ECE 732: Mobile Communication Systems
Prof. B.-P. Paris
Homework 3
Due: October 2, 2018

Suggested Reading: Goldsmith Chapter 3

Problems

1. A wireless communications channel is modeled as a discrete multipath channel such that it's (passband) impulse response has the form
$$h(t) = \sum_k a_k \delta(t - \tau_k).$$
Initially, assume that the gains $a_1 = 1$, $a_2 = 0.7$, and $a_3 = 0.3$. Furthermore, the delays are $\tau_1 = 0.5\mu s$,$\tau_2 = 1.0\mu s$, and $\tau_3 = 1.3\mu s$. Assume that the carrier frequency is 1GHz.
   (a) Determine the baseband equivalent impulse response for this channel.
   (b) Compute the Fourier transform of the baseband equivalent impulse response, i.e., the baseband equivalent Frequency response of the channel.
   (c) Plot (using MATLAB) the frequency response for a band ranging from 5MHZ below the carrier frequency to 5MHz above the carrier frequency.
   (d) Assume now, that the mobile node has moved a small distance and that the channel coefficients have changed. Specifically, assume that τ_1 has increase by $0.5ns$ and that τ_3 has decreased by $0.5ns$; τ_2 is unchanged. Also, the path gains a_k have not changed. Approximately what distance did the mobile move?
   (e) Compute and plot the baseband equivalent frequency response of the changed channel and compare. Comment on the observed differences between the two channels.
2. Goldsmith Problem 3.1
3. Goldsmith Problem 3.2
4. Goldsmith Problem 3.5

5. **MATLAB Experiment**
   (a) Retrieve the MATLAB function `SimulateCOSTChannel.m` and analyze it.
   (b) In MATLAB, generate a constant input signal of duration one second (20,000 samples per second) and let it be input to the the function `SimulateCOSTChannel`. Choose, the carrier frequency equal to 1 GHz and vary the Doppler shift to simulate vehicle speeds from 0 km/h to 100 km/h. Plot the absolute value of the resulting signal for different vehicle speeds.
   (c) In Matlab generate a BPSK modulated signal (see e.g. MATLAB function `LinearModulation.m` and MATLAB function `plot_LinearModRect.m`for an example how to do this). Consider 20 bit periods and sample the signal 10 times per bit-period. Let the BPSK signal be input to `SimulateCOSTChannel` and plot the real part of the resulting signal. Vary the bit rate between 50 Kbit/s and 1 Mbit/s.
   (d) Summarize and analyze your findings. Do NOT include any plots without clearly labeling the plot and accurately describing how it contributes to your conclusions. Do NOT include MATLAB code unless it contributes to your observations.
6. Discuss the relevance of the parameters delay spread and maximum doppler spread. Explain how they capture the characteristics of a multi-path fading channel and how they will affect transmission of message bearing signals. What properties do signals have to possess so that they are essentially immune to the consequences of
   (a) fading
   (b) delay spread
   (c) fading and delay spread.
7. A fictitious mobile FDMA system operates at a data rate of 100Kbit/s. Assume that the bandwidth occupied by the transmitted signals is 100KHz and that transmissions continue for an infinite time. A competing TDMA system divides each frequency band of 800KHz into 8 time-slots in which 500 bits are transmitted. Hence, the data rate in each frequency band is 800Kbit/s but 8 different users

combine their signals by transmitting non-overlapping bursts of 500 bits each.

For each of the two systems, discuss the provisions that must be made at the receiver to allow reliable transmission over multi-path fading channels. Try to assess their relative complexity and indicate which system approach you would choose.