Communication System

Lab 1: Modulation and Demodulation

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1. Comparison between Natural Code and Gray Code using 16-QAM Modulation

Figure 1 is the BER-SNR (E_b/N_0) graph for Natural Code and Gray Code using 16-QAM modulation:

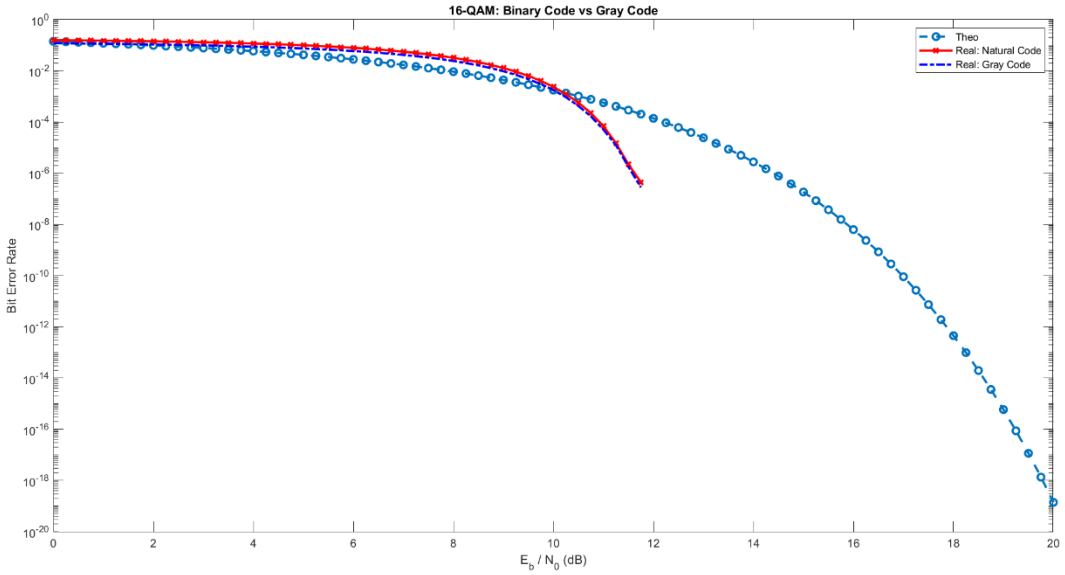

Figure 1. 16-QAM: Natural Code vs Gray Code

We can observe that the BER of simulated transmission of signals is higher than the theoretical value, which is reasonable for there are more uncertainties in real scenario.

Here, the SNR range such that the BER ranges from 10^{-1} to 10^{-7} (reaching a BER of 10^{-9} is takes too much memory and time) is 0 ~ 12 dB. For E_b/N_0 greater than 12 dB, due to the limitations of the number of symbols, we cannot obtain meaningful BER.

From Figure 1, we can see that Gray Code has a slightly better performance. This is because we only change one bit for adjacent symbols. By considering the AWGN channel, if a symbol is erroneous, then the received symbol differs from the original transmitted symbol for one bit for the most of time.

2. Comparison of BPSK, QPSK and 8-PSK using Gray Code

Figure 2 is the BER-SNR (E_b/N_0) graph for BPSK, QPSK and 8-PSK using Gray Code:

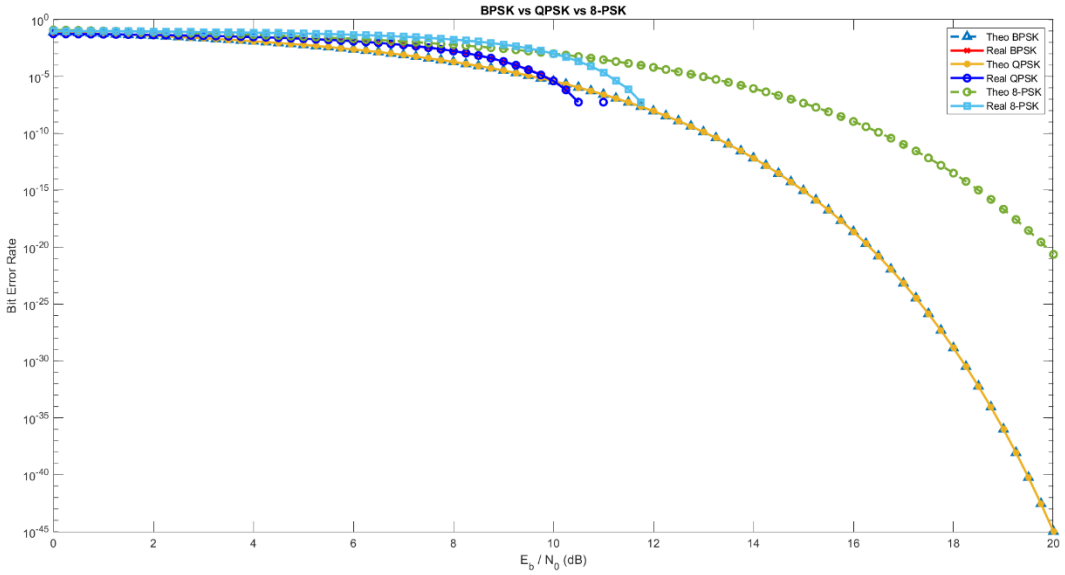

Figure 2. BER of BPSK, QPSK and 8-PSK

From Figure 2, we can see that 8-PSK has higher BER due to its increased possibility, while BPSK and QPSK have lower BER. In addition, we can observe that BPSK and QPSK has the same performance in terms of BER. From the design of QPSK, even when we take the AWGN channel transmission into account, each symbol is still distinct. We can view QPSK as 2 sets of BPSK.

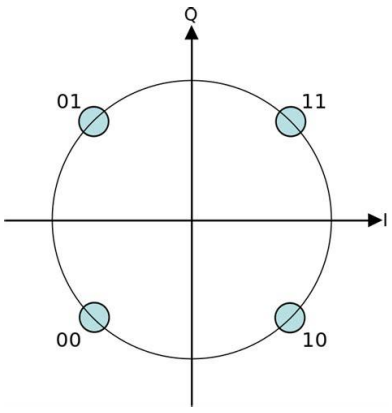

Figure 3. QPSK

For BPSK, the SNR range such that the BER ranges from 10^{-1} to 10^{-7} is from 0 ~ 11 dB. The range is similar for QPSK. For 8-PSK, the SNR range such that the BER ranges from 10^{-1} to 10^{-7} is 0 ~ 12 dB. Such BER range is subject to the limitation of memory and running time.

3. Comparison between 16-PSK and 16-QAM using Gray Code

Figure 3 is the BER-SNR (E_b/N_0) graph for BPSK, QPSK and 8-PSK using Gray Code:

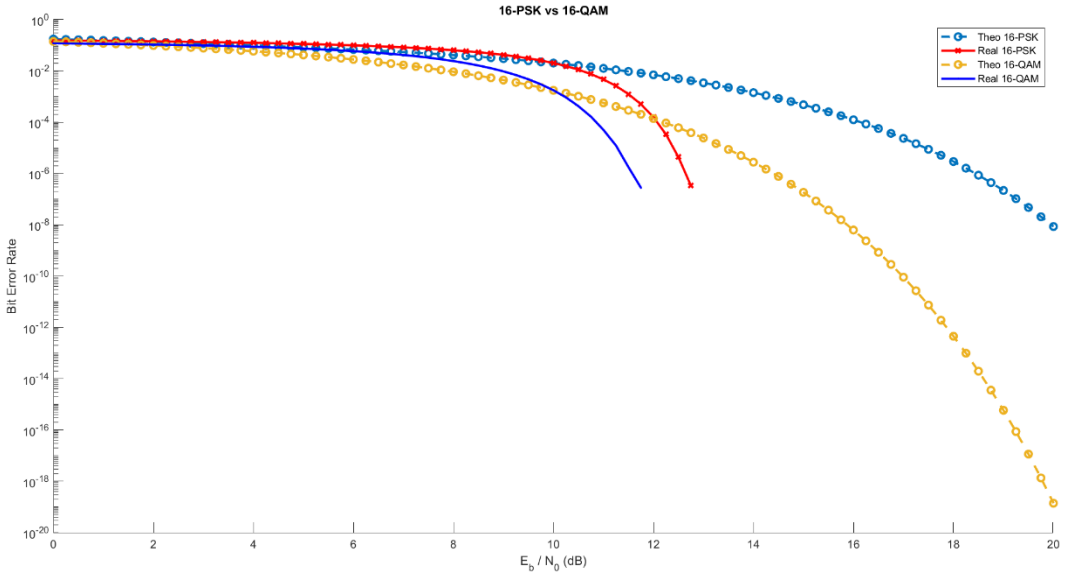

Figure 4. 16-QAM vs 16-PSK

From Figure 3, we can observe that 16-QAM has lower BER, it is a better modulation method. For 16-PSK modulation, we only differentiate symbols by phases. However, 16-QAM also uses amplitude to categorize different symbols. This makes 16-QAM easier to demodulate.

For 16-QAM, the SNR range such that the BER ranges from 10^{-1} to 10^{-7} is from 0 ~ 12 dB. On the other hand, for 16-PSK, the SNR range such that the BER ranges from 10^{-1} to 10^{-7} is from 0 ~ 13 dB.