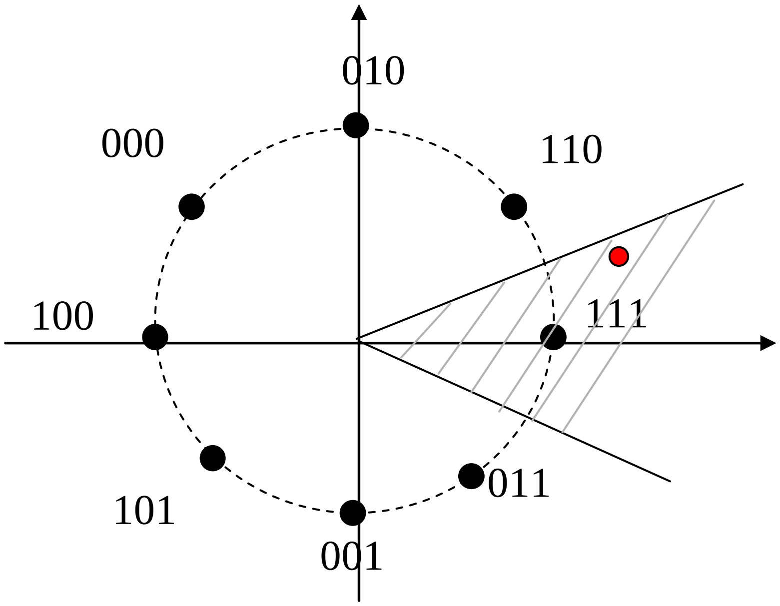
ELEG5663 Project 4
8PSK Modulation and Demodulation

I. Objectives

1. Understand the concepts of baseband complex modulation.
2. Understand the process of modulation and demodulation in complex baseband.
3. Learn to simulate communication system with flat Rayleigh fading and AWGN.

II. Theories

The constellation diagram of 8PSK modulation is shown in the following figure.



In 8PSK modulator, every 3 bits are mapped to one complex-valued 8PSK symbol. The transmitted symbols are corrupted by both Rayleigh flat fading and additive white Gaussian noise.

$$r_k = x_k + n_k \tag{1}$$

where x_k is the 8PSK modulated information symbol, r_k is the symbol at receiver, and n_k is AWGN.

For 8PSK modulation, the entire coordinate system can be equally divided into 8 angel sectors, with each angle sector corresponding to one of the 8 constellation symbols. The demodulation process can be performed by using the angle sectors. For example, the angle sector defined by $[-\pi/8, \pi/8]$ corresponds to the 8PSK symbol $\sqrt{E_s}e^{j0}$. If y_k falls in the angle sector of $[-\pi/8, \pi/8]$, then the demodulated symbol is $\sqrt{E_s}e^{j0}$, which means the output of the demodulator is (1, 1, 1) based on the constellation diagram.

III. Procedures

1. Write a function, EightPSK_mod.m, to perform baseband 8PSK modulation. The input of the function is a vector containing binary ‘0’s and ‘1’s, the output of the function is a vector containing the baseband complex 8PSK symbols. The energy of the output symbols is 1.
2. Write a function, EightPSK_demod.m, to perform baseband 8PSK demodulation. The input of the function is a vector containing baseband complex 8PSK symbols, the output of the function is a vector containing the binary sequence.
3. Test your modulator and demodulator by passing a short binary sequence through the modulator, and then pass the output of the modulator to the demodulator. Compare the original binary sequence and the output of the demodulator to make sure they are working properly.

4. In the simulation, we are going to use a slot structure similar to the second generation cellular standard IS-136. The symbols are transmitted in slots (bursts). Each slot has 162 symbols, with the symbol rate being 24.3ksym/s. We are going to find the BER at Eb/N0 = [0:5:25] dB.
5. How to generate zero-mean AWGN. In Matlab, AWGN can be generated with the function randn(m, n). Since both the inphase component and quadrature component of the signals are going to be corrupted by AWGN, the AWGN sequence should have complex-values.
   a) Generate the complex valued AWGN sequence by using the following command
      noise = noise_amplitude*(randn(1, N) + j*randn(1, N));
      where N is the number of symbols per block. noise_amplitude depends on Eb/N0. What is the variance of the noise in terms of noise_amplitude?
   b) The relationship between noise variance and Eb/N0 can be expressed by the following equation

      $$E_b / N_0 = \frac{E_s}{\text{noise\_variance} \times \log_2 M}$$

      where E_s the energy of one symbol, and M is the modulation constellation size. What should be the noise_amplitude for $E_s = 1$, M = 8, and $E_b / N_0 = 0dB$?
   c) Generate the noise component by using the noise_amplitude calculated from the previous step. Add the noise vector to the fading corrupted signal vector.

IV. Questions

1. Write the equation describing the relationship between Eb/N0 (dB) and noise_amplitude used to generate AWGN as described in step 5.