Communications Lab

Experiment 4

180030036

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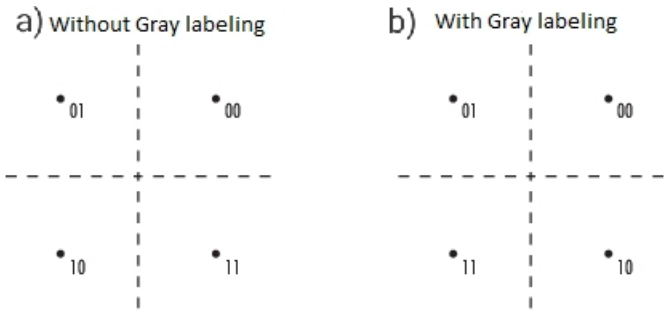
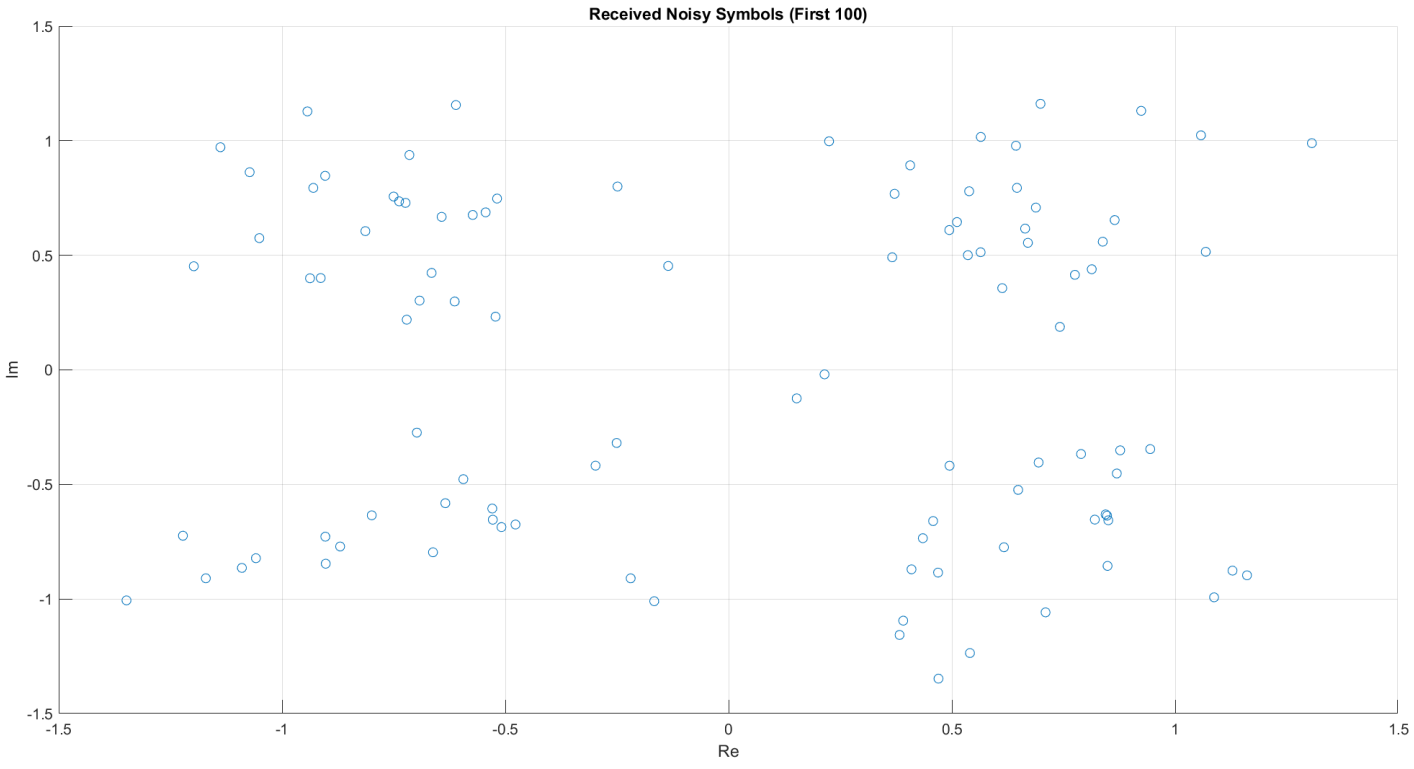
QPSK Communication: Running an example

