EE477 HW-2
Eror Performances with Monte Carlo Simulations

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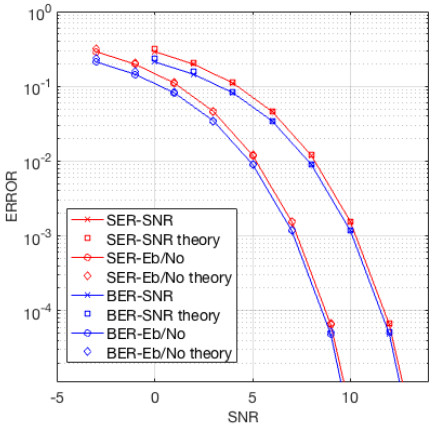
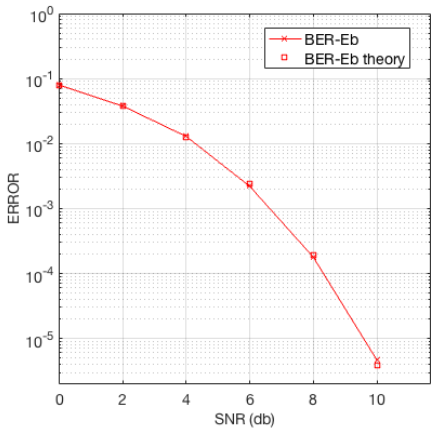
Question-1



QPSK SNR-error

Law of large numbers theorem says that when we perform same experiment large number of times, the results converge the expected value. So if we increase ferlim or max-nframe, result of experiment will converge to theoretical probability. Similarly, decreasing these parameters implies worse results. Because $E_b = \frac{E_s}{m}$ and m=2 in QPSK case, $10\log_{10}\frac{E_s}{2} = 10\log_{10}E_s - 3$ so it shifts approximately 3db to left. On the other hand, the number of bit errors are grater than the number of symbol error. In contrast, the probability of bit error is smaller than the probability of symbol error. The simulation results are almost same with theory. Because i add theoretical formulation on matlab, i do not give formulation here.

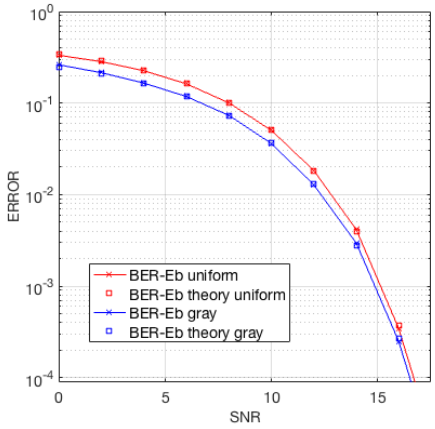
Question-2



BPSK SNR-error

The simulation results are almost same with theory. The bit error probability for BPSK is smaller than the bit error probability for QPSK. It can be easily seen from constellation diagram. Complex noise does not effect on BPSK,because two symbol are on the real axis. However, complex noise can implies symbol error, because two of symbols are on the complex axis. When i say complex axis, i mean the sinusoidal axis. So BPSK is better than QPSK for bit error probability.

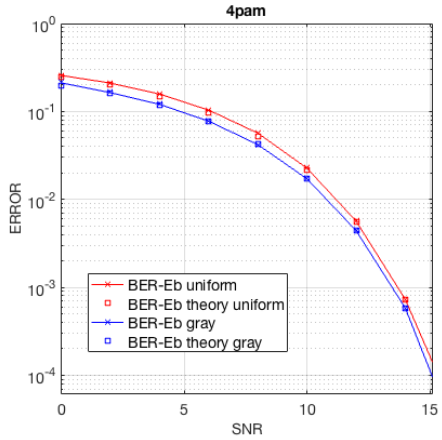
Question-3



8-PSK SNR-error

When we employ gray mapping to constellation diagram, we get better result, the bit error probability decreases. Because gray mapping implies that, any two neighbor symbol has only one different bit. In contrast to gray mapping, uniform mapping is bad design strategy, because two neighnor symbol can have more than two different bits. For example, 000 and 111 are two different symbol and the number of diferent bits is 3. In gray mapping it was 1.

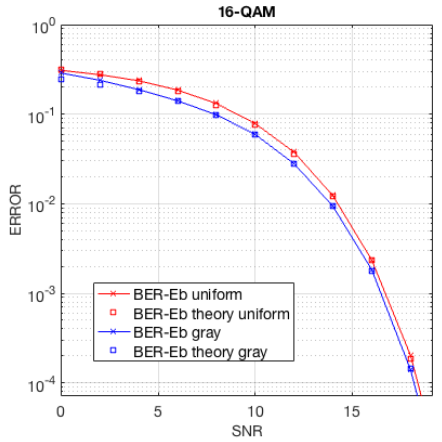
Question-4



4-PAM SNR-error

Like question 3, gray mapping implies better result, because in gray mapping any two neighbor symbol has only one bit differences. Lets look the cases: Between 00 and 01, there is one difference. Between 01 and 10 there is 2 bits difference. At gray mapping, between 00-01, there is 1 bit difference. Between 01-11, there is again 1 bits difference.

Question-5



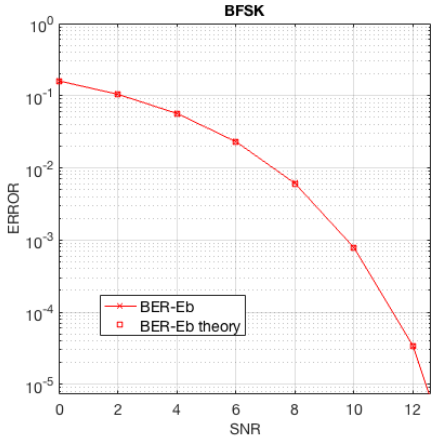
16-QAM SNR-error

$$E_{average} = \frac{(\Delta)^2(M^2-1)E_g}{6} + \frac{(\Delta)^2(N^2-1)E_g}{6}$$

In order to set average energy to the unity=1/2, the Δ should be equal to $sqrt(2/5)$. My matlab code has more detail information about this.

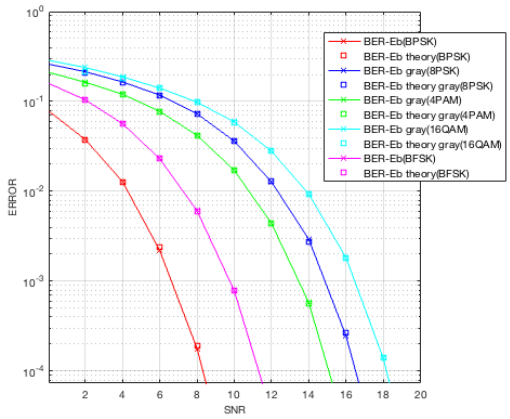
There is also difference for uniform and gray mapping. Gray mapping gives better results. The reason is explained before and for this case, this explanation is also valid.

Question-6



BFSK SNR-error

Question-7



All Modulations SNR-error graph

I put to the curve all modulations error performance that are already obtained from the questions 2-6 according to their gray mapping cases. BPSK is the best modulation. 16-QAM is the worst modulation about bit error. To give them in sequence according to their performance is:

$$BPSK > BFSK > 4 - PAM > 8 - PSK > 16 - QAM$$