EE 5140: Digital Modulation and Coding: Quiz 2

Consider the pulse

$$p(t) = \begin{cases} 1 & 0 \le t \le 1 \\ 0 & \text{Otherwise.} \end{cases}$$

We use a 4-ary signalling scheme with the following signal waveforms:

$$\begin{aligned} s_1(t) &= p(t) \\ s_2(t) &= 0 \\ s_3(t) &= p(t) + p(t-1) \\ s_4(t) &= -p(t-1) \end{aligned}$$

We use additive white Gaussian noise model for the received waveform. Answer the following questions regarding the above scheme:

1. Choose a suitable orthonormal basis for the signal space and find the signal-space/vector representations for the signals $\{s_i(t), i = 1, 2, 3, 4\}$. Mark the signal constellation points in the 2D plane. [5 marks]
   `Remark:` Do this part carefully/correctly since it is useful for the following parts.

2. For the signal constellation obtained above, sketch the decision regions for the ML rule. [5 marks]

3. Suppose the received signal is

$$y(t) = \begin{cases} 1 - t & 0 \le t \le 1.5 \\ 0 & \text{Otherwise.} \end{cases}$$

   Find the output of the ML demodulator. [3 marks]
   `Hint:` May be easier to solve using the signal space representations.

4. Find the intelligent union bound on the average probability of the symbol error (in terms of $\frac{E_b}{N_o}$). [4 marks]

5. From the above 4-ary scheme, we want to get a ternary ($M = 3$) signalling scheme by removing one of the signals. Which signal will you remove so that the resulting ternary scheme has the largest power efficiency. Find the corresponding power efficiency of the resulting ternary signalling scheme. [3 marks]