Lab6 Report

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1 Problem1

Randomly generate 3 test cases, and the results are listed in following:

- Test data: 110110011101101, M = 8, d = 2, module = PAM
  Result: 1.00 1.00 -3.00 5.00 5.00
- Test data: 0011110111, M = 4, d = 3, module = PSK
  Result: (-1.50, 1.50) (1.50, -1.50) (1.50, -1.50) (-1.50, -1.50) (1.50, -1.50)
- Test data: 11010100001101000110, M = 16, d = 4, module = QAM
  Result: (2.00, -2.00) (-2.00, -6.00) (-6.00, 2.00) (-2.00, -6.00) (-2.00, 6.00)

2 Problem2

2.1 Plot the three 2-D histogram of $\{r_i\}$ for E_b/N_0 = 0, 10, and 20dB.

The red lines indicate the decision regions. From Fig.1, for $\{b_i\}$ is randomly generated, $\{u_i\}$ is scattered at (0.5, 0.5), (0.5, -0.5), (-0.5, -0.5), and (-0.5, 0.5). After we add some noises, we can get Fig.2, Fig.3, and Fig.4 for SNR = 0dB, 10dB, and 20dB, respectively. And we can see that $\{r_i\}$ becomes closer to $\{u_i\}$ as SNR increases.

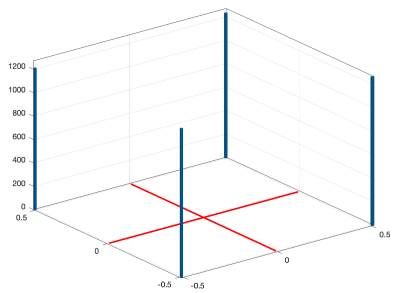

Figure 1: Histogram of $\{u_i\}$

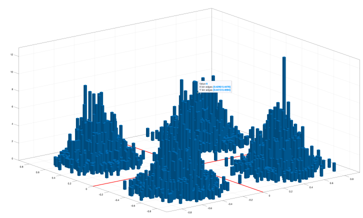

Figure 2: Histogram of $\{r_i\}$ with 0dB

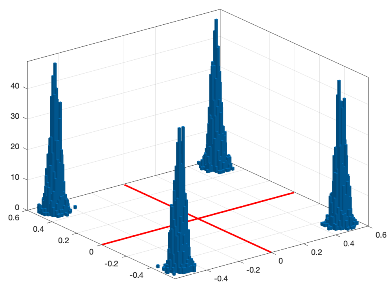

Figure 3: Histogram of $\{r_i\}$ with 10dB

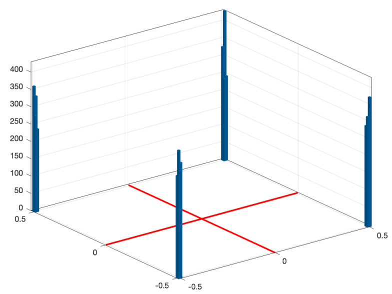

Figure 4: Histogram of $\{r_i\}$ with 20dB

2.2 Compute simulated SER from the received symbol sequence $\{r_i\}_i$ in Problem 2a

From Table 1, we can directly decode $\{u_i\}$ to get the correct result, and so as the setting of SNR=10dB and 20dB. However, for the setting of SNR=0dB, it exists 4.3% SER because of the larger noise. The results is corresponding to the figures in Problem 2a.

Test Case	SER
$\{u_i\}$	0
$\{r_i\}$ with 0dB	0.0002
$\{r_i\}$ with 10dB	0
$\{r_i\}$ with 20dB	0

