

# Lab 6 Report

## Digital Modulation

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Q1.

Please check the file

[https://github.com/yuanchiachang/CommLab/blob/main/Lab6/src/symbol\\_mapper.m](https://github.com/yuanchiachang/CommLab/blob/main/Lab6/src/symbol_mapper.m)

```
sym_seq = symbol_mapper(bin_seq, M, d, name);
```

bin\_seq: the binary sequence we want to symbol mapping

M: the size of every symbol

d: the minimum distance among the constellation points

name: the name of modulations

For example, if the input is a 30-bit binary sequence

```
1 0 0 0 0 1 1 0 1 0 0 0 1 1 0 0 0 1 1 1 0 1 1 0 0 0 1 0 1 0
```

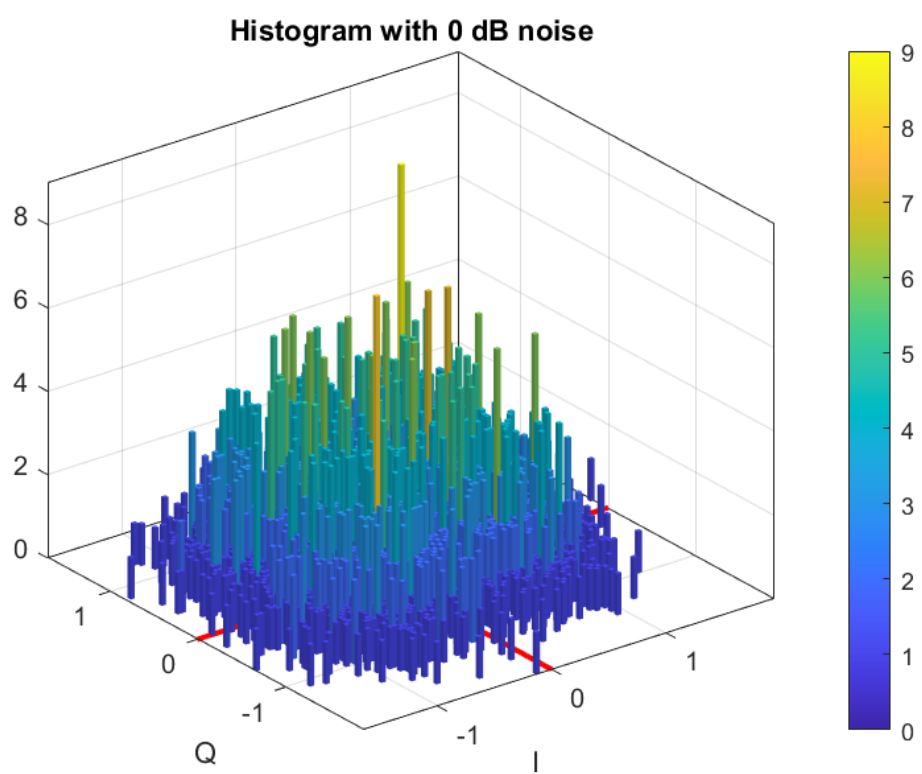
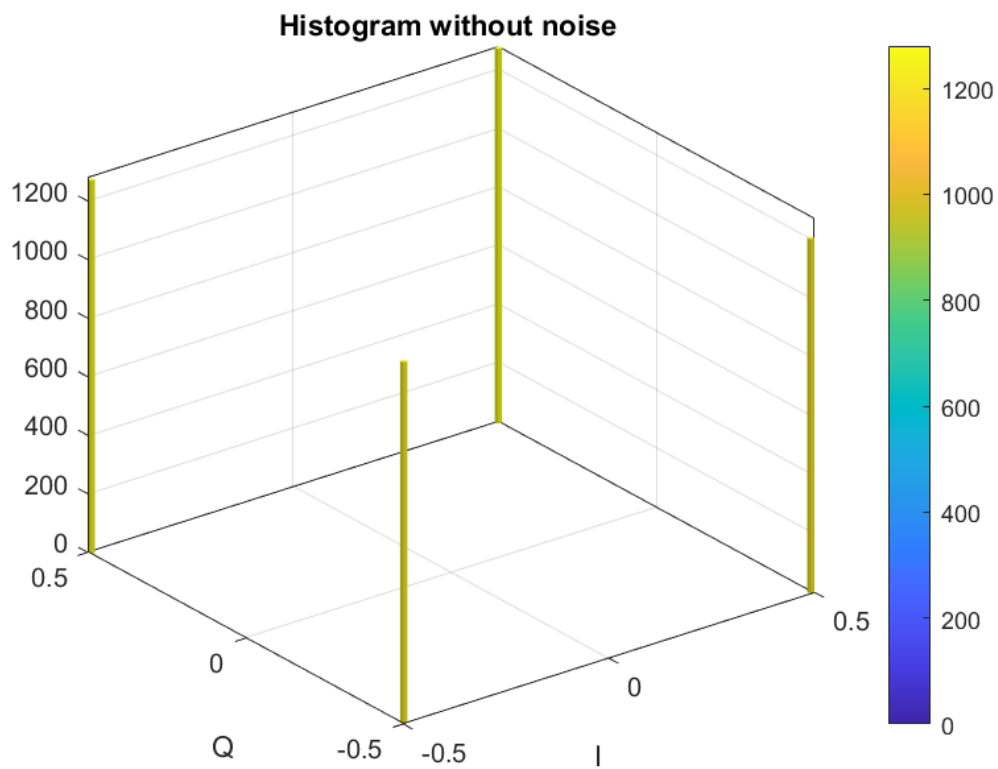
Then the output will be an array with 15 complex numbers

