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

Assignment #2 - Due Date: Monday, November 14, 2014 @ 4:00 pm

Problem 1

Consider a coherent BPSK wireless system where the received signal *r(t)* over a fading channel is expressed as: $r(t) = As(t) + n(t)$ where *s(t)* is the BPSK modulated signal and *n(t)* is additive white Gaussian noise of single-sided power spectral density N_o. The parameter *A* is a multiplicative factor that accounts for fading and takes on discrete values {0.01, 0.5, 1.0} with probability $Pr\{A = 0.01\} = 0.1$, $Pr\{A = 0.5\} = 0.3$ and $Pr\{A = 1.0\} = 0.6$.

i) For each value of *A*, write the expression for $SNR_{fad}(A)$, the received faded signal to noise ratio, in terms of *A* and E_b/N_o
ii) Using the result of part i), derive the expression for $P_{e,ave}$, the average probability of bit error in terms of the *Q*-function and E_b/N_o
iii) If $E_b/N_o = 7$ dB, calculate the value of the average probability of bit error over the fading channel.

Problem 2

Suppose that, due to signal transmission over a wireless channel using coherent BPSK MODEM, a carrier phase synchronization error $\Delta\phi$ is introduced. Under this condition, the bit error rate (BER) for coherent BPSK MODEM is given by:

$$P_e = Q\left(\sqrt{2\frac{E}{N_o}\cos^2(\Delta\phi)}\right)$$

where E/N_o is the energy per bit to noise power spectral density ratio and *Q(.)* is the *Q*-function.

a) If $\Delta\phi$ is a random variable uniformly distributed over [-*a*, +*a*], where $0 < a << \pi$, derive the expression for the average BER as a function of *a*.
b) If $E/N_o = 6$ dB and $a = \pi/8$, using the expression derived in part a), calculate the average BER.
c) Calculate the BER for an ideal BPSK coherent receiver when $\Delta\phi = 0$ (i.e., perfect carrier phase recovery) and $E/N_o = 6$ dB. What is the percent reduction in the BER of the imperfect receiver to achieve the ideal BER?
d) Repeat parts b) and c) if $a = \pi/4$ and $E/N_o = 6$ dB.
e) Comment on the impact of the range of the uniformly distributed phase error on the bit error rate.