Table 1: SER for the received symbol sequences

3 Problem3

3.1 Simulate the SER with different SNRs E_b/N_0 for PAM, M=2,4,8,16

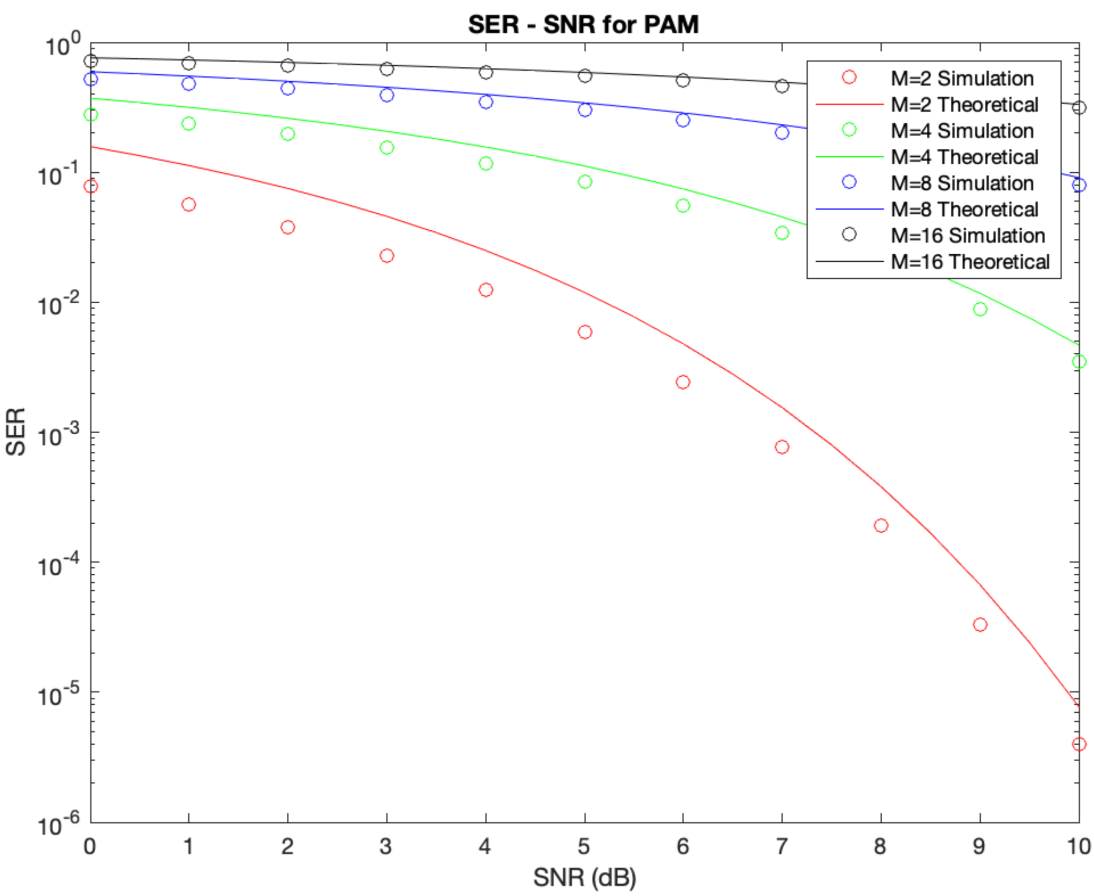

Figure 5: SER - SNRs for PAM

3.2 Simulate the SER with different SNRs E_b/N_0 for PSK, M=2,4,8,16

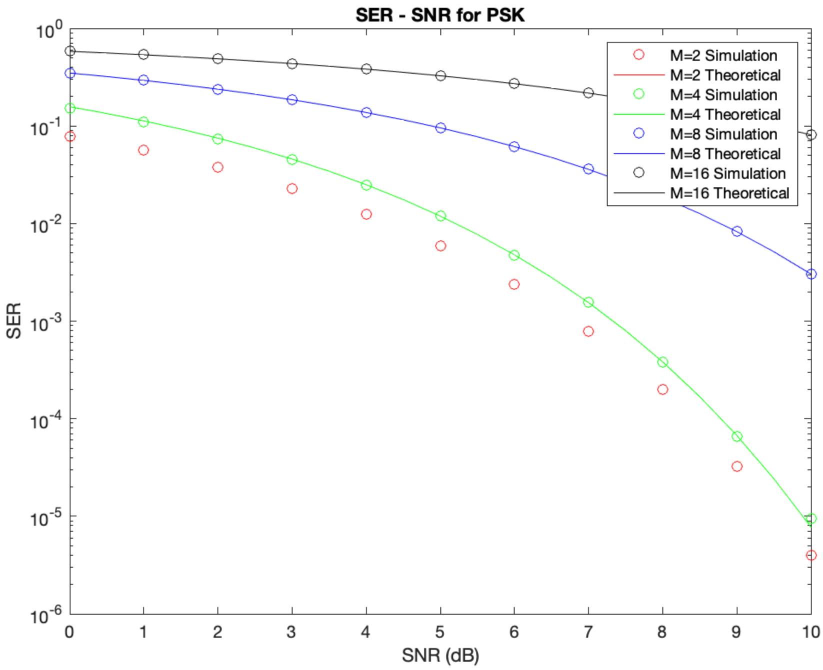

Figure 6: SER - SNRs for PSK

3.3 Simulate the SER with different SNRs E_b/N_0 for QAM, M=4,16,64

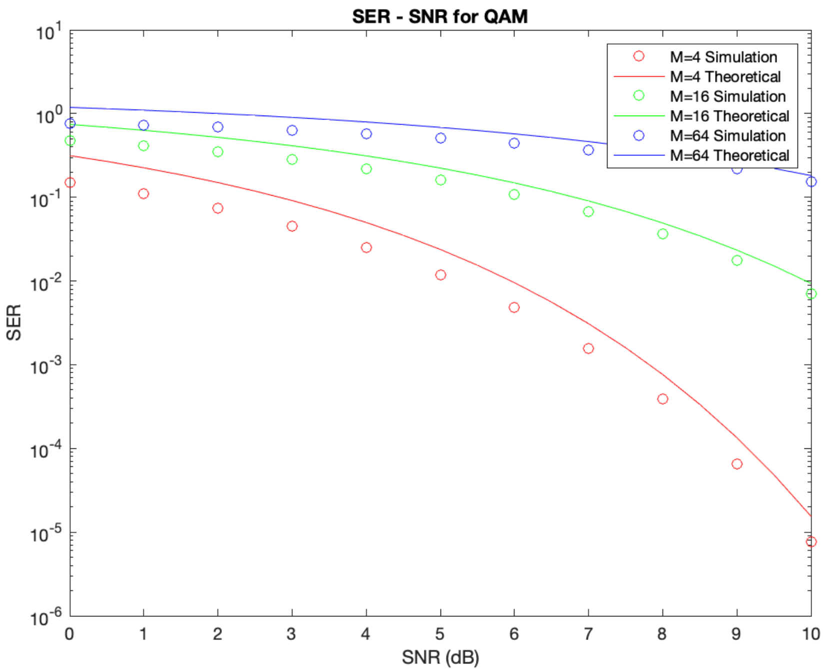

Figure 7: SER - SNRs for QAM

3.4 Comments

From Fig.5, Fig.6, and Fig.7, we can tell that the experimental values of SER are all smaller than the theoretical values, only those in Fig.6 are equal when M=4, 8, 16. On the other hand, with the same setting of M, the SER of PAM is the highest, follow by PSK, and QAM is the lowest. Note that when M = 2, the values of SER of PAM are nearly equal to those of PSK, for the gray-code mapping of these two settings is the