Minnesota State University, Mankato

Electrical and Computer Engineering Department

Lab Assignment 4 – Simulating BPSK Transmission and BER in an AWGN Channel

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Simulating BPSK Transmission and BER in an AWGN Channel

*Abstract*

In this lab, we simulate the transmission of binary data using **Binary Phase Shift Keying (BPSK)** modulation over an **Additive White Gaussian Noise (AWGN)** channel. The goal is to analyze the **Bit Error Rate (BER)** performance by computing the BER for different **Eb/N0 (SNR in dB) values**. The simulation involves generating random binary data, modulating it using BPSK, transmitting it over an AWGN channel, demodulating the received signal, and calculating the BER. The results are plotted to compare the theoretical and simulated BER curves.

*Materials*

**Equipment Needed                                        Quantity.**

Laptop (Visual Studio Code)                                 1

**Methods (Procedure, Data Collection, and Analysis)**

**Part A: BPSK Modulation and Transmission**

1. **Develop a Python function bpsk\_modulate(bits) that:**
   * Maps binary data (0s and 1s) to BPSK symbols:
     + **0 → -1**
     + **1 → +1**
2. **Generate random binary data** to simulate a digital transmission system.
3. **Transmit the BPSK-modulated signal through an AWGN channel** by:
   * Generating **Gaussian noise** with variance based on **SNR (dB)**.
   * Adding noise to the modulated signal.

**Part B: Demodulation and BER Calculation**

1. **Create a function bpsk\_demodulate(received\_signal) that:**
   * Decides **1 if the received signal ≥ 0**, otherwise **0**.
2. **Compute Bit Error Rate (BER) using compute\_ber(original\_bits, received\_bits) by:**
   * Comparing transmitted and received bits.
   * Calculating the ratio of bit errors to total transmitted bits.

**Part C: Simulation and Analysis**

1. **Simulate BER over an SNR range of 0 to 10 dB.**
2. **Compute theoretical BER** using:

BERtheory=1/2erfc(10^(SNR/10))

1. **Plot BER vs. SNR** on a **semi-logarithmic scale** to compare simulated and theoretical results.
2. **Analyze results** by observing how BER decreases as SNR increases, validating system performance.

*Results*

A graph with a line

AI-generated content may be incorrect.

*Conclusion*

In this lab, we successfully simulated and analyzed **BPSK transmission over an AWGN channel** using Python. Our results confirmed that **BER decreases as SNR increases**, aligning with theoretical expectations. By comparing simulated and theoretical BER, we validated our approach and gained insights into **noise impact on digital communication**. Challenges included accurate noise modeling and ensuring statistical reliability in BER computations. This exercise reinforced our understanding of **modulation, noise modeling, and performance analysis** in communication systems.

*Appendices*

A screenshot of a computer program

AI-generated content may be incorrect.

A computer screen shot of code

AI-generated content may be incorrect.

*References*

1. <https://rodzah.files.wordpress.com/2011/07/how-to-write-lab-report.pdf>
2. EE343- LAB Assignment 4.pdf