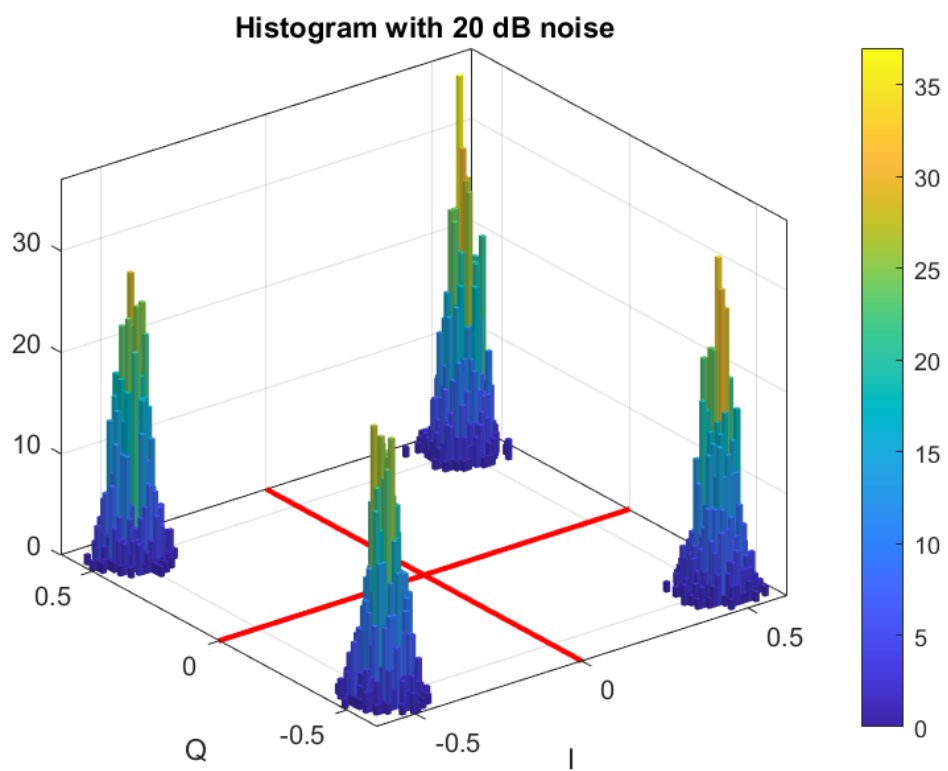
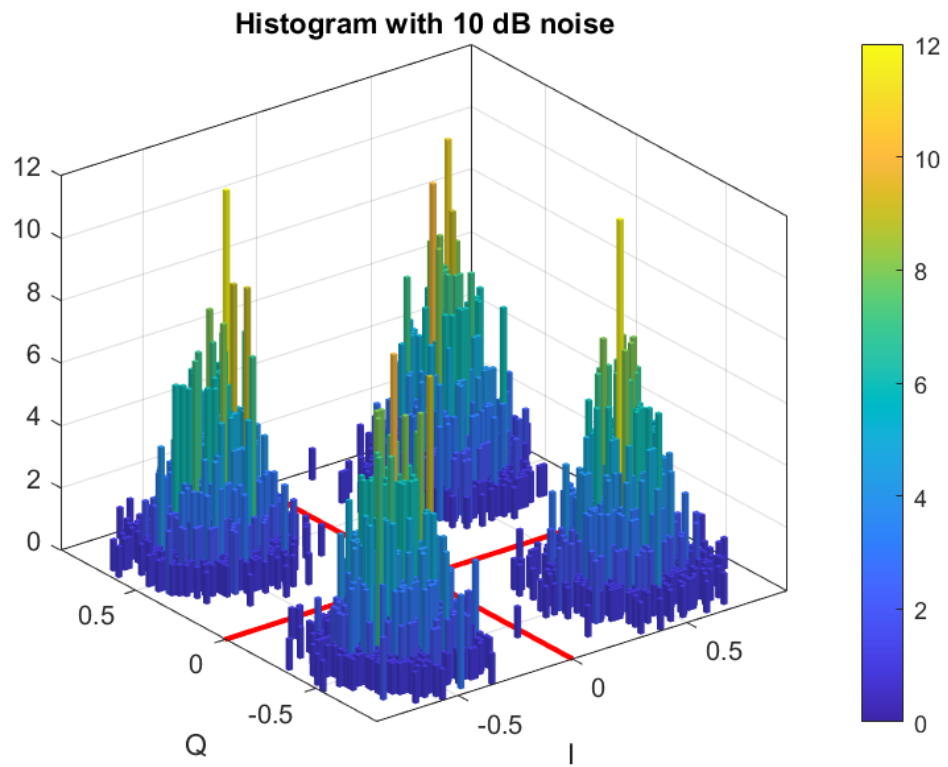
```
Columns 1 through 9
-0.0000 - 1.4142i  1.4142 + 0.0000i  0.0000 + 1.4142i -0.0000 - 1.4142i -0.0000 - 1.4142i  1.4142 + 0.0000i -1.4142 + 0.0000i  1.4142 + 0.0000i  0.0000 + 1.4142i

Columns 10 through 15
-1.4142 + 0.0000i  0.0000 + 1.4142i -0.0000 - 1.4142i  1.4142 + 0.0000i -0.0000 - 1.4142i -0.0000 - 1.4142i
```

Q2

(a)





(b)

Please check the file

[https://github.com/yuanchiachang/CommLab/blob/main/Lab6/src/symbol\\_demapper.m](https://github.com/yuanchiachang/CommLab/blob/main/Lab6/src/symbol_demapper.m)