We generate a signal of randomly generated bits and perform QPSK modulation. The modulation is done with Gray labelling and without Gray labelling:



(We choose the symbols so that the norm of each symbol vector is 1)

We then add white Gaussian noise (using an SNR = 5 dBW) to our signal and the resulting noisy signal (on z-plane) is as follows (first 100 symbols):



Then we perform demodulation based on distance boundaries (ML rule) between the symbols. We get the following bit error rates in the two cases:

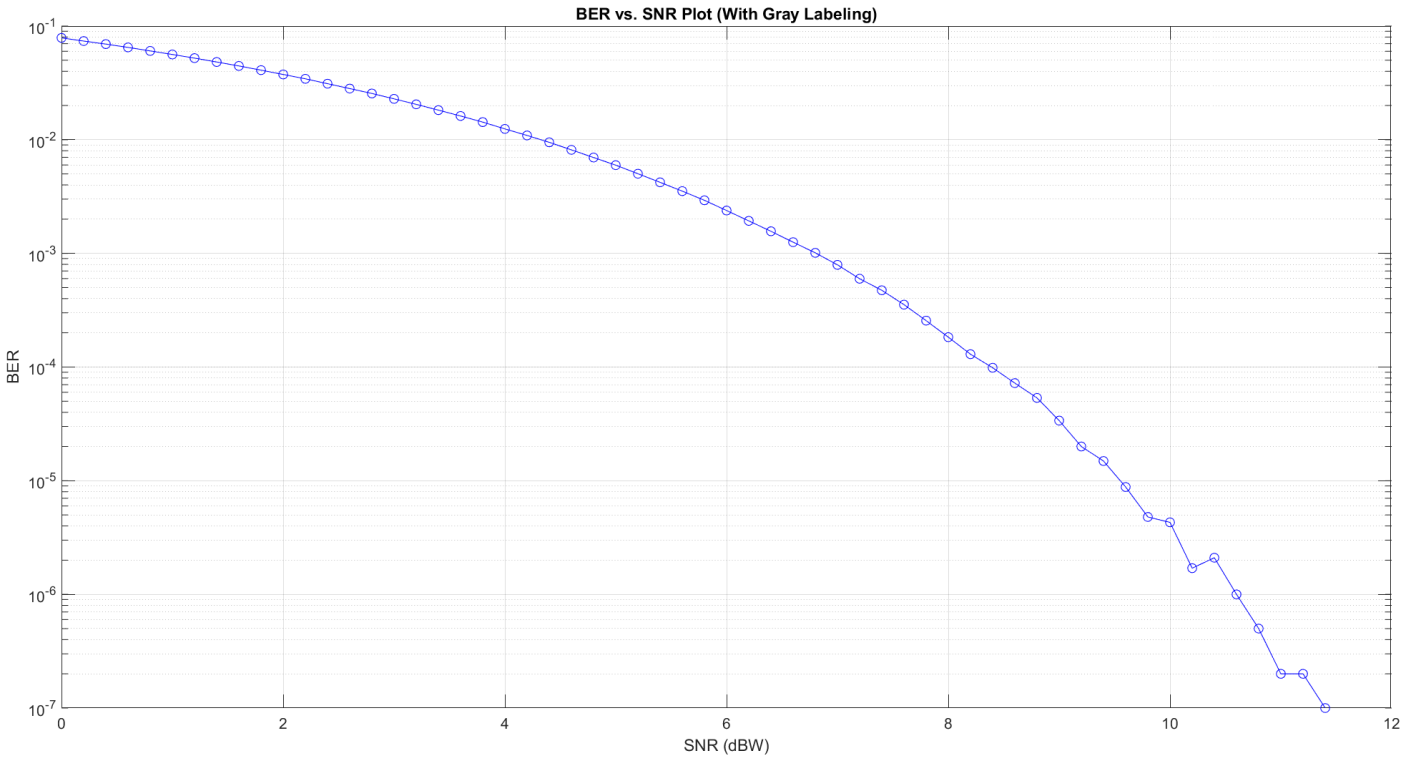
BER with Gray Labelling = 0.0069

BER without Gray Labelling = 0.0084

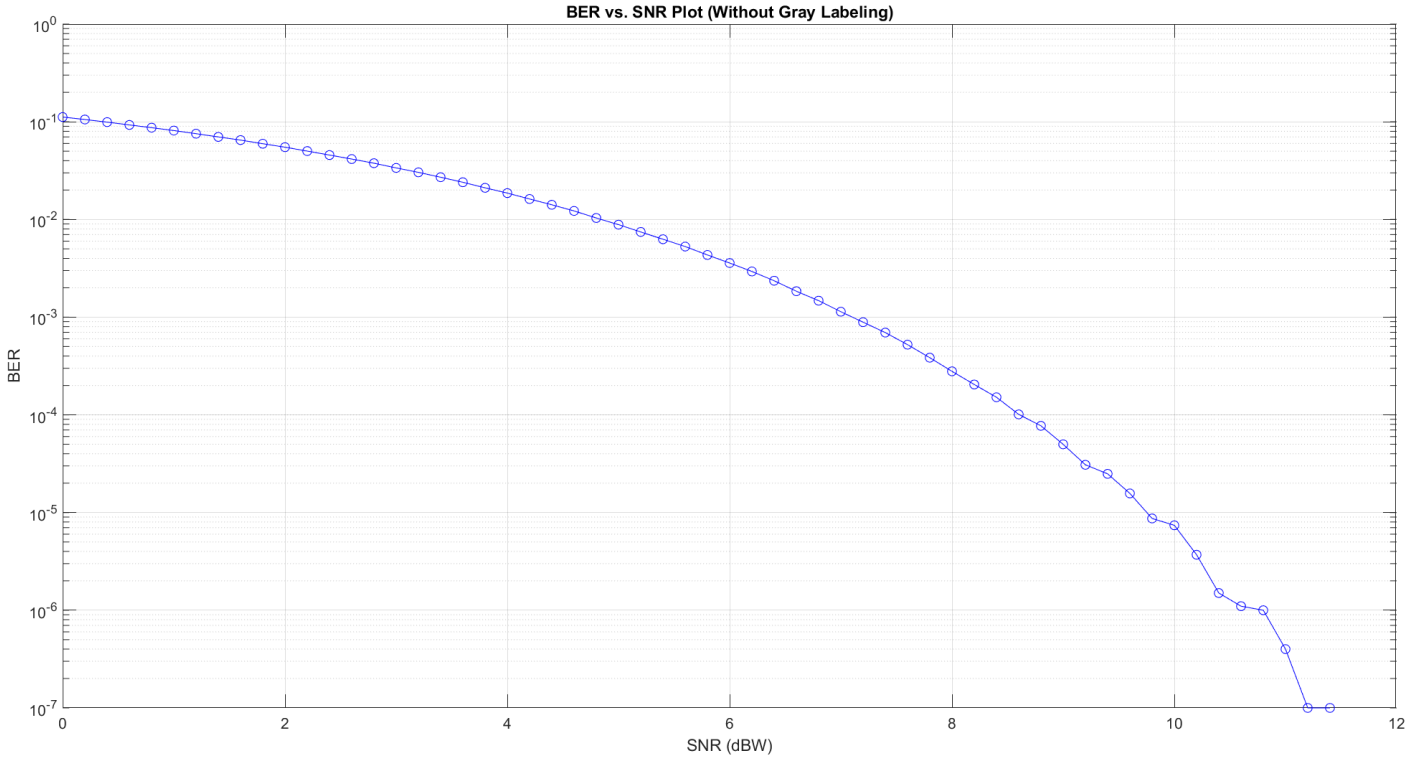
Bit Error Rate (BER) Calculation:

We run a randomly generated message signal of length 100000, for 100 iterations (we have a resolution of 10^-7) for each value of SNR from 0 to 15 dBW. The resulting bit error rate plots are as follows:

1. With Gray Labelling:



2. Without Gray Labelling:



Theoretical Calculation of Error Probability:

Theoretical value of error probability for our QPSK communication system in both Gray labelled and not Gray labelled cases is calculated as follows:

$$SNR = \frac{E_b}{N_o}, \quad \sigma^2 = \frac{N_o}{2}$$

Where σ^2 is the variance of the real and imaginary components of the AWGN.

We have, $E_b = 0.5$ for our choice of symbols. Therefore, standard deviation:

$$\sigma = \sqrt{\frac{1}{4SNR}}$$

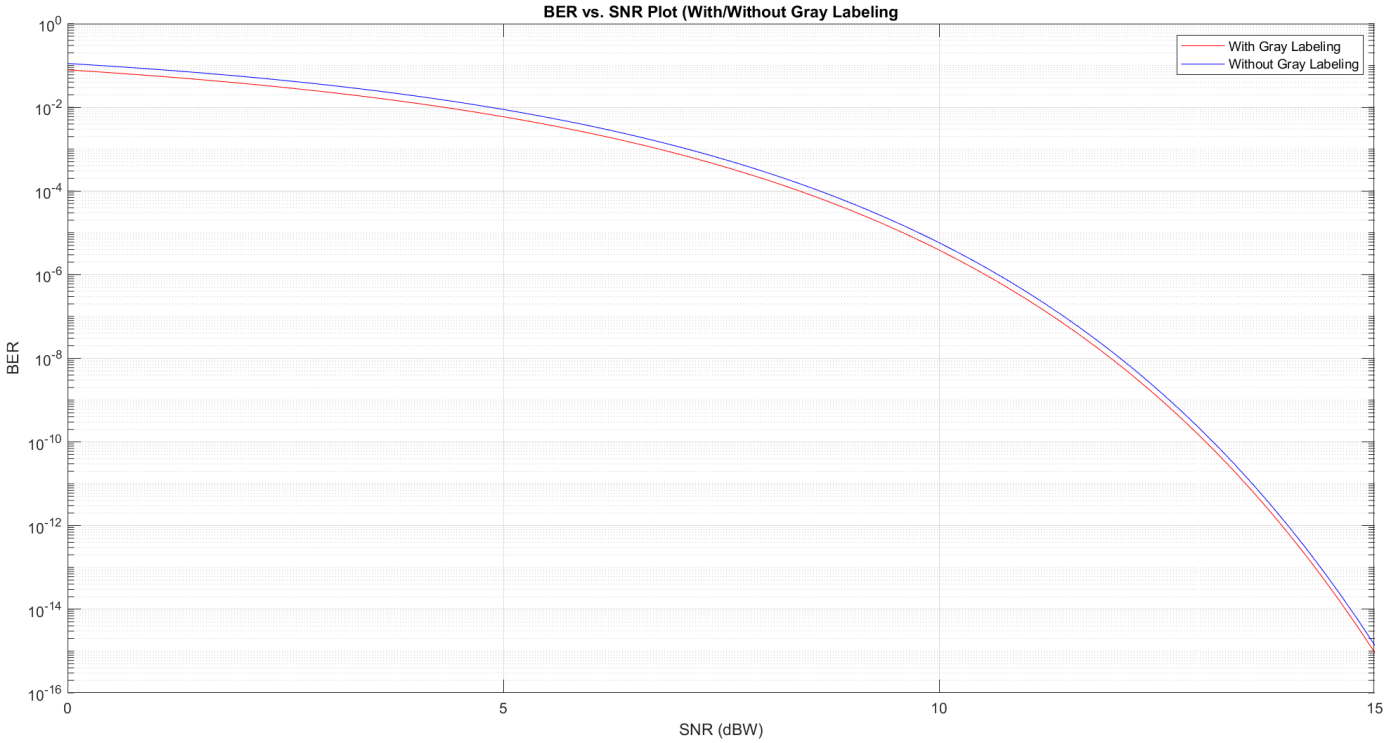
1. With Gray Labelling (entire derivation not shown):