same. This can also be observed between PSK and QAM when M =4. In conclusion, as M increases, SER will increase, and it needs larger SNR to maintain the same SER, which is corresponding to the formulas.

4 Problem4

4.1 Plot the BER curves with different SNRs all together on one figure.

Hard decoding is the red line in Fig.8, and we can see that when SNR=5dB, BER is lower than 10^{-5}, so I sample points from 0dB to 5dB, and the interval is 0.5dB.

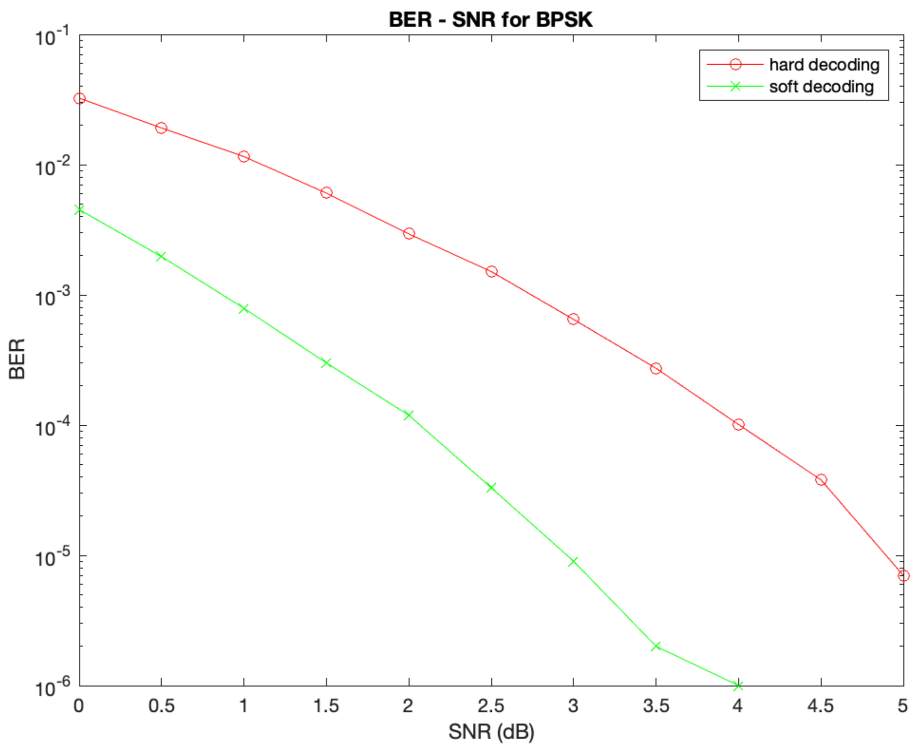

Figure 8: Relationship between BER and SER

4.2 Simulate the performance for the soft decoding as you did in Problem 4a, and compare its performance to that of the hard decision decoding

Soft decoding is the green line in Fig.8. Comparing to the red line, which represents the hard decoding, we can derive that using soft decoding helps to lower BER significantly, and the performance is more obvious when SNR gets larger.