FACULTY OF ENGINEERING AND ARCHITECTURE
AMERICAN UNIVERSITY OF BEIRUT
FALL 2013 - 2014

FINAL EXAM

Communication Systems (EECE442)- Dr. Youssef Nasser

December 16, 2013

NAME: _____ ID: _____

CLOSED BOOK, OPEN LECTURES (120 MINUTES)

WRITE YOUR NAME AND ID NUMBER IN THE SPACE PROVIDED ABOVE.

PROVIDE YOUR ANSWERS IN THE SPACE PROVIDED ON THE QUESTION SHEET.

THE SCRATCH BOOKLET WILL NOT BE CONSIDERED IN GRADING.

Problem	Total Points	Earned Points
1	26	
2	20	
3	24	
4	15	
3	15	
Total	100	

Problem 1 [26 points]: Cocktail Questions

1- What is the difference between baseband signals and bandpass signals? (2pts)

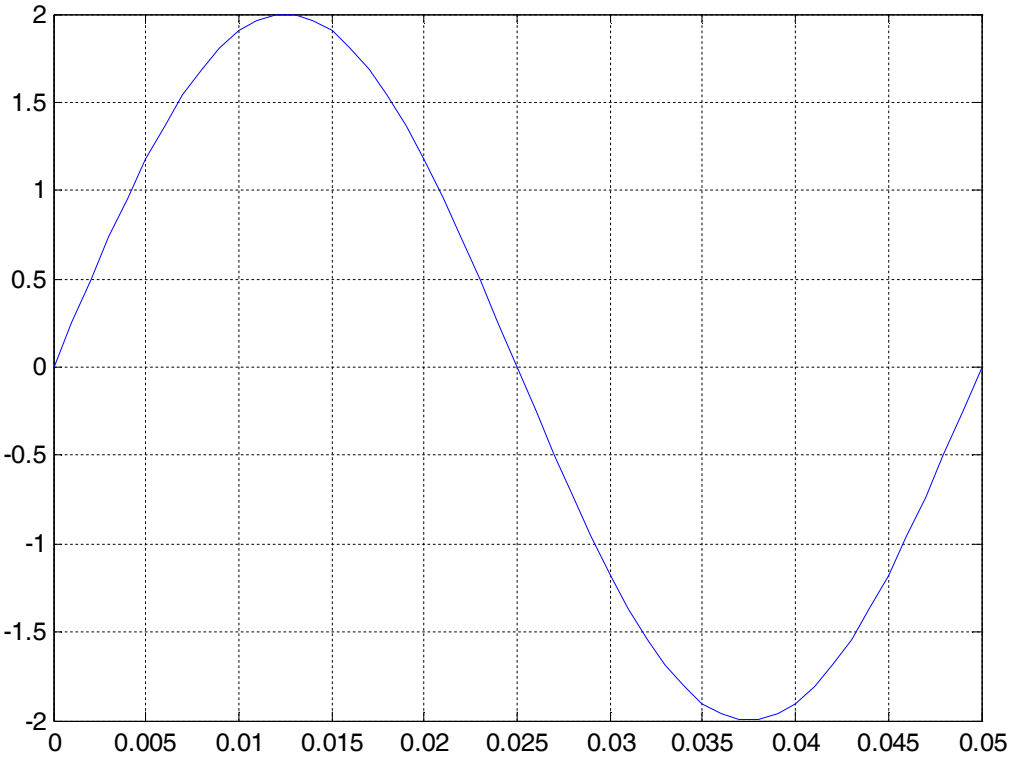
2- Draw the block diagram of a baseband transmission and the block diagram of a bandpass transmission (TX/RX). (4pts)

3- To modulate a signal at a carrier frequency, a pulse shaping filter is necessary; In class, we have seen the rectangular filter, the sinc filter and the raised cosine filter. If it is required to select a filter among these three to have a time-limited signal, which one and only one would you select? Justify your answer. (2pts)

4- Repeat the same question above if the required signal should be a band-limited signal. Justify (2pts)

5-**Quantization**: Consider the signal $x(t) = Asin(2\pi f_0 t)$ where A=2 and $f_0 = 20Hz$. It is required to plot the quantized signal at the output of the quantizer, on the figure below, when:

a. An 8-levels Uniform quantizer is used assuming that the sampling rate is $f_s = 400Hz$. Use a dot (.) to represent a sample and a dash (-) to represent a quantized sample (6pts)



6- Consider the binary sequence of 12 bits: 010101011111. It is required to **express** (mathematical expression) the bandpass signal at each symbol duration $k.T_s$ corresponding to the transmission of this sequence when:

a. 8-PSK digital modulation is used (4 pts)

b. QPSK modulation is used. (4 pts)

c. Assume that the duration of one transmitted bit is T_b; deduce the duration T_s of the transmitted symbol in each case a and b above. (2 pts)

Problem 2 [20 points]: Log Likelihood ratio

In communications systems, a soft decision is usually required at the input of the channel decoding due to its efficient. The soft decision is expressed as log likelihood ratio (LLR) defined for each transmitted bit as:

$$LLR(b) = ln\left(\frac{P(b_1/y)}{P(b_0/y)}\right) \xrightarrow[Bayes\ rule]{} = ln\left(\frac{P(y/b_1)}{P(y/b_0)}\right)$$

where y is the received signal, b_0 is the transmitted bit '0' and b_1 is the transmitted bit 1.