$$P_e = Q\left(\frac{\sqrt{2}}{2\sigma}\right) = Q(\sqrt{2SNR})$$

2. Without Gray Labelling (entire derivation not shown):

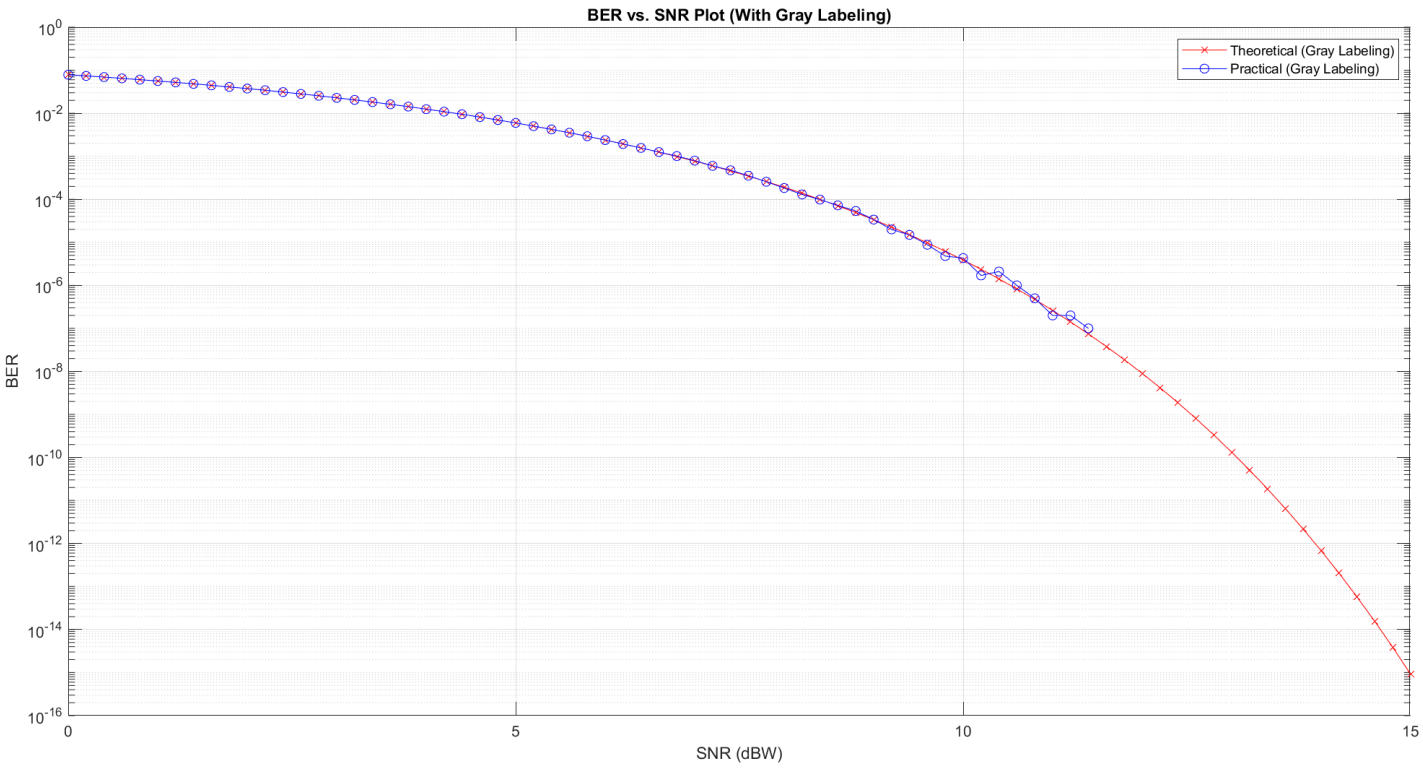
$$P_e = \frac{3}{2}Q\left(\sqrt{2SNR}\right) - Q\left(\sqrt{2SNR}\right)^2$$

