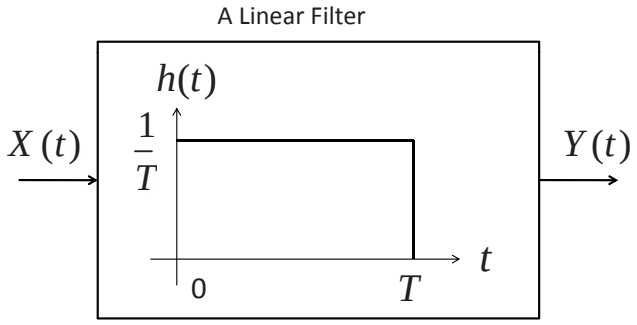
GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING
Final Examination - Fall 2010
EE 4601: Communication Systems

Aids Allowed: Course notes, calculator
Attempt all questions
All questions are of equal value

DATE: Friday December 17, 2010.
TIME: 2:50pm - 5:40pm
INSTRUCTOR: Professor G.L. Stüber

1) Random Processes: The noise process $X(t)$ applied to the filter shown in the figure below is modeled as a wide sense stationary (WSS) random process with power spectral density $\Phi_X(f)$. Let $Y(t)$ be the random process at the output of the filter.



a) 2 marks: Is $Y(t)$ a WSS noise process? Why?

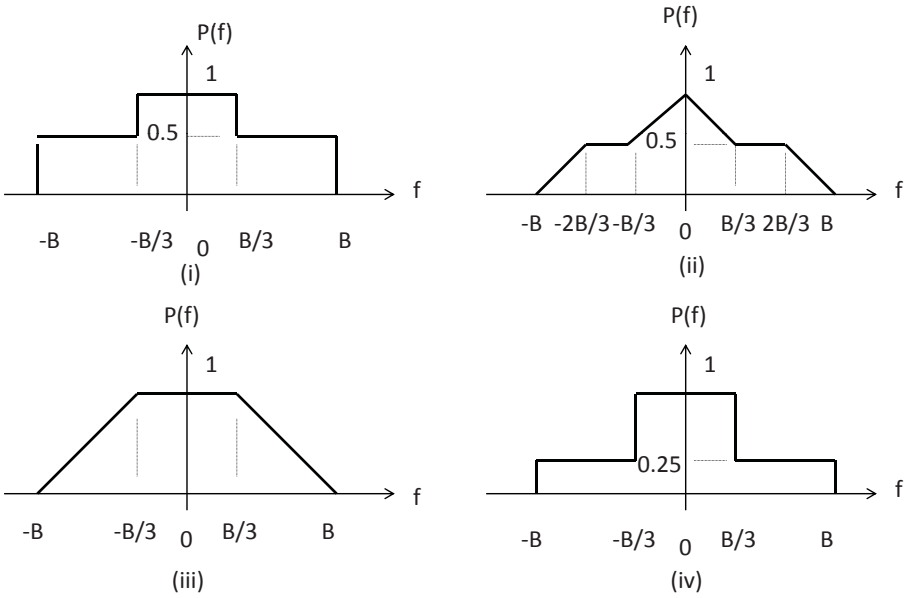
b) 3 marks: Find the frequency response, $H(f)$, of the filter.

c) 3 marks: If $X(t)$ is a white noise process with power spectral density (psd) $N_o/2$, find the psd of the noise process $Y(t)$.

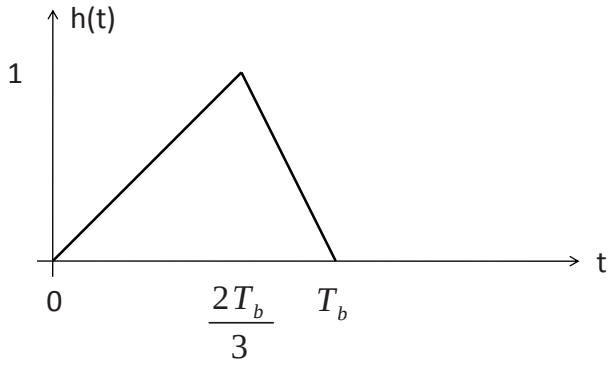
d) 2 marks: What frequency components cannot be present in the output process? Explain.

2) Intersymbol Interference:

a) 10 marks: For each of the overall system responses $P(f) = G(f)C(f)H(f)$ ($G(f)$ is the transmit filter, $C(f)$ is the channel, $H(f)$ is the receiver filter) in the figure below, determine if one can signal at a rate which would result in zero ISI, and if so what the baud rate R is.



3) Binary Signaling: A communications magazine carries an advertisement for a bargain basement filter that has the impulse response shown in the figure below.

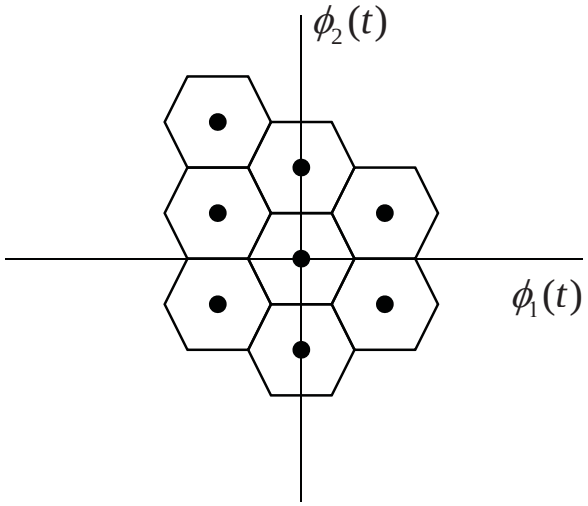


The manager of your division notices this and asks you to design an antipodal binary modulator for an AWGN channel, where the noise has a two-sided power spectral density of $N_o/2$ watts/Hz. The goal of this design is to take advantage of this filter in the receiver for an optimum demodulation.

a) 5 marks: Design the modulator, basically the signal set to take advantage of this filter. Explain.

b) 5 marks: Assume that $N_o = 10^{-9}$ watts/Hz. What is the maximum bit rate that can be sent with a probability of error $P_b \leq 10^{-3}$?

4) 8-QAM Design: You have been asked to design a modulation scheme to conserve bandwidth and it has been decided to use an 8-QAM signal constellation. A conventional 8-QAM constellation based on an odd-integer lattice does not use the available power efficiently. You decide on a different signal constellation. Inspired by the tile design on the floor of a local shopping mall you come up with the design shown in the figure below.



Assume that the side of each hexagon is of length Δ. Determine

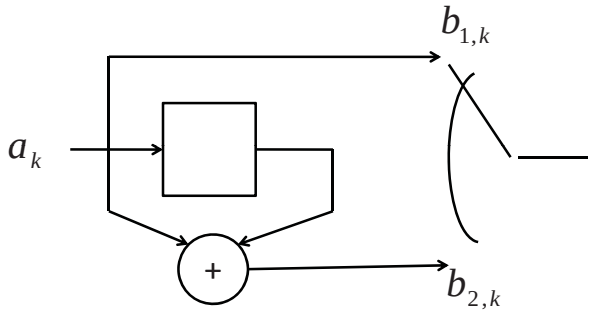
a) 2 marks: The *minimum* distance between the signals in terms of Δ.

b) 4 marks: The average transmitted energy per bit in terms of Δ.

c) 3 marks: Assuming that all signal points are equally likely, draw the decision regions of the minimum error probability receiver.

c) 3 marks: A simple upper bound on the probability of symbol error in terms of the *bit energy-to-noise ratio*, E_b/N_o.

5) Coding: Consider the simple 2-state convolutional code shown in the figure below



a) 2 marks: Draw the state diagram.

b) 3 marks: Draw the augmented state diagram.

b) 3 marks: Determined the transfer function $T(D, N, L)$ of the code.

b) 2 marks: What is the minimum distance of the code?