2.1 Lab 2A: MIMO Detection Algorithms (Zero-Forcing and Minimum Mean Square Error (MMSE)) for a 2x2 System

In this 2x2 MIMO system, there are two transmitters, each with a single antenna, and one receiver with two antennas. This sort of scenario may occur anywhere there are several devices that need to talk to a single base station. Each of the transmitters will transmit their own signal, but the receivers have no choice but to listen to all of the air at once.

Goal: Given the transmitted and received data in a 2x2 MIMO system, decode the signal using a zero-forcing receiver and an MMSE receiver.

Files of transmitted and received data will be provided to you in a combined format (2User2AntennaBS.mat) or as raw data files (tx1.dat, tx2.dat, rx1.dat, rx2.dat). In 2User2AntennaBS.mat, the signals from the transmitters 1 and 2 are in the vectors x1 and x2, respectively. The received signals on antennas 1 and 2 are in y1 and y2, respectively.The transmitted data is organized as follows. Note that all transmitted bits are pseudo random, encoded using BPSK with 40 sample long rectangular pulses.

Sample #	**Transmitter 1**	**Transmitter 2**
1-5,000	5000 zero samples	5000 zero samples
5,001-10,120	128 pseudo random bits	5120 zero samples
10,121-15,120	5000 zero samples	5000 zero samples
15,121-20,240	5120 zero samples	128 pseudo random bits
20,241-25,240	5000 zero samples	5000 zero samples
25,241-66,200	1024 data bits	1024 data bits

Each transmitter transmits for a period of time while the other one sends zeros. These portions can be used as "training signals" to extract an approximation of the channel properties. In this lab, we assume:

- The channels are flat fading with additive Gaussian noise.
- The transmitters and receivers are frequency locked, so no carrier synchronization is necessary.

In practice, you will use known training data to approximate the channel properties, but will not know the data trying to be sent at the receiver. **Only use the data bits to check if the decoding algorithm works.** If you would like a challenge and would like to transmit and receive signals on USRPs yourselves, please consult instructor.

Deliverables: Please turn in your MATLAB implementation of the zero-forcing receiver and the MMSE receiver *and* the corresponding report. Make sure to refer to the technical writing expectations for this course in the appendix as you write your report.

Table 2.1: Lab 2A Rubric

	Points	Self-Assessment
Introduction Section *Introduction of the goal of the lab and any contextual information*	5 points	
System Explanation *Explanation of the physical system; Diagrams are well suited to this*	10 points	
Explanation of the Zero-Forcing Receiver Algorithm *Explanation of Zero-Forcing receiver* *- Why is the zero-forcing receiver called this?* *- How does it work mathematically?*	20 points	
Explanation of the MMSE Receiver Algorithm *Explanation of the MMSE receiver and how it differs from the Zero-Forcing receiver* *- Why is the MMSE decoder called this?* *- Why should the MMSE decoder work better in noisy scenarios?* *- What are the differences between the MMSE decoder and the Zero-Forcing receiver? Look into why a "variance term" is introduced and the properties of linear receivers (helpful terms are "singular values" and "condition numbers" of a matrix).*	20 points	
Implementation Section *Discussion of your particular implementation that highlights any design decisions*	10 points	
Code Explanation *Explanation of your code that isn't super granular; Include a flow diagram for each algorithm implemented*	10 points	
Results Section *An overview of the results of your implementation; Include all plots that illustrate your implementation* *Include:* *- Plots that show the sent and received data before rounding* *- Plots that show the sent and received data after rounding* *- BER*	10 points	
Technical Writing *Refer to the technical writing guidelines*	10 points	
Self-Assessment *Fill out this rubric and include it in your submission.*	5 points	