Department of Electrical & Computer Engineering
The University of Calgary
ENEL 529 – Wireless Communications Systems
Fall 2014

Assignment #3. Due Date: Friday, November 28, 2014 @ 12:00 pm

Problem 1

The instantaneous signal-to-noise ratio (SNR) in a Rayleigh channel is given by $A^2(E_b/N_o)$, where E_b is the energy per bit, N_o is the noise power spectral density and A is the Rayleigh distributed envelope. The average signal-to-noise power ratio (in dB) at the receiver is $E[A^2](E_b/N_o)$ = 3 dB.

a) Calculate the outage probability without the use of a diversity system, assuming an SNR threshold of 0 dB.
b) To mitigate the effects of Rayleigh fading, the service provider is planning to use a six-branch (i.e., $M = 6$) diversity receiver with maximal ratio combining (MRC). If outage occurs when the instantaneous SNR at the output of the MRC goes below 0 dB, calculate the outage probability with MRC diversity.
c) In part b), if the diversity is instead based on selection combining, calculate the outage probability.
d) In part b), if the MRC is replaced with the equal gain combiner, calculate the outage probability.
e) Comment on the results obtained in parts b) to d). What is the percent reduction in the outage probability without diversity to obtain the results in parts b) to d)?

Problem 2

Consider a 2-branch diversity using binary phase shift keying (BPSK) modulation and coherent detection. The channel envelope in branch 1, a_1 and channel envelope in branch 2, a_2 can take on the values of $a_1 \in \{1.0, 0.1\}$ and $a_2 \in \{1.0, 0.1\}$, respectively. In each branch i (i = 1, 2), the channel envelope $a_i = 1$ with probability of 0.8 and $a_i = 0.1$ with probability of 0.2. The 2 branches have independent channel envelopes.

i) Assuming equal gain combining (EGC), derive the expression for the average probability of bit error. Express your result in terms of the Q-function and E_b/N_o.
ii) Using the expression derived in i), calculate the average probability of bit error with diversity for E_b/N_0 values selected from 0 to 20 dB, in steps of 5 dB (i.e., 0, 5, …, 15, 20 dB).
iii) If no diversity is considered, calculate the average probability of error over the fading channel for E_b/N_0 values selected from 0 to 20 dB, in steps of 5 dB. (*Hint:* Use the answer to the Problem #2, Nov 3 Tutorial)
iv) Plot the results of parts ii) and iii) on a semi-log graph paper
v) For each E_b/N_0 value considered in parts ii) and iii), calculate the diversity gain (i.e., percent reduction in the result of part iii) to achieve the result of part ii)).