**EE451 Mobile Communication Systems**

**Homework 2**

**Due Date: Oct 26, 2023 (in Class)**

**All assignments received after deadline will not be marked. This is the hard deadline.**

**Problem 1 (CLO-2):**

Assume a receiver is located 10km from a 50W transmitter. The carrier frequency is 6GHz and the free space propagation is assumed, Gt=1 and Gr=1.

1. Evaluate the power at the receiver
2. Compute the magnitude of E-field at the receiver antenna
3. What is the receiver power in dBm?
4. If the receiver sensitivity is -96dBm, would the receiver be able to decode the message? Justify your answer.

**Problem 2**:

A brief measurement campaign indicates that the median propagation loss at 420 MHz in a mid-size city can be modeled by the following path loss equation

i.e., the path loss exponent is β = 2.8 and there is a 25 dB fixed loss.

1. Assuming a cell phone receiver sensitivity of -95 dBm, what transmitter power is required to service a circular area of radius 10 km?
2. Suppose the measurements were optimistic and β = 3.1 is more appropriate. What is the corresponding increase in transmit power (in decibels) that would be required?
3. If log-normal shadowing is present with σ = 8 dB, how much additional transmit power is required to ensure 10% thermal noise outage at a distance of 10 km?
4. For the same 10% probability of outage, estimate the fraction of total area within a radius of 10 km, where the signal is successfully decoded?

**Problem 3 (CLO-2):**

Suppose the three baseband channel impulse responses (IRs) on next page were measured when the transmitter was in a fixed position and the receiver (RX) was moved to three consecutive positions along a line, such that every pair of adjacent positions is separated by 2 wavelengths. Each IR corresponds to a distinct RX position.

1. Compute an estimate of the power delay profile for this channel.
2. Compute the rms delay spread for this channel.



**Problem 4 (CLO-2):**

Let a static wireless channel be described by the following power delay profile: P (τ) = δ(τ) + 0.5 δ(τ- 300ns). Suppose the transmitted signal is modulated with BPSK at a symbol rate of 105 symbols per second.

1. Compute the mean excess delay of the channel.
2. Evaluate the rms delay spread of the channel.
3. Classify this channel in terms of its type of fading.

**Problem 5: Channels**

1. Calculate the 90% and 50% correlation coherence bandwidths for the power delay profiles of following indoor and outdoor channels.



1. Would these channels be suitable for following standards without the use of an equalizer? 
   * 1. GSM bandwidth 200KHz
     2. IS-95 (CDMA) bandwidth 1.25MHz
     3. WCDMA bandwidth 5MHz
     4. LTE bandwidth 20MHz

**Problem 6 (CLO-3)**:

Design and create a computer program that produces an arbitrary number of samples of propagation pathloss using a d^n pathloss model with lognormal shadowing. Your program is a radio propagation simulator, and should use, as inputs, the T-R separation, frequency, the pathloss exponent, the standard deviation of the log-normal shadowing, the close-in-reference distance, and the number of desired predicted samples. Your program should provide a check that insures that the input T-R separation is equal to or exceeds the specified input close-in-reference distance, and should provide a graphical output of the produced samples as a function of pathloss and distance ( this is called a scatter plot).

Verify the accuracy of your computer program by running it for 50 samples at each of 5 different T-R separation distances (a total of 250 predicted pathloss values), and determine the best fit pathloss exponent and the standard deviation about the mean pathloss exponent of the predicted data using the techniques as described in example in the class. Draw the best fit mean pathloss model on the scatter plot to illustrate the fit of the model to the predicted values. You will know your simulator is working if the best fit pathloss model and the standard deviation for your simulated data is equal to the parameters you specified as inputs to your simulators.

**Problem 7: Use Matlab/Python (CLO-3):**

1. Generate 200 samples of a Rayleigh random variable R with E{R2}=1. Plot the samples in a stem plot. Remember that R = |X+jY|, where X and Y are zero mean, independent Gaussian random variables (r.v). Your Gaussian r.v. X and Y (produced by randn command) must each have equal variance equal to ½.
2. Give the estimated rms value of R, based on the 200 samples generated, which is given as .
3. What fraction (if any) of these Rayleigh samples are 10dB below the estimated rms value?(Note that this threshold corresponds to in the context of level crossing)
4. Generate 200 samples of a Rician random variable by adding means mr=5cos(π/3) and mi = 5sin(π/3), respectively to the real part (X) and imaginary part (Y) in part (a). Plot the samples in stem plot. What is the K factor of this Rician random variable?
5. Repeat part (d) except use mr=5cos(π/6) and mi = 5sin(π/6). Plot the samples in stem plot. What is the effect of phase change on the appearance of stem plot?
6. We now normalize the Rician random variables to have unit mean square value. Let Rn be the nth sample from Part (d). Make 200 normalized r.v. as . Plot the Wn’s as a stem plot and compare to Part (a). What fraction of samples of W are 10dB below the rms value of W (should be fewer, because there should be less fading).