0 1 1]/sqrt(3)`

   This gives RAKE demodulator performance with *maximum-ratio combining* (MRC).

   (b) Run the script again, *without closing the figure*, using the same path gains as part (a) but now using as estimated path gains

   `[1 1 1 1]/2`

   to obtain the performance with *equal-gain combining* (EGC).

   (c) Use the simulated BER curves to assess the difference in performance between MRC and EGC in a wireless multipath fading scenario using a RAKE demodulator.

      i. Which of the two diversity combining techniques is better?

      ii. Estimate the difference in required average E_s/N_0 in dB to achieve a BER equal to 10^{-3}

2. Nine-tap adaptive equalizer for BPSK over a four-path channel

   Download MATLAB Simulink model `Equalizer_Multipath_2024b.slx` from Canvas. This simulates the performance of a 9-tap adaptive equalizer when BPSK modulation over a symbol-spaced 4-path channel under Rayleigh fading. The equalizer is trained using 700 known symbols in 3000 symbol frames (23.33% overhead). The path gains are set using variable `c`, with default value `c=[0.9 1 0.3 0.2]/sqrt( 1.94);`, and the equalizer step size set with variable `delta`, having a default value `delta = 0.007;`

   (a) Use your student ID number as `seed`, by typing in the command window:

   `seed=ID_number;`

   Run the model and observe the variations of the path gains due to Rayleigh fading (center window) and the 9 coefficients of the equalizer (as rectangular pulses on the bottom right window). Upon finishing the simulation, record the bit error rate (BER) shown in the model's window.

   (b) Set the step size `delta=0.0007` in the command window, run the model again and record the BER value.

   (c) Repeat for step size `delta=0.02`.

   (d) Discuss the effect that the step size has on the adaptive equalizer performance. You can try other values if you want.

[1]You will need MATLAB 2024b or a newer version. `MATLAB` is free for SJSU students.

3. Software-radio demo # 1

   Lab demos shall be conducted by each term project team. A door code to access room E238 will be sent as an announcement to each group in Canvas. Do not share the code with anyone outside your group.

   Importantly, the RF Communications Lab has a variety of circuits, radios and instruments. Be respectful and **DO NOT TOUCH** them.

   Download the procedure (`demo1.pdf` file) and MATLAB Simulink models located in Canvas under `Files/Lab demos/Demo 1`. Complete the prelab work and answer all of the *"for the report"* questions in the procedure and attach to your individual homework (even though the lab demo is performed in a group.)

   Each team can work with two radios. A radio is specified by a label of the form `E238-XX` of the desktop computer it is connected to. Check the front of each desktop computer to find the label. The pair of radios assigned to each team is found in file `EE161-Lab-Weekly-Planner.pdf` in Canvas under `Files/Redio experiments/`