Digital Modulation Analysis using BPSK and QPSK over AWGN Channel

1. Introduction

Digital modulation techniques are fundamental to modern communication systems as they enable reliable transmission of digital information over noisy channels. Among various modulation schemes, Binary Phase Shift Keying (BPSK) and Quadrature Phase Shift Keying (QPSK) are widely used due to their robustness and spectral efficiency.

This project focuses on the simulation and performance analysis of BPSK and QPSK modulation schemes over an Additive White Gaussian Noise (AWGN) channel using MATLAB. The performance is evaluated in terms of Bit Error Rate (BER) as a function of Signal-to-Noise Ratio (SNR).

2. Objective of the Project

The main objectives of this project are:

- To implement BPSK and QPSK digital modulation schemes in MATLAB.
- To model the effect of an AWGN channel on transmitted signals.
- To perform demodulation at the receiver using hard-decision detection.
- To analyze the BER performance of BPSK and QPSK under varying SNR conditions.
- To visualize the effect of noise using constellation diagrams.

3. System Model

The digital communication system implemented in this project consists of the following blocks:

1. Random Bit Generator
2. Modulator (BPSK / QPSK)
3. AWGN Channel
4. Demodulator
5. BER Analyzer

The transmitted signal passes through the AWGN channel, where noise is added, and the receiver attempts to recover the original bits.

4. BPSK Modulation

In BPSK modulation, each bit is mapped to one of two possible symbols:

- Bit `0` → −1
- Bit 1 → +1

The modulated symbols are transmitted over an AWGN channel. At the receiver, demodulation is performed using a zero-threshold decision rule. The BER is computed by comparing the transmitted bits with the detected bits.

5. QPSK Modulation

In QPSK modulation, two bits are grouped together to form a single complex symbol. The in-phase (I) and quadrature (Q) components represent the two bits. Gray coding is used to minimize bit errors.

The QPSK symbols are normalized to maintain unit average energy. Complex Gaussian noise is added to model the AWGN channel. Demodulation is performed by making independent decisions on the I and Q components

6. AWGN Channel Model

The AWGN channel adds zero-mean Gaussian noise to the transmitted signal. The noise variance is determined by the specified SNR value. The received signal can be expressed as:

$r(t)=s(t)+n(t)$r(t)=s(t)+n(t)

where $s(t)$s(t) is the transmitted signal and $n(t)$n(t) is the Gaussian noise.

7. BER Performance Analysis

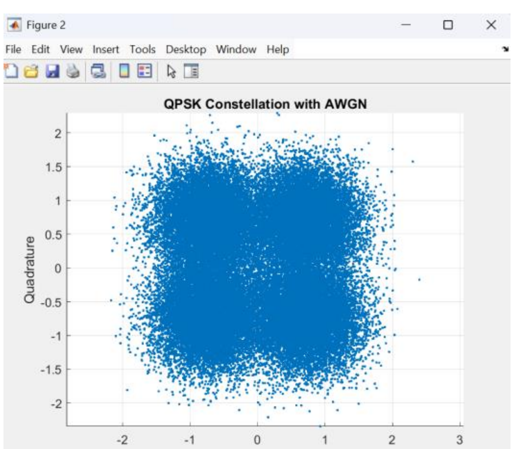
The Bit Error Rate (BER) is calculated as:

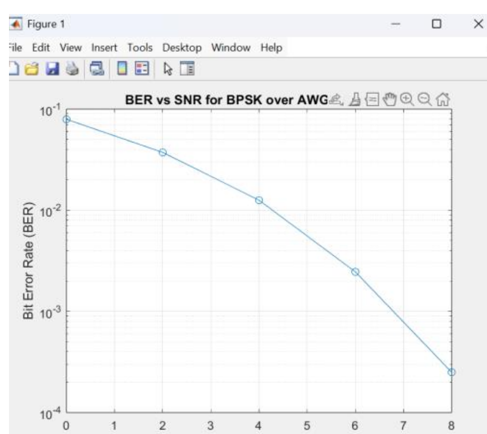
$$\text{BER} = \frac{\text{Number of erroneous bits}}{\text{Total number of transmitted bits}}$$

BER is evaluated for different SNR values to study the performance of the modulation schemes. A BER vs SNR curve is plotted for BPSK, and BER values are computed for QPSK as well.

8. Results and Observations

- The BER decreases as SNR increases for both BPSK and QPSK modulation schemes.
- The BER performance of QPSK is similar to that of BPSK in an AWGN channel.
- QPSK achieves higher data rate efficiency by transmitting two bits per symbol.
- Constellation diagrams clearly show the effect of noise on the transmitted symbols.





9. Conclusion

This project successfully demonstrates the implementation and performance analysis of BPSK and QPSK digital modulation schemes over an AWGN channel. MATLAB simulations confirm theoretical expectations, showing improved BER performance with increasing SNR. The project provides a strong foundation for understanding more advanced communication systems such as OFDM.

10. Future Scope

The project can be extended in the following ways:

- Implementation of OFDM using BPSK and QPSK modulation.
- Comparison with higher-order modulation schemes such as 16-QAM.
- Analysis over fading channels like Rayleigh and Rician channels.
- Inclusion of theoretical BER curves for comparison.

11. Tools Used

- MATLAB (Simulation and visualization)