A- We consider a **BPSK modulation**, and an additive white Gaussian noise (AWGN) channel with zero mean and variance σ_0^2, it is required to:

1- Find the probability distribution function (pdf): $P(y/b_0)$ (probability of y such that b_0 is transmitted. (4pts)

2- Find the probability distribution function (pdf): $P(y/b_1)$ (probability of y such that b_1 is transmitted (4pts)

3- Deduce from 2 and 3 the LLR of a bit b. (4pts)

B- We consider a modified BPSK modulation where the bit b_0 is represented by ($-A_0$), the bit b_1 is represented by A_1 where A_0 and A_1 two arbitrary deterministic values. Using the same methodology of part A, find the LLR of a bit b. (8 pts)

Problem 3 [24 points]: Probability of error

We consider a modified BPSK modulation where the bit b_0 is represented by A_0, the bit b_1 is represented by A_1 where A_0 and A_1 two arbitrary deterministic values. We consider an AWGN transmission model with zero mean and variance equal to $N_0/2$.

a- Find the average energy per transmitted bit E_b in terms of A_1, A_0 and T_b.(3pts)

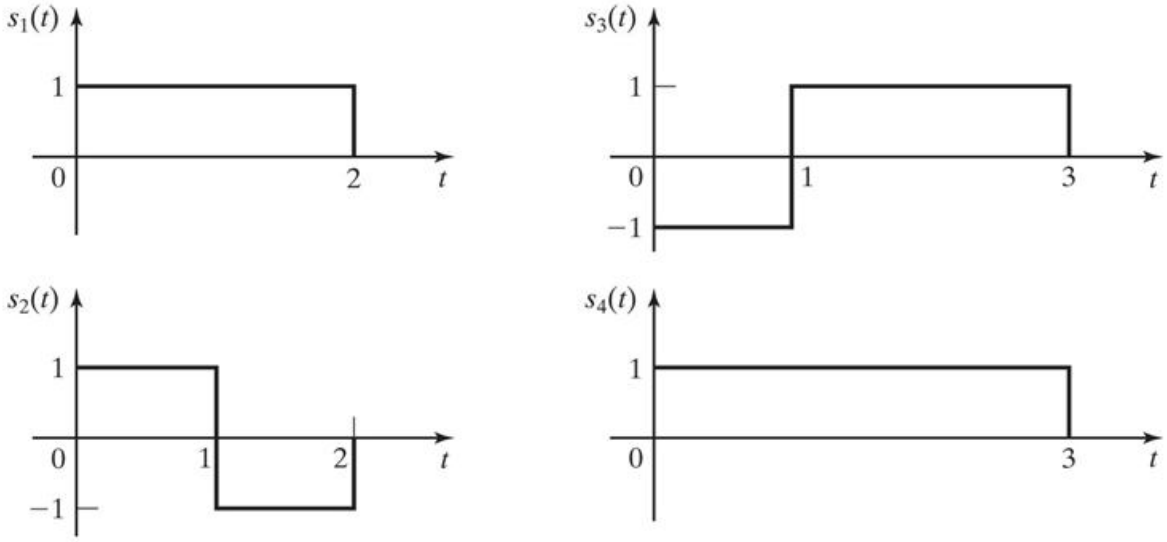
b- It is required to find the probability of error of this modified BPSK modulation. (15pts)

c- Deduce the probability of error when $A_1=A_0$ and compare your results with the derivation done in class. (3pts)

d- We assume that A_1=2 and A_0=1. We define the cross energy $E_{bc} = A_1 A_0 T_b$. Using the look-up table in the appendix (page 11), find the probability of error of this modified BPSK when Eb/N0=10dB and Ebc/N0=4.7dB (3pts)

Problem 4 [15 points]: Gram-Shmit Orthogonalization

Find and plot the orthonormal basis functions of the following set of symbols using the Gram-Schmidt Orthogonalization



Problem 5 [15 points]: Matched filter

Consider the following pulse shaping filter defined by:

$$g(\tau) = \begin{cases} 1 & if\ 0 \le \tau \le 1 \\ -\tau + 2 & if\ 1 \le \tau \le 2 \end{cases}$$

a- Plot the pulse shape of this filter $g(\tau)$. (1 pt)

b- Derive and plot the expression of the output of the matched filter. (8 pts)

c- At which time, this (absolute value) output is maximized. Find this maximum (2 pts)

d- We assume that this filter is used for a signal of bandwidth B=10MHz and that the noise power is 50dBw. Find the maximum SNR value at the output of the matched filter. (4 pts)

Appendix: The Q-function Look-up table

z	$Q(z)$	z	$Q(z)$
0.0	0.50000	2.0	0.02275
0.1	0.46017	2.1	0.01786
0.2	0.42074	2.2	0.01390
0.3	0.38209	2.3	0.01072
0.4	0.34458	2.4	0.00820
0.5	0.30854	2.5	0.00621
0.6	0.27425	2.6	0.00466
0.7	0.24196	2.7	0.00347
0.8	0.21186	2.8	0.00256
0.9	0.18406	2.9	0.00187
1.0	0.15866	3.0	0.00135
1.1	0.13567	3.1	0.00097
1.2	0.11507	3.2	0.00069
1.3	0.09680	3.3	0.00048
1.4	0.08076	3.4	0.00034
1.5	0.06681	3.5	0.00023
1.6	0.05480	3.6	0.00016
1.7	0.04457	3.7	0.00011
1.8	0.03593	3.8	0.00007
1.9	0.02872	3.9	0.00005

The definition of Q function is:

$$Q(z) = \int_z^\infty \frac{1}{\sqrt{2\pi}} e^{-y^2/2} dy$$