The graph of theoretical BER vs. SNR for both cases is as follows:

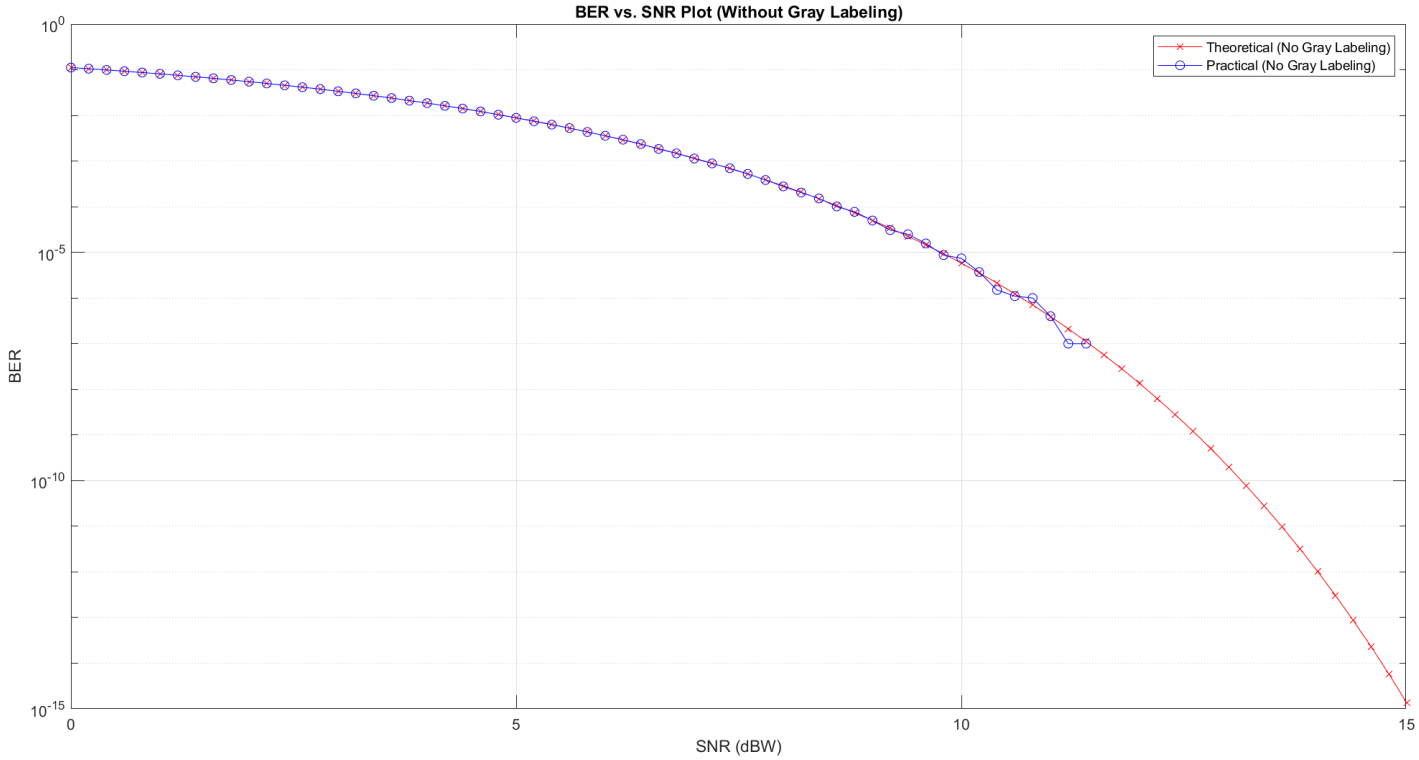


The experimental curves match really well with the theoretical curves as shown in the following plots:

1. With Gray Labelling:



2. Without Gray Labelling:



Both theoretical and both experimental curves are plotted together for comparison: