



# **Indian Institute of Technology Goa**

## **Lab Report 7**

### **Monte Carlo Simulation for BPSK, QPSK and 8PSK**

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## Aim

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- To find the experimental Symbol Error Rate(SER) and Bit Error Rate(BER) by transmitting N symbols coded using BPSK, QPSK and 8PSK and comparing them with theoretical values for different values of Signal to Noise ratio(SNR).
- Comparing error probabilities obtained in the case of Gray coded symbols with error probabilities obtained without Gray code labelling.

## Theory

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- Average probability of symbol error can be computed as,

$$P_e = \sum_{i=0}^{N-1} \pi_i * P_{e/i}$$

$$SER = P_e$$

Where N is the number of symbols and  $\pi_i$  is the prior probability that symbol 'i' is transmitted.  $P_e$  is the average probability of symbol error.

- The probability of symbol error,  $P_e$  could be approximated using nearest neighbor approximation to:

$$P_e = N_{dmin} Q \left( \sqrt{\frac{d_{min}^2}{E_b} * \frac{E_b}{2N_o}} \right)$$

Where  $\frac{E_b}{N_o}$  is called the Signal to Noise Ratio, SNR.  $N_{dmin}$ , is the average number of symbols at minimum distance from each of the symbols.  $d_{min}$  is the minimum distance between symbols.

- The variance,  $\sigma^2$  of Gaussian Random variable can be found out using:

$$N_o = E_b/SNR$$

$$\sigma^2 = N_o/2$$

- Experimentally, noise is added to the transmitted signal using Gaussian Random vector generated by multiplying 'randn' function which chooses a random value sampled out of Gaussian random variable by  $\sigma$ .
- Experimentally

$$SER = N_{es}/N$$

$$BER = \frac{N_{eb}}{M * N}$$

Where  $N_{es}$  = no. of error symbols detected

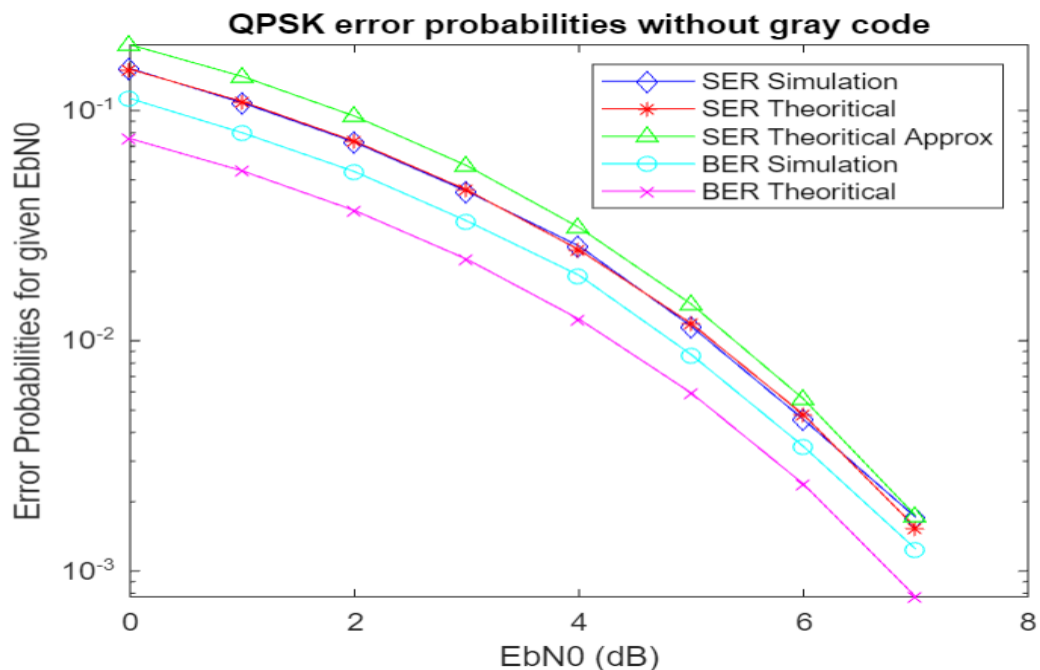
$N_{eb}$  = no. of error bits detected

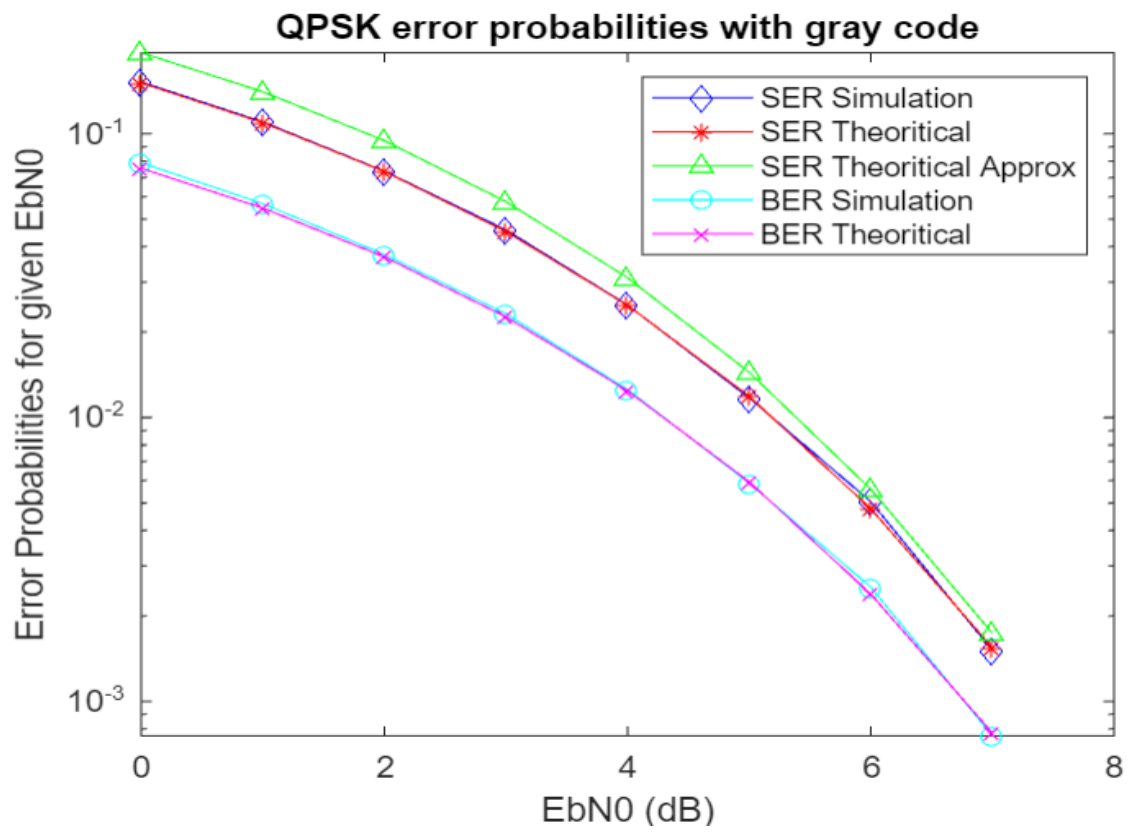
$M$  = no. of bits used to represent in respective PSK

$N$  = no. of symbols transmitted

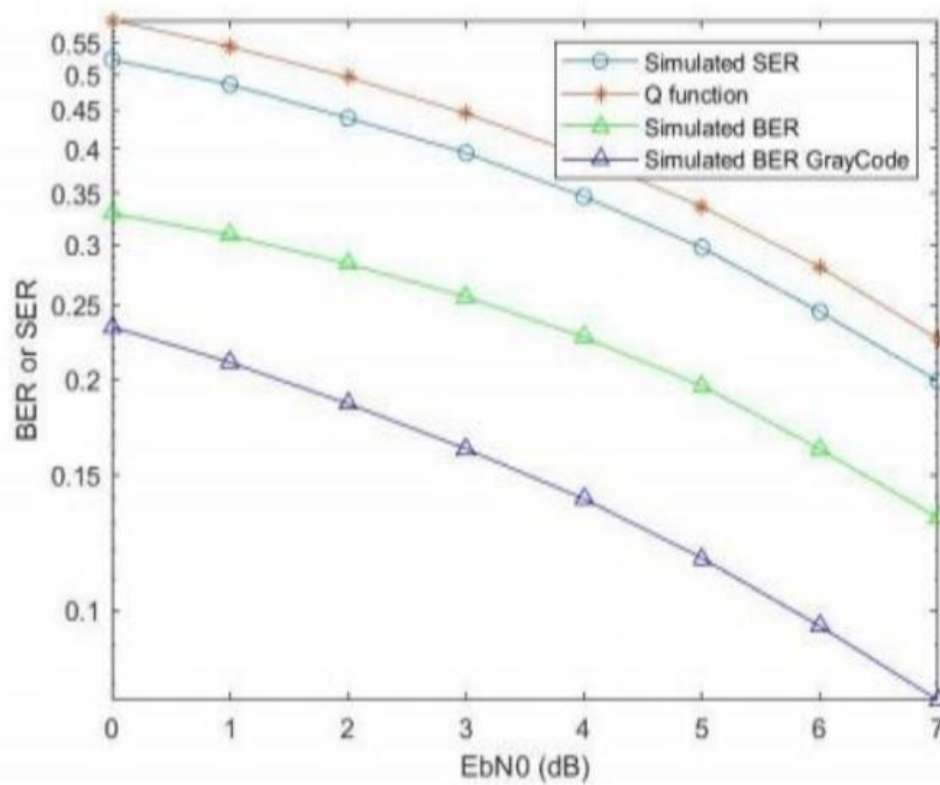
## CALCULATION and OBSERVATION

- QPSK





8 PSK output



## RESULT

As you can see in plots above that the BER of the system with gray coding is lower than that for the system with normal coding. Thus using gray code to indicate the signals reduces the BER for the system.