In Q2(a)

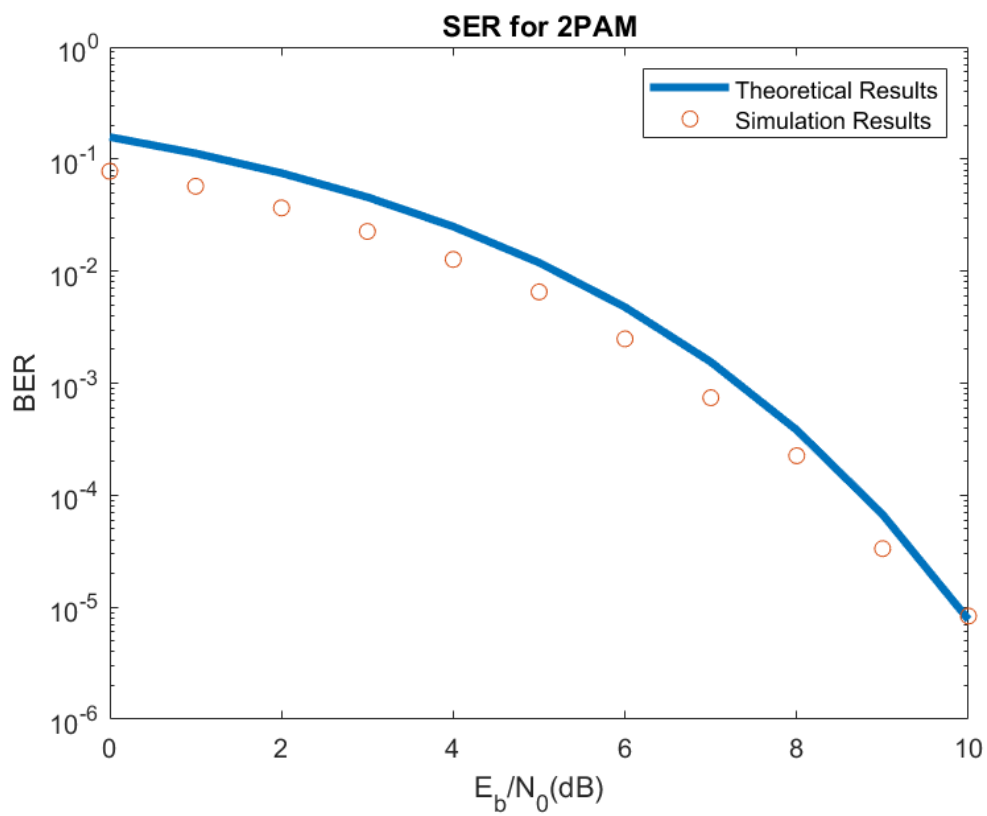
$$\frac{E_b}{N_0} = 0dB \quad \text{SER:0.1446}$$

