Reading

- Chapter 3 in the Anderson text

Problems

1. Consider the 4-QASK Y-constellation described

bits	symbol
0 0	$\mathbf{s}_1 = (0, 0)$
1 0	$\mathbf{s}_2 = \left(A\cos\frac{\pi}{6}, A\sin\frac{\pi}{6}\right)$
0 1	$\mathbf{s}_3 = \left(A\cos\frac{5\pi}{6}, A\sin\frac{5\pi}{6}\right)$
1 1	$\mathbf{s}_4 = \left(A\cos\frac{9\pi}{6}, A\sin\frac{9\pi}{6}\right)$

   (a) Sketch the constellation.

   (b) Compute the average symbol energy in terms of A.

   (c) Determine the value of A so that the average symbol energy is $E_s = 3$.

   (d) Sketch the decision region boundaries for this constellation.

   (e) Assuming a unit-energy NRZ pulse, the basis functions are

$$\phi_1(t) = \sqrt{\frac{2}{T}}\cos(\omega_0 t)$$
$$\phi_2(t) = -\sqrt{\frac{2}{T}}\sin(\omega_0 t)$$

   Sketch the modulated signal corresponding to the bit sequence 1 1 0 1 0 0 1 1. Use $\omega_0 = 4\pi/T$.

   (f) Determine the estimated bit sequence for the following sampled matched filter outputs:

$$(r_1, r_2) = \{(-0.03, +1.97), (-0.01, +1.97), (+0.01, +1.97), (+0.03, +1.97)\}$$

   (g) Suppose the ML receiver uses a bank of filters matched to the signal pulses $s_1(t), s_2(t), s_3(t)$, and $s_4(t)$ and that the matched filter outputs are:

$$\langle \mathbf{r}, \mathbf{s}_1 \rangle = 0$$
$$\langle \mathbf{r}, \mathbf{s}_2 \rangle = A^2/4$$
$$\langle \mathbf{r}, \mathbf{s}_3 \rangle = A^2/5$$
$$\langle \mathbf{r}, \mathbf{s}_4 \rangle = A^2/6$$

   What symbol does the ML receiver choose in this case?

   (h) What is the probability of making a symbol error? Express your answer in terms of E_b/N_0.

   (i) How does this constellation compare with QPSK in terms of probability of symbol error and bandwidth?