

### *Experiment No. 4*

## **Bit error rate of Quadrature Phase Shift Keying (QPSK) (with and without Gray labelling) in Additive White Gaussian Noise (AWGN)**

Write a MATLAB program (without using communication toolbox inbuilt functions like 'comm.QPSKModulator') to perform QPSK Modulation and demodulation technique in AWGN.

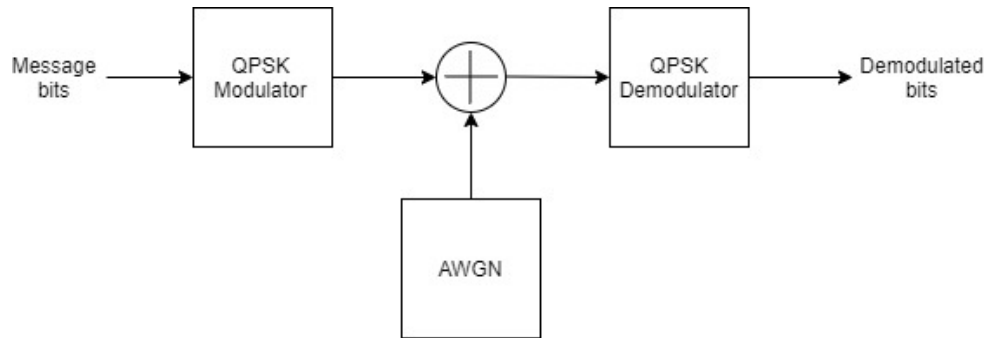


Figure 1: BPSK modulation block diagram

Generate random bits sequence and perform QPSK modulation. Add additive white gaussian noise (AWGN) with SNR varying in the range of -10 to +10 dB in steps of 1 dB. The generation of noise remains same as in BPSK experiment (Note that the noise has to be complex as QPSK modulated signals are complex in nature). Demodulate the received signal. Compare the demodulated bits and the message bits to obtain the error bits. Find out the error probability and plot Bit Error Rate (BER) vs. Signal to Noise Ratio (SNR) curve for simulated values in the following two cases:

- QPSK without Gray labelling (Figure 2a).
- QPSK with Gray labelling (Figure 2b).

Compare them with the plots obtained by plotting theoretical values computed using the equations based on Q-function.

## Gray labelling

Gray labelling is an ordering of symbols where there is a one bit difference between successive symbols while other labellings can have a difference of more than one bit between successive symbols as shown in the figure below.



Figure 2: Constellation diagram for QPSK a)Without gray labelling b)With gray labelling

(For your reference, an example code for 8PSK can be found in *Introduction to communication systems* by Upamanyu Madhow, page no.: 321, code fragment: 6.3.1)