**CLASS: BE (E&TC) SUBJECT: MC**

**EXPT. NO: 04 DATE:**

**I. TITLE**: RAYLEIGH FADING WIRELESS CHANNEL

**II. OBJECTIVE:** Simulate the BER performance over Rayleigh fading wireless channel with BPSK transmission for SNR 0 to 60 dB

**III. SOFTWARE USED:** OS: Unix or windows 7/8/10,

Processor: i3/i5/i7,

Software: MATLAB/Octave

**IV. THEORY:**

In this experiment, we will derive the theoretical equation for bit error rate (BER) with Binary Phase Shift Keying (BPSK) modulation scheme in Additive White Gaussian Noise (AWGN) channel. The BER results obtained using Matlab/Octave simulation scripts show good agreement with the derived theoretical results.

With Binary Phase Shift Keying (BPSK), the binary digits 1 and 0 maybe represented by the analog levels + and – respectively. The system model is as shown in the Figure below.



**Channel Model**

The transmitted waveform gets corrupted by noise , typically referred to as **Additive White Gaussian Noise** (AWGN) where,

**Additive**: As the noise gets ‘added’ (and not multiplied) to the received signal

**White**: The spectrum of the noise if flat for all frequencies.

**Gaussian**: The values of the noise follows the Gaussian probability distribution function as,

where, µ = 0 and

**Computing the probability of error**

The received signal is,

when bit 1 is transmitted

when bit 0 is transmitted

The conditional probability distribution function (PDF) of for the two cases are:

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Figure: Conditional probability density function with BPSK modulation

Assuming that and are equally probable i.e. p() = p() = 1/2 , the threshold 0 forms the optimal decision boundary.

▪ if the received signal, y > 0 then the receiver assumes that was transmitted.

▪ if the received signal, y ≤ 0 then the receiver assumes that was transmitted.

With this threshold, the probability of error given that is transmitted is (the area in blue region):

where,

Similarly, calculating for , we get,

The total probability of bit error is given as,

As it is assumed that both the bits and are equally probable. Hence,

**Simulation model**

Matlab/Octave source code for computing the bit error rate with BPSK modulation for two cases: theoretical and simulation. Following are steps of experiments:

(a) Generation of random BPSK modulated symbols +1′s and -1′s

(b) Passing them through Additive White Gaussian Noise channel

(c) Demodulation of the received symbol based on the location in the constellation

(d) Counting the number of errors

(e) Repeating the same for multiple Eb/No value.

**MATLAB code:**

clear

N = 10^6 % number of bits or symbols

rand('state',100); % initializing the rand() function

randn('state',200); % initializing the randn() function

% Transmitter

ip = rand(1,N)>0.5; % generating 0,1 with equal probability

s = 2\*ip-1; % BPSK modulation 0 -> -1; 1 -> 1

n = 1/sqrt(2)\*[randn(1,N) + j\*randn(1,N)]; % white gaussian noise, 0dB variance

Eb\_N0\_dB = [-3:10]; % multiple Eb/N0 values

for ii = 1:length(Eb\_N0\_dB)

% Noise addition

y = s + 10^(-Eb\_N0\_dB(ii)/20)\*n; % additive white gaussian noise

% receiver - hard decision decoding

ipHat = real(y)>0;

% counting the errors

nErr(ii) = size(find([ip- ipHat]),2);

end

simBer = nErr/N; % simulated ber

theoryBer = 0.5\*erfc(sqrt(10.^(Eb\_N0\_dB/10))); % theoretical ber

% plot

close all

figure

semilogy(Eb\_N0\_dB,theoryBer,'b.-');

hold on

semilogy(Eb\_N0\_dB,simBer,'mx-');

axis([-3 10 10^-5 0.5])

grid on

legend('theory', 'simulation');

xlabel('Eb/No, dB');

ylabel('Bit Error Rate');

title('Bit error probability curve for BPSK modulation');

**IV. RESULT:**

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**V. CONCLUSION:**

**SIGNATURE**

**REFERENCES**:

1. “Wireless Communications--Principles and Practice” – Rappaport, T. S.

2. “Principles of Modern Wireless Communication Systems” – Jagannathan, A. K.