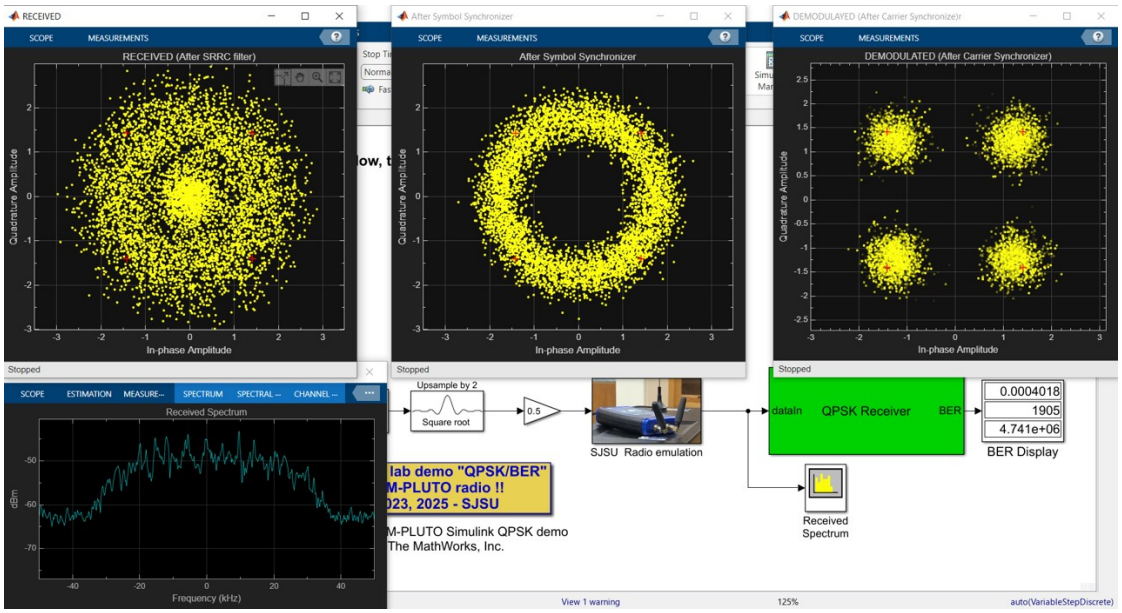
**EE161 — Spring 2025** **San José State University**
**Homework # 8** **Due: Thu. 4/17/25**

1. BER of a wireless QPSK link with ADALM-PLUTO software radio emulation

   In class we discussed a model that emulates the ADALM-PLUTO radio with QPSK modulation, Below is a snapshot:




   Download MATLAB Simulink model `Baseband_QPSK_emulation_2024b.slx` from Canvas directory `Files/Matlab/_Simulink models`. Then in the command window enter `seed=IDnumber`, where `IDnumber` equals the last 4 digits of your student ID number.

   (a) Run the model and fill the BER values in the table below. The first row are default values. Use the command window to modify the values of $\Delta f$ and `SNR`. For example, for the second row, enter `Deltaf = 3000; SNR = 15;`

| $\Delta f$ | `SNR` | BER |
|---|---|---|
| 3000 | 12 | |
| 3000 | 15 | |
| 3000 | 9 | |
| 3000 | 6 | |
| 500 | 12 | |
| 500 | 15 | |
| 500 | 9 | |
| 500 | 6 | |
| 0 | 12 | |
| 0 | 15 | |
| 0 | 9 | |
| 0 | 6 | |

   (b) Comment on the effects that frequency error and SNR values have on the BER.

2. DPSK versus BPSK under AWGN and flat Rayleigh fading with phase errors

Download MATLAB script `dpsk_vs_bpsk_AWGN_rayleigh.m` from Canvas directory `Files/Matlab/_Scripts`. The script simulates the performance of BPSK and DPSK under both AWGN and flat Rayleigh fading with a phase error at the receiver.

(a) Run the script using your student ID for each of the following values of phase error and attach the resulting BER curves.

i. $\phi = 0$ deg.

ii. $\phi = 40$ deg.

iii. $\phi = 85$ deg.

(b) (BONUS) For part ii. above, compute the theoretical loss in dB of BPSK with respect to an ideal channel (i.e., $\phi = 0$) and compare it with the simulation results.

3. DPSK under frequency errors

Download MATLAB script `dpsk_deltaf.m` (Canvas directory `Files/Matlab/_Scripts`). The script simulates DPSK modulation over an AWGN channel with an initial random phase $\Delta\phi$, given a normalized frequency error value $\Delta f\, T_b$.

(a) Run the script for the each of the following values of normalized frequency error:

i. $\Delta f\, T_b = 0.15$

ii. $\Delta f\, T_b = 0.05$

iii. $\Delta f\, T_b = 0.01$

iv. $\Delta f\, T_b = 0$

Print or sketch the resulting figure.

(b) Comment of the effects that frequency errors have on the BER performance of DPSK.

4. Outage probability

Download MATLAB script `outages.m` from Canvas directory `Files/Matlab/_Scripts`. The script simulates a flat Rayleigh fading channel's received energy-to-noise ratio $\Gamma$ and computes the outage rate $R_o$, using a threshold $\gamma_T = 5$ dB. The average received energy-to-noise ratio $\gamma_0$ is set randomly based on your student ID. Upon running the script, **Figure 2 will have in its title the value of $\gamma_0$ in dB**.

(a) Run the script and attach both the histogram of fading amplitudes and power $\Gamma$ as well as the plot of the first 250 samples of $\Gamma$.

(b) From the values of $\gamma_0$ and $\gamma_T$, compute the outage probability $P_o = \Pr\{\Gamma \leq \gamma_T\}$ and compare it to the simulated outage rate. Comment.