Université Laval
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Département de génie électrique
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GEL10280: Communications numériques
2003 Examen Partiel

Mercredi le 12 mars 2003; Durée: 10h30 à 12h20
Une feuille documentation permise; une calculatrice permise

Problème 1 (20 points sur 100)

Suppose we have a signal with infinite time duration, that is

$$s(t) = \begin{cases} e^{-t} & t \geq 0 \\ 0 & \textit{ailleurs} \end{cases}$$

Further suppose that the channel is ideal with infinite bandwidth. The noise $n(t)$ is additive, white and Gaussian (AWGN) with PSD=$N_0/2$.

A. (5 points) Sketch the optimal receiver for this system using BPSK modulation.

B. (10 points) Suppose we use the same form for the receiver, but instead our observation window (time between samples) has a 1 second duration. Give the probability of error as a function of N_0.

C. (5 points) What is the loss in dB of the sub optimal receiver in part B, as compared with the optimal receiver of part A?

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Problème 2 (20 points sur 100)

We are going to compare the performance of rectangular 16QAM and non-coherent 16FSK with minimal separation between carriers. The bit rate is R_b=9600 bits/s and the symbol rate is R_s=2400 symbols/sec. Suppose the pulses are rectangular with symbol interval T_s =1/ R_s. Use the null-to-null bandwidth for this pulse.

A. (6 points) Sketch the spectrum for 16QAM and for 16FSK.

B. (6 points) Give the bandwidth efficiency for 16QAM et de 16FSK (show your work)

C. (8 points) Give the asymptotic loss in dB for 16QAM and for 16FSK relative to QPSK. (show your work)

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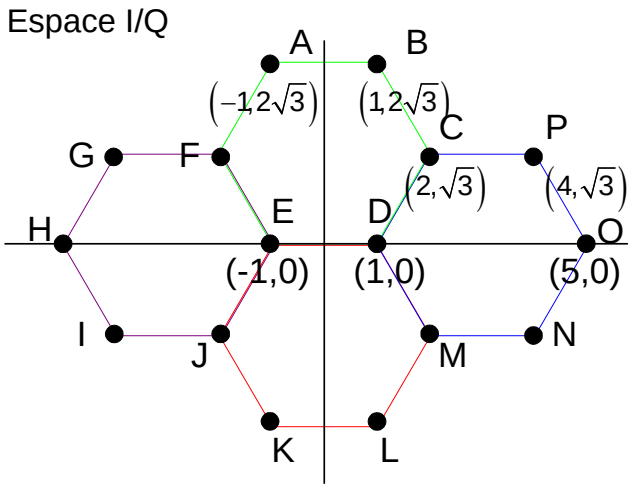
Problème 3 (30 points sur 100)

Symbol	Coordinates in I/Q space	Distance to the origin
A	$(-1,2\sqrt{3})$	$\sqrt{13}$
B	$(1,2\sqrt{3})$	
C	$(2,\sqrt{3})$	
D	$(1,0)$	
E	$(-1,0)$	
F		
G		
H		
I		
J		
K		
L		
M		
N		
O	$(5,0)$	
P	$(4,\sqrt{3})$	

Consider the hexagonal constellation for 16QAM given in the following diagram.



A. (5 points) What are the coordinates for symbols F-N in I/Q space? Complete the table and place it in the blue exam book.

B. (10 points) Find the minimal distance in signal space a s function of the average energy per symbol E_s.

C. (10 points) Find the probability of error using the union bound approximation.

D. (5 points) Does this constellation have an asymptotically better error probability than rectangular 16QAM with $D_{\min} = 2\sqrt{E_s/10}$? Justify your answer

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Problème 4 (30 points sur 100)

A. (10 points) Give the motivation for use of DPSK instead of BPSK. Give the receiver for DPSK and explain how it functions.

B. (10 points) What is the difference between a MAP and a MLE receiver? Give a simple example.

C. (5 points) What is the advantage to using orthogonal modulation?

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D. (5 points) What Nyquist pulse has minimal bandwidth?