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SINHGAD COLLEGE OF ENGINEERING

VADGAON, PUNE-41

**Department of Electronics and Telecommunications**

**Experiment No. –** 04

**Subject: - Mobile Computing**

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**Date:** 13/2/24 **Marks & Signature: -**

**Subject Teacher**

e: Simulate BER Performance over Rayleigh Fading wireless channel with BPSK Transmission

blem Statement:

ulate BER Performance over Rayleigh Fading wireless channel with BPSK Transmission for SNR 0 to db..

bjectives:

- What is a Rayleigh Fading
- Study of BPSK transmission

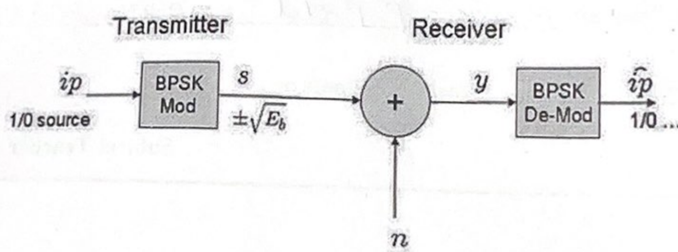
oftware Requirements:

- Windows 7/10/11
- Matlab

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 $+\sqrt{E_b}$ and $-\sqrt{E_b}$ respectively. The system model is as shown in the Figure below.




**Channel Model**

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

**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 $n$ follows the Gaussian probability distribution function, $p(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ with $\mu = 0$ and $\sigma^2 = \frac{N_0}{2}$.

**Computing the probability of error**

Using the derivation provided

The received signal,

$y = s_1 + n$ when bit 1 is transmitted and

$y = s_0 + n$ when bit 0 is transmitted.

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

$$p(y|s_0)=\frac{1}{\sqrt{\pi N_0}}e^{\frac{-(y+\sqrt{E_b})^2}{N_0}}$$

$$p(y|s_1)=\frac{1}{\sqrt{\pi N_0}}e^{\frac{-(y-\sqrt{E_b})^2}{N_0}}.$$

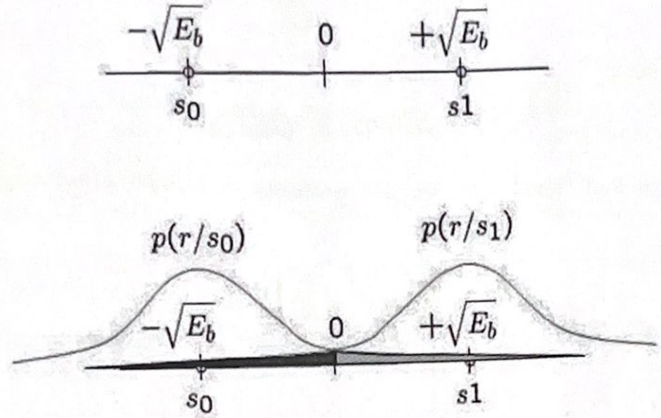



**Figure: Conditional probability density function with BPSK modulation**

Assuming that $s_1$ and $s_0$ are equally probable i.e. $p(s_1)=p(s_0)=1/2$, the threshold 0 forms the optimal decision boundary.

- if the received signal is $y$ is greater than 0, then the receiver assumes $s_1$ was transmitted.
- if the received signal is $y$ is less than or equal to 0, then the receiver assumes $s_0$ was transmitted.

i.e.

$y>0 \Rightarrow s_1$ and

$y \leq 0 \Rightarrow s_0$.

Probability of error given $s_1$ was transmitted.

With this threshold, the probability of error given $s_1$ is transmitted is (the area in blue region):

$$p(e|s_1)=\frac{1}{\sqrt{\pi N_0}}\int_{-\infty}^{0} e^{\frac{-(y-\sqrt{E_b})^2}{N_0}}dy=\frac{1}{\sqrt{\pi}}\int_{\sqrt{\frac{E_b}{N_0}}}^{\infty} e^{-z^2}dz=\frac{1}{2}erfc\left(\sqrt{\frac{E_b}{N_0}}\right),$$

where,

$$erfc(x)=\frac{2}{\sqrt{\pi}}\int_{x}^{\infty} e^{-x^2}dx$$

Probability of error given $s_0$ was transmitted

Similarly the probability of error given $s_0$ is transmitted is (the area in green region):

$$p(e|s_0) = \frac{1}{\sqrt{\pi N_0}} \int_0^{\infty} e^{\frac{-(y+\sqrt{E_b})^2}{N_0}} dy = \frac{1}{\sqrt{\pi}} \int_{\sqrt{\frac{E_b}{N_0}}}^{\infty} e^{-z^2} dz = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right)$$

Total probability of bit error

$$P_b = p(s_1)p(e|s_1) + p(s_0)p(e|s_0).$$

Given that we assumed that $s_1$ and $s_0$ are equally probable i.e. $p(s_1) = p(s_0) = 1/2$, the bit error **probability is,**

$$P_b = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right).$$

**Simulation model**

Matlab/Octave source code for computing the bit error rate with BPSK modulation from theory and simulation. The code performs the following:

(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.