Digital Communications
Midterm Exam
March 4, 2004

I pledge that I have neither given nor received any assistance on this exam.

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(signed)

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Name (print) Student Number

1. (15 points) Short answer. Please answer the following questions.

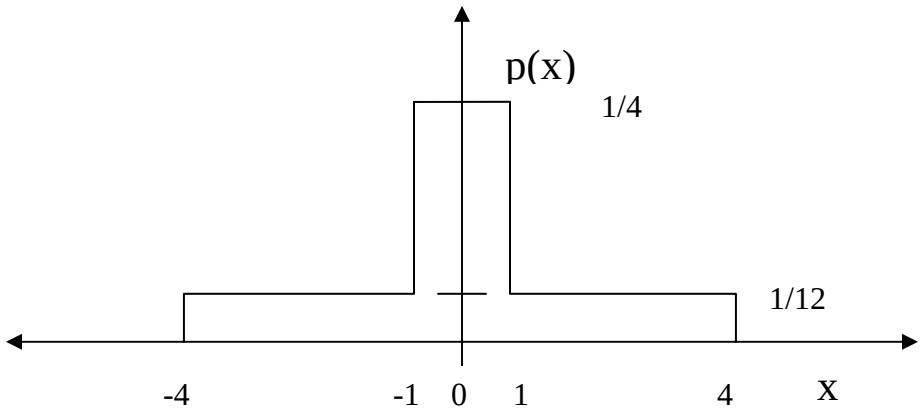
   a. (5 points) Why does vector quantization provide improvement over scalar quantization ?

   b. (5 points) Describe the “optimum” pulse shape as we have described it in class. In what sense is it optimum?

   c. (5 points) How does knowing the distribution of a source help improve the design of a source coder? Be specific!

2. (30 points) Quantization

Consider a memoryless source with a distribution function given in the figure below. A quantizer defined by $\tilde{x} = \{-3, -1, 1, 3\}$ is to be used for this source.

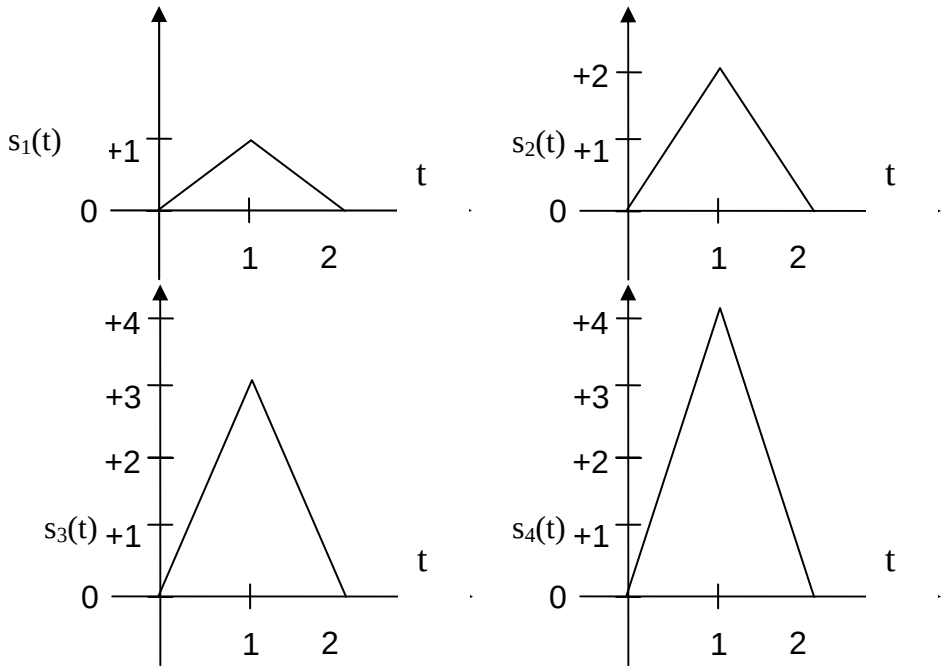


(a) (5 points) Is the quantizer described above optimum in terms of SNR for the rate used? How do you know?

(b) (10 points) Determine the SNR associated with the quantizer.

(c) (15 points) If the quantizer in part (a) is not optimum, determine a better quantizer for the same rate (you must show that it is better). If the quantizer in part (a) is optimum, show that any other quantizer will provide a worse SNR.

3. (25 points) Basis Functions

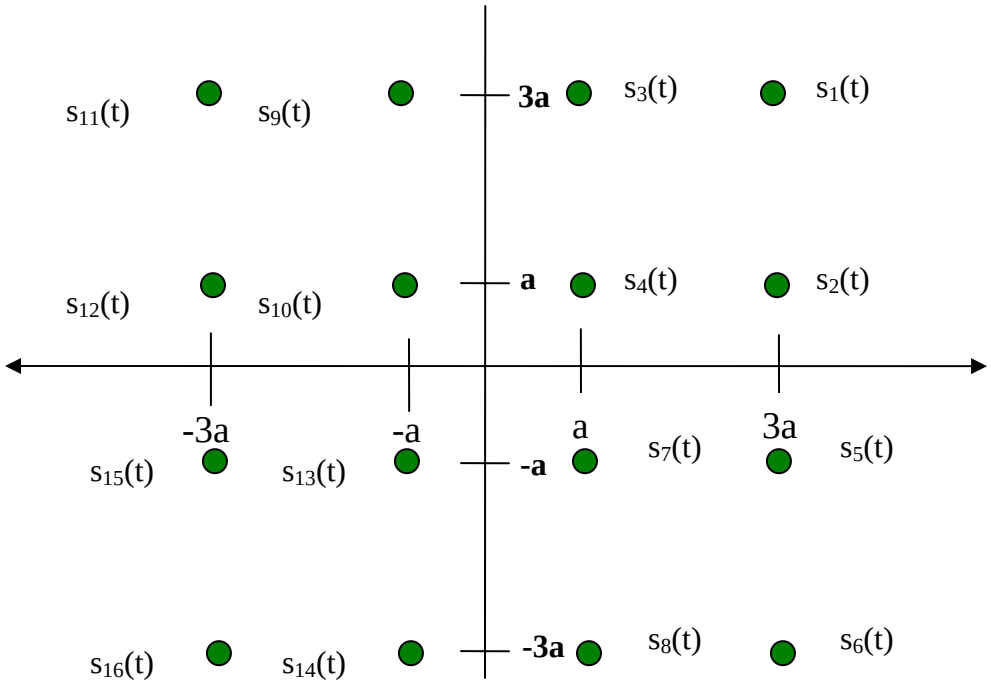


(a) (10 points) Determine a set of orthonormal basis functions for the above signal set. (You may either use Gram-Schmidt or inspection.)

(b) (10 points) Plot the constellation diagram in terms of E_s for the set and draw the decision regions assuming equally likely symbols. Label all points and axes.

(c) (5 points) Is this scheme more or less energy efficient than BPSK? More or less bandwidth efficient than BPSK?

4. (30 points) Assume that we are transmitting the following symbols in an AWGN channel



Using the Improved Union Bound, determine the average probability of symbol error in terms of E_b/N_o assuming that all symbols are equally likely.

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