Multi-Channel Communications

Mini-Project #6

OFDM - Part II (Channel Estimation and Bit Loading)

Due December 2, 2022

Note: You may use outside references including books and notes and may discuss the project with your classmates in general terms. However, you may not obtain code or direct assistance from another person.

PLEASE MAKE SURE YOU ANSWER ALL PARTS OF EACH PROBLEM AND CLEARLY MARK YOUR ANSWERS BY PUTTING A BOX AROUND EACH ANSWER. YOUR ANSWERS SHOULD BE AS COMPLETE AND CLEAR AS POSSIBLE – NOT JUST A LISTING OF THE ANSWER. MATLAB CODE SHOULD BE CLEARLY DOCUMENTED AND SUBMITTED SEPARATELY FROM YOUR REPORT.

I pledge that I have neither given nor received any unauthorized assistance on this project.

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(signed)

_____ _____

Name (print) Student Number

1 Mini-Project Overview

In this project you will expand upon your previous projects by adding channel estimation, bit loading (adaptive modulation) and synchronization to your OFDM transmitter and receiver. You will turn in two primary components: (1) Matlab code (uploaded to Canvas as a zip file) and (2) A report validating your design (uploaded to Canvas as a pdf file and a hard copy submitted in class).

2 Detailed Description

You will update your previously designed transmitter and receiver code. The transmit function should include an option for transmitting an OFDM signal with varying modulation/coding on each sub-carrier (or group of sub-carriers). Note that the transmitter code should take three inputs: a block of N_b input data bits, a feedback message (needed for modulation and coding choices or channel feedback) and an object/struct named "parameters" which provides the input parameters defining the modulation scheme (or adaptation scheme in this case), and any other needed parameters (you will have hopefully already included various items to the Parameters struct including the number of subcarriers, the pilot locations, etc.). The receiver function should take two inputs: the complex received samples (after going through a channel function) and a parameters object/structure that has the necessary details concerning the OFDM scheme, the modulation scheme used, etc. The receiver function should output the data and the feedback bits.

3 Required Validation

You will create a report describing your function briefly and providing validation plots. Specifically, you must validate the channel function by providing the following plots/analyses:

1. Channel Estimation
   (a) Implement either LS/MLE or MMSE channel estimation based on known pilots and pilot locations. Choose a particular set of channel parameters (delay spread and Doppler spread) and show the performance of QPSK modulation with a varying number of pilots. What is the minimum number of pilots needed and why? Assume perfect synchronization.
   (b) Increase the delay spread used in the previous validation by a factor of two and repeat (1a). How is the performance affected?
2. Bit Loading
   (a) Simulate the performance of OFDM with N subcarriers and adaptive bit loading (assuming perfect synchronization and channel estimation) in an AWGN channel for SNR ranging from 0dB to 8dB in 1dB steps. Plot the resulting BER vs SNR in dB for both theory and simulated. Also plot the throughput versus E_b/N_o. Show that the modulation and coding scheme is varied to maximize throughput for a target BER/FER.

(b) Simulate (assuming perfect synchronization and channel estimation) and plot the performance (simulated and theoretical) with SNR ranging from 0dB to 20dB in a *slow* flat Rayleigh fading channel. How do you know that your receiver is working properly?

(c) Simulate (assuming perfect synchronization and channel estimation) and plot the performance (simulated and theoretical) with SNR ranging from 0dB to 20dB in a *constant* frequency selective Rayleigh fading channel. Plot the channel and show that the modulation schemes chosen are consistent with the sub-carrier channel gains.