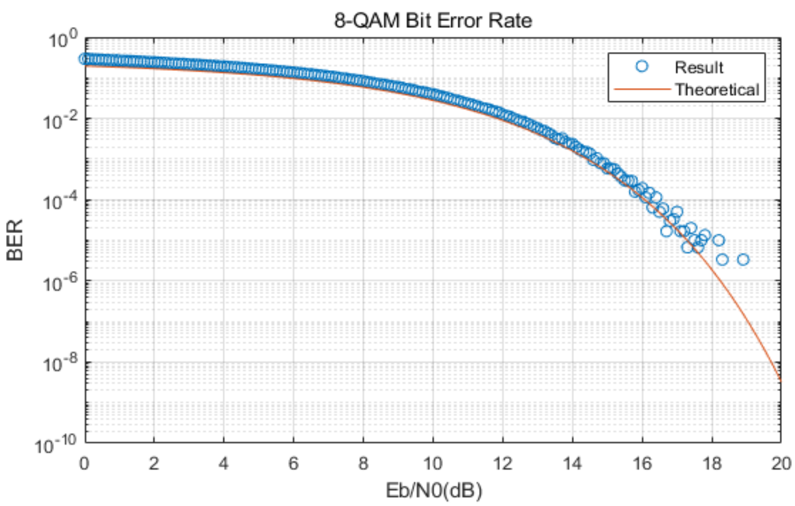
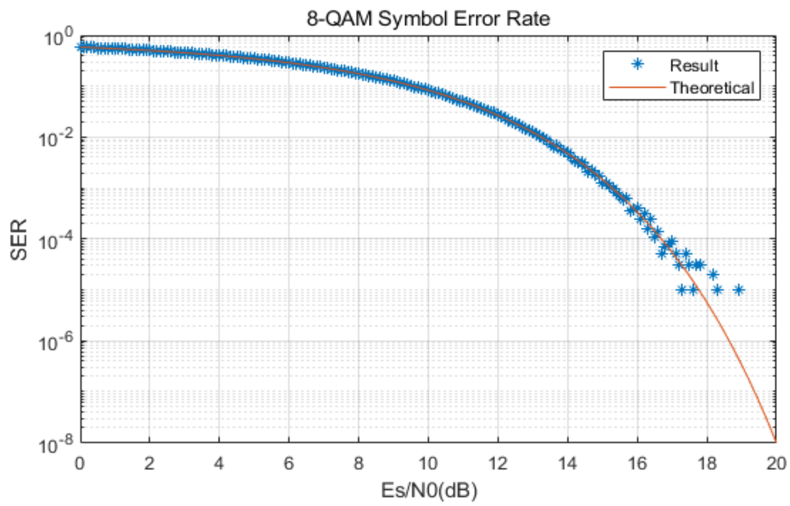
Assignment 1 - Simulation of an 8-ary Digital Communication System

Digital Communications (EEEN40060), 2020/2021

William

Result:





Modelling:

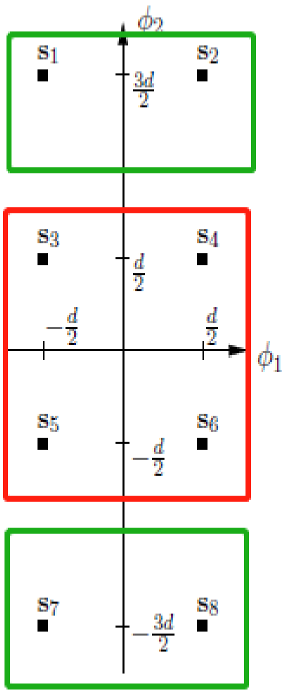
1. We first generated 100000 messages (a message consists of 3 bits).
2. On transmitter side, the reflected binary code (RBC), also known as Gray code is used to map the random input digital signal to symbols. Gray code is an ordering of the binary numeral system such that two successive values differ in only one bit (binary digit). Gray codes are widely used to prevent spurious output from electromechanical switches and to facilitate error correction in digital communications. In my code, I used Gray code and symbols in decimal form to make them more straight-forward.
3. AWGN was added to modulated vectors and demodulated the signal by calculating the Euclidean distance to each symbol and mapping the modulated signal (with the AWGN) to the nearest one.
4. Because of the equiprobable transmission, the metrics like SER and BER can be obtained by counting the number of error symbols.

Analysis:

- **Derivation of Theoretical SER**

  Recall the signal-space diagram for the 8-ary modulation scheme on the right.

  The overall SER equals to the sum of the SER of Red symbols and the SER of the Green (equiprobable transmission).



  $Red\ SER$

  $$= P_{\emptyset_2}\left(n \geq \frac{d}{2}\right) + P_{\emptyset_1}\left(n \geq \frac{d}{2}\right) - P_{\emptyset_2}\left(n \geq \frac{d}{2}\right) * P_{\emptyset_1}\left(n \geq \frac{d}{2}\right)$$

  $$= 2P\left(n \geq \frac{d}{2}\right) + P^2\left(n \geq \frac{d}{2}\right) = 2Q\left(\frac{d}{2\sigma}\right) - Q^2\left(\frac{d}{2\sigma}\right)$$

  Similarly,

  $Green\ SER$

  $$= 2P\left(n \geq \frac{d}{2}\right) + P^2\left(n \geq \frac{d}{2}\right) = 3Q\left(\frac{d}{2\sigma}\right) - 2Q^2\left(\frac{d}{2\sigma}\right)$$

  Average,

  $$SER = \frac{1}{8}(4 * Red\ SER + 4 * Green\ SER)$$

  $$= \frac{5}{2}Q\left(\frac{d}{2\sigma}\right) - \frac{3}{2}Q^2\left(\frac{d}{2\sigma}\right)$$

  The average energy to d, $d = \frac{\sqrt{2E_s}}{3}$, and $2\sigma^2 = 2N_0$

  Substitute into the formula, we obtain:

  $$SER = \frac{5}{2}Q\left(\sqrt{\frac{E_s}{3N_0}}\right) - \frac{3}{2}Q^2\left(\sqrt{\frac{E_s}{3N_0}}\right)$$

- Value of Eb/N0 is greater 5.333 than where BER lies below e-4