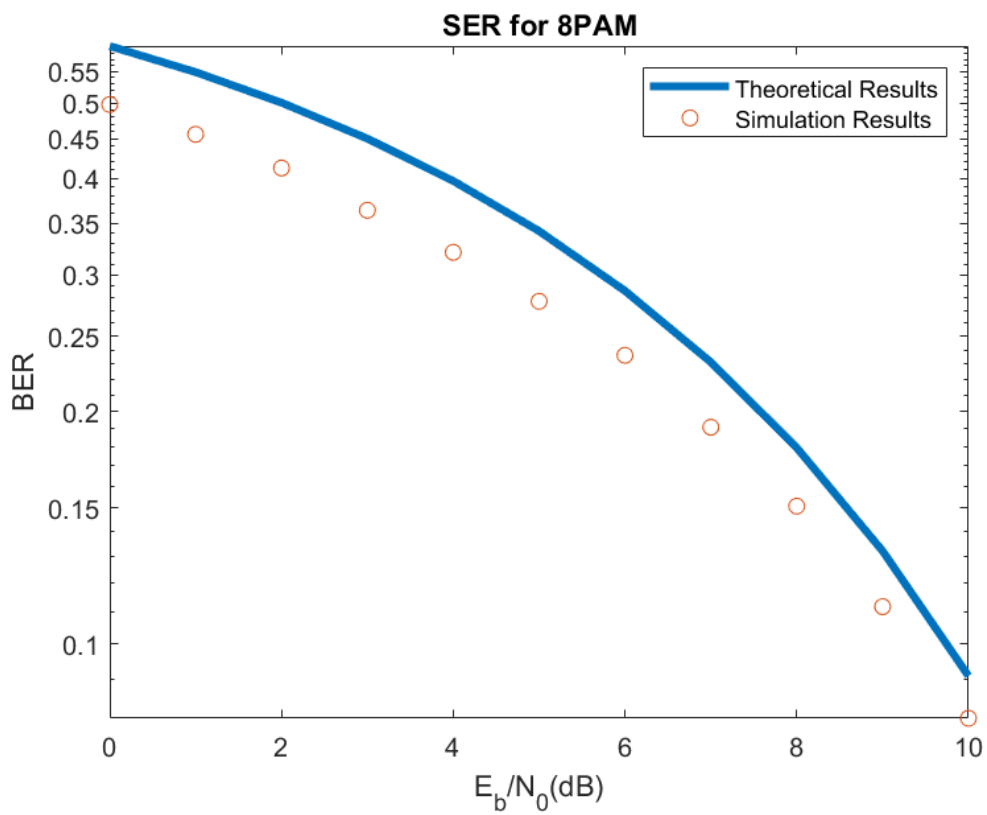
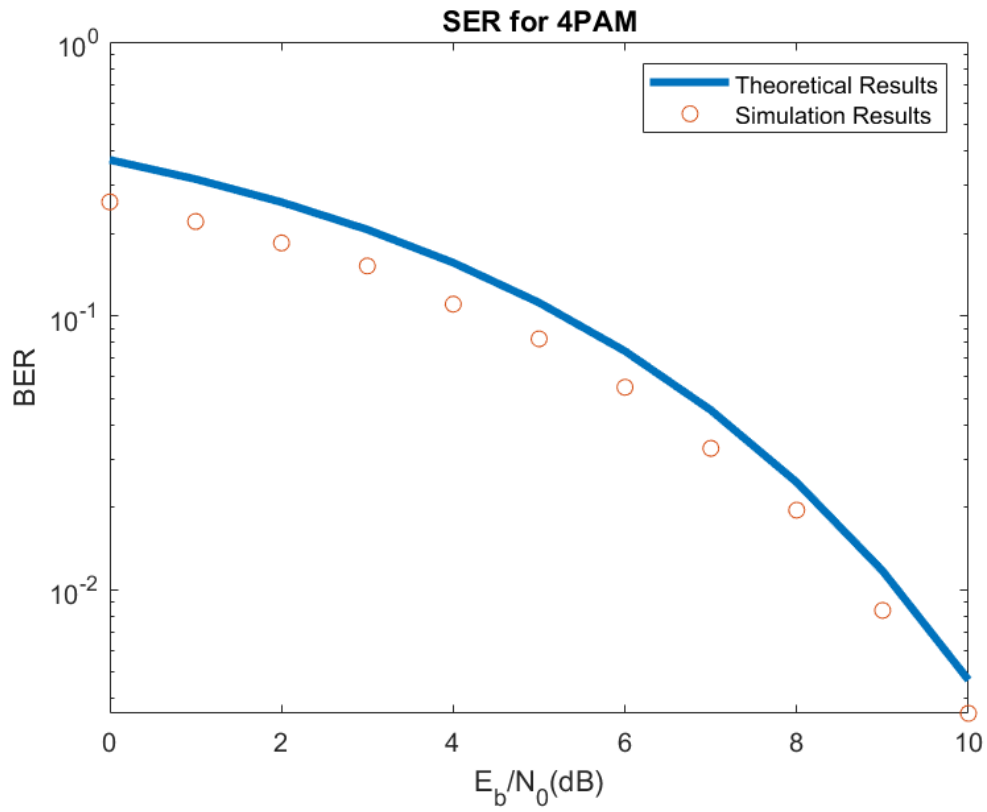
$$\frac{E_b}{N_0} = 10dB \quad \text{SER:0 (due to the lack of bits)}$$

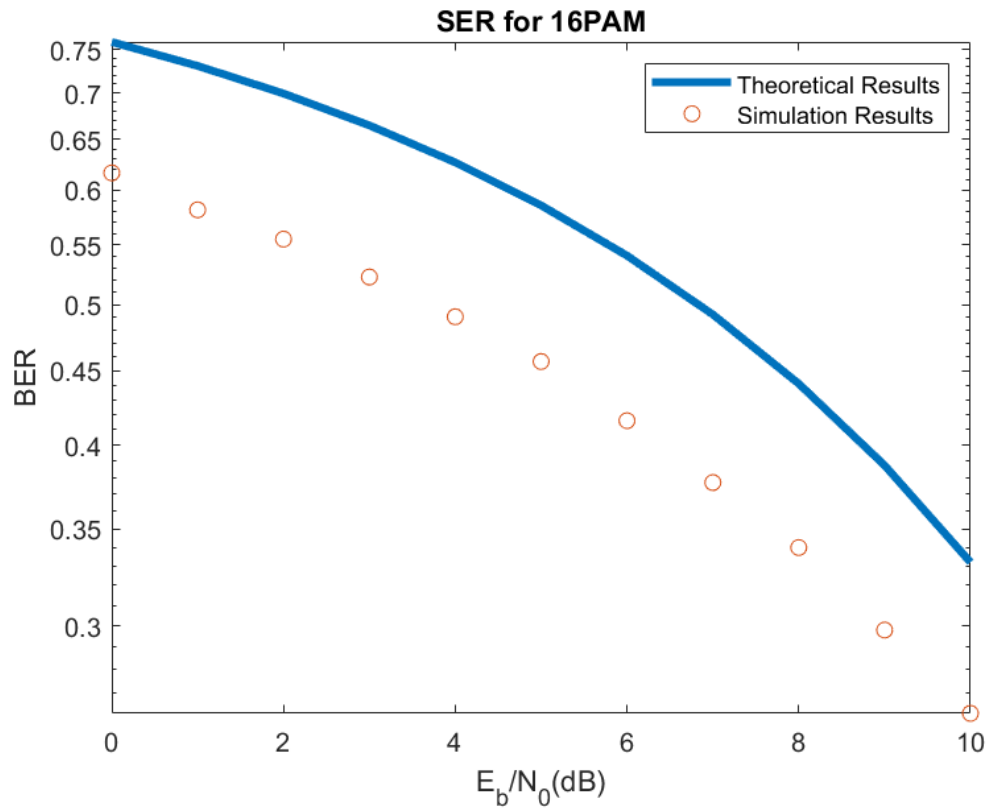
$$\frac{E_b}{N_0} = 20dB \quad \text{SER:0 (due to the lack of bits)}$$

Q3

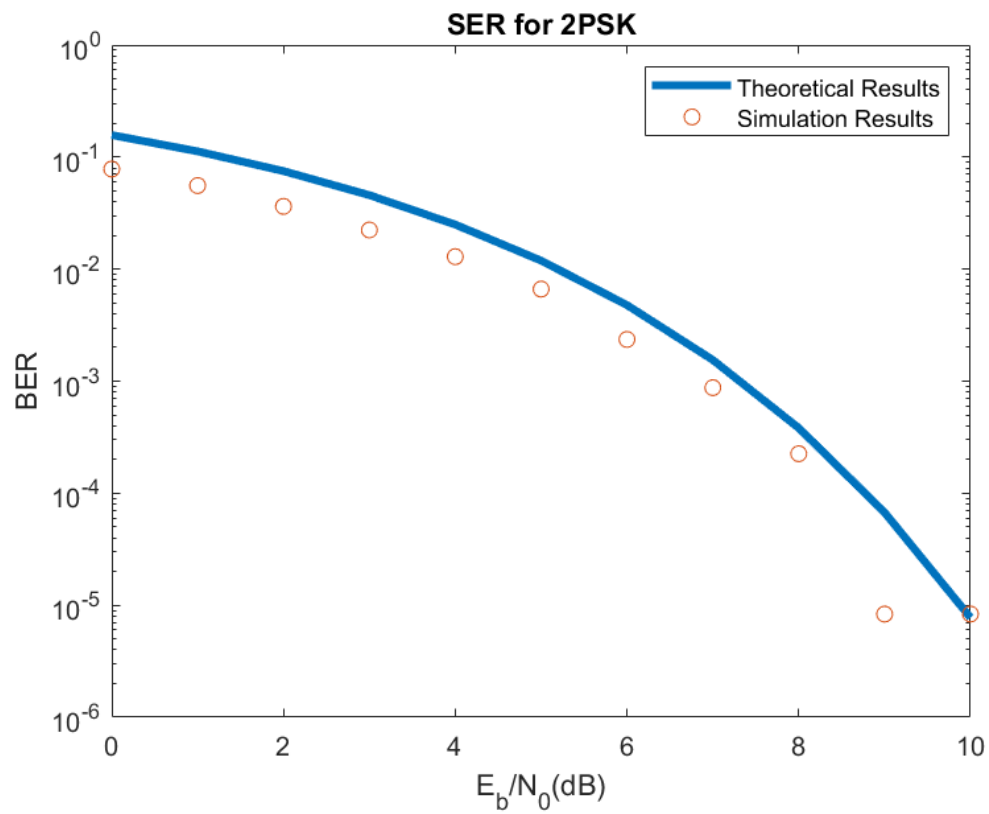
(a)

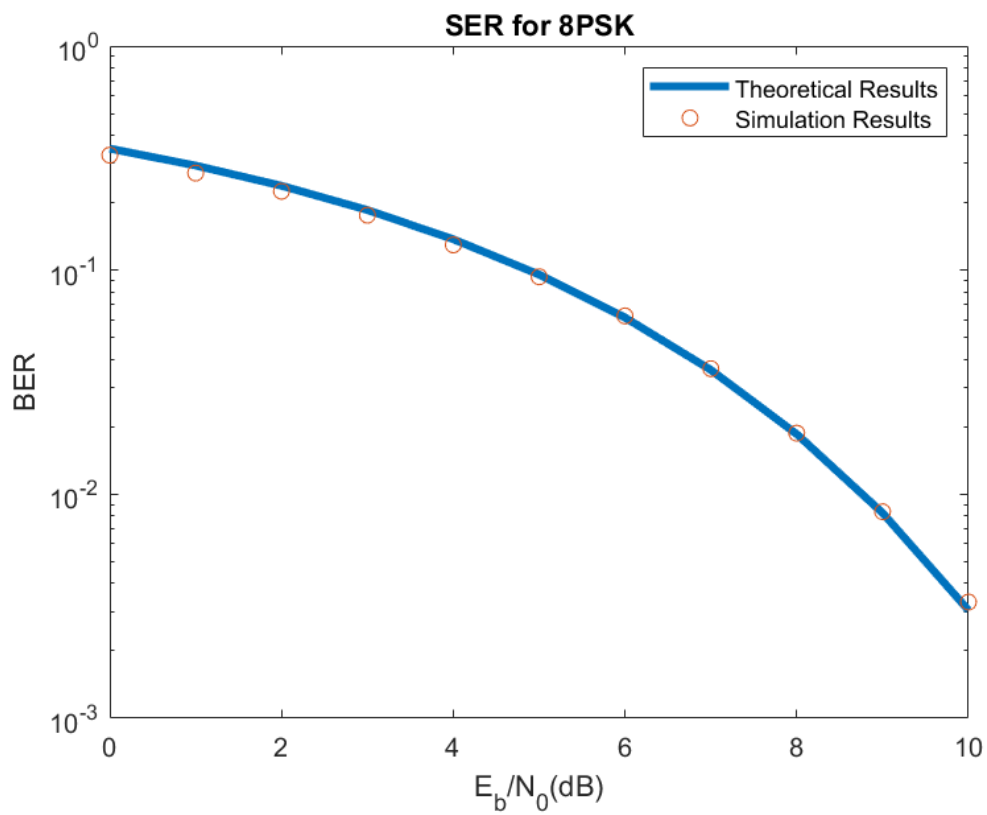
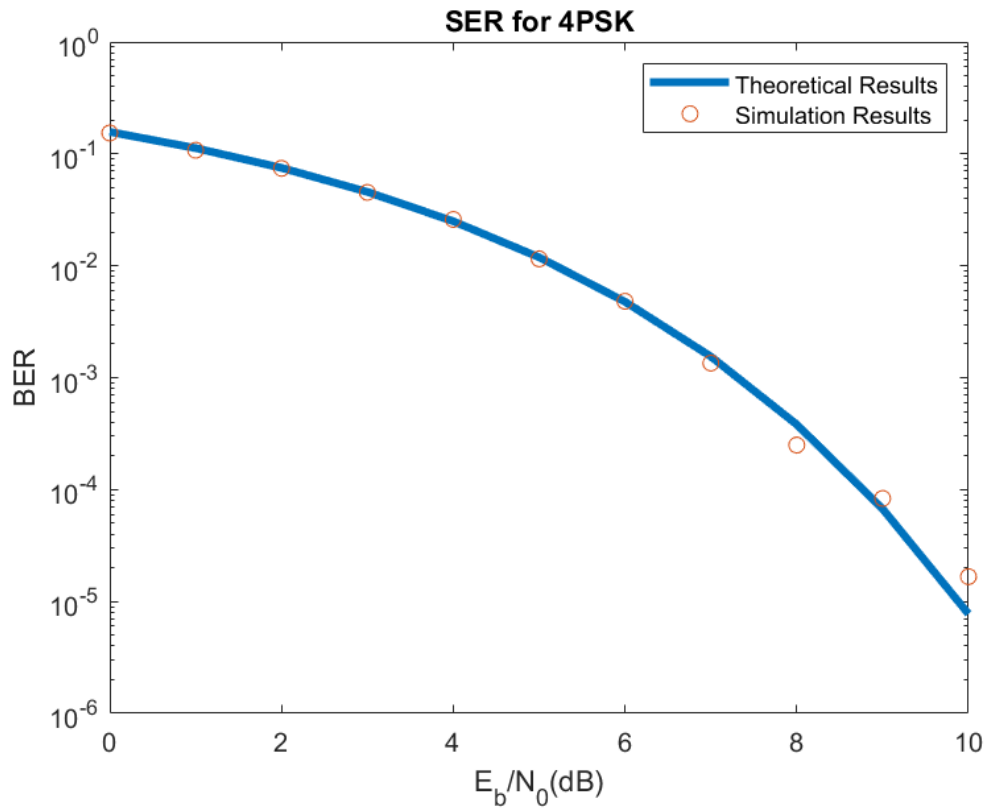


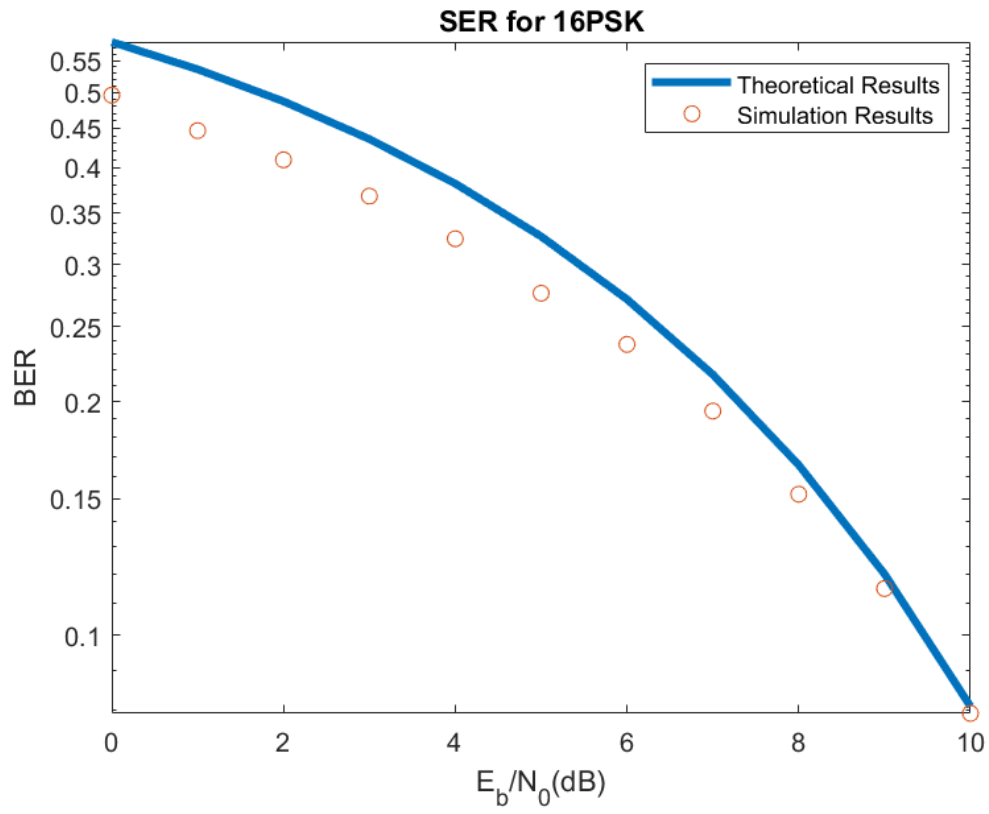




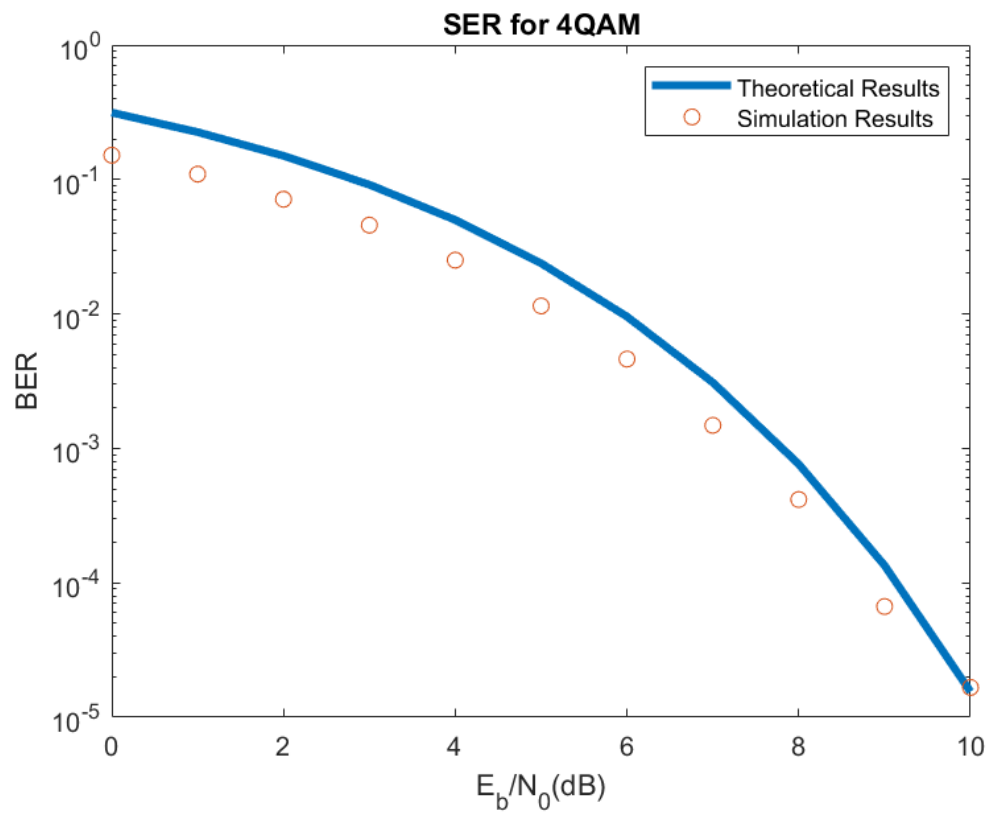
(b)



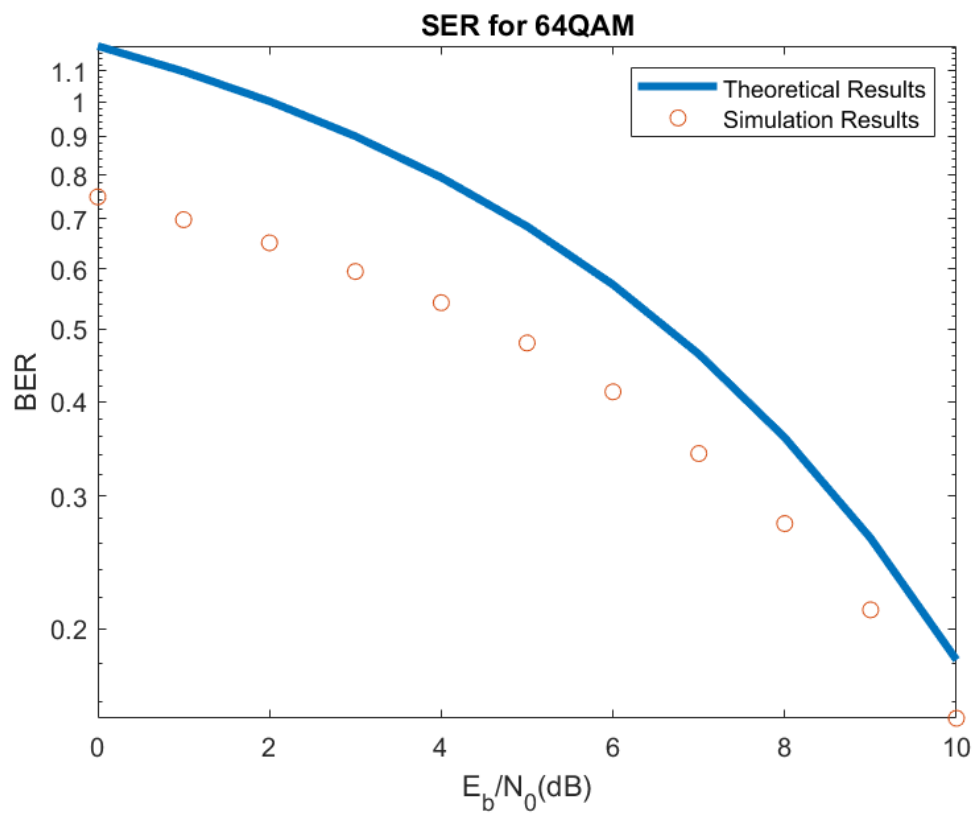
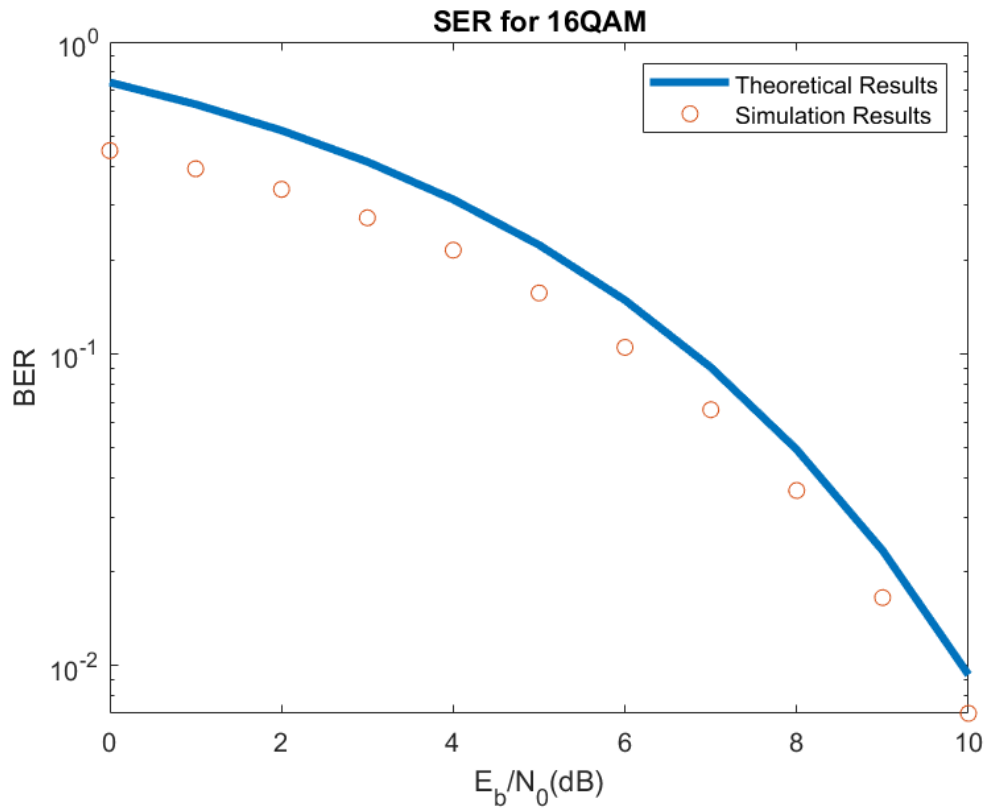




(c)





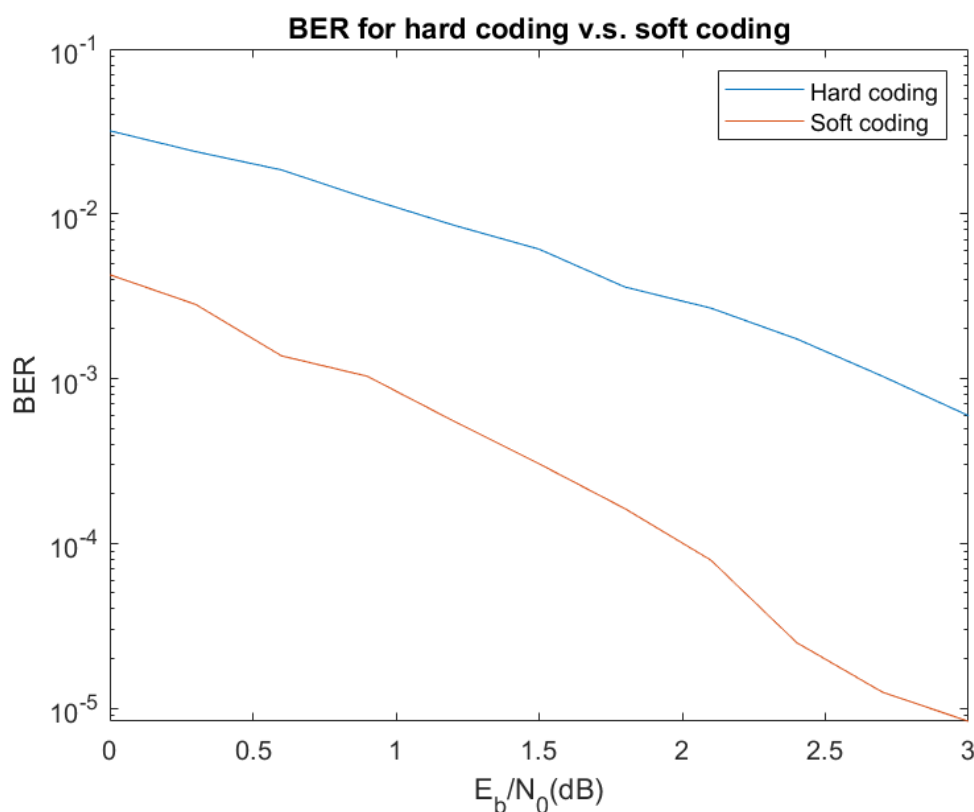


(d)

1. Almost Every simulation result has lower error probability than the theoretical upper bound, which supports the correction of the code.
2. larger dB, smaller M will lead to smaller SER. Specifically, for 10dB, M=2, name="PSK" or "PAM", and for 10dB, M=4, name="QAM", the SER is approximately  $10^{-5}$
3. Larger M will lead to fewer running time. The reason is that for the same length of input sequence, larger M make the length of symbol sequence smaller.
4. the simulation result of 4-PSK and 8-PSK is closest to the theoretical upper bound. For 4-PSK 9dB and 10dB, the simulation result is even higher than the theoretical upper bound due to the small SER and the lack of the error bit, which leads to the statistical error.

Q4

(a)(b)



This figure shows that the performance of soft coding is better than hard coding. BER of soft coding is approximately 1% to 10% of BER of hard coding.

## Appendix

#### Code

<https://github.com/yuanchiachang/CommLab/blob/main/Lab6/src>

#### Reference

<https://openhome.cc/Gossip/AlgorithmGossip/GrayCode.htm#Java>