GEL10280: Communications numériques
2004 Examen Partiel

Problem 1 (40 points out of 100)

A. (5 points) Give the definition of a Nyquist pulse.

B. (5 points) What is the most spectrally efficient Nyquist pulse?

C. (10 points) Explain the origin of intersymbol interference and the motivation for using Nyquist pulses.

D. (20 points) Here is the equation for the Nyquist pulse raised cosine,

$$v(t) = \frac{\sin(\pi t/T_s)}{\pi t/T_s}\frac{\cos(r\pi t/T_s)}{1-4r^2t^2/T_s^{\,2}}$$

and its Fourier transform

$$V(f) = \begin{cases} 1 & 0 < |f| < \dfrac{1+r}{2T_s} \\ \cos^2\left[\dfrac{\pi T_s}{2r}\left(f - \dfrac{1-r}{2T_s}\right)\right] & \dfrac{1-r}{2T_s} < |f| < \dfrac{1+r}{2T_s} \\ 0 & ailleurs \end{cases}$$

Describe the effect in the time and frequency domain for choosing $r \in \{0,.3,1\}$? Indicate in what situations we would select each of these three possible values for *r*.

Problem 2 (30 points out of 100)

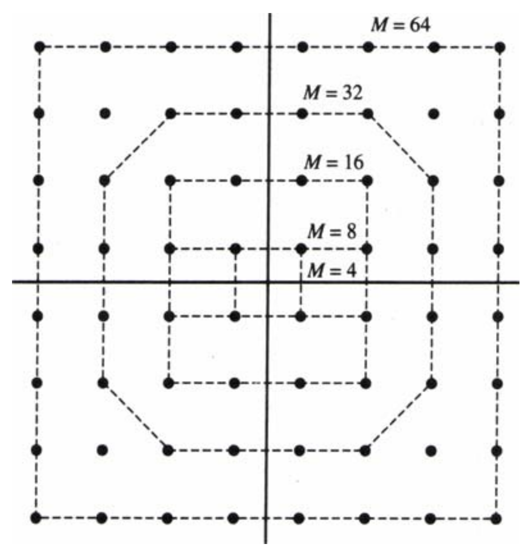
Rectangular 64 QAM

A. (15 points) Find the minimal distance (D_{min}) for rectangular 64QAM as a function of the average energy per symbol E_s. You should complete the table provided to assist you in your calculations. Do not forget to place the completed table in your blue exam book.

B. (5 points) Find the normalized minimal distance (d_{min}) for rectangular 64QAM.

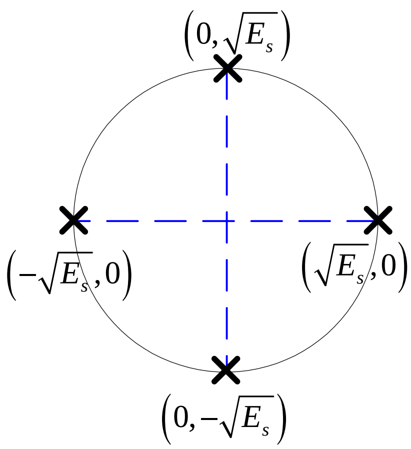
C. (10 points) Give an expression for the probability of error as a function of E_b/N_0 for rectangular 64QAM using the approximation derived from the union bound.

$\left(a_n^I, a_n^Q\right)$	# de points	$distance^2$ de l'origine	Sous-total
$(\pm1, \pm1)$			
$(\pm1, \pm3)$ $(\pm3, \pm1)$			
$(\pm3, \pm3)$			
$(\pm1, \pm5)$ $(\pm5, \pm1)$			
$(\pm5, \pm5)$			
$(\pm1, \pm7)$ $(\pm7, \pm1)$			
$(\pm7, \pm7)$			
$(\pm3, \pm5)$ $(\pm5, \pm3)$			
$(\pm3, \pm7)$ $(\pm7, \pm3)$			
$(\pm5, \pm7)$ $(\pm7, \pm5)$			
$\sum_{i=1}^{M}\left[\left(a_n^I\right)^2+\left(a_n^Q\right)^2\right]$			



Problem 3 (30 points out of 100)

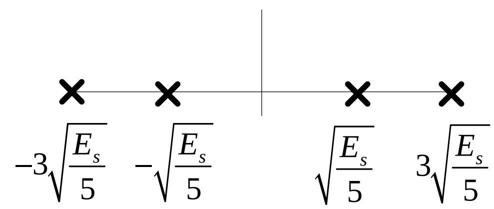
A. (10 points) For coherent detection and ideal Nyquist pulses, give the spectral efficiency for the three following constellations:



QPSK

$$s_1 = [1 \quad 0 \quad 0 \quad 0]\sqrt{E_s}$$
$$s_2 = [0 \quad 1 \quad 0 \quad 0]\sqrt{E_s}$$
$$s_3 = [0 \quad 0 \quad 1 \quad 0]\sqrt{E_s}$$
$$s_4 = [0 \quad 0 \quad 0 \quad 1]\sqrt{E_s}$$

4FSK



4PAM

B. (10 points) For each constellation indicate

a. If the use of Gray code would be appropriate.

b. If so, give a Gray code for the constellation.

C. (10 points) Compare the performance of QPSK and 4PAM in terms of spectral efficiency